HEVOLUTION

THE GLOBAL HEALTHSPAN REPORT

Second Edition

Hevolution.com

Foreword

A niche field just a few years ago, the field of healthspan research is now burgeoning with unprecedented promise and potential. The concept of healthspan – the years lived in good health – has captured the imagination of scientists, investors, global enterprises, founders, policymakers, and the public alike, heralding a future in which living longer is truly aligned with living better.

Hevolution Foundation's mission to extend healthy human lifespan has gained significant momentum, too, thanks to our strategic investments and partnerships across the field.

In three years, we have allocated over $400 million to bring more scientists into the healthspan field, create more companies to address this issue, and attract more funding to the field to advance it, making us the largest philanthropic funder in the emerging healthspan science field. To date we have supported about 200 grants, over 250 grantees, over 25 partnerships, 4 biotech impact investments with more currently under due diligence.

Securing a future for the industry requires investing in human capital, too, which is why we were proud to announce the third cohort of recipients for our New Investigator Awards in Aging Biology and Geroscience Research, a collaboration with the American Federation for Aging Research (AFAR). We also created the Global Healthspan Summit: the world's largest healthspan convening of its kind, bringing together global leaders across the entire healthspan ecosystem. The success of our two summits opened doors and conversations with leaders in key forums from the United Nations General Assembly to the World Health Organization.

Our second edition of the Global Healthspan Report shows that the momentum behind healthspan research and deployment is accelerating. Across the world, there is a growing appetite for, and an understanding of, healthspan as a global force for universal health and positive economic outcomes.

But there is still much to do, and we should not be complacent: acceleration is an opportunity for success, not a guarantee. We must do more to convince, develop, and deploy healthspan at scale and for everyone.

As Hevolution, we are dedicated to playing a catalytic role in mobilizing the healthspan ecosystem and the movement behind it. To researchers, we look forward to supporting you in advancing the field of healthspan science further and faster. To investors, let us co-invest in the companies that will bring these solutions to the market and in the innovations that will make them affordable to the broader population. To policymakers, we look forward to supporting you in your efforts to ensure fair and equitable access to healthspan solutions.

The shift required to advance the healthspan science field globally is both systemic and complex. It calls for new ways of thinking and larger amounts of capital. But it can and must be achieved. We will have achieved success if in five years Hevolution is among the smallest players in the field, at its current funding level. This will require action from all stakeholders. This report highlights some of the critical avenues for acceleration – we hope you enjoy it. Together, let us architect a future where healthy lifespan is expanded for the benefit of all humanity.

DR. MEHMOOD KHAN
Chief Executive Officer, Hevolution Foundation

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Executive Summary

Since the publication of the first Global Healthspan Report two years ago, the field of healthspan has seen substantial growth. Across the board, interest in healthspan is on the rise. With this comes opportunities for acceleration, as well as challenges that will need to be met to ensure that the growth of credible science is sustained and healthspan opportunities are accessible to all. Drawing on two global surveys, investment data, expert interviews, and research, this second edition of the Global Healthspan Report examines the current state and future prospects of healthspan, highlighting key developments and actions the field can take as an ecosystem to bring healthspan to the next level.

Science has expanded the realm of possibilities; we now need alignment.

From mRNA vaccines to senotherapeutics, genome editing or cellular reprogramming, science has seen amazing developments in a very short time. Confidence in translating healthspan science into actionable therapies is also growing. It is now time to align and increase the focus on healthspan. One area where this will be key is novel biomarkers, which are experiencing a surge in innovation and where consensus is needed to drive progress. The role of gender, socio-economic factors, and ethnicity in healthspan represent other areas where acceleration is needed, with the majority of B2B scientists noting that gender considerations are key to more equitable healthspan research and development.

Despite a doubling of investments since 2023, healthspan remains severely under-invested as a field.

Investment in the fields of healthspan and longevity are connected, yet distinct. Investments in the domains tracked for this report reached $7.3bn in 2024 (more than double the 2023 levels). Deals have also increased in size over the years, with a 77% rise in average deal size since 2020.This is in large part driven by later-stage deals, reflecting a maturation of the field. Despite these important developments, the field remains severely under-invested when compared with the scale of the challenge. Early-stage VC investment has also declined, making the support of the transition from lab to market more urgent than ever.

Consumer demand is surging; with it comes opportunities and challenges.

Two-thirds of B2B medical professionals surveyed report frequent patient inquiries about healthspan interventions, with one-third encountering them weekly. Public interest in participating in healthspan research is also growing, creating opportunities for national programs at unprecedented scales. The emergence of public longevity clinics marks a significant milestone in translating healthspan innovations into mainstream healthcare. Yet the arrival of actors making unsubstantiated longevity claims poses risks to patients and to the field's credibility. This makes safety, efficacy, and effectiveness critical lenses through which to evaluate interventions. Education and standardization of protocols and frameworks will also be key for the industry's sustainable growth and scale.

Technology is heralding a phase of acceleration; keeping the human in the loop will be essential to sustained growth.

Artificial intelligence (AI) is reshaping the future of healthspan across the value chain with efficiencies that defy traditional timelines. Most respondents in our B2B and B2C surveys are supportive of AI use, though 26-30% still oppose its use in diagnosis, drug development, and clinical trials. Ensuring equitable data representation and demonstrating tangible benefits in patient care will be key to AI's further integration into healthcare systems. New approaches to data collection and use are vital, while addressing regulatory and ethical challenges is needed to ensure safe, equitable advancements in healthspan.

Healthspan is an economic imperative; achieving it will not be free, but it will provide significant returns.

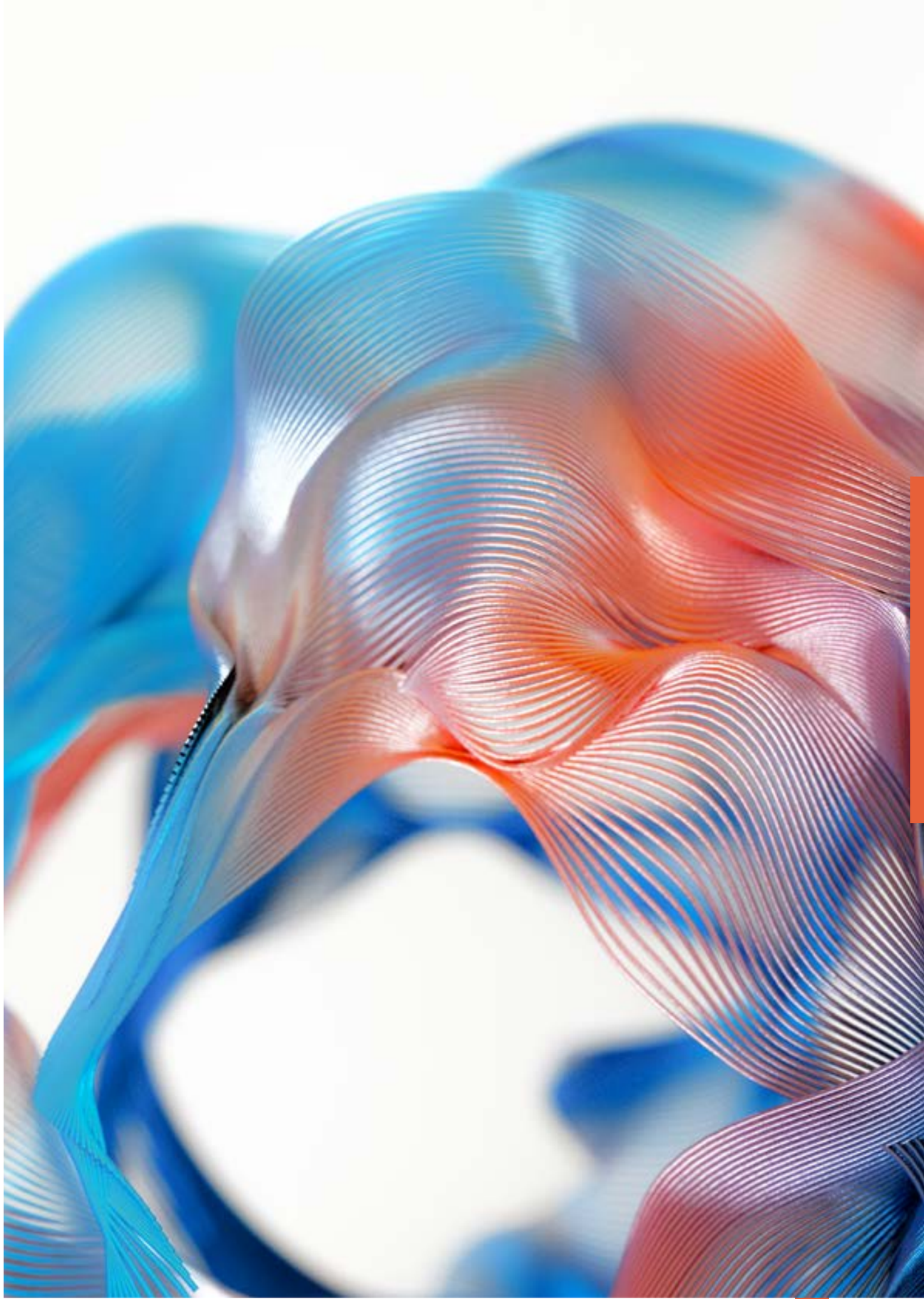
Healthspan is not just another item on the healthcare agenda – it is the key to unlocking future economic prosperity. Delivering healthspan is not free, but it can provide significant returns. A more detailed and comprehensive evaluation of the benefits of healthspan is essential to convince policy makers and mobilize capital. It will also be important for developing countries to create the fiscal space necessary for investment.

Policy change requires leadership; it also requires innovation.

While one-third of B2C respondents believe governments should lead, only one in four believe governments will. This misalignment between hopes and expectations doesn't just highlight different perspectives – it signals an urgent need to bridge the gap between private sector capabilities. For governments, the challenge lies not in recognizing the opportunity but in marshalling the political will and public support to seize it. This calls for a whole-of-economy approach, from policy design to implementation. Policy innovations are needed, including on prevention. Equity considerations cannot be overlooked, and partnerships will be central to that effort.

Effective advocacy is needed for acceleration.

A change in deeply entrenched beliefs about aging and health is urgently needed. Many still view aging as an inevitable decline rather than a process that can be actively managed. By shifting the focus to societal and economic implications, we can foster a meaningful dialogue that recognizes healthspan as a cornerstone of public health and economic policy, unlocking its full potential. This will require healthspan advocates to outreach to an entirely new set of stakeholders. In engaging this wider public, the evidence-based healthspan community faces an important challenge: tackling the noise coming from those in the broader longevity space overselling on the promises of what is still a very nascent field. Sticking to evidence-based information when advocating for healthspan is therefore crucial to the credibility of the movement.



About the data in this report

To inform the report and complement its research and interview program, Hevolution Foundation commissioned two global surveys and collected investment data, the findings of which are described in this report.

23 Countries Were Covered across 6 Key Regions

Africa
- Kenya
- Nigeria
- South Africa

Asia-Pacific
- Australia
- China
- India
- Japan
- Singapore

Europe
- France
- Germany
- United Kingdom
- Russian Federation

Latin America
- Brazil
- Mexico

Middle East
- Bahrain
- Egypt
- Kuwait
- Oman
- Qatar
- Saudi Arabia
- United Arab Emirates

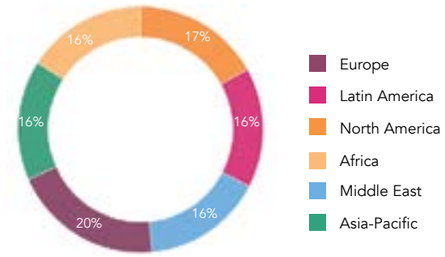
North America
- Canada
- United States

Data for the citizen survey (N=4000) was collected via online surveys. Data for the healthcare professionals (N=1000) survey was collected using computer-assisted telephone interviews methodology. A ponderation was applied to allow for comparison between 2023 and 2024 waves.

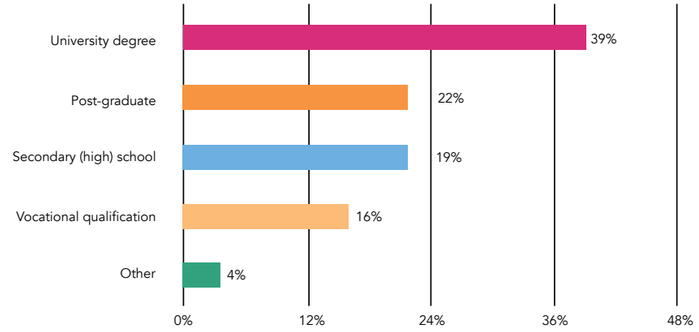
Financial data on investment is provided by Longevity.Technology. The company analyzes the wider industry across 25 domains, but for the purposes of this report, data has been limited to domains that are closer to healthspan science (and education), namely: Genetics, Diagnostics, Senotherapeutics, Reproductive health, Discovery platforms, Healthspan drugs, Immune health, Metabolic rejuvenation, Microbiome, Neurotech, Rejuvenation, Reprogramming, Regeneration, Repurposed drugs, Neuropharma, and Education. A full description of these domains is provided in Annex 1. Collectively, these domains offer a more accurate set for tracking healthspan investments compared to the broader longevity space. However, they remain an approximation and should be understood as such.

4,000 Citizens (B2C) Survey

Region
(Percentage may not total 100 due to rounding)

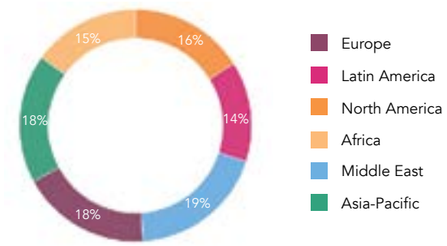


Highest level of education



1,000 Healthcare Professionals (B2B) Survey

Region
(Percentage may not total 100 due to rounding)



Industry
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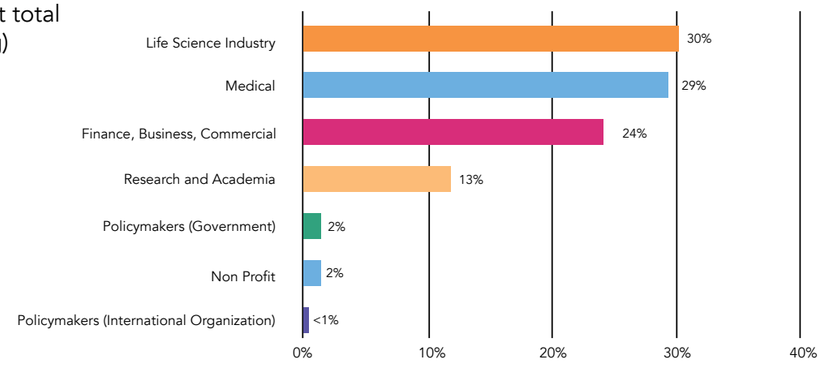

01 AWARENESS

INTEREST IN HEALTHSPAN IS ON THE RISE

Healthspan is gaining momentum as governments and private sectors recognize the economic and social advantages of healthy aging. While both healthspan and longevity are terms related to the duration of life, healthspan refers to the period of life spent in good health, free from chronic diseases and disabilities associated with aging. In other words, healthspan emphasizes the quality of life rather than just its duration.

The US National Institute on Aging has seen funding increases, with its budget reaching $4.4bn for 2025, from $3.8bn in 2021 (1,2,3,4). Healthspan-focused equity investments, meanwhile hit $7.3bn in 2024 – more than double the 2023 levels (see Chapter 3: Investment). This combination of public and private capital is supporting advancements in regenerative medicine and anti-aging therapies (5,6), while driving the healthspan dialogue in academic, industry, and public domains. Though still too small compared with what is needed, these are important and promising developments for the nascent field of healthspan.

"We're right at the beginning of something that will be transformative for society," says Dr. Eric Verdin, President & CEO of the Buck Institute for Research on Aging. "The advances that we've made in preclinical research have been extraordinary, and so one can reasonably hope that we are on the verge of a whole series of discoveries."

Indeed, the dialogue is increasingly focused on healthspan as a key metric, recognizing that extending life without improving its quality is not the ultimate goal. Commenting on healthspan awareness in the broader academic and clinical fields, Professor Andrea Maier, Oon Chiew Seng Professor in Medicine at the National University of Singapore, notes: "We are defining what the biomarkers of aging are. We are defining what healthy longevity medicine is, we are defining what gerotherapeutics and gerodiagnostics are, and we are defining what precision geromedicine is."

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> President and CEO, Buck Institute for Research on Aging

There is also stronger interest within the general population, with two-thirds of the B2B medical professionals surveyed encountering patients asking about healthspan solutions/ interventions at least once a month (one-third weekly). One of the segments to benefit from this interest is the wearable tech market, which is expected to reach a staggering $231bn by 2032 and a 14.60% Compound Annual Growth Rate (CAGR), driven primarily by consumer demand for health monitoring devices that empower individuals with insights into their behaviors and health trajectories. Wearable tech has evolved far beyond simple step counters, and now offers a wide range of health metrics tracking capabilities, bridging the gap between consumer wellness products and professional healthcare services (7,8,9).

This greater interest in healthspan solutions comes with greater demands from governments, with 80% of B2C respondents agreeing that governments should fund preventive care to extend healthspan. For example, Australia announced it would allocate $545mn to preventive health research over the next decade (10). In Singapore, the Healthier SG reform, which started with personalized health plans for citizens aged 60+, was expanded to cover those aged over 40 (11,12,13). Launched just over two years ago, the UK's 'Our Future Health Program' uses genetic analysis and lifestyle data to identify diseases early (14,15). With two million individuals participating so far, this program is now the UK's most extensive health research program and one of the largest in the world. More recently, the US Advanced Research Projects Agency for Health (ARPA-H) announced a program for the development of new therapeutics specifically designed to increase healthspan.

Recent successes are fueling this momentum

Aging is a common and major risk factor for multiple chronic diseases, and over the past few years, we have witnessed scientific progress in addressing the aging drivers implicated as 'aging pathways' in numerous preclinical and clinical studies. Over 30 clinical trials investigating senolytic and senomorphic agents have been completed, are currently in progress, or are scheduled for various indications. These drugs selectively induce senescent cell removal or attenuate the tissue-destructive secretory state of specific senescent cells, showing promise in delaying or alleviating multiple aging-related diseases (16).

Metformin and rapamycin, which target the AMPK and mTOR signaling pathways, respectively, are among the most extensively studied compounds, having exhibited a range of beneficial effects, including immunomodulatory properties and alterations in cellular metabolism, in both in vitro and in vivo models of healthy aging (17).

The success of GLP-1 agonists has also demonstrated the appetite for preventative therapies. "I'm very excited about the GLP-1 agonists. They didn't come from the aging field, but I think they could be the first global anti-aging drug that we have," says Dr. Verdin. While the longer-term impact of these drugs will require careful oversight, their implications for patient care in the clinical community cannot be overstated.

"GLP-1 agonists represent a remarkable leap forward in addressing an array of conditions – spanning metabolic disorders, anxiety, oncology, and cardiovascular disease. While close monitoring of side effects remains essential, these therapies have already propelled us past the peak of the global obesity crisis, placing us on a promising downward trajectory," says Dr. Jordan Shlain, Founder & Chairman of Private Medical. GLP-1 agonists have also delivered commercial success, with two of the largest producers alone having gained $1tn of market value since 2021 (18).

The societal and economic opportunities that come with healthspan science are not lost on the investor community. Indeed, 75% of B2B investors surveyed agree that the success of weight loss drugs has increased their confidence that other major new segments can open in the healthspan space. "There has been tremendous progress across various approaches to addressing morbidity, fueling a growing ambition across the healthcare industry. GLP-1s are a prime example of this progress. They attack such an intractable problem - first by overcoming a major barrier to improving human health and second, by offering a solution that has far-reaching societal impacts across the globe. Their success underscores the potential for breakthroughs in other transformative areas within the healthspan space," says Mr. Jorge Conde, General Partner, a16z Bio + Health.

Effective advocacy is needed for acceleration

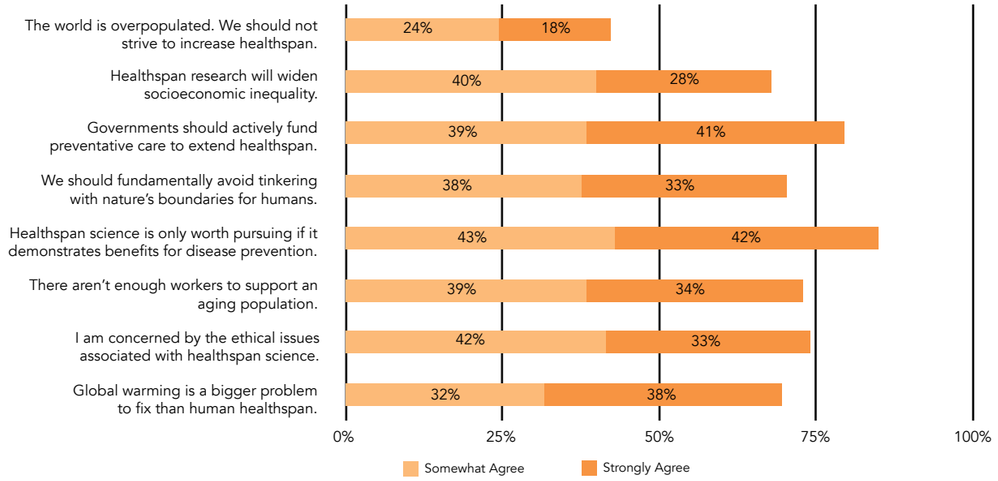
A change in deeply entrenched beliefs about aging and health is urgently needed. "At this moment in time, healthspan and the extension of health by 10 to 15 years is not a technological problem. It is entirely a problem of mindset, organization and financing. And that, unfortunately, is the most difficult cultural aspect that we need to overcome if we want to turn what today is a global system of sick care," says Dr. Helmut Schuehsler, Chairman & CEO of TVM Capital Healthcare, Singapore.

Many still view aging as an inevitable decline rather than a process that can be actively managed. Transforming this mindset requires a cultural shift, where maintaining health into old age becomes a universal goal rather than an exception. By fostering positive narratives around aging and emphasizing the achievable benefits of preventative care, we can motivate individuals and their governments to embrace new approaches with optimism and urgency.

Expanding awareness around healthspan is about more than consumer interest. The current focus on longevity claims, often centered on supplements and anti-aging products, obscures the true dialogue about healthspan science's broader benefits and potential for significant societal change. Opinions from our B2C survey illustrate that there is still work to be done to communicate the advantages of healthspan across all aspects of society, for instance.

Figure 1

B2C Healthspan Perception & Expectations



It is also about more than just the health dimension. "Change is not going to happen if all we say is 'let's do things that'll help all of us live better, longer.' People just don't think in those terms," notes Dr. Michael Hodin, CEO, Global Coalition on Aging. "The reason you're going to get people to spend money and focus on the underlying aging process is because it's going to be the basis for economic growth in a world of more old than young. 82-year-olds have to keep working, and they have to keep being very active consumers. And the only way they keep working and being active consumers and engaged is if they're healthier."

To accelerate, healthspan advocates will need to outreach to an entirely new set of stakeholders. "Healthspan is an echo chamber," says Dr. John Beard, Irene Diamond Professor and Director of the International Longevity Center at Columbia University. "I know what it means when somebody talks to me about senescent cells or stem cells, but it means nothing to somebody outside the echo chamber. We need to be able to talk about healthspan in a more coherent way if we want to really change things."

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> CEO, Global Coalition on Aging

In engaging this wider public, the evidence-based healthspan community faces an important challenge: tackling the noise coming from those in the broader longevity space overselling on the promises of what is still in practice a very nascent field. "My sense is that all of the attention is being drawn to the people who make the most fantastic claims. But many of them have absolutely no track record of doing anything for health except enriching themselves," notes Dr. Verdin. Indeed, 35% of B2B investors surveyed saw the difficulty of distinguishing hype from reality as one of the main barriers to investment in healthspan. "Healthy longevity medicine is not yet regulated. People can buy 'medical longevity products' without analyses if they need it; consumers want something, and the market is providing products. The market is huge. This way of healthcare provision should never be democratized – it can be harmful, and it's dangerous," warns Prof. Maier.

Relying on evidence when advocating for healthspan is therefore crucial to the credibility of the movement. "In advancing healthspan science, our focus must transcend mere longevity. It's about establishing a shared language within our industry and outside it that emphasizes living healthier, longer lives, not just extending years without regard for quality," notes Michael Torres, Chief Communications and Marketing Officer, Hevolution Foundation. "We face a critical challenge: distinguishing evidence-based science from unsubstantiated claims in the broader longevity landscape. To safeguard the integrity of healthspan advancements, we must immunize the public against misleading promises and prioritize scientifically validated approaches and treatments. This ensures our efforts remain grounded in genuine progress towards understanding aging biology and combating age-related diseases for the benefit of all."

Scientific research provides a solid foundation for understanding the complexities of aging and the interventions that can truly extend the years lived in good health. Unlike anecdotal consumer longevity claims often shared by less-qualified influencers, insights grounded in scientific research are subject to thorough testing, critical evaluation, and peer review to ensure their validity. This level of scrutiny helps separate fact from fiction, minimizing the risk of misinformation. Economic data will be particularly important in mobilizing policy makers and investors. "Link the communications and the advocacy strategy to the structural population transformations, which then will benefit a healthspan set of goals," Dr. Hodin advises. He points to the example of a successful advocacy effort that used data and modeling to convince Japanese authorities to implement a new reimbursement framework for Fracture Liaison Services (i.e. healthcare programs that identify and treat patients with fragility fractures to prevent future fractures) helping to increase healthspan while reducing costs (19).

Health is a long-term asset

One important opportunity in this context is the concept of health as wealth. "Nobody talks about health as a pillar of wealth, which I think it needs to be," says Dr. Shlain. "We are all depreciating assets after the age of 24, so if your wealth manager is not asking you about your health strategy, they're doing you a disservice," he notes.

By recognizing health as a long-term asset to be invested in, governments, industries, and individuals can redefine the trajectory of healthspan. And just like in finance, this requires a strategy and the opportunity to pursue it. "From a consumer perspective, why would you invest in optimizing your health and healthspan? Because you want to feel better," adds Prof. Maier. "You heard about it, and it seems that it's feasible. You can measure your biological age. You have a target. Why should you wait?"

TRENDS

Increased investment in healthspan research, rapid technological progress, and rising consumer and policy interest indicate a growing recognition of healthspan as a positive and transformative force. These trends suggest that people are increasingly aware of the potential benefits of extending their healthy lifespan and are actively seeking strategies to achieve this goal.

EVIDENCE

The budget for the US National Institute on Aging reached $4.4bn in 2023. Over 30 trials of senolytic and senomorphic agents are completed, underway, or planned.

GLP-1 agonist success boosted producer valuations by $1tn+ since 2021. Healthspan-focused equity investment market hit $47.3bn in 2024.

ACCELERATION AVENUES

Raising healthspan awareness requires clear communication of its benefits and a shift in mindset. Promoting health as a long-term asset can help. Sticking to evidence-based information will also be key to countering exaggerated claims in what is a rapidly growing but still nascent field.

02 SCIENCE

DEVELOPMENTS ARE HAPPENING ACROSS ALL PHASES OF DRUG DEVELOPMENT

"The next decade will witness game-changing technologies that hold transformative potential for extending healthspan," says Dr. Peter Diamandis, Founder and Executive Chairman, XPRIZE Foundation. "Gene editing tools, such as Gene Writing (specifically, integration of genes into genomic safe harbor [GSH] sites ensures their safe and prolonged expression) and CRISPR, are advancing rapidly and will soon allow precise corrections of genetic mutations and activation of protective genes. AI-powered diagnostics and sensors will enable the early prediction and prevention of diseases by analyzing biomarkers years before symptoms manifest. Meanwhile, regenerative medicine, including 3D-bioprinted organs, organoids, and stem cell therapies, are poised to tackle organ failure and rejuvenate aging tissues. These innovations, when combined, promise to redefine how we approach aging and healthspan, creating unprecedented opportunities to extend both lifespan and vitality."

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> Founder and Executive Chairman, XPRIZE Foundation

Existing approved drugs have demonstrated significant progress. GLP-1 receptor agonists have shown promise in reducing cardiovascular mortality, with a large clinical trial demonstrating a substantial reduction in major adverse cardiovascular events (20,21). SGLT2 inhibitors have been associated with decreased hospitalization, death, and long COVID, suggesting they may enhance the body's resilience to severe diseases (22,23,24). Additionally, metformin, a type 2 diabetes drug, has shown potential in targeting hallmarks of aging, protecting DNA, and decreasing inflammation (25).

Advancements have also materialized on the clinical trial front. Human trials for mRNA vaccines are underway in the areas of oncology (26), immunogenicity (27,28), age and frailty (29, 30) – all of which are areas that could contribute to extending healthspan. Our understanding of their impact on aged populations is also improving, with research showing mRNA vaccines' ability to elicit robust antibody production even in individuals up to 96 years of age (31) and new methods being developed to study age-specific vaccine responses. The latter method, known as MEMPHIS (Modular Evaluation of Immunogenicity using Multi-Platform Human In vitro Systems), could provide insights into how vaccines can be tailored to improve efficacy in older adults (32,33).

Senotherapeutics is another promising avenue, with numerous clinical trials currently planned or underway. This type of therapeutic shows great promise over the next five years, according to Dr. David B. Allison, Professor of Pediatrics, Endowed Chair, and Director of the USDA Children's Nutrition Research Center at Baylor College of Medicine. "There are results in humans that suggest benefit, and in other species as well, but it's the results in mice that really say that dealing with these senescent cells can be very beneficial," he notes.

Immunotherapy has shown promising results in preclinical studies. Researchers at Brock University have developed a groundbreaking monoclonal antibody, isoDGR-mAb, designed to target and eliminate accumulated damaged proteins, a primary driver of aging and age-related diseases. In animal trials, this therapy extended lifespan by a significant margin, preserved cognitive function and motor skills, and reduced inflammation. Concurrent research is exploring the broader potential of immunotherapies to combat aging, investigating how age-related declines in immune system function influence treatment effectiveness (34,35,36). While promising, experts like Dr. Nir Barzilai caution that more clinical trials are needed to fully validate immunotherapies for widespread use in humans.

CRISPR-Cas9 genome editing, a revolutionary technology, offers precise DNA modification capabilities. By targeting genes involved in cellular senescence, this technology holds the potential to enhance regenerative abilities and delay the aging process (37). Notably, CRISPR screens have identified over 300 gene knockouts that can rejuvenate neural stem cell function in aged brains, highlighting pathways like glucose import and cilium organization as crucial for reversing cognitive decline (38,39). Because it enables epigenetic modifications, this technology can also be used to reactivate silent genes critical for cell viability and function, offering to extend cellular health and creating potential therapeutic avenues for aging-related diseases.

Another approach is partial cellular reprogramming, which recent studies have shown can decrease epigenetic age and improve tissue regeneration, with evidence of lifespan extension in mice through intermittent induction of these factors (40). This process has demonstrated the ability to restore mitochondrial function and reduce inflammation, two critical aspects of cellular aging (41). Partial reprogramming has emerged as a promising approach to reversing age-related decline. Unlike complete reprogramming to induced pluripotent stem cells, which carries the risk of tumor formation, partial reprogramming can mitigate age-related conditions without inducing cancer (42). Despite its promise, challenges remain in translating these findings into clinical applications, particularly in ensuring safety and efficacy in humans (43).

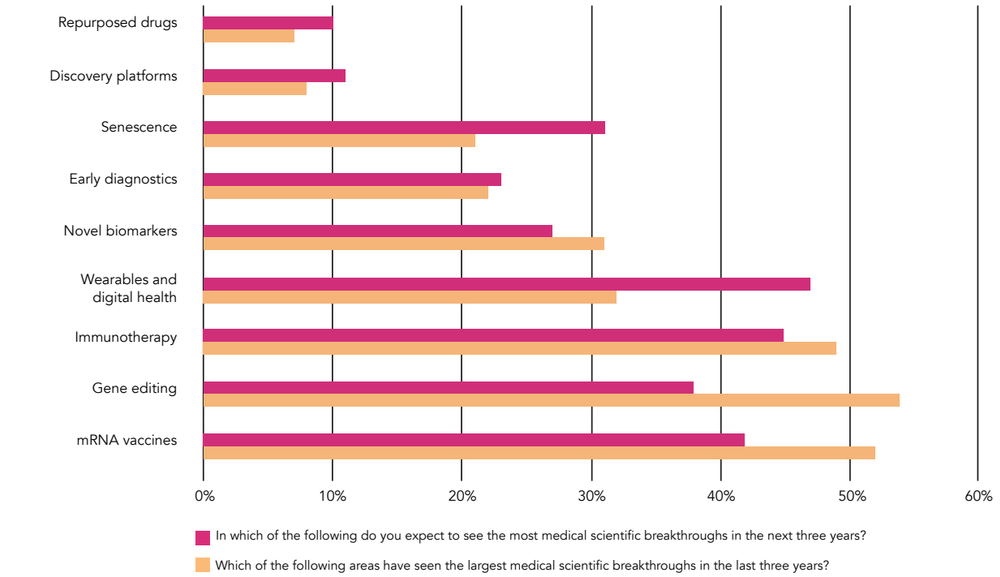
How significant all of these developments have been depends on who you ask. According to our B2B survey, the most significant breakthroughs over the past three years have been in mRNA vaccines, gene editing, and immunotherapy. However, while North American and African scientist respondents highlight mRNA technology as having seen the most significant advances (77% and 79%, respectively), Asia-Pacific researchers express particular enthusiasm for gene editing (74%) and novel biomarkers (67% – more than double the global average). European scientists are particularly excited about progress in senescence research (43% vs. 21% globally).

The need for better alignment and focus will be critical. "I would argue that we haven't delivered much to healthspan yet because it's just not been the focus," says Dr. Eric Verdin, President and CEO of the Buck Institute for Research on Aging. "I think there's a global shift that's happening in the field, and Hevolution is playing a big role in this, which is to really put the emphasis on healthspan."

Figure 2

Perspective and outlook on medical science

(B2B Scientific respondents – 2024 Data)



Progress is driving both collaboration and optimism

Interdisciplinary scientific collaboration is increasingly essential in advancing healthspan research, as breakthroughs in aging science often require expertise spanning biology, genetics, immunology, and data science. Researchers worldwide recognize the need to integrate these disciplines to address the complexity of aging drivers and translate findings into impactful therapies, with two-thirds (68%) of B2B scientist respondents expressing satisfaction with the quality of interdisciplinary collaboration. "An intriguing dynamic unfolding in our industry is the natural experiment we're witnessing: once a target is validated, it sparks a global race to develop therapeutics against it," explains Mr. Jorge Conde, General Partner at a16z Bio + Health.

Confidence in translating healthspan science into actionable therapies is also growing, with more than two-thirds (72%) of B2B scientists believing that current research will result in clinically relevant therapies.

These clinically relevant healthspan therapies are moving closer to realization. "The next step is something that's much closer to the idea of slowing overall aging with gerotherapeutic agents or procedures, things that really prolong median and maximum lifespan, and not just prevent a single disease or treat a single disease," says Dr. Allison. "We have lots of promising preclinical data, and we're starting to translate them into humans, but I don't think we have overwhelming, clear and convincing evidence in humans yet."

> **"THE NEXT STEP IS SOMETHING THAT'S MUCH CLOSER TO THE IDEA OF SLOWING OVERALL AGING WITH GEROTHERAPEUTIC AGENTS OR PROCEDURES"**
>
> **– DR. DAVID B.ALLISON**
> Professor of Pediatrics, Endowed Chair, Director, USDA Children's Nutrition Research Center, Baylor College of Medicine

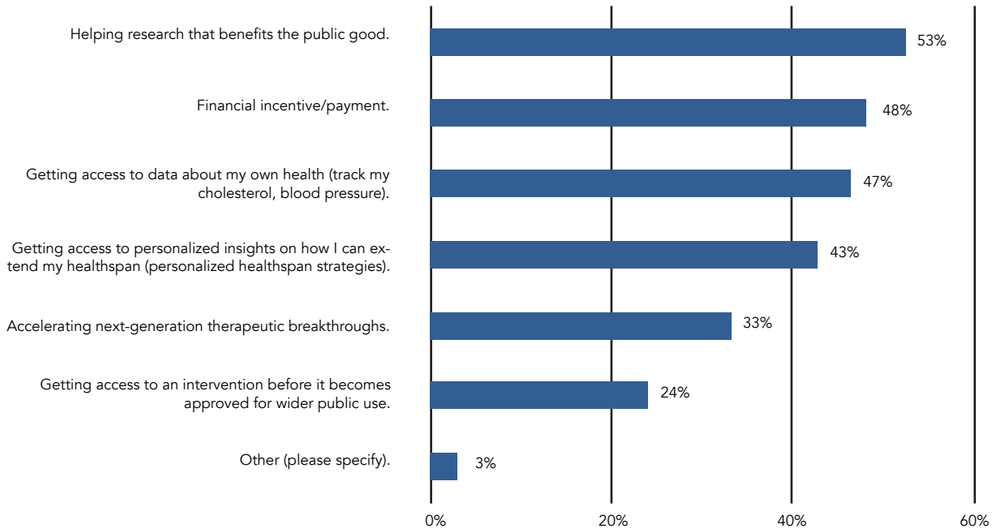
Increased public interest in participating in research is a significant positive development, with 56% of B2C survey respondents saying they are open to volunteering for medical research projects. This number rises to 70% in Latin America and 67% in Africa, though interest in participation remains lower in Europe (41% don't want to take part) and North America (32%).

Familiarity with healthspan correlates strongly with participation – 38% of B2C respondents identifying themselves as deeply familiar with the concept have participated in research vs. just 13% for those identifying themselves as 'unfamiliar' with the idea of healthspan. While the primary motivation is altruistic (53%), the financial incentive is not far behind for B2C (48% globally), with that share going up to 58% for B2C North America (for whom it is the first motivation). Compared with the global average, MENA B2C respondents tend to be more motivated by accelerating next-generation therapeutic breakthroughs (43% vs. 33% globally) and accessing an intervention before it becomes approved for wider public use (30% vs. 24% globally).

Figure 3

Participation in healthspan research is mostly driven by altruism, but personal interest is not far behind

Which of the following factors would most likely entice you to participate in healthspan research as a healthy volunteer? (B2C data)



> **"WE'RE ASKING PARTICIPANTS FOR QUITE A LOT [IN TERMS OF INFORMATION]. THAT TAKES A HIGH LEVEL OF TRUST, AND I THINK THAT SHOWS THERE'S AN APPETITE OUT THERE"**
>
> **– DR. RAGHIB ALI OBE**
> CEO and Chief Medical Officer of Our Future Health

In comparison, Latin American respondents tend to care more about personalized insights about their health (52%) and healthspan extension strategies (50%).

Getting people to participate at scale requires a diversified approach. "We've used pharmacies, mobile units, shopping centers and provided hundreds of venues. We also work with community organizations to include people from all backgrounds," notes Dr. Raghib Ali OBE, CEO and Chief Medical Officer of Our Future Health. Launched two years ago, the program combines multiple sources of health and health-relevant information, including genetic, health, and lifestyle data from volunteers in the UK to understand the factors influencing health conditions. With 2 million volunteers already participating, it is now the largest prevention research program in the world.

"We're asking participants for quite a lot [in terms of information]. That takes a high level of trust, and I think that shows there's an appetite out there," notes Dr. Ali. While altruism was important in kickstarting the program, getting to the 5 million mark (the program's stated objective) will require a more individualized approach. "Not everyone will join on the basis of a vague benefit in the future. Other people rightly want to know what they are going to find out and how it will help them. So the next iteration of this is to be able to tell people about their future risks of disease (e.g. diabetes, heart disease, breast cancer, Alzheimer's, etc.) and when you will find this out," he notes.

Consumer interest in some countries is so strong that an 'early adopters' segment has appeared. This segment is characterized by a stronger willingness to pay for new diagnostics technologies and a greater openness to experimenting with solutions. "We need the early adopters, we can't wait until governments decide that that's what they want for their population.

That may or may not happen in a reasonable period of time. This field needs to grow through private engagement, and private engagement will come from the individual," says Dr. Helmut Schuehsler, Chairman & CEO of TVM Capital Healthcare, Singapore. "All the people who are now paying $10,000 or $20,000 or even more are the early adopters, and they pay that price for maintaining their own health. But as a consequence, I am convinced that the effect of it is that in 10 to 20 years from now, almost everybody will have access to it for a much, much lower price."

> **"WE NEED THE EARLY ADOPTERS, WE CAN'T WAIT UNTIL GOVERNMENTS DECIDE THAT THAT'S WHAT THEY WANT FOR THEIR POPULATION. THAT MAY OR MAY NOT HAPPEN IN A REASONABLE PERIOD OF TIME.**
>
> **– DR. HELMUT SCHUEHSLER**
> Chairman & CEO, TVM Capital Healthcare

Rapid innovation and strong consumer demand heighten the importance of the precautionary principle. GLP-1s are a case in point where despite rapid advancements, important unknowns and challenges remain. For instance, while they have been used for decades in diabetes, the long-term effects of other applications remains to be fully evaluated, stressing the need for an approach that prioritizes safety, efficacy, and ethical considerations (59). Likewise, its high cost limits accessibility, underscoring the need for a careful balancing of pharmaceutical innovation, affordability, and equity (60,82,83).

This makes efficacy and effectiveness two critical lenses through which to evaluate interventions. "The evaluation of any medical intervention rests fundamentally on a binary framework of safety and efficacy – these serve as the foundations through which we must filter all medical, diagnostic & therapeutic decisions,"

observes Dr. Jordan Shlain, Founder & Chairman of Private Medical. “Every diligence I undertake is measured against one question: is it safe and is it effective? When both criteria are met, we proceed with confidence. However, when an intervention has established safety profiles but lacks robust efficacy data, we enter the realm of probabilistic medicine. While such interventions may pose minimal risk, their therapeutic value remains indeterminate. Most concerning are interventions that fail both criteria; if it’s neither safe nor effective, it should be avoided outright. Unfortunately, many people continue to head down that path, influenced and impressed by what I call the overlap of shiny object syndrome, FOMO and existential angst – all promulgated on social media."

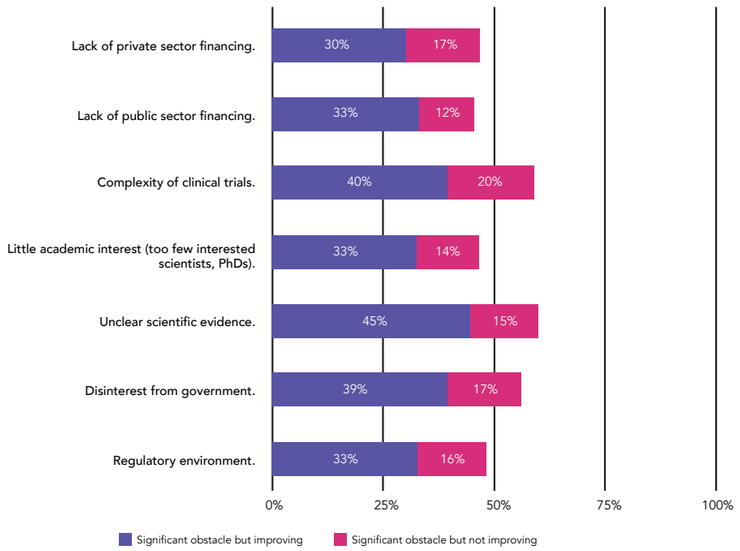
More needs to be done

Despite notable progress, significant barriers hinder the scaling up of healthspan research. Our B2B survey identified key challenges, which include the complexity of clinical trials (60%), unclear scientific evidence (60%), disinterest from governments (56%) and lack of private sector financing (47%). That being said, scientists are cautiously optimistic overall, with most believing that the situation is improving for those obstacles (see figure below). Funding expectations align with this sentiment, with two-thirds of B2B scientists (67%) predicting modest R&D increases of up to 20%. European and Middle Eastern researchers are particularly hopeful, with 15-17% anticipating funding growth between 21-50% – double the global average.

Figure 4

Barriers to healthspan research (and whether or not they’re improving)

How much of a barrier are the following elements in scaling up healthspan research?
(B2B scientific respondents – 2024 data)



The role of gender in healthspan represents another area where progress is needed. The large majority of B2B scientists surveyed (79%) believe we need more research on aging dynamics in females vs. males to support more equitable healthspan research and development (37% strongly agree), with 56% believing that better data in healthy aging between male and female is essential for supporting innovation in healthspan. Likewise, 83% of scientists we surveyed agreed that the biological sex of the patient must be considered in the design of effective healthspan solutions (50% strongly agree). As for gender representation within the research community, 70% agree there is equal gender representation in the healthspan research community (29% strongly agree), and 47% agree that more participation from female scientists would be 'very important' for supporting innovation in healthspan research.

Figure 5

The importance of gender in and for healthspan research

How important are the following considerations for supporting innovation in healthspan research?
(% of B2B Scientists respondents answering ‘very important')

Alignment is needed on novel biomarkers

Novel biomarkers are foundational for healthspan science, offering new tools for early diagnostics and personalized interventions. The field is experiencing a surge of innovation, offering unprecedented insights into the biological processes that drive aging.

- **Retroelement Clocks:** New research suggests that specific DNA sequences linked to retroelements, may contribute to the aging process. These retroelement-based biological clocks, embedded within our genome, offer a novel way to measure biological age, distinct from traditional chronological age (44).
- **Machine Learning (ML) and Biomarker Clusters:** Machine learning has been employed to uncover specific patterns of biomarkers linked to healthy aging without chronic diseases. These patterns indicate favorable levels of certain substances in the body, such as high levels of HDL cholesterol, adiponectin, and IGFBP, and low levels of triglycerides. These biomarker profiles are associated with a reduced risk of developing major chronic diseases as we age (45).
- **Epigenetic Clocks:** Epigenetic clocks measure DNA methylation patterns across the genome to estimate biological age. By using advanced machine learning techniques, scientists have created a new epigenetic clock capable of differentiating between genetic variations that either slow down or speed up the aging process. This innovative clock can predict biological age with greater accuracy (46,47).
- **Protein Biomarkers:** By analyzing over 5,000 proteins in a large group of older adults aged 65 to 95, researchers have identified significant age-related changes in protein levels. This analysis, using a cutting-edge technique called Slow Off-Rate Modified Aptamer, revealed significant fluctuations in hundreds of proteins, including those involved in tissue breakdown and cellular processes. These findings underscore the critical role of protein degradation in the aging process (48).
- **Digital Biomarkers:** By continuously monitoring an individual's physiological state, behaviors, and environmental factors, real-time data biomarkers provide a comprehensive understanding of their overall health. This wealth of information empowers healthcare professionals to proactively identify and address potential health risks and tailor treatment plans for individuals with non-communicable chronic diseases (NCDs) (49).

Consensus on these is needed to drive progress, and we must recognize that the solution may come from a combination of biomarkers assisted by AI and sophisticated indexing. "Biomarkers are going to be key and ground the field into t he m ost s erious, e stablished science. This is the concept that should drive all of us unless we just want to sell a dream," says Dr. Eric Verdin. Efforts like the Biomarkers of Aging Consortium, which aims to promote collaboration and data sharing to establish reliable biomarkers of aging, are a particularly important development in this regard.

> **"BIOMARKERS [ARE] GOING TO BE KEY AND GROUND THE FIELD INTO THE MOST SERIOUS, ESTABLISHED SCIENCE. THIS IS THE CONCEPT THAT SHOULD DRIVE ALL OF US UNLESS WE JUST WANT TO SELL A DREAM"**
>
> **– DR. ERIC VERDIN**
> President and CEO, Buck Institute for Research on Aging

TRENDS

Investments in healthspan research, advancements in drug developments (e.g., GLP-1 receptor agonists, senotherapeutics), and innovative technologies like CRISPR/mRNA vaccines point to growth in extending healthy lifespan. Collaboration and increasing participation of the public further drive progress.

EVIDENCE

Healthspan research is advancing rapidly, with senolytic agents in trials targeting cellular senescence, and compounds like metformin, rapamycin, and GLP-1 agonists showing broad therapeutic potential. Tools like CRISPR, cellular reprogramming, and biomarkers are enhancing aging interventions, driven by global collaboration.

ACCELERATION AVENUES

Agreement on biomarkers as well as a focus on safety and efficacy will be essential. Greater focus on gender aspects of healthspan research will also be needed.

03

INVESTMENT

HEALTHSPAN INVESTMENT DOUBLED IN 2024

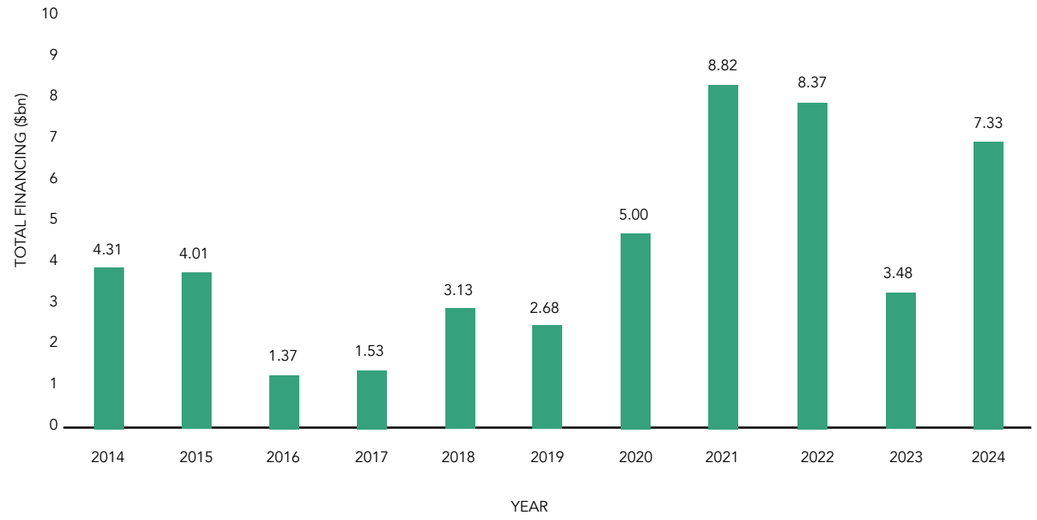
Investments in the fields of healthspan and longevity are connected, yet distinct. The wider longevity investable universe includes sectors such as consumer diagnostics and supplements, longevity clinics and advanced aesthetics. Healthspan investments, by contrast, focus on evidence-based scientific interventions to extend healthspan – extended lifespan is not the objective, though it can be a positive byproduct of the intervention.

As of today, there is no commonly agreed database tracking healthspan investments. For this second edition, this was achieved by working with data from research company Longevity.Technology and narrowing down the domains to those listed in Annex 1. Collectively, these domains offer a more accurate set for tracking healthspan investments compared to the broader longevity space. However, they remain an approximation and should be understood as such. The data is then combined with insights from our proprietary B2B survey to provide an insightful perspective on the investment climate shaping the future of the healthspan and healthy longevity fields.

Over the past decade, healthspan investment has experienced significant fluctuations, starting at $4.1bn in 2014 and experiencing various peaks and troughs before reaching an all-time high of $8.8bn in 2021. While the sector maintained strong momentum, with $8.3bn in investments during 2022, it experienced a substantial decline to $3.4bn in 2023, recovering significantly in 2024 to hit $7.3bn in 2024 – over double the previous like-for-like period.

Figure 6

Healthspan investment over the last decade (2014-2024)



Healthspan companies financing activity 2014-2024 in $bn. Deal types included in the analysis are: Accelerator/Incubator, Angel, Corporate, Early Stage VC, Later Stage VC, Equity Crowdfunding, IPO, PE Growth/Expansion, PIPE, Public Investment Second Offering, and Seed Round. Domains included are: Genetics, Diagnostics, Senotherapeutics, Reproductive health, Discovery platforms, Healthspan drugs, Immune health, Metabolic rejuvenation, Microbiome, Neurotech, Rejuvenation, Reprogramming, Regeneration, Repurposed drugs, Neuropharma, and Healthspan education. Analysis by Longevity.Technology, according to Pitchbook data as of December 09 2024, based on 889 companies.

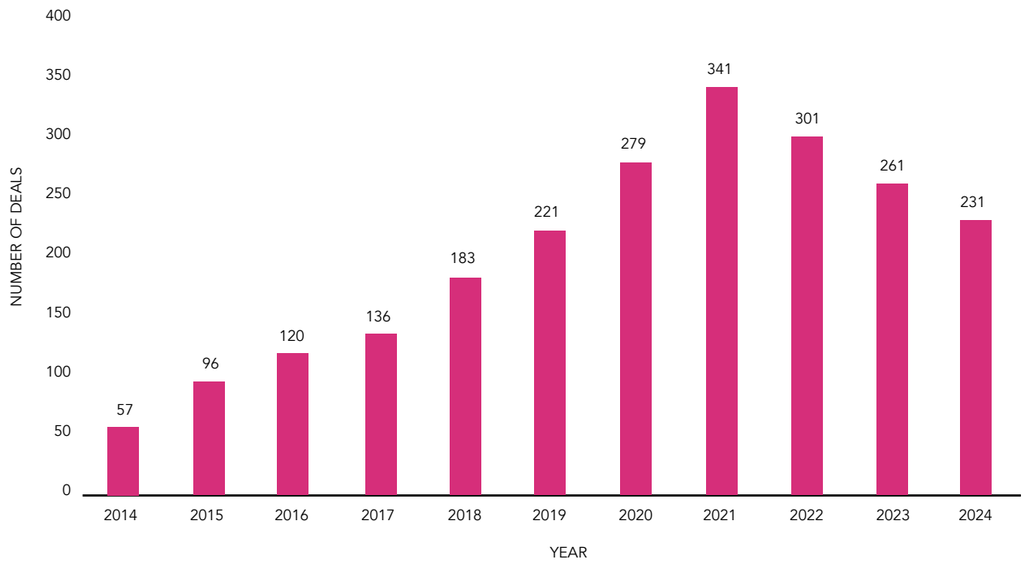
The majority of these investments are US-based, where 58% of healthspan companies are located as of 2024. While this highlights the central role of this geography for the healthspan market globally, other regions have seen important developments too, with Europe hosting 15% of healthspan companies, followed by the United Kingdom with 10%.

Though they share similarities, each region is influenced by different market drivers. Beyond the obvious drivers of rising costs of health systems focused on disease care or the cost of old age care, our survey helped to shed some light on regional differences. Positive market sentiment around biotech, for instance, was seen as a key driver of healthspan investment in the EU (44%), while the entry of mainstream investors in the sector is an important driver for MENA B2B investors (46% vs. 28% globally).

Deals have also grown larger over the years, with $7.3bn invested in 231 deals across the investable universe tracked in 2024, vs. $5bn invested across 279 deals in 2020 – representing a +77% increase in average deal size over the period. This in large part driven later-stage, and therefore more progressed, clinical stage therapeutic investments are attracting more capital, reflecting a maturation of the field.

Figure 7

Healthspan investment deals over time

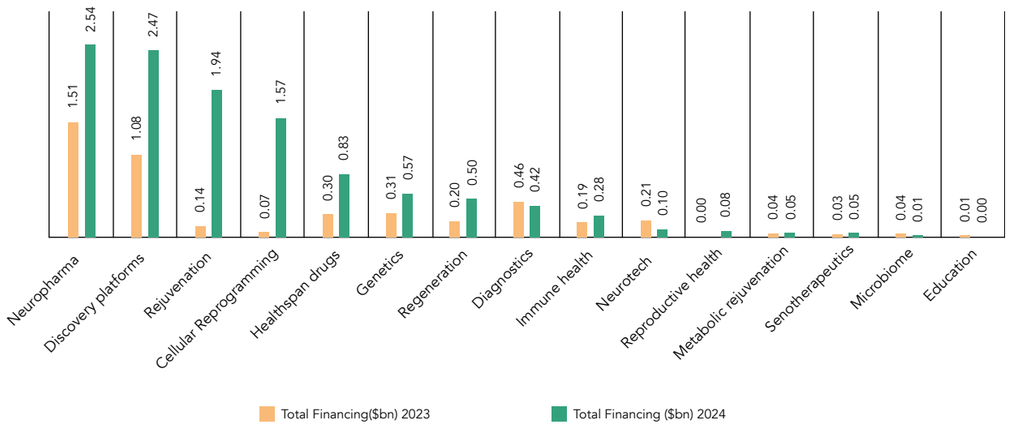


Healthspan companies and number of deals in 2014-2024 in $bn. Deal types included in the analysis are: Accelerator/Incubator, Angel, Corporate, Early Stage VC, Later Stage VC, Equity Crowdfunding, IPO, PE Growth/Expansion, PIPE, Public Investment Second Offering, and Seed Round. Domains included are: Genetics, Diagnostics, Senotherapeutics, Reproductive health, Discovery platforms, Healthspan drugs, Immune health, Metabolic rejuvenation, Microbiome, Neurotech, Rejuvenation, Reprogramming, Regeneration, Repurposed drugs, Neuropharma, and Education. Analysis by Longevity.Technology, according to Pitchbook data as of December 09th 2024, based on 889 companies.

The investment space remains diversified, with Neuropharma claiming the top spot this year ($2.54bn), followed by Discovery platforms ($2.47bn), and Rejuvenation ($1.94bn). The current trend is swinging back to disease specific assets as opposed to discovery platforms that create multiple asset candidates.

Figure 8

Healthspan investments by domain (2024 vs. 2023)



Total investment in $bn by domain in 2023 vs. 2024. Deal types included in the analysis are: Accelerator/Incubator, Angel, Corporate, Early Stage VC, Later Stage VC, Equity Crowdfunding, IPO, PE Growth/Expansion, PIPE, Public Investment Second Offering, and Seed Round. Domains included are: Genetics, Diagnostics, Senotherapeutics, Reproductive health, Discovery platforms, Healthspan drugs, Immune health, Metabolic rejuvenation, Microbiome, Neurotech, Rejuvenation, Reprogramming, Regeneration, Neuropharma, and Education. Analysis by Longevity.Technology, according to Pitchbook data as of the 09th of December 2024, based on 889 companies.

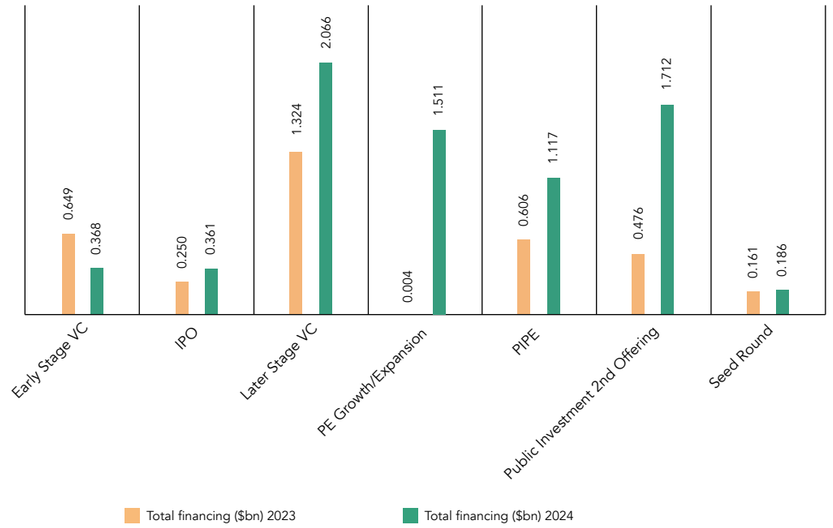
The field is attracting a wide range of investors

Despite its volatility, the sector's resilience remains steadfast through various economic cycles, encompassing investments across multiple channels including accelerator/incubator funding, venture capital, equity crowdfunding, IPOs, and private equity growth expansions. In 2024, Later-stage VC claimed the top spot in total financing by stage with $2bn (+56% Y-O-Y), followed by Public second offerings with $1.7bn (+260% Y-O-Y), and PIPE (Private Investment in Public Equity), which nearly doubled from $0.6bn in 2023 to $1.1bn in 2024.

Private equity investment resurged from effectively nothing in 2023 to $1.5bn in 2024. This, combined with PIPE and a surge in public second offerings indicates a maturing of attitudes in later-stage and institutional investing in healthspan companies.

Figure 9

Healthspan investment by stage (2024 vs. 2023)



Total financing in $bn by stage 2023 vs. 2024. Deal types included in the analysis are:Early Stage VC, Later Stage VC, IPO, PE Growth/Expansion, PIPE, Public Investment Second Offering, and Seed Round. Domains included are: Genetics, Diagnostics, Senotherapeutics, Reproductive health, Discovery platforms, Healthspan drugs, Immune health, Metabolic rejuvenation, Microbiome, Neurotech, Rejuvenation, Reprogramming, Regeneration, Repurposed drugs, Neuropharma, and Education. Analysis by Longevity.Technology, according to Pitchbook data as of December 09th 2024, based on 889 companies.

There has also been an important injection of catalytic capital. Hevolution Foundation has emerged as the world's most prominent philanthropic backer of aging biology and emerging healthspan science, for instance, allocating over $400mn to the field in a little over two years (50). As the single-largest lead funder, Hevolution was also instrumental in the creation of the $101mn XPRIZE Healthspan competition, launched at the Global Healthspan Summit in 2023 (51).

The outlook is optimistic yet cautious

While R&D spending is expected to grow, investor sentiment has moderated compared with previous years. Only 71% of B2B investors anticipate a net increase in R&D spending over the next five years, a decline from the 93% recorded in 2023. This reflects expectations for investments to stabilize rather than increase drastically, with 32% of investors globally believing the sector already has adequate funding. Notably, North America and Latin America are more optimistic about the current climate, with 36% and 20% of investors viewing the sector as ripe for investment – well above the global average of 13%. Conversely, APAC remains more cautious, with 37% of investors stating the investment environment is not yet attractive enough.

The need to support the transition of healthspan science from the university lab into well-funded commercial entities has never been greater. As illustrated in the 'Healthspan investment by stage' chart, there is very low investment activity in early-stage companies, with early-stage VC investment declining between 2023 and 2024. The gap between R&D grants and later-stage clinical companies is growing, meaning that riskier, but potentially groundbreaking healthspan science, is not well-placed to realize its full potential.

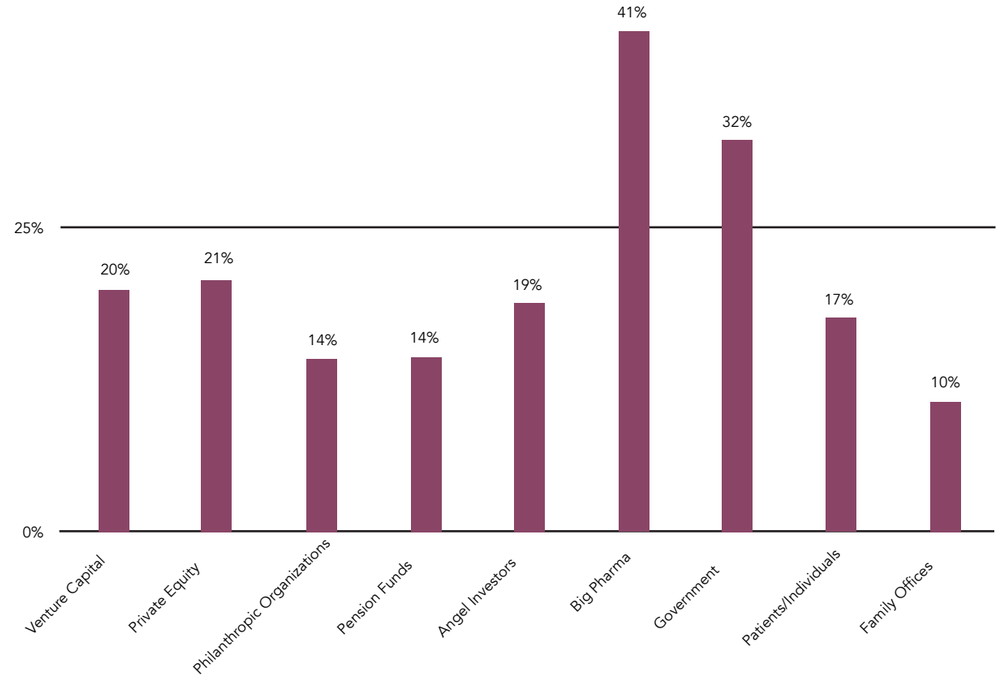
Increased investment activity is expected across most of the areas tracked by our survey. We are also seeing a diversification of investment taking place, with 16-21% of investors surveyed expecting to start investing in early diagnostics (20%), novel biomarkers (16%), senescence (17%), and cellular reprogramming (21%) over the next three years.

Looking forward, B2B investor respondents expect a significant increase in healthspan investment from Big Pharma (41%) and the Government (32%) over the next two years. This, in part, reflects an expectation from B2B respondents that these two actors can and should lead the development of healthspan solutions (see policy section for more details). One in five B2B investors also expect a significant increase from VC and PE in the healthspan space.

Figure 10

Pharmaceuticals and governments are expected to increase their investments

(% of B2B investor respondents expecting a 'significant increase' in healthspan investment by actor over the next two years)



Despite growth, the healthspan sector remains severely under-invested

2024 saw promising developments, but important barriers to investment still exist. Lack of public awareness remains the most significant one, according to B2B investors. This is followed up by a lack of regulatory frameworks (up from 8 last year) and a lack of industry experts (a problem particularly acute in APAC and Africa, where it is an issue for more than half of the B2B investor respondents). Many investors in EU and MENA also struggle to distinguish hype from reality (49% and 45%, respectively). This underscores the need for clearer data and narratives to guide healthspan investment.

Table 1

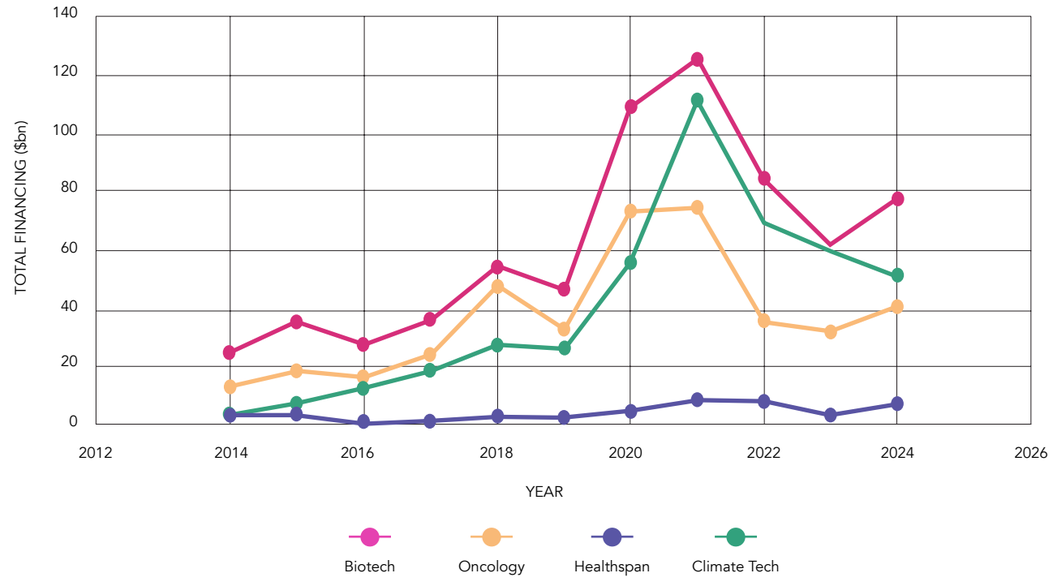
Largest barriers to investment at scale in the sector of healthspan
(B2B Investor Respondents)

Top barriers (ranking)	**2024**	**2023**
#1	Lack of public awareness (59%)	Lack of public awareness (50%)
#2	Lack of regulatory frameworks (46%)	Limited industry experts (47%)
#3	Limited industry experts (46%)	Lack of scientific evidence (39%)
#4	Lack of scientific evidence (46%)	Lack of investment case (34%)

Importantly, the healthspan field remains severely under-invested compared with the scale of the challenge. A simple comparison with both health sectors and other technology sectors aimed at tackling global systemic risks – all of which are underinvested in – shows how far healthspan still has to go if we are to address the healthspan gap at the global level.

Figure 11

Healthspan Investment: on the rise but far from sufficient



Longevity, Biotech, Oncology, and Climate Tech financing activity ($bn) 2014-2024. Deal types included in the analysis are: Accelerator/Incubator, Angel, Corporate, Early Stage VC, Later Stage VC, Equity Crowdfunding, IPO, PE Growth/Expansion, PIPE, Public Investment 2nd Offering, and Seed Round. Analysis by Longevity.Technology, according to Pitchbook data as of the 09th of December 2024, based on 889 Healthspan companies, 33,698 Biotech companies, 12,829 Oncology, and 43,743 Climate Tech companies.

Acceleration requires investment strategies with clear focus and adequate time horizons

Healthspan is increasingly becoming an investment narrative of its own, with 48% of B2B investors having healthspan as a dedicated investment thesis – a proportion that rises to 57% in the EU. It is much lower in Latin America (33%) where healthspan is part of the wider focus on healthcare (47%). Meanwhile, nearly one in four APAC B2B investors (22%) see their healthspan investments within their broader focus technology – double the global average of 10%. These regional variations underline the diverse approaches shaping investment in healthspan.

"Healthspan is currently much smaller than other areas of healthcare investment, but it's growing very fast. The big question is: how will we manage the societal transformation from sick care to true health care as a focus of our healthcare systems?" says Dr. Helmut Schuehsler, Chairman & CEO of TVM Capital Healthcare, Singapore.

Using a clear definition to scope the investable universe will be essential to a successful investment strategy. Homing in on the precise definition of healthspan is key from an investable class perspective, says Mr. Jorge Conde, General Partner at a16z Bio + Health. "When we talk about investing in healthspan, the focus is on reducing acute morbidities. Addressing morbidity is ultimately the entry point – the 'tip of the spear' – that drives investment in this space," he explains.

Allocating resources according to different time horizons across meaningful aligned themes and initiatives is important to the development of an effective portfolio. For large players with strong balance sheets, Sir Jonathan Symonds CBE, Chair of the Board, GSK, recommends a segmentation in three distinct time horizons, or 'time zones' plays. "Time zone 1 is the attention span of the financial markets, which is one to maybe three years. Time zone 2 is how do you grow over 5 years, and that's about visible, late-stage pipeline. The really exciting thing is time zone 3, the 5-10 year period when you are building and assembling the technologies that will drive you 10 years out."

> **"WHEN WE TALK ABOUT INVESTING IN HEALTHSPAN, THE FOCUS IS ON REDUCING ACUTE MORBIDITIES. ADDRESSING MORBIDITY IS ULTIMATELY THE ENTRY POINT – THE 'TIP OF THE SPEAR' – THAT DRIVES INVESTMENT IN THIS SPACE"**
>
> **– MR. JORGE CONDE**
> General Partner, a16z Bio + Health

While healthspan is at this stage mostly a time zone 3 play for large pharmaceuticals players, there are healthspan plays present across all time horizons at any single point in time. Improving the infectious disease portfolio that considers both responders and non-responders is a time zone 2, for instance, as is developing solutions and services that can help improve treatment adherence to existing products on the market. "Even with effective medicines, people don't take them. This is a healthspan gap caused because compliance is appalling – not because there are no available therapies," notes Sir Jonathan Symonds. As for time zone 1, it comes down to companies looking at their existing portfolio through the lens of the prevention agenda to identify the specific markets where such an application could be deployed effectively and commercially.

Playing across multiple long-term horizons may be challenging for investors who are more upstream. "What pharma defines as an epoch, startups define as a lifetime," says Mr. Conde. The solution for early-stage investors, he argues, is to go after a reduction in morbidity that can be measured on a practical time scale for a startup company. Technologies like AI that can help identify novel, unexpected causal targets by processing large amounts of existing longitudinal data sets is one avenue – as once targets are identified, there is usually a strong competition to develop a diverse set of modalities and therapeutics against that target. "There's a lot of work happening at all the top pharmaceutical companies to think through this very deeply," he notes. Another avenue is for companies to create single-cell resolution data on multi-omic axes using technologies that can perturb and understand biological systems at the cellular level. Mr. Conde notes that an advantage of this approach is that the number of companies with a clear ability to do this is limited, making it a clear and well-defined investable universe for investors. "Closed loop AI with perturbed biology are the most powerful examples of where I think we're going to see alpha," he adds.

The congruence of technologies will create an investment boon. "The next big players are expected to emerge from the convergence of AI, cellular medicine, and synthetic biology – fields accelerating at exponential rates," notes Dr. Yianni Psaltis, Managing Director of Exponential Ventures. The real objective, however, should remain democratization. "Investors should prioritize companies that focus on reducing the cost of diagnostics and therapies to ensure global accessibility while supporting translational research to bring lab discoveries to practical applications," he adds.

> **"THE NEXT BIG PLAYERS ARE EXPECTED TO EMERGE FROM THE CONVERGENCE OF AI, CELLULAR MEDICINE, AND SYNTHETIC BIOLOGY – FIELDS ACCELERATING AT EXPONENTIAL RATES"**
>
> **– DR. YIANNI PSALTIS**
> Managing Director, Exponential Ventures

TRENDS

The healthspan investment space is growing, becoming more diversified both in terms of investable universe and investment players. Healthspan is also becoming an investment narrative of its own though this differs by region.

EVIDENCE

Healthspan investments reached $7.3bn in 2024, over double the 2023 levels. Deals have also become larger (+77% in average deal size since 2020), indicating a move towards later-stage deals and a maturing of the field. Early stage investments are on the decline, however. The need to support the transition from lab to market has never been greater.

ACCELERATION AVENUES

Despite rapid growth, healthspan remains severely under-invested compared with the scale of the challenge. Using a clear definition to scope the investable universe will be key to a successful investment strategy, as will playing across multiple time-horizons.

04

TECHNOLOGY

THE HEALTHSPAN SECTOR HAS EMBRACED THE POTENTIAL OF AI

Artificial intelligence (AI) is reshaping the future of healthspan. This digital revolution is not confined to a single field; it orchestrates breakthroughs in drug discovery, diagnostics, and clinical trials with an efficiency that defies traditional timelines. Each dataset processed – whether genomics, biomarkers, or real-time outputs from wearable devices – feeds into a growing ecosystem of predictive health models.

"AI is the catalyst accelerating healthspan progress at every level," says Dr. Peter Diamandis, Founder and Executive Chairman, XPRIZE Foundation. "AI has already played a pivotal role in advancing healthspan research by mapping the protein universe through tools like AlphaFold and enabling the rapid identification of drugs targeting aging pathways. In clinical practice, AI-powered wearables and diagnostic tools now provide real-time insights into key biomarkers, transforming preventive care - and this is just the start'' said Dr. Diamandis. "Over the next few years, AI will revolutionize predictive modeling for clinical trials, reducing costs and timelines, while driving the development of personalized platforms for optimizing nutrition, exercise, and therapies," he adds.

By examining multifaceted datasets, AI can be used to uncover patterns and relationships that traditional methods might overlook. This capability is particularly valuable in healthspan research (52). "Healthspan is a really complex landscape, and we don't yet know the combination of things that actually work best and in what circumstances," says Mr. George MacGinnis, Healthy Ageing Challenge Director, UK Research and Innovation. "And I think that complexity is made for AI to actually generate insight, in the way that we would struggle to do using conventional analytics."

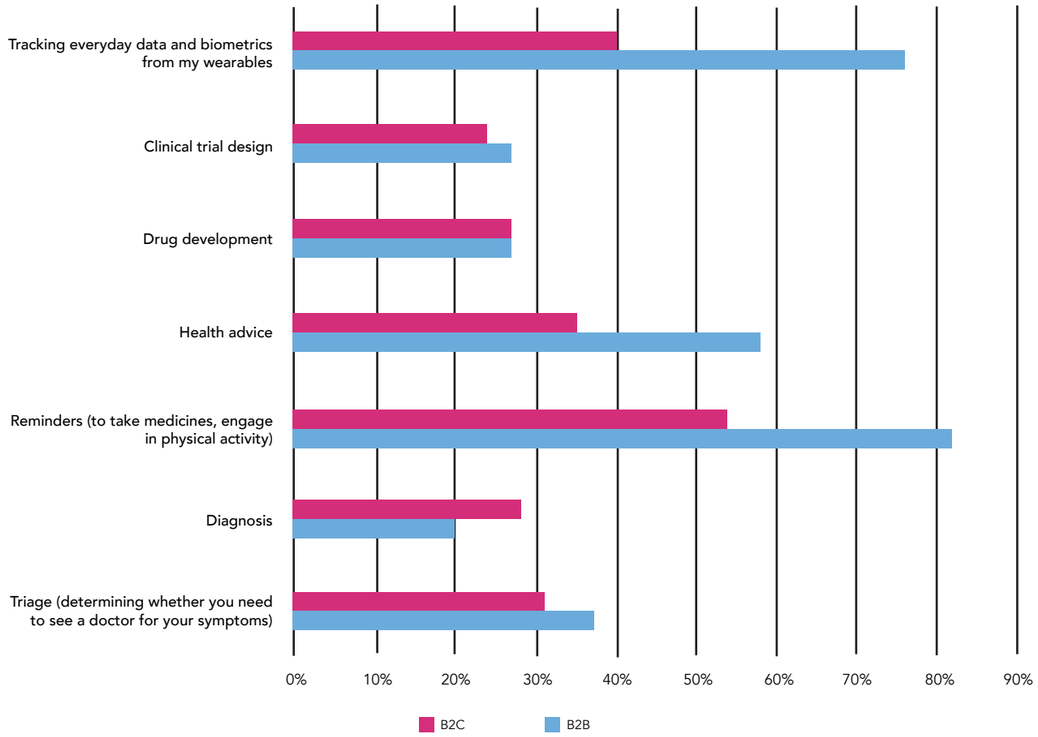
In clinical trials, digital twins, which are virtual replicas of patients, simulate patient responses, cutting trial durations in half while reducing costs by billions annually (53,54,55,56,57). In diagnostics, AI tools outperform human precision, predicting heart disease and macular degeneration with startling accuracy.

Our survey data reveals encouraging acceptance of AI in healthcare for both B2B and B2C respondents, with the majority of respondents being either very comfortable or 'open to it' for most applications explored by the survey. Concerns remain strong around diagnosis, drug development, and clinical trial designs, with 27-30% of B2B and B2C saying they would not want AI being used in it.

Figure 12

Most people are open to AI being used in healthcare

Share of respondents answering 'Very Comfortable' to the question: "How comfortable are you with AI solutions being used in the following health areas?"



AI's efficiencies span the entire value chain

AI is transforming drug discovery, dramatically reducing development time. Analysts predict that AI could unlock $60-$110bn in annual economic value for the pharmaceutical and medical-product industries (58). Aside from this, AI can also potentially reduce R&D costs in drug discovery by at least 25-50% from discovery up to preclinical stages, based on the modelling of publicly available data from early AI programs (59). These savings enable a broader exploration of healthspan-related therapies, increasing the likelihood of breakthroughs. Platforms like AIDDISON™ combine traditional computational chemistry with AI and machine learning, creating powerful tools to explore vast chemical spaces efficiently (60).

AI also enables the design of novel compounds. Healthspan science involves intricate biological processes, making it an ideal field for AI-driven analysis. Recursion Pharmaceuticals exemplifies this trend, using AI to expedite drug discovery through its extensive proprietary database, the Recursion Data Universe. This platform allows millions of weekly laboratory experiments, providing early indications of drug potential failure (61). The company has recently released OpenPhenom-S/16, a foundation model for microscopy data that outperforms traditional analysis pipelines without additional tuning (62). Similarly, Shift Bioscience is advancing cell simulation AI to understand gene activation in reversing the aging process. Their platform combines generative AI with a high-throughput biological aging clock to predict and validate gene sets for safe cell rejuvenation, aiming to develop treatments for age-related illnesses (63).

Gains are present in clinical trials, from design to patient recruitment and data management. AI advancements are propelling healthspan innovations through clinical phases with unprecedented speed and efficiency. AI-powered tools such as HINT (Hierarchical Interaction Network) and SPOT (Sequential Predictive Modeling of Clinical Trial Outcome) reshape how trials are planned. These systems predict trial success by analyzing drug molecules, target diseases, and patient eligibility criteria, enabling researchers to refine designs before committing significant resources (64).

Other AI solutions, like AutoTrial, automate the generation of standardized eligibility criteria, such as body mass index ranges, ensuring consistent and optimized trial designs across studies (64). Meanwhile, AI models incorporating multimodal imaging markers can reduce required sample sizes without compromising statistical power – a critical advantage for complex healthspan studies (65). Together with innovations like digital twins, these AI-generated patient models can reduce the need for control group participants by 20–50%, significantly shortening trial durations for healthspan interventions (64).

These developments are significant, as recruiting patients for clinical trials can be a lengthy process. AI systems address this by automating patient matching based on detailed inclusion parameters, expediting recruitment timelines (65). AI also ensures more diverse study samples by identifying underrepresented populations based on factors like age, gender, and medical history – an essential consideration for healthspan research, which must account for demographic variations (66). Lastly, by analyzing vast datasets from electronic health records and real-world evidence, AI can identify potential participants who may otherwise be unaware of their eligibility (67).

AI also plays a pivotal role in managing the complexity of modern clinical trials. For example, AI can extract data from unstructured reports, annotate images or lab results, and complete missing data points, ensuring comprehensive and accurate datasets (64). Real-time data analysis powered by AI can identify safety concerns, adverse events, or protocol deviations as they occur, enhancing patient safety and study reliability. Furthermore, AI algorithms can simulate trial scenarios and provide data-driven recommendations for adaptations, ensuring studies remain aligned with their objectives (66). "What's really changing right now already with AI is the clinical trials and selecting the right patients and understanding quickly from our medicines that we're giving to patients what the effects might be," says Dr. Christoph Westphal, Co-founder and General Partner of Longwood Fund.

Diagnostics are a key opportunity

A recent study published in JAMA Network Open in 2024 provides updated insights into AI's performance in medical diagnostics. This research found that large language models (LLMs) outperformed physicians in terms of diagnostic accuracy (68), which challenges the notion of human superiority in medical diagnosis and highlights AI's transformative potential in healthcare.

AI-powered tools are also surpassing human accuracy in detecting conditions like heart failure and age-related macular degeneration (AMD), enabling earlier interventions that could significantly impact healthspan. For instance, a 'smart' stethoscope using AI has demonstrated superior accuracy compared with standard echocardiograms. In ophthalmology, AI models have outperformed human experts in predicting AMD development, highlighting AI's potential to revolutionize preventive care (69).

One of AI's most valuable capabilities is its proficiency in analyzing intricate medical imaging data – particularly important in age-related conditions, as they often require detailed imaging studies. AI's consistency and ability to handle complexity make it particularly effective in these scenarios (70). One example of that potential is the use of AI-assisted methods for predicting dementia through advanced image and speech analysis techniques (71,72).

Importantly, AI diagnostic systems offer fatigue-free, consistent performance. This reliability is crucial for preventive medicine and managing age-related conditions that demand frequent monitoring or large-scale screening programs (70).

Ensuring equitable data representation and demonstrating tangible benefits in patient care will be key to AI's integration into healthcare systems. Indeed, despite their many advantages, current AI diagnostics still face certain limitations, including:

- **Clinical Applicability:** Most studies comparing AI to human diagnosticians occur in controlled settings, which may not fully replicate the complexities of real-world clinical environments (73).
- **Data Quality and Bias**: The effectiveness of AI models heavily depends on the quality of their training data. Concerns about biases in datasets highlight the need for diverse, representative inputs (74).
- **Lack of AI skills:** One of the reasons AI outperforms doctors in some diagnoses might be their inability to leverage AI effectively to enhance their own knowledge (75).
- **Patient Outcomes:** More research is needed to assess how AI diagnostic tools impact patient outcomes in everyday clinical practice (73).

"While there's growing enthusiasm about AI's diagnostic capabilities surpassing human physicians, this represents a fundamental misunderstanding of comprehensive medical care," explains Dr. Jordan Shlain, Founder & Chairman of Private Medical. "Diagnosis, while critical, is merely one component in the complex ecosystem of healthcare delivery. The true challenge lies in preventing illness and extending healthspan – the period during which we maintain optimal function and vitality. AI excels as a pattern recognition engine and will undoubtedly democratize access to medical information, accelerating our ability to process and analyze data. However, it's crucial to recognize that healthcare exists at the intersection of science and human experience. The irreplaceable elements of clinical intuition, emotional intelligence, and therapeutic relationships remain firmly in the human domain. AI will augment rather than replace the nuanced art of medicine."

AI might facilitate the transition to healthspan-focused healthcare systems

AI's ability to support predictive and personalized care could be a major accelerator to transitioning to a healthspan-focused healthcare system. AI systems can easily integrate diverse datasets, including genomics, aging biomarkers, biometrics, and cellular data, along with inputs from wearable technology. This multidimensional capability creates a 360-degree perspective of an individual's aging profile, allowing for accurate, tailored, healthspan recommendations (76). AI platforms such as the PROTEIN project, for instance, are advancing personalized care by integrating lifestyle, age, health data, and preferences to create individualized diet plans (71).

In addition to dietary interventions, AI-powered healthspan platforms leverage a vast array of data to create personalized healthspan strategies. By analyzing information from multiple sources, these platforms can help manage chronic conditions such as high blood pressure, type 2 diabetes, and high cholesterol through tailored care approaches (76, 71).

AI models have also demonstrated strong potential in predicting patient responses to treatments. A study by Huang et al. found that AI could predict chemotherapy responses with over 80% accuracy across multiple drugs by analyzing gene expression data (110). Similarly, Alowais, Alghamdi, Alsuhebany, et al. highlighted AI's ability to forecast antidepressant efficacy using electronic health records (77).

AI's predictive capabilities are strongly aligned with the preventive approach underlying healthspan. AI algorithms can analyze genetic predispositions, lifestyle choices, and environmental factors to identify individuals at heightened risk for specific diseases. By flagging these risks early, clinicians can implement preventive measures and interventions to reduce the likelihood of disease progression and extend healthspan. (77) Likewise, AI can be used to promote a gamified approach to health, helping individuals sustain healthy behaviors. The majority of medical professional respondents in the B2B survey (58%) saw exercise as the main area where gamification and digital apps could bring the most behavioral change.

Properly leveraged, this continuous learning from new clinical data, research findings, and patient outcomes could help AI ensure that healthspan medicine remains at the cutting edge, with algorithms refining accuracy over time (78. "I think we're just at the start of what AI might be enabling in healthspan," says Mr. MacGinnis.

Capturing the AI opportunity for healthspan requires a new approach to data

The economic impact of all these advancements is profound. Recent analysis suggests efficiencies from generative AI alone could generate an annual economic value of $15–$28bn for the drug discovery phase while delivering up to 50% cost reductions in the clinical trial phase (79).

In such a context, access to data is key. "We have a voracious appetite for data," says Sir Jonathan Symonds CBE, Chair of the Board, GSK. "In fact, we have rebuilt the company around the data and the analytical tools," he adds.

However, much of the data is concentrated or siloed. This is in part because of competitiveness concerns. "Many companies view data as a very proprietary and valuable asset," notes Mr. Jorge Conde, General Partner at a16z Bio + Health, although in the case of healthspan, he says: "There is probably some value in treating some of this like pre-competitive data." Some of the data is also missing: "Health systems have tons of data [on sick individuals]. What we don't have is data on healthy people," notes Sir Jonathan Symonds. Progress is being made on that front, with programs like 'All of US' in the United States and 'Our Future Health' in the UK, which are collecting comprehensive health data from millions of individuals, including healthy ones. This creates unique opportunities when it comes to AI and data analyses, notes Dr. Raghib Ali OBE, CEO and Chief Medical Officer of Our Future Health. "We will be able to combine genetic data, with lifestyle exposures, past medical history and the social determinants of health – that's what will be unique about the data set that we have."

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> Chair of the Board, GSK

A different approach to data will be required to unleash the benefits of AI for healthspan. Many of the leaders interviewed pointed to the example of biobanks in the UK, Iceland, and Finland as interesting models that could be replicated. It will also be important to engage technology companies. This has yet to be achieved at scale. "My hope is that companies like NVIDIA, OpenAI, Microsoft, and Google, of course, which just won the Nobel Prize for protein structures, can work constructively with countries and with some of the leading biopharma companies to try and integrate these data sets and make them broadly available…I think that would be beautiful," says Dr. Westphal.

The future of healthspan science, powered by the convergence of AI, quantum computing, and specialized chips, holds immense promise. We stand on the brink of a new era where aging itself could be precisely measured, modeled, and potentially modified. However, this technological revolution also brings ethical considerations and the need for careful governance to ensure equitable access and responsible use. As we move forward, it will be crucial to foster collaboration between tech giants, biotech companies, and research institutions to fully harness these technologies' potential.

TRENDS

AI is transforming healthspan science, accelerating drug discovery, enhancing diagnostics, and improving clinical trials. Despite privacy concerns and regulatory hurdles, AI adoption is growing, promising significant advancements in personalized healthcare and longevity research.

EVIDENCE

AI outperformed physicians in diagnostic accuracy. AI-generated patient models can also reduce the need for control group participants by 20–50%. Gen AI alone could create up to $110bn in value across the pharmaceutical value chain.

ACCELERATION AVENUES

Extending healthspan with AI requires integrating diverse data like genomics and biomarkers to create precise models and interventions. Collaboration through data-sharing and biobanks is vital. It will also be necessary to address regulatory and ethical challenges to ensure safe, equitable advancements in healthspan.

05 CLINICAL

HEALTHSPAN CLINICS ARE TAKING OFF

Clinicians stand at the forefront of integrating healthspan innovations into mainstream healthcare. Around the world, successful initiatives are bridging research with clinical applications, demonstrating how this integration can be done in practice. These efforts, complemented by advancements in artificial intelligence (AI, are shaping a future where personalized, efficient, and equitable care is attainable (80, 81.

The emergence of public longevity clinics marks a significant milestone in this transformation, making healthspan-focused care accessible to a broader population. For instance, the Mayo Clinic in Rochester established the first public longevity clinic in the United States in July 2023, treating approximately 100 patients ranging from 35 to 81 years old in its first year (80. This wide age range demonstrates the broad appeal of healthspan interventions across various life stages. Similarly, Israel's Sheba Longevity Centre has implemented a Health Longevity Roadmap within a major public hospital, guiding clinicians to emphasize preventative care (17, while Abu Dhabi's Department of Health has just recently licensed the Institute for Healthier Living Abu Dhabi (IHLAD as the world's first specialized Healthy Longevity Medicine Centre. This innovative center will offer personalized treatments to optimize healthspan and reduce chronic diseases. It marks a significant step towards a proactive healthcare model that prioritizes prevention and wellness (82. In addition to the Hevolution Foundation, which was established by Royal Order in 2018, and aims to drive efforts to extend healthy human lifespan globally and catalyze the healthy longevity field, The Kingdom of Saudi Arabia has also initiated several programs and initiatives such as The Quality of Life Program, The Health Sector Transformation Program, and telehealth services to reduce hospital visits for non-emergency cases, using applications like Sehhaty and the 937 Center (83, 84, 85).

Academic institutions are also playing a crucial role in bridging research with real-world applications. Singapore's National University Health System at Alexandra Hospital launched a healthy longevity clinic in 2023, combining comprehensive, personalized assessments with the latest research (81, 17). These initiatives highlight the potential of academic ecosystems to accelerate innovation and implement evidence-based practices in healthspan science. As the healthcare model shifts from sickcare to preventative healthspan, clinicians will play a leading role.

"Here in Singapore, we are bringing the field towards building that ecosystem – we even have a publicly funded hospital with a healthy longevity clinic," says Professor Andrea Maier, Oon Chiew Seng Professor in Medicine at the National University of Singapore." Translational aging research is driving innovation and implementation into clinical care. There are not many established protocols yet – clinician scientists are learning from high quality research what is working and what is not. The next decade will be a huge learning curve to fine tune diagnostics and interventions to optimize healthspan. While working together we will have to establish how healthy longevity medicine care could best be delivered to the public. At this moment in time, nobody can claim to have established a clinically effective and cost-effective framework yet."

> **"THE NEXT DECADE WILL BE A HUGE LEARNING CURVE TO FINE TUNE DIAGNOSTICS AND INTERVENTIONS TO OPTIMIZE HEALTHSPAN"**
>
> **– PROFESSOR ANDREA MAIER**
> Oon Chiew Seng Professor in Medicine,
> National University of Singapore

While public and academic initiatives aim to democratize access to healthspan solutions, private longevity clinics remain pivotal players in the field. Despite their limited accessibility due to high costs, these clinics contribute valuable insights that can influence public health strategies and inform future interventions (17, 81). In the same way that Formula 1 innovated anti-lock brakes, which are now in every car produced for consumers around the world, early adopter patients of healthspan clinics will support the development of protocols and innovations that wider populations will benefit from in future years.

"The healthspan optimization landscape is undergoing a remarkable transformation," observes Dr. Jordan Shlain, Founder & Chairman of Private Medical. "We're witnessing an unprecedented convergence of scientific inquiry and clinical innovation in the pursuit of extending functional longevity. The evolution of this field appears to be following a classic diffusion of innovation model: the private sector serves as an experimental laboratory where novel approaches to healthspan enhancement can be developed and refined under careful clinical observation. This creates a natural knowledge transfer pipeline, where evidence-based interventions that demonstrate efficacy in boutique medical settings can be systematically adapted and scaled for broader public health implementation. The private sector's ability to rapidly iterate and validate interventions serves as a crucial proving ground, accelerating the development of evidence-based protocols that can ultimately benefit population health at scale."

The growing interest in healthspan solutions is evident in our 2024 survey. 49% of consumer respondents expressed interest in longevity-enhancing products or services, a significant increase from 32% in 2023. Regional variations are notable, with particularly strong demand in the Middle East and North Africa (MENA) region, where 35% of respondents were definitely interested, compared with the global average of 19%. Conversely, the European Union showed more reticence, with 50% of respondents expressing negative sentiment (80,81,17). European countries' robust, publicly-funded healthcare systems provide comprehensive coverage, potentially fostering a greater trust in existing healthcare and reducing the perceived need for alternative healthspan solutions. EU systems also often emphasize preventive care and early interventions, which may further diminish the demand.

This increasing interest is reflected in patient inquiries to medical professionals. 68% of surveyed medical professionals encountered patients asking about healthspan solutions or interventions at least once a month, with one-third (36%) reporting weekly inquiries. Additionally, one-third (35%) of professionals encountered patients interested in participating as healthy volunteers in medical research projects on healthspan on a monthly basis.

Training of health practitioners is urgently needed

Half of consumers (50%) surveyed prefer to have a healthspan consultation in person. However, there are regional variations, with North American and MENA respondents more open to virtual consultations (20% vs. 14% globally). Cost and convenience are the most compelling reasons for virtual consultations globally (51% and 49%, respectively), while in Latin America and Africa, better access is a significant factor (52% and 58%, respectively).

When seeking healthspan support, 46% of consumers would first turn to their medical practitioners, which rises to 58% for North American respondents. This preference underscores the importance of training general practitioners in healthspan science to enable large-scale delivery of healthspan interventions (80,81).

Education will play a crucial role in the healthspan transition. Programs like the UCI Center for Healthspan Sciences at UC Irvine are equipping high school, college, and Pharm.D (Doctor of Pharmacy) students with the tools and knowledge to address the complexities of aging (86). However, there's a growing recognition of the need for continued education. While 74% of medical and clinical respondents in 2024 felt equipped to advise patients on healthy longevity strategies, this figure is down from 84% in the previous year, highlighting the need for ongoing professional development in this rapidly evolving field (87). Longevity.Technology's Longevity Clinics Survey 2024 identified that 74% of clinic teams pursue CMEs (Continuing Medical Education) in healthy longevity medicine and that 66% would consider safely sharing anonymized client/patient data to help the industry analyze and improve client/patient outcomes.

Efforts are underway to integrate longevity science into training programs, but they must accelerate to keep pace with research. Over 6,000 individuals have completed a longevity-focused course available at four medical schools (80), yet experts stress that these numbers must rise significantly to meet growing demand. The complexity of aging, coupled with challenges in measuring long-term outcomes, necessitates a multidisciplinary approach to care. Insights from geroscience, clinical medicine, and public health are essential to establishing effective standards (88).

Professional oversight is key to sustain growth

The growing wellness market – expected to reach $13tn by 2031 – presents significant opportunities but also risks, particularly from unregulated providers (89). This highlights the need for clinician-led oversight and evidence-based interventions to ensure safety and equity.

Standardized protocols and frameworks will be key for the industry to scale. They help reduce variability in practice and improve patient outcomes (90). In the context of healthspan-enhancing diagnostics, standardized protocols could ensure that all patients receive consistent and comprehensive assessments of their biological age and health status. These guidelines should be based on the latest research in geroscience and related fields (81). By establishing clear, evidence-based standards, healthcare providers can implement healthspan-enhancing diagnostics and interventions more effectively.

One recent development in that regard comes from the Middle East, with Abu Dhabi establishing the world's first evidence-based clinical guidelines for longevity-focused healthcare. Developed through collaboration with the Department of Health Abu Dhabi (DOH), the Institute for Healthier Living Abu Dhabi (IHLAD), and the Healthy Longevity Medicine Society (HLMS), these guidelines prioritize prevention and proactive health management. This initiative is bolstered by the licensing of the world's first specialized Healthy Longevity Medicine Center, setting comprehensive standards for diagnostics, personalized care, and multidisciplinary interventions (82). "This is a tremendous milestone in the field," says Prof. Maier. "It is so exciting to see a government embracing the idea that prevention should be the key and supporting a scope of practice for healthy longevity medicine physicians," she adds.

International collaboration efforts to define standards will be necessary. Organizations like the Healthy Longevity Medical Society (HLMS) are working to establish a clinically credible framework for healthy longevity medicine (91). There is demand for such standardization efforts; according to Longevity.Technology's latest clinics survey, 36% of clinics would change their protocol to match and qualify for an internationally recognized standard for 'healthy longevity medicine' and 58% would consider doing so when armed with further information.

Standardization may also help reduce cost over time. While offering innovative diagnostics and therapies, many private clinics position themselves as luxury services, often priced beyond the reach of the average consumer (17). Finding ways to reduce costs is critical to ensuring equitable access to healthspan solutions worldwide.

TRENDS

Clinical innovation, technology, and education is revolutionizing healthspan science. While clinics, private ventures, and AI-driven diagnostics expand access to longevity care, challenges like misinformation and equity persist. The field continues to evolve through collaborative efforts, balancing lifespan extension with enhanced quality of life.

EVIDENCE

Clinics like the Mayo Clinic and Sheba Longevity Centre are pioneering healthspan services, while academic institutions provide comprehensive assessments. With consumer interest in longevity products increasing and clinicians encountering monthly healthspan inquiries, the field demonstrates strong growth in both clinical practice and patient demand.

ACCELERATION AVENUES

Advancing healthspan services requires integrating longevity science into medical education while fostering partnerships for standardized protocols. As regulatory frameworks evolve to ensure patient safety and equity, technology integration and collaboration will be crucial for democratizing access to evidence-based healthspan innovations.

06 ECONOMY

HEALTHSPAN IS AN ECONOMIC IMPERATIVE

Time is ticking for the global economy. As people live longer and fewer babies are born, nations face a significant demographic shift with far-reaching economic implications. The stark reality is that fertility rates in OECD countries have plummeted from 3.3 children per woman in 1960 to a mere 1.5 in 2022 (92). Globally, the median age of death is expected to reach 78 by 2050 (93), which, under the current sick care model, will lead to a surge in healthcare costs. Global costs of chronic obstructive pulmonary disease alone are expected to double by 2030 (from 2010 levels) to reach $4.8tn by 2030 (94).

"I think governments feel the pain. The number of dollars they have to spend on healthcare is rising and rising, while the healthspan of their population is not. So there's a mismatch between investment and return on investment with their current healthcare services," says Professor Andrea Maier, Oon Chiew Seng Professor in Medicine at the National University of Singapore.

The implications of these demographic shifts go beyond healthcare, however. Across the world, age dependency ratios are expected to increase through 2050 – with Sub-Saharan Africa the only exception (95). Under a business-as-usual scenario, this shift could threaten workforce productivity, putting pressure on pension and economic systems.

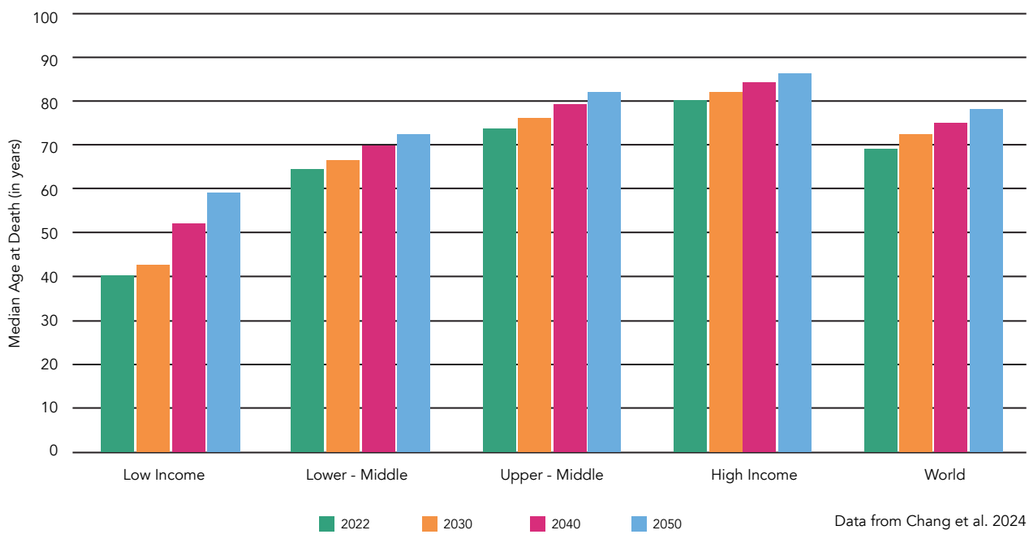
"If you have an aging population, and you have a sicker population with a decline in healthspan, you have a problem," says Prof. Maier, adding that "For the first time, governments are hearing the arguments and acting on it. It's a financial argument, and not just because of health costs – it's much, much broader. It's about productivity; it's about keeping people healthy to be able to function."

Our survey shows the general population is concerned. While B2B and B2C respondents are concerned about living longer (less than 3% say they are not), B2C respondents tend to be more concerned about economic factors (44% B2C vs. 22% B2B). In comparison, B2B are more concerned about ageism (34% B2B vs. 20% B2C) and frailty/impairment. Despite – or perhaps because of – these concerns, there is a significant willingness to invest in healthspan extension, with 49% of B2C respondents indicating they would pay up to half a year's income for a therapy that could potentially extend their healthspan by 10 years.

> **"FOR THE FIRST TIME, GOVERNMENTS ARE HEARING THE ARGUMENTS AND ACTING ON IT. IT'S A FINANCIAL ARGUMENT, AND NOT JUST BECAUSE OF HEALTH COSTS – IT'S MUCH, MUCH BROADER."**
>
> **– PROFESSOR ANDREA MAIER**
> Oon Chiew Seng Professor in Medicine, National University of Singapore

Figure 13

In an aging world, healthspan is a priority

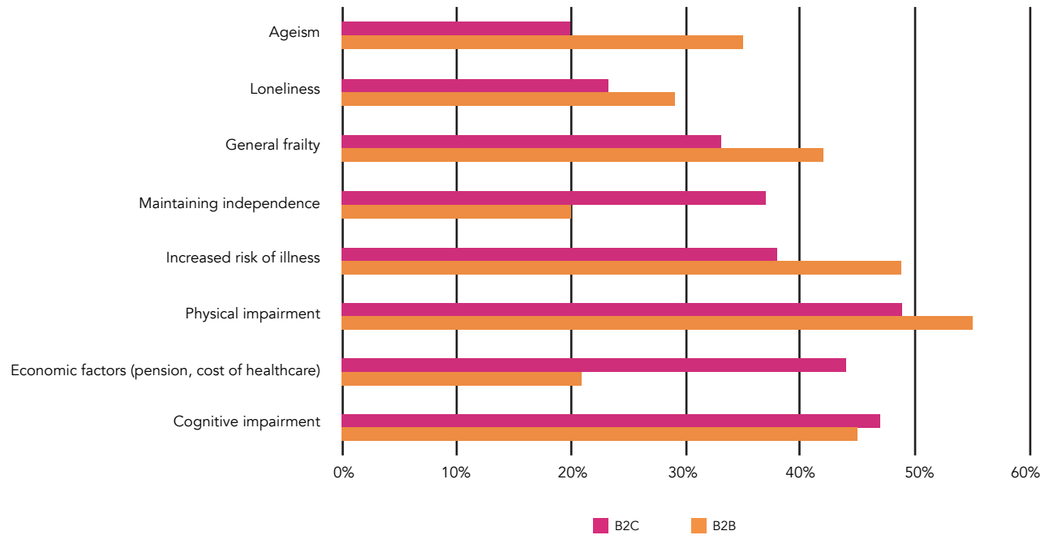


Data from Chang et al. 2024

Figure 14

Concerns around lifespan (B2C vs. B2B)

Which of the following would most concern you about living longer?



This makes healthspan an economic imperative. Research conducted by the World Health Organization (WHO) in high-income countries has revealed that early cancer diagnosis can significantly reduce treatment costs. Patients diagnosed with cancer at earlier stages often require less intensive and costly treatments compared with those diagnosed at advanced stages. This finding underscores the importance of early detection and screening programs in reducing the financial burden of cancer (96).

The healthspan economic dividend is substantial

Delivering healthspan will not be free, but it will provide significant returns. Recent estimates from the World Bank – which focuses on measures helping to reduce the incidence and onset of non-communicable diseases – put this figure at $220bn per year by 2050 for Low- and Middle-Income countries alone. The returns are substantial (up to 16:1, according to the World Bank), making the investment worth it (97). For instance, a one-year extension of healthy life expectancy in the US could generate as much as $40tn. This figure is a testament to the immense potential of healthspan (98). China's flourishing 'silver economy' is poised to triple, reaching $4.2tn by 2035, a substantial 10% of its GDP (1,99,100). For the poorest countries, however, capturing these benefits will also come with increased healthcare spending, something many have struggled to do.

Creating the fiscal space for making those necessary investments will be critical. Given the expected returns, the use of development financing could be an avenue to explore. However, it will also be essential to start effectively pricing the externalities associated with products that negatively affect long-term health outcomes. Taxing smoking is a clear example, and indeed a great opportunity for low-income countries, where tobacco taxes are low and the cost of tobacco-related disease (as a share of overall health expenditures) is high (101).

A more detailed comprehensive evaluation of the benefits of healthspan will also be necessary. "The only contributions economists routinely seem to account for are workforce participation, but older people contribute in many other ways," notes Dr. John Beard, Irene Diamond Professor and Director of the International Longevity Center at Columbia University. "What we need is a much more nuanced approach that values the contributions that older people make," he adds.

> **"THE ONLY CONTRIBUTIONS ECONOMISTS ROUTINELY SEEM TO ACCOUNT FOR ARE WORKFORCE PARTICIPATION, BUT OLDER PEOPLE CONTRIBUTE IN MANY OTHER WAYS"**
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> **– DR. JOHN BEARD**
> Irene Diamond Professor and Director of the International Longevity Center, Columbia University.

Such a comprehensive evaluation will need to extend to socio-economic issues. This is in part because of the relationship between income and healthspan. "People in more affluent areas live longer and spend less time in poor health than people in poor areas," observes Mr. George MacGinnis, Healthy Ageing Challenge Director, UK Research and Innovation. More generally, between 30–55% of health outcomes can be attributed to social determinants, according to the WHO (102).

A more comprehensive evaluation is also required to better understand how health interventions can support the entire ecosystem. "Governments have looked at economically challenged parts of the country and tried to regenerate them. But I don't think health has ever been on the map as part of an economic regeneration effort," notes Sir Jonathan Symonds CBE, Chair of the Board, GSK.

Collecting this data is an investment, but it does not have to be borne by the public sector alone – nor does it have to be a sunk cost. The 'Our Future Health' program, for instance, is based on a combination of public and private funding, and it will charge for the use of the data to fund its operations and recoup its costs. "Once you have comprehensive data at scale, then you can charge researchers from industry and academia to use it, so eventually you can make the program financially self-sustaining," notes Dr. Raghib Ali OBE, CEO and Chief Medical Officer of Our Future Health.

Indeed, the private sector will often be open to funding projects that benefit the ecosystem as a whole. "Investing in a system which is not directly benefiting just one company is something that many companies do to make sure that ultimately their business interests are benefiting. It doesn't have to be immediate, but it does have to be direct," notes Mr. Anil Soni, CEO, WHO Foundation.

Pursuing it will be a source of competitive advantage

This will require nimble, more open-minded policies. "We are so rigidly stuck in outdated ageist stereotypes that people can't even think straight on these topics," notes Dr. Beard. Among these stereotypes is the definition of aging through chronological age, which leads to an assumption of homogeneity, whereas "with increasing [chronological] age, we actually see increasing heterogeneity, particularly in terms of health experience," he notes. Research also shows that countries with rigid systems of "study till 25, work till 60 or 65, then retire" will also have a more challenging time capturing the full extent of the healthspan dividends. "They're the ones who are struggling," he notes.

The message is clear: investing in healthspan isn't just another item on the healthcare agenda – it's the key to unlocking future economic prosperity. Nations that seize this opportunity today won't just survive the silver tsunami; they'll ride the wave of innovation, leading the charge in a world where longer lives fuel, rather than drain, economic growth. The choice is simple: adapt and thrive, or resist and risk being left behind in the greatest demographic transformation of our time.

TRENDS

From declining birth rates to aging populations, demographic shifts are driving a focus on healthspan as an economic imperative. Healthspan is about more than just risk management or health, it's about capturing a multi-trillion dividend and securing an important competitive advantage.

EVIDENCE

Delivering healthspan will not be free, but it will deliver significant return of up to 16:1. Adding one healthy life year could create up to $40tn in the US alone. In emerging markets it could increase GDP up to by 4–5%.

ACCELERATION AVENUES

A more detaied evaluation of the benefits of healthspan is key to convince policy makers and mobilize capital. It will also be important for developing countries to create the fiscal space necessary for investment.

07 POLICY

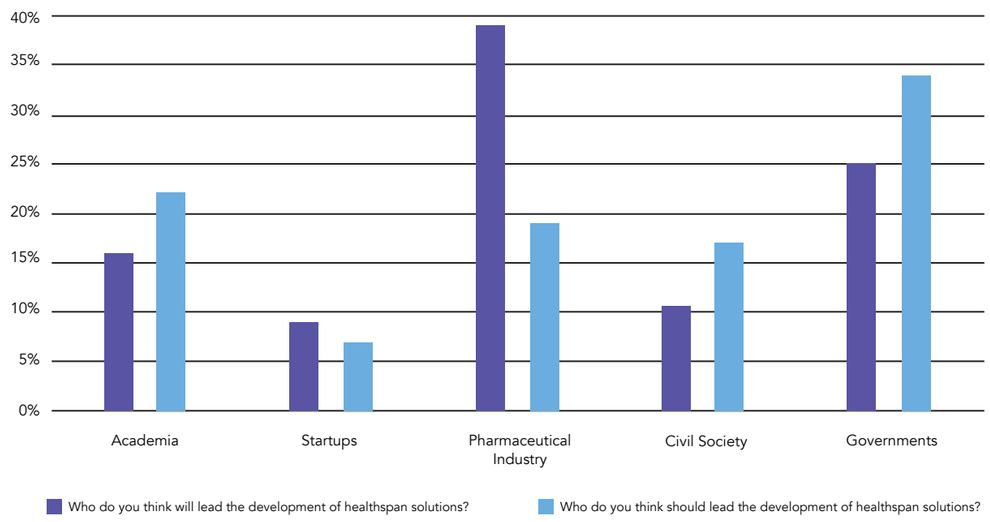
CHANGE REQUIRES LEADERSHIP

Who will shape tomorrow's healthspan solutions? The answers from our survey reveal a fascinating divide in expectations. B2B respondents overwhelmingly bet on pharmaceutical companies, with nearly half (47%) seeing them as the driving force behind the development of healthspan solutions. Yet the everyday consumers tell a different story: they are looking to governments for leadership, with 34% believing the public sector should lead the development of healthspan solutions.

Our survey also shows a large gap in public leadership. While one-third of B2C respondents believe governments should lead, only one in four (25%) believe governments will actually step up, exposing a critical confidence gap in public policy leadership. This misalignment between hopes and expectations doesn't just highlight different perspectives – it signals an urgent need to bridge the gap between private sector capabilities and public sector responsibilities in advancing healthspan science.

Figure 15

Leadership Gap: Expectations vs. Reality (B2C respondents)



For governments, the challenge lies not in recognizing the opportunity but in marshalling the political will and public support to seize it. "I think Saudi [Arabia] and the UAE get it, and I think Singapore gets it. They're investing significantly in data and technology, and in the case of Singapore, really rebuilding the system around individual health needs and an individual assessment, which moves the medical side from atomizing diseases to a more holistic approach," says Sir Jonathan Symonds CBE, Chair of the Board, GSK. "I've also had really good conversations with the Chinese government. They have got a demographic problem that's off the charts. And they've got to keep healthy people healthy if they want to maintain productive capacity."

> **"I THINK SAUDI [ARABIA] AND THE UAE GET IT, AND I THINK SINGAPORE GETS IT. THEY'RE INVESTING SIGNIFICANTLY IN DATA AND TECHNOLOGY"**
>
> **– SIR JONATHAN SYMONDS CBE**
> Chair of the Board, GSK

New approaches to policy design and implementation are needed

Countries that embrace healthspan science today are poised to lead the future of global economic growth, fostering innovation, reducing healthcare costs, and creating healthier, more productive populations. Realizing these benefits demand a shift in political, economic, and social strategies to prioritize long-term health outcomes over short-term gains. "It's not that we shouldn't talk about healthspan benefits, but health ministers are not the target because there's no money available, so we need to be speaking to ministers of economy and finance, who want to know what impact their policies are going to have on economic growth," says Dr. Michael Hodin, CEO, Global Coalition on Aging.

The complexity of the task at hand calls for a whole-of-economy approach. "Economic factors, housing factors, things we often don't think of as 'biology', are all important," says Dr. David B. Allison, Professor of Pediatrics, Endowed Chair, and Director of the USDA Children's Nutrition Research Center at Baylor College of Medicine. These complex interdependencies, over which we often lack data, make sandboxing an essential approach to deploying healthspan solutions at scale.

The whole-of-economy approach also applies to governance and budgeting. In Chile, for instance, multiple ministries contribute to the health budget (103). Likewise, in Saudi Arabia, the Saudi Health Council helps to mainstream

health considerations across different ministerial programs and policies (104).

Policy innovations are needed. Helping people save for old age will be necessary, especially for low-income populations – who may not always be in the formal economy. Different approaches are being explored in that regard, from public matching contributions for workers of the informal sector in Rwanda and Korea to consumption-based contributions in places like China or Spain (105,106,107,108).

This includes new approaches to prevention. "Prevention is relatively simple, and it can be delivered through pharmacies, mobile units, and digitally and without needing medical doctors," notes Dr. Raghib Ali OBE, CEO and Chief Medical Officer of Our Future Health. "I think we're going to have something new – call it a national prevention service, which will have a mission to keep us in good health." Designing evidence-based interventions will be central to success in that regard. "In an ideal world, every country should produce its own evidence," he adds. "But for countries that can't do that, then it would be reasonable to use our evidence to at least do something in prevention rather than just following the standard sickness model. That's not good for patients, for the population and it's not good for the country, and it will bankrupt most health systems within the next few decades."

Equity considerations cannot be overlooked. "Ensuring equitable access to healthspan technologies is essential to avoid exacerbating global health disparities. Healthspan must not remain a privilege of the wealthy; it should become a universal right," says Dr. Peter Diamandis, Founder and Executive Chairman, XPRIZE Foundation. Today, we are still far from that reality. "If we look at most of the diagnostics and therapeutics which are being offered, they are a la carte and not affordable for 99% of the population," notes Professor Andrea Maier, Oon Chiew Seng Professor in Medicine at the National University of Singapore.

Partnerships will be central to the democratization effort. "Public-private partnerships can subsidize the cost of advanced therapies and diagnostics, making them accessible to underserved populations," notes Dr. Diamandis. Collaboration can also help increase the amount of human capital deployed.

"There's a lot of expertise in the life sciences community that you lose out on if you restrict yourself only to academia, NHS, or government" notes Dr Ali. Open-source research can also be a way to help accelerate discoveries.

Change is possible, but it needs to happen now. "The implementation of nationwide healthspan medicine represents an achievable paradigm shift in public health policy, but the window for optimal intervention is immediate," asserts Dr. Jordan Shlain, Founder & Chairman of Private Medical. "With strategic investment and political will, a nation could fundamentally transform its healthcare infrastructure to prioritize healthspan optimization within a single decade. This timeline aligns with other major public health initiatives we've seen succeed historically, but requires the same level of coordinated effort and resource allocation that characterized campaigns like tobacco control or vaccine implementation. The key differentiator is that healthspan medicine represents a proactive rather than reactive approach to population health management, potentially offering unprecedented returns on public health investment."

The stakes are high. With the global population over age 60 expected to double to 2.1 billion by 2050 (109), the cost of inaction is immense. The potential rewards – trillions in economic savings, improved health, and global leadership – demand urgent, sustained investment in healthspan. The question now is not if but how quickly nations can pivot toward a healthier, more prosperous future.

"ENSURING EQUITABLE ACCESS TO HEALTHSPAN TECHNOLOGIES IS ESSENTIAL TO AVOID EXACERBATING GLOBAL HEALTH DISPARITIES. HEALTHSPAN MUST NOT REMAIN A PRIVILEGE OF THE WEALTHY; IT SHOULD BECOME A UNIVERSAL RIGHT"

– DR. PETER DIAMANDIS
Founder and Executive Chairman, XPRIZE Foundation

TRENDS

Some countries are actively tackling the healthspan challenge. At the global level, however, there is still a critical confidence gap in public policy leadership.

EVIDENCE

34% of B2C respondents believe governments should lead the development of healthspan solutions, but only 25% believe governments will actually step up. Globally, just 108 of the WHO's 194 member countries have a plan, policy or strategy aligned to healthy aging.

ACCELERATION AVENUES

More action is urgently needed globally. A whole-of-economy approach will be necessary for policy design, implementation and governance. Given the interdependencies, governments should also proceed through experimentation before applying an intervention at national scale.

CONCLUSION

The dawn of a new healthspan era

As we conclude this comprehensive report, it is clear that we stand at the threshold of a transformative era in healthspan science and industry. The field is experiencing unprecedented growth, driven by a convergence of scientific breakthroughs, increased funding, and a shifting paradigm in approaching health and aging.

Funding for healthspan research has steadily increased, with notable growth in public and private investments. This financial backing is propelling advancements in regenerative medicine and anti-aging therapies, further driving the healthspan dialogue across academic, industry, and public domains.

The global healthspan market is projected to reach significant valuation in the coming years, underscoring the economic potential of this emerging sector. However, challenges remain in expanding awareness around healthspan. There is still work to be done to communicate the advantages of healthspan for all layers of society. Engaging decision-makers is critical, as they need to understand the economic and societal benefits of extending healthspan, such as reduced healthcare costs and a healthier workforce.

A shift in deeply entrenched beliefs about aging and health is needed. Many still view aging as an inevitable decline rather than a process that can be actively managed. Transforming this mindset requires a cultural shift, where maintaining health into old age becomes a universal goal for the benefit of all. In engaging the wider public, the healthspan community faces the challenge of tackling misinformation and overselling promises in a developing field. Relying on evidence when discussing healthspan is crucial to ensure that the information shared is accurate, credible, and actionable.

Alignment within the scientific and clinical community will be essential to sustain growth. From agreeing on biomarkers to standardizing healthspan clinical protocols or developing innovative policies, collaboration will be needed to ensure healthspan solutions get deployed at scale.

Delivering healthspan will require investments, but it will deliver significant returns. The opportunity is clear: investing in healthspan isn't just another item on the healthcare agenda – it is the key to unlocking future economic prosperity. Creating the fiscal space for making those necessary investments is critical.

Together, we can architect the future

The convergence of scientific advancements, increased funding, and growing public interest create a fertile ground for transformative discoveries and interventions. Nevertheless, realizing this potential necessitates addressing the following key challenges:

1. Improving public understanding and engagement with healthspan concepts.
2. Ensuring evidence-based practices and communication to build credibility.
3. Developing regulatory frameworks that can keep pace with scientific advancements.
4. Fostering collaboration between academia, industry, and government to accelerate progress.
5. Addressing ethical considerations and ensuring equitable access to healthspan-extending interventions.

By fostering a culture that values health as a long-term asset, promoting evidence-based practices, and addressing the complex ethical and societal implications of extended healthspan, we can work towards a future where healthier, longer, lives are not just a possibility for a few, but a reality for many.

The journey ahead will be complex and challenging, but it has started; it is now time to accelerate. The potential rewards for improved quality of life, reduced healthcare burdens, and increased societal productivity are immense. National initiatives and pilot programs have started to emerge across the world and will need to be replicated. Doing so in a way that benefits all will require the sharing of learnings, experience, technology, data, and capital. The time to scale and ensure equitable access to healthspan solutions is now.

ANNEX 1

Investment in the fields of healthspan and longevity are connected yet distinct. The wider longevity investable universe includes sectors such as consumer diagnostics and supplements, longevity clinics and advanced aesthetics. Healthspan investments, by contrast, focus on evidence-based scientific interventions that enable to extend healthspan – extended lifespan is not the objective, though it can be a positive byproduct of the intervention.

As of today, there is no commonly agreed database tracking healthspan investments. For this second edition, this was achieved by working with data from research company Longevity. Technology and narrowing down the domains to those listed below.

- **Genetics:** About 25 percent of human healthspan variation is determined by genetics, but specific genes and their contributions are not well understood. Healthspan genetic companies aim to identify and correct genes with therapies to facilitate a longer period of good health.
- **Diagnostics:** By tracking intrinsic bodily changes as we age and monitoring exposure to health determinants, healthspan diagnostics have the potential to promote a healthier aging process and extend the period of life lived in good health.
- **Senotherapeutics:** Encompasses various methods addressing senescence: senolytics, senomodulators, senoblockers, and senescence-associated immunomodulators. Each method presents unique opportunities and challenges, potentially used in combination to tackle cellular senescence and promote healthier aging.
- **Reproductive health:** Companies tackling infertility and menopause by modulating aging drivers of reproductive organ aging, aiming to extend the period of reproductive health and overall well-being.
- **Discovery platforms:** Drug discovery is long, expensive, and often unsuccessful. Platform technologies are valuable tools to improve efficiency and quality in drug product development. Many companies are developing proprietary discovery platforms to enable the identification of therapeutic targets for extending healthy life years.
- **Healthspan drugs:** The healthspan pharmacology field promises to revolutionize healthcare for the aging population. A healthspan drug is any novel molecule designed or discovered to act on a specific gene/pathway related to maintaining health with age (e.g., rapalogs, PGC1-activators, sirtuin modulators).
- **Immune health:** Efficient immune defense mechanisms play a crucial role in extending healthy life years. Studies show centenarians exhibit significant immune system differences compared with other elderly individuals. Immune health companies target the immune system directly to modulate and improve overall health as we age.
- **Metabolic rejuvenation:** Inhibiting high-nutrient-sensing pathways and activating low-nutrient-sensing proteins extend healthspan in various model organisms. Companies studying metabolic rejuvenation focus on diet-based and pharmacological interventions to improve aspects of aging, even when administered later in life.
- **Microbiome:** Evidence suggests the gut microbiome contributes to many age-associated changes, including immune system dysregulation and disease susceptibility. The gut microbiota undergoes extensive changes across the lifespan, influencing metabolic alterations.
- **Neurotech:** This field offers unique solutions for an aging population by improving detection and diagnosis of neurological conditions, facilitating treatment, and potentially aiding prevention. It helps monitor lifestyle and environmental impacts on brain health and plays a key role in understanding pathology and early intervention.
- **Rejuvenation:** Rejuvenation reduces the biological age of cells, organs, or individuals. This category focuses on intracellular clearance or rejuvenation of organelles within cells, distinct from reprogramming and regeneration, aiming to restore cells and systems to a healthier state.
- **Reprogramming:** Companies aiming to reverse older cells into younger states by directly reprogramming genetic or epigenetic makeup. Some seek new genetic targets to reduce epigenetic age while maintaining somatic identity (partial cellular reprogramming), focusing on extending the period of healthy life.
- **Regeneration:** All organisms can regenerate to maintain tissues and organs. Regeneration replaces damaged cells, tissues, organs, and body parts. Stem cell companies play a crucial role in regeneration, while others aim to replace entire organs through methods like xenotransplantation or tissue engineering.
- **Repurposed drugs:** Various approved medications have shown health-promoting effects in experimental models. Common pharmaceuticals like metformin and rapamycin are being investigated in clinical trials to repurpose them for extending human healthspan.
- **Neuropharma:** Brain function often deteriorates with age, even without disease. This category includes developing drugs targeting the nervous system, aiming to benefit common age-related neurodegenerative diseases and maintain cognitive health throughout life.
- **Education:** With rapidly evolving aging science and technology, knowledge needs to be shared beyond the scientific community. Today's healthspan education providers aim to enable healthcare professionals to learn about the status and future of the field, focusing on extending healthy years of life.

Collectively, these domains offer a more accurate set for tracking healthspan investments compared to the broader longevity space. However, they remain an approximation and should be understood as such. The data is then combined with insights from our proprietary B2B to provide an insightful perspective on the investment climate shaping the future of the healthspan and healthy longevity fields.

Bibliography

1. Roche, C. (2024, February 8). Shaping a future of healthy ageing: reflections from the Global Healthspan Summit. Economist Impact – Perspectives. https://impact.economist.com/perspectives/health/shaping-future-healthy-ageing-reflections-global-healthspan-summit

2. Friedman, H. A. (2017, May 30). Healthspan Is More Important Than Lifespan, So Why Don't More People Know About It? | Institute for Public Health | Washington University in St. Louis. Washington University in St. Louis. https://publichealth.wustl.edu/heatlhspan-is-more-important-than-lifespan-so-why-dont-more-people-know-about-it/

3. National Institute on Aging. (2024). Fiscal Year 2024 Budget. National Institute on Aging. https://www.nia.nih.gov/about/budget/fiscal-year-2024-budget

4. National Institute on Aging. (2024). Fiscal Year 2025 Budget. National Institute on Aging. https://www.nia.nih.gov/about/budget/fiscal-year-2025-budget

5. New York Stem Cell Foundation. (12 C.E., December 14). Our Community's Top 10 Stem Cell and Neuroscience Breakthroughs of 2023. New York Stem Cell Foundation. https://nyscf.org/resources/our-communitys-top-10-stem-cell-and-neuroscience-breakthroughs-of-2023/

6. Ruger, J. P., & Yach, D. (2009). The Global Role of the World Health Organization. Global Health Governance : The Scholarly Journal for the New Health Security Paradigm, 2(2), 1. https://pmc.ncbi.nlm.nih.gov/articles/PMC3981564/

7. Psico-smart Editorial Team. (2024, August 28). The Impact of Wearable Technology on Personal Health Monitoring. Psico-Smart.com. https://psico-smart.com/en/blogs/blog-the-impact-of-wearable-technology-on-personal-health-monitoring-162704

8. Evans, H. (2022, April 28). The Powerful Opportunities of Wearable Technology in Healthcare. Velvetech. https://www.velvetech.com/blog/wearable-technology-in-healthcare/

9. Pharmiweb. (2024, April 18). Wearable Technology Market Trends: A Journey Towards USD 231 Billion by 2032 (Wired Release, Ed.). PharmiWeb.com. https://www.pharmiweb.com/press-release/2024-04-18/wearable-technology-market-trends-a-journey-towards-usd-231-billion-by-2032

10. Australian Government (Department of Health and Aged Care). (2023, October 3). Preventive and Public Health Research initiative. Australian Government Department of Health and Aged Care. https://www.health.gov.au/our-work/mrff-preventive-and-public-health-research-initiative

11. Medina, A. F. (2022, October 21). Singapore Introduces New Healthcare Reform Plan. ASEAN Business News; Asean Briefing. https://www.aseanbriefing.com/news/singapore-introduces-new-healthcare-reform-plan/

12. The Lancet Regional Health – Western Pacific. (2023, August 31). Healthier SG: for a healthier Singapore and beyond. The Lancet. https://www.thelancet.com/journals/lanwpc/article/PIIS2666-6065(23)00211-0/fulltext

13. Toh, C., Chew, S., & Tan, C. (2002). Prevention and Control of Non- Communicable Diseases in Singapore: A Review of National Health Promotion Programmes. Singapore Med J, 43(7), 333–339. http://www.smj.org.sg/sites/default/files/4307/4307a1.pdf

14. Wels-Maug. (2024, January 25). "Our Future Health": Shifting from curative to preventive care. Healthcare-In-Europe.com. https://healthcare-in-europe.com/en/news/our-future-health-curative-preventive-care.html

15. Genomics Education Programme. (2024, June 27). Our genomic future – Genomics Education Programme. Genomics Education Programme. https://www.genomicseducation.hee.nhs.uk/blog/our-genomic-future/

16. Suda, M., Paul, K. H., Tripathi, U., Tohru Minamino, Tchkonia, T., & Kirkland, J. L. (2024). Targeting Cell Senescence and Senolytics: Novel Interventions for Age-Related Endocrine Dysfunction. Endocrine Reviews. https://doi.org/10.1210/endrev/bnae010

17. Falshaw, N., Sagner, M., & Siow, R. C. (2024). The Longevity Med Summit: insights on healthspan from cell to society. Frontiers in Aging, 5. https://doi.org/10.3389/fragi.2024.1417455

18. The Economist. (2024, October 24). It's not just obesity. Drugs like Ozempic will change the world. The Economist. https://www.economist.com/leaders/2024/10/24/its-not-just-obesity-drugs-like-ozempic-will-change-the-world

19. Fragility Fracture Network (2023, July 11). Japan: Policy changes increase access to osteoporosis management for fragility fracture patients – Fragility Fracture Network. Fragility Fracture Network. https://fragilityfracturenetwork.org/japan-policy-changes-increase-access-to-osteoporosis-management-for-fragility-fracture-patients/

20. Gao, L., Byung Wan Lee, Chawla, M., Kim, J., Huo, L., Du, L., Huang, Y., & Ji, L. (2023). Tirzepatide versus insulin glargine as second-line or third-line therapy in type 2 diabetes in the Asia-Pacific region: the SURPASS-AP-Combo trial. Nature Medicine, 29(6), 1500–1510. https://doi.org/10.1038/s41591-023-02344-1

21. Lamija Ferhatbegović, Mršić, D., & Amra Macić-Džanković. (2023). The benefits of GLP1 receptors in cardiovascular diseases. Frontiers in Clinical Diabetes and Healthcare, 4. https://doi.org/10.3389/fcdhc.2023.1293926

22. Kyoung Ree Lim, Kwang Jin Chun, Bum Sung Kim, & Lee, S. (2024). The Effect of Sodium–Glucose Cotransporter-2 Inhibitors on COVID-19 Patients with Type 2 Diabetes Mellitus: A Retrospective Cohort Study Using the Common Data Model. Journal of Clinical Medicine, 13(2), 431–431. https://doi.org/10.3390/jcm13020431

23. Tisch, C., Xourgia, E., Aristomenis Exadaktylos, & Mairi Ziaka. (2024). Potential use of sodium glucose co-transporter 2 inhibitors during acute illness: a systematic review based on COVID-19. Endocrine. https://doi.org/10.1007/s12020-024-03758-8

24. Dimnjaković, J., Buble, T., Ivanko, P., Pristaš, I., Brborović, O., & Brborović, H. (2024). Association of anti-diabetic drugs and COVID-19 outcomes in patients with diabetes mellitus type 2 and cardiomyopathy. Scientific Reports, 14(1). https://doi.org/10.1038/s41598-024-57871-9

25. Cheng, F.-F., Liu, Y.-L., Du, J., & Lin, J.-T. (2022). Metformin's Mechanisms in Attenuating Hallmarks of Aging and Age-Related Disease. Aging and Disease, 13(4), 970. https://doi.org/10.14336/ad.2021.1213

26. Winstead, E. (2022, January 20). Can mRNA Vaccines Help Treat Cancer? National Cancer Institute. https://www.cancer.gov/news-events/cancer-currents-blog/2022/mrna-vaccines-to-treat-cancer

27. Lee, J., Woodruff, M. C., Kim, E. H., & Nam, J.-H. (2023). Knife's edge: Balancing immunogenicity and reactogenicity in mRNA vaccines. Experimental & Molecular Medicine, 1–9. https://doi.org/10.1038/s12276-023-00999-x

28. Brockman, M. A., Mwimanzi, F., Lapointe, H. R., Sang, Y., Agafitei, O., Cheung, P. K., Ennis, S., Ng, K., Basra, S., Lim, L. Y., Yaseen, F., Young, L., Umviligihozo, G., Omondi, F. H., Kalikawe, R., Burns, L., Brumme, C. J., Leung, V., Montaner, J. S. G., & Holmes, D. (2021).

Reduced Magnitude and Durability of Humoral Immune Responses to COVID-19 mRNA Vaccines Among Older Adults. The Journal of Infectious Diseases, 225(7), 1129–1140. https://doi.org/10.1093/infdis/jiab592

29. Semelka, C. T., DeWitt, M. E., Blevins, M. W., & Alexander-Miller, M. A. (2022, July 21). Frailty and Age Impact Immune Responses to Moderna COVID-19 mRNA Vaccine. ResearchGate; unknown. https://www.researchgate.net/publication/362409349_Frailty_and_Age_Impact_Immune_Responses_to_Moderna_COVID-19_mRNA_Vaccine

30. Jergović, M., Uhrlaub, J. L., Watanabe, M., Bradshaw, C. M., White, L. M., LaFleur, B. J., Edwards, T., Sprissler, R., Worobey, M., Bhattacharya, D., & Nikolich-Žugich, J. (2022). Competent immune responses to SARS-CoV-2 variants in older adults following two doses of mRNA vaccination. Nature Communications, 13(1). https://doi.org/10.1038/s41467-022-30617-9

31. Parry, H., Tut, G., Bruton, R., Faustini, S. E., Stephens, C., Saunders, P. O., Christopher, Hilyard, K. L., Brown, K. K., Gayatri Amirthalingam, Charlton, S., Leung, S., Chiplin, E., Coombes, N., Bewley, K. R., Elizabeth Maggie Penn, Rowe, C., Otter, A., Watts, R., & D'Arcangelo, S. (2021). mRNA vaccination in people over 80 years of age induces strong humoral immune responses against SARS-CoV-2 with cross neutralization of P.1 Brazilian variant. 10. https://doi.org/10.7554/elife.69375

32. News Medical. (2024, November 15). MEMPHIS system sheds light on vaccine response differences across ages. https://www.news-medical.net/news/20241115/MEMPHIS-system-sheds-light-on-vaccine-response-differences-across-ages.aspx

33. Boston Children's Hospital. (2024, November 15). In vitro model enables study of age-specific responses to COVID mRNA vaccines. Medicalxpress.com. https://medicalxpress.com/news/2024-11-vitro-enables-age-specific-responses.html

34. Majtenyi, C. (2024). Brock-led immunotherapy research shows potential to extend healthy lifespan of humans. The Brock News, a News Source for Brock University. https://brocku.ca/brock-news/2023/11/brock-led-immunotherapy-research-shows-potential-to-extend-healthy-lifespan-of-humans/

35. Technology Networks. (2023, November 22). Promising Immunotherapy Could Potentially Extend Healthy Human Lifespan. Biopharma from Technology Networks; Technology Networks. https://www.technologynetworks.com/biopharma/news/promising-immunotherapy-could-potentially-extend-healthy-human-lifespan-381302

36. Hunt, D., & University, B. (2023, November 21). Immunotherapy research shows potential to extend healthy lifespan of humans. Medicalxpress.com. https://medicalxpress.com/news/2023-11-immunotherapy-potential-healthy-lifespan-humans.html

37. Huang, J. (2024, July 1). CRISPR-Cas Genome Editing For Rejuvenation Of Aging Stem Cells. Www.cellandgene.com. https://www.cellandgene.com/doc/crispr-cas-genome-editing-for-rejuvenation-of-aging-stem-cells-0001

38. Palmgren , G. (2024, October 3). News: CRISPR-Cas9 screens identify ageing regulators in neural stem cells – CRISPR Medicine. CRISPR Medicine. https://crisprmedicinenews.com/news/crispr-cas9-screens-identify-ageing-regulators-in-neural-stem-cells/

39. Ruetz, T. J., Kashiwagi, C. M., Morton, B., Yeo, R. W., Leeman, D. S., Morgens, D. W., Tsui, C. K., Li, A., Bassik, M. C., & Brunet, A. (2021, November 23). In vitro and in vivo CRISPR-Cas9 screens reveal drivers of aging in neural stem cells of the brain [Review of In vitro and in vivo CRISPR-Cas9 screens reveal drivers of aging in neural stem cells of the brain]. BioRxiv. https://www.biorxiv.org/content/10.1101/2021.11.23.469762v1.full

40. Carolina Cano Macip, Hasan, R., Hoznek, V., Kim, J., Yuancheng Ryan Lu, Metzger, L. E., Sethna, S., & Davidsohn, N. (2024, February 15). Gene Therapy-Mediated Partial Reprogramming Extends Lifespan and Reverses Age-Related Changes in Aged Mice. Cellular Reprogramming, 26(1), 24–32. https://doi.org/10.1089/cell.2023.0072

41. Yücel, A. D., & Gladyshev, V. N. (2024). The long and winding road of reprogramming-induced rejuvenation. Nature Communications, 15(1), 1941. https://doi.org/10.1038/s41467-024-46020-5

42. Ocampo, A., Reddy, P., Martinez-Redondo, P., Platero-Luengo, A., Hatanaka, F., Hishida, T., Li, M., Lam, D., Kurita, M., Beyret, E., Araoka, T., Vazquez-Ferrer, E., Donoso, D., Roman, J. L., Xu, J., Rodriguez Esteban, C., Nuñez, G., Nuñez Delicado, E., Campistol, J. M., & Guillen, I. (2016). In Vivo Amelioration of Age-Associated Hallmarks by Partial Reprogramming. Cell, 167(7), 1719-1733.e12. https://doi.org/10.1016/j.cell.2016.11.052

43. Paine, P. T., Nguyen, A., & Ocampo, A. (2023). Partial cellular reprogramming: A deep dive into an emerging rejuvenation technology. Aging Cell. https://doi.org/10.1111/acel.14039

44. Weill Cornell Medicine. (2024, August 19). Study Finds Potential Link Between DNA Markers and Aging Process. WCM Newsroom; Weill Cornell Medicine. https://news.weill.cornell.edu/news/2024/08/study-finds-potential-link-between-dna-markers-and-aging-process

45. Reichmann, R., Schulze, M. B., Pischon, T., Weikert, C., & Aleksandrova, K. (2024, May 11). Biomarker signatures associated with ageing free of major chronic diseases: results from a population-based sample of the EPIC-Potsdam cohort. Age and Ageing, 53(Supplement_2), ii60–ii69. https://doi.org/10.1093/ageing/afae041

46. The Harvard Gazette. (2024, February 16). Looking to rewind the aging clock. Harvard Gazette. https://news.harvard.edu/gazette/story/2024/02/looking-to-rewind-the-aging-clock/?utm_source=chatgpt.com

47. Ying, K., Liu, H., Tarkhov, A. E., Sadler, M. C., Lu, A. T., Moqri, M., Horvath, S., Kutalik, Z., Shen, X., & Gladyshev, V. N. (2024). Causality-enriched epigenetic age uncouples damage and adaptation. Nature Aging, 1–16. https://doi.org/10.1038/s43587-023-00557-0

48. Whaley, A. (2021, August 5). New Developments in Human Healthspan and Longevity – NYAS. NYAS – the New York Academy of Sciences. https://www.nyas.org/shaping-science/events/ebriefing/new-developments-in-human-healthspan-and-longevity/

49. Ivica Smokovski, Steinle, N., Behnke, A., Bhaskar, M., Grech, G., Richter, K., Günter Niklewski, Birkenbihl, C., Parini, P., Andrews, R. J., Bauchner, H., & Golubnitschaja, O. (2024, May 11). Digital biomarkers: 3PM approach revolutionizing chronic disease management – EPMA 2024 position. the EPMA Journal, 15(2), 149–162. https://doi.org/10.1007/s13167-024-00364-6

50. Hevolution. (2024, June 10). Hevolution Foundation: Transforming Healthspan Science with Unprecedented $400M Funding Surge [Review of Hevolution Foundation: Transforming Healthspan Science with Unprecedented $400M Funding Surge]. Hevolution. https://hevolution.com/en/web/guest/w/hevolution-foundation-transforming-healthspan-science-with-unprecedented-400m-funding-surge

51. Lee, S. (2024, February 2). What We Learned About Healthspan in 2023. Rupa Health. https://www.rupahealth.com/post/what-we-learned-about-healthspan-in-2023

52. Blanco-González, A., Cabezón, A., Seco-González, A., Conde-Torres, D., Antelo-Riveiro, P., Piñeiro, Á., & Garcia-Fandino, R. (2023). The Role of AI in Drug Discovery: Challenges, Opportunities, and Strategies. The Role of AI in Drug Discovery: Challenges, Opportunities, and Strategies, 16(6), 891–891. https://doi.org/10.3390/ph16060891

53. Katsoulakis, E., Wang, Q., Wu, H., Shahriyari, L., Fletcher, R., Liu, J., Achenie, L., Liu, H., Jackson, P., Xiao, Y., Syeda-Mahmood, T., Tuli, R., & Deng, J. (2024). Digital twins for health: a scoping review. Npj Digital Medicine, 7(1), 1–11. https://doi.org/10.1038/

s41746-024-01073-0

54. Bates, D. A. (2024, January 17). Euralis. Eularis – Accelerating Business Growth. https://eularis.com/how-synthetic-data-and-digital-twins-are-transforming-research-and-clinical-trials/

55. Sanofi. (2024, May 22). Digital "Twinning": Clinical Trials Powered by AI. Www.sanofi.com. https://www.sanofi.com/en/magazine/our-science/digital-twinning-clinical-trials-aif

56. Wan, C. (2023, January 18). 4 Ways AI Transforms Clinical Trials. Ambiq. https://ambiq.com/blog/4-ways-ai-transforms-clinical-trials/

57. Natural Antibody. (n.d.). How AI reduces the cost and time of drug discovery and development – NaturalAntibody. Www.naturalantibody.com. https://naturalantibody.com/use-case/how-ai-reduces-the-cost-and-time-of-drug-discovery-and-development/

58. McKinsey & Company. (2024, January 9). Generative AI in the pharmaceutical industry: Moving from hype to reality | McKinsey. Www.mckinsey.com. https://www.mckinsey.com/industries/life-sciences/our-insights/generative-ai-in-the-pharmaceutical-industry-moving-from-hype-to-reality

59. Boston Consulting Group. (2023). Unlocking the potential of AI in Drug Discovery Current status, barriers and future opportunities. https://cms.wellcome.org/sites/default/files/2023-06/unlocking-the-potential-of-AI-in-drug-discovery_report.pdf

60. AIDDISONTM, AI-powered drug discovery software | Merck KGaA, Darmstadt, Germany. (n.d.). https://www.emdgroup.com/en/research/science-space/envisioning-tomorrow/future-of-scientific-work/aiddison.html?global_redirect=1

61. Dylan, C. (2024, December 3). Recursion Pharmaceuticals' (RXRX) Bold Acquisition Places it as an Industry Leader. TipRanks Financial; Tipranks. https://www.tipranks.com/news/recursion-pharmaceuticals-rxrx-bold-acquisition-makes-it-a-leader-in-ai-drug-discovery

62. Recursion Pharmaceuticals, Inc. (2024, November 12). Recursion Announces the Release of OpenPhenom-S/16 in Google Cloud's Model Garden. GlobeNewswire News Room; Recursion Pharmaceuticals, Inc. https://www.globenewswire.com/news-release/2024/11/12/2979786/0/en/Recursion-Announces-the-Release-of-OpenPhenom-S-16-in-Google-Cloud-s-Model-Garden.html

63. Businesswire. (2024, October 15). Shift Bioscience Raises $16M to Advance Cell Simulation AI Platform [Review of Shift Bioscience Raises $16M to Advance Cell Simulation AI Platform]. Businesswire. https://www.businesswire.com/news/home/20241015745730/en/Shift-Bioscience-Raises-16M-to-Advance-Cell-Simulation-AI-Platform

64. Hutson, M. (2024). How AI is being used to accelerate clinical trials. Nature, 627(8003), S2–S5. https://doi.org/10.1038/d41586-024-00753-x

65. Zhang, B., Zhang, L., Chen, J., Jin, Z., Liu, S., & Zhang, S. (2023). Harnessing artificial intelligence to improve clinical trial design. Communications Medicine, 3(1). https://doi.org/10.1038/s43856-023-00425-3

66. Gupta, S. (2024, August 21). AI in Clinical Trials: Optimizing study design for Better results | blog. Maxis Clinical Sciences. https://www.maxisclinical.com/insights/blog/ai-in-clinical-trials-optimizing-study-design-for-better-results/

67. Du, R., Gordon, J., Phuong , A., & Liu, S. (2024, April 22). AI in clinical trial planning and design feasibility. ZSassociates; ZS. https://www.zs.com/insights/ai-for-clinical-trial-design-and-planning

68. Dr. Chinta Sidharthan. (2024, November 6). News-Medical. News-Medical. https://www.news-medical.net/news/20241106/AI-outperforms-doctors-in-diagnostics-but-falls-short-as-a-clinical-assistant.aspx

69. Roy, A. (2023, July 28). Artificial intelligence: 10 promising interventions for healthcare. NIHR Evidence. https://evidence.nihr.ac.uk/collection/artificial-intelligence-10-promising-interventions-for-healthcare/

70. Kumar, Y., Koul, A., Singla, R., & Ijaz, M. F. (2022). Artificial Intelligence in Disease diagnosis: a Systematic Literature review, Synthesizing Framework and Future Research Agenda. Journal of Ambient Intelligence and Humanized Computing, 14(7), 8459–8486. https://doi.org/10.1007/s12652-021-03612-z

71. Taha Shiwani, Relton, S. D., Evans, R., Kale, A. U., Heaven, A., Clegg, A., Aseel Abuzour, Alderman, J., Anand, A., Cini Bhanu, Bunn, J., Collins, J., Cutillo, L., Hall, M., Keevil, V. L., Mitchell, L., Giulia Ogliari, Penfold, R., James van Oppen, & Vardy, E. (2023). New Horizons in artificial intelligence in the healthcare of older people. Age and Ageing, 52(12). https://doi.org/10.1093/ageing/afad219

72. Dorsa Shirini, Schwartz, L. H., & Laurent Dercle. (2023). Artificial intelligence for aging research in cancer drug development. Aging, 15(22), 12699–12701. https://doi.org/10.18632/aging.204914

73. Sandoiu, A. (2019, September 26). AI just as good at diagnosing illness as humans. Www.medicalnewstoday.com. https://www.medicalnewstoday.com/articles/326460

74. 74 – Ghaffar Nia, N., Kaplanoglu, E., & Nasab, A. (2023). Evaluation of artificial intelligence techniques in disease diagnosis and prediction. Discover Artificial Intelligence, 3(1). https://doi.org/10.1007/s44163-023-00049-5

75. Goh, E., Gallo, R., Hom, J., Strong, E., Weng, Y., Kerman, H., Cool, J. A., Kanjee, Z., Parsons, A. S., Ahuja, N., Horvitz, E., Yang, D., Milstein, A., Olson, A. P. J., Rodman, A., & Chen, J. H. (2024). Large Language Model Influence on Diagnostic Reasoning. JAMA Network Open, 7(10), e2440969. https://doi.org/10.1001/jamanetworkopen.2024.40969

76. Protected Wellness. (2024, September 16). Healthspan AI Executive Summary. Protected Wellness. https://protectedwellness.com/healthspan-ai-executive-summary/

77. Alowais, S. A., Alghamdi, S. S., Alsuhebany, N., Alqahtani, T., Alshaya, A., Almohareb, S. N., Aldairem, A., Alrashed, M., Saleh, K. B., Badreldin, H. A., Yami, A., Harbi, S. A., & Albekairy, A. M. (2023). Revolutionizing healthcare: the role of artificial intelligence in clinical practice. BMC Medical Education, 23(1). https://doi.org/10.1186/s12909-023-04698-z

78. Parekh, A.-D. E., Shaikh, O. A., Simran, Manan, S., & Hasibuzzaman, M. A. (2023). Artificial intelligence (AI) in personalized medicine: AI-generated personalized therapy regimens based on genetic and medical history: short communication. Annals of Medicine and Surgery, 85(11), 5831. https://doi.org/10.1097/MS9.0000000000001320

79. McKinsey & Company, Shah, B., Viswa, C. A., Zurkiya, D., Leydon, E., & Bleys, J. (2024, February). Generative AI in the pharmaceutical industry | McKinsey (L. Kanter, Ed.). Www.mckinsey.com. https://www.mckinsey.com/industries/life-sciences/our-insights/generative-ai-in-the-pharmaceutical-industry-moving-from-hype-to-reality#/

80. Hamzelou, J. (2024, May 20). The quest to legitimize longevity medicine. MIT Technology Review. https://www.technologyreview.com/2024/03/18/1089888/the-quest-to-legitimize-longevity-medicine/

81. Sara, Strauss, T., Palmer, A. K., Hurt, R. T., Island, L., Goshen, A., Laureen, Kirkland, J.

L., Bischof, E., & Maier, A. B. (2024). Establishing healthy longevity clinics in publicly funded hospitals. GeroScience. https://doi.org/10.1007/s11357-024-01132-0

82. The Department of Health – Abu Dhabi (DoH) (2024). Department of Health – Abu Dhabi licenses Institute for Healthier Living Abu Dhabi as world's first specialised Healthy Longevity Medicine Centre. Mediaoffice.abudhabi; Abu Dhabi Media Office. https://www.mediaoffice.abudhabi/en/health/department-of-health-abu-dhabi-licenses-institute-for-healthier-living-abu-dhabi-as-worlds-first-specialised-healthy-longevity-medicine-centre/

83. PricewaterhouseCoopers. (2024). Gulf's longevity sector has a long way to go. PwC. https://www.pwc.com/m1/en/media-centre/articles/gulf-longevity-sector-has-long-way-to-go.html

84. Health Sector Transformation Program. (2022). Vision2030.Gov.sa. https://www.vision2030.gov.sa/en/explore/programs/health-sector-transformation-program

85. Hevolution Foundation. (2023). ENABLING A HEALTHY LIFESPAN FOR SAUDI ARABIA. https://hevolution.com/documents/20121/0/Enabling+A+Healthy+Lifespan+-for+Saudi+Arabia.pdf

86. UCI Center for HealthSpAN Sciences: Evidence-Based Education to Improve Health. (2022, January 28). UCI School of Pharmacy & Pharmaceutical Sciences. https://pharmsci.uci.edu/2022/01/28/uci-center-for-healthspan-sciences-evidence-based-education-to-improve-health/

87. Majumder, M. a. A., Haque, M., & Razzaque, M. S. (2023). Editorial: Trends and challenges of medical education in the changing academic and public health environment of the 21st century. Frontiers in Communication, 8. https://doi.org/10.3389/fcomm.2023.1153764

88. Garmany, A., Yamada, S., & Terzic, A. (2021). Longevity leap: mind the healthspan gap. Npj Regenerative Medicine, 6(1), 1–7. https://doi.org/10.1038/s41536-021-00169-5

89. BRANDVOICE. (2023, November 6). US$13 trillion by 2031: The megatrend shaping the growing wellness industry. Forbes Australia. https://www.forbes.com.au/brandvoice/brandvoice/13-trillion-by-2031-megatrend-wellness-industry/

90. Manca, D. P., Campbell-Scherer, D., Aubrey-Bassler, K., Kandola, K., Aguilar, C., Baxter, J., Meaney, C., Salvalaggio, G., Carroll, J. C., Faria, V., Nykiforuk, C., & Grunfeld, E. (2015). Developing clinical decision tools to implement chronic disease prevention and screening in primary care: the BETTER 2 program (building on existing tools to improve chronic disease prevention and screening in primary care). Implementation Science, 10(1). https://doi.org/10.1186/s13012-015-0299-9

91. Healthy Longevity Medicine Society. (2022). Hlms.co. https://hlms.co/

92. OECD. (2024). Declining fertility rates put prosperity of future generations at risk. OECD. https://www.oecd.org/en/about/news/press-releases/2024/06/declining-fertility-rates-put-prosperity-of-future-generations-at-risk.html

93. Institute for Health Metrics and Evaluation (IHME). (2024, May 17). Global life expectancy to increase by nearly 5 years by 2050 despite geopolitical, metabolic, and environmental threats, reports new global study | Institute for Health Metrics and Evaluation. Www.healthdata.org. https://www.healthdata.org/news-events/news-room/news-releases/global-life-expectancy-increase-nearly-5-years-2050-despite

94. Bloom D.E., et al. The Global Economic Burden of Noncommunicable Diseases. Geneva: World Economic Forum. (2011) Accessible at: https://world-heart-federation.org/wp-content/uploads/2017/05/WEF_Harvard_HE_GlobalEconomicBurdenNonCommunicableDiseases_2011.pdf

95. Pew Research Center. (2014, January 30). Chapter 3. Aging in Major Regions of the World, 2010 to 2050. Pew Research Center. https://www.pewresearch.org/global/2014/01/30/chapter-3-aging-in-major-regions-of-the-world-2010-to-2050/

96. World Health Organization. (n.d.-b). WHO: Early cancer diagnosis, better trained medics can save lives, money. United Nations Sustainable Development. Retrieved December 16, 2024, from https://www.un.org/sustainabledevelopment/blog/2017/02/who-early-cancer-diagnosis-better-trained-medics-can-save-lives-money/

97. Altuwaijri, S., Jha, P., Alleyne, G., Isenman, P., Saadat, S., Garcia, G., & Veillard, J. (2024, August). THE HEALTHY LONGEVITY INITIATIVE: KEY INSIGHTS FOR POLICY AND ACTION [Review of THE HEALTHY LONGEVITY INITIATIVE: KEY INSIGHTS FOR POLICY AND ACTION]. https://openknowledge.worldbank.org/server/api/core/bitstreams/5fe9c705-a036-4049-9603-1221e447eb26/content

98. Hevolution. (2023, November 14). Igniting a New Era in Global Health: Hevolution Foundation Announces... Hevolution Foundation. https://hevolution.com/en/web/guest/w/igniting-a-new-era-in-global-health-hevolution-foundation-announces

99. Financial Times. (2024, July 19). Unlocking the 'silver economy. PingAn. https://group.pingan.com/media/perspectives/2024/Unlocking-the--silver-economy.html

100. Coulson, J. (2024, February 2). Opinion-Editorial: Ensuring all older people can benefit from the development of the silver economy. UNFPA China. https://china.unfpa.org/en/news/opinion-editorial-ensuring-all-older-people-can-benefit-development-silver-economy

101. Fuchs, A., Márquez, P., Dutta, S., & González Icaza, F. (n.d.). IS TOBACCO TAXATION REGRESSIVE? EVIDENCE ON PUBLIC HEALTH, DOMESTIC RESOURCE MOBILIZATION, AND EQUITY IMPROVEMENTS Public Disclosure Authorized Public Disclosure Authorized Public Disclosure Authorized Public Disclosure Authorized. Retrieved December 16, 2024, from https://documents1.worldbank.org/curated/ar/893811554737147697/pdf/Is-Tobacco-Taxation-Regressive-Evidence-on-Public-Health-Domestic-Resource-Mobilization-and-Equity-Improvements.pdf

102. World Health Organization. (2024). Social Determinants of Health. World Health Organization. https://www.who.int/health-topics/social-determinants-of-health#tab=tab_1

103. Cuadrado, C., Fuentes-García, A., Barros, X., Martinez, S., & Pacheco, J. (2021). SCOPING REPORT Financing Primary Health Care in Chile. https://www.lshtm.ac.uk/media/59776

104. Saudi Health Council. (2019). Shc.gov.sa. https://shc.gov.sa/EN/Pages/default.aspx

105. Rwanda Social Security Board. (2017). EjoHeza. Rssb.rw. https://www.rssb.rw/scheme/ejo-heza

106. Jeong, H.-S. (n.d.). Expanding insurance coverage to informal sector populations: Experience from Republic of Korea HEALTH SYSTEMS FINANCING. Retrieved December 16, 2024, from https://cdn.who.int/media/docs/default-source/health-financing/technical-briefs-background-papers/whr-2010-background-paper-38.pdf?sfvrsn=b-16da7ab_3

107. Liu, H., & Zhong, K. (2022). Relationship between health spending, life expectancy and renewable energy in China: A new evidence from the VECM approach. Frontiers in Public Health, 10. https://doi.org/10.3389/fpubh.2022.993546

108. Sergi, J. C.-F., Cristina, J., & Prieto, V. (n.d.). Universalizing the Access to Long- term Care: Evidence from Spain. https://documentos.fedea.net/pubs/eee/2023/eee2023-19.pdf

109. World Health Organization. (2022, October 1). Ageing and health. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

110. Huang, C., Clayton, E.A., Matyunina, L.V. et al. Machine learning predicts individual cancer patient responses to therapeutic drugs with high accuracy. Sci Rep 8, 16444 (2018). https://doi.org/10.1038/s41598-018-34753-5

Glossary

Age-related macular degeneration (AMD)
A progressive eye condition causing damage to the macula, leading to loss of central vision typically in older adults.

AIDDISON™:
A web-based platform integrating AI and machine learning tools to accelerate drug discovery processes.

American Federation for Aging Research (AFAR):
A non-profit organization funding biomedical research on aging to extend healthier human lifespans.

AMP-activated protein kinase (AMPK):
An enzyme that regulates cellular energy homeostasis, activating when cellular energy is low.

Asia-Pacific (APAC):
Asia-Pacific region, typically referring to East Asia, South Asia, Southeast Asia, and Oceania in business and economic contexts.

Artificial intelligence (AI):
Computer systems able to perform tasks that normally require human intelligence, such as visual perception and decision-making.

Big Pharma:
Collective term for the largest and most influential pharmaceutical companies in the global market.

CMEs (Continuing Medical Education):
Educational activities for healthcare professionals to maintain and update their knowledge and skills.

Compound Annual Growth Rate (CAGR):
The mean annual growth rate of an investment over a specified time period longer than one year.

CRISPR or CRISPR-Cas9 genome editing:
A genetic engineering technique allowing precise modification of DNA sequences in living organisms.

Digital twins:
Virtual representations of physical objects or processes, used for simulation and analysis in various industries.

DNA, or deoxyribonucleic acid: The molecule carrying genetic instructions for the development and functioning of living organisms.

Genomic safe harbor (GSH):
Specific sites in the genome suitable for inserting new genetic material with minimal risk to the host organism.

Global Coalition on Aging (GCOA):
An alliance of businesses across industries focused on transforming the global dialogue on aging and longevity.

Glucagon-like peptide-1 (GLP-1):
A hormone that stimulates insulin secretion and inhibits glucagon release, important in diabetes treatment.

Gross domestic product (GDP):
The total monetary value of all finished goods and services produced within a country's borders in a specific time period.

Healthier SG reform:
A Singapore government initiative aimed at transforming healthcare towards proactive prevention and community-based care.

HINT (Hierarchical Interaction Network):
A machine learning model designed to predict clinical trial outcomes using multi-modal data.

Initial public offering (IPO):
The process of offering shares of a private company to the public in a new stock issuance.

IsoDGR-mAb: An antibody targeting isoDGR-modified proteins, showing potential in reducing inflammation and extending lifespan in animal models.

Machine Learning (ML):
A subset of AI focusing on the development of algorithms that improve automatically through experience and data use.

MEMPHIS (Modular Evaluation of Immunogenicity using Multi-Platform Human In vitro Systems):
A system for evaluating the immunogenicity of drugs using multiple human in vitro platforms.

mRNA vaccines:
Vaccines that use messenger RNA to instruct cells to produce an immune response against specific pathogens.

NHS (National Health Service):
The publicly funded healthcare system in the United Kingdom, providing services free at the point of use for UK residents.

Non-communicable chronic diseases (NCDs):
Long-term medical conditions that are not infectious or transmissible between people, such as diabetes or heart disease.

PE (Private equity) Growth/ Expansion:
A type of private equity investment in relatively mature companies seeking capital for expansion or restructuring.

Pharm.D (doctor of pharmacy):
A professional doctorate in pharmacy, required to practice as a pharmacist in many countries.

Private investment in public equity (PIPE):
The buying of shares of publicly traded stock at a price below the current market value per share.

Proliferator-activated receptor gamma coactivator 1-alpha (PGC-1α):
A protein that regulates genes involved in energy metabolism and mitochondrial function.

PROTEIN (PeRsOnalized nutriTion for hEalthy living) project:
A research initiative focused on developing personalized nutrition strategies for healthy living.

Research and development (R&D):
Activities companies undertake to innovate and introduce new products and services.

Sodium-glucose Cotransporter-2 (SGLT2) Inhibitors:
A class of medications used in the treatment of type 2 diabetes that work by preventing glucose reabsorption in the kidneys.

SPOT (Sequential Predictive Modeling of Clinical Trial Outcome):
A machine learning system for predicting clinical trial outcomes sequentially.

The mammalian target of rapamycin (mTOR):
A protein kinase that regulates cell growth, proliferation, and survival, implicated in aging and various diseases.

The United Arab Emirates (UAE):
A federation of seven emirates in the eastern part of the Arabian Peninsula, known for its rapid development and oil wealth.

Y-O-Y (year-on-year):
A method of evaluating two or more measured events to compare the results at one time period with those of a comparable time period on an annualized basis.