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# GENOMICS FOR LONGEVITY
# FROM VISION TO REALITY

## An Abu Dhabi Perspective

In collaboration with

Institute for Healthier Living Abu Dhabi | M42

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# INTRODUCTION

Over the last decade, the spotlight on longevity — expanding not just lifespan but also healthspan — has intensified, fueled by scientific advances and a growing desire for more proactive, personalized care. This focus on extending the healthy phase of life emphasizes a shift from reactive treatment to proactive prevention.

As genomics-related technologies such as high-throughput sequencing, multi-omics analytics, and precision medicine continue to evolve, the resulting breakthroughs reveal earlier risk factors and pave the way for increasingly tailored interventions. Interest in longevity has soared alongside these developments, bringing genomics to the forefront as a vital longevity 'tool'. Longevity is rapidly emerging as a new field of medicine — one that promises a paradigm shift in how healthcare is conceived and delivered.

Abu Dhabi, located in the  United Arab Emirates (UAE), is uniquely positioned to capitalize on the developments in genomics, which are key to longevity. The emirate has a rapidly maturing healthcare infrastructure, digitally proficient population, and government commitment to public health as a strategic priority. Additionally, The Emirati Genome Program serves as a strong foundation, with 800,000 genomes sequenced.

By examining the emirate's initiatives and frameworks, we can gain valuable insights into the broader implications of genomics on healthcare worldwide. Systematically embedding genomics into healthcare can accelerate the transition toward preventive, data-centric, and economically sustainable medical care. Through this lens, we will present a phased roadmap that highlights how genomics and longevity can be navigated, offering lessons that can be applied in diverse contexts around the globe.

### This whitepaper aims to:

1. **Articulate** the multifaceted benefits of genomics for longevity, encompassing improved clinical outcomes as well as broader economic and social advantages.
2. **Illustrate** Abu Dhabi's strategic vision for precision medicine, anchored in its existing initiatives while addressing gaps — providing lessons that can be applied globally.
3. **Delineate** the technical and organizational frameworks required to translate these objectives into verifiable outcomes.
4. **Present** a phased roadmap that outlines potential pathways for how pilot successes can evolve into a globally acclaimed genomics and longevity ecosystem — viewed through the lens of Abu Dhabi.

## Longevity

The term longevity describes the ability to live a long life beyond the species-specific average age at death. In humans, it focuses on extending the period of life without necessarily detailing the quality of health during the latter years

## THE ABU DHABI LANDSCAPE

Abu Dhabi's healthcare sector has undergone a transformative evolution, with the introduction of world-class clinical facilities, a focus on patient-centric solutions, and the development of advanced digital ecosystems (such as Malaffi, Abu Dhabi's health exchange platform introduced in 2019 that connects public and private healthcare providers).[1]

Buoyed by significant governmental investments, clear policy frameworks, and leading-edge digital infrastructure, Abu Dhabi is in the position to scale its genomic programs in a manner that not only enhances clinical outcomes but also fortifies economic resilience, curtails protracted healthcare expenditures, and positions itself as a nucleus for future biotech progress. Additionally, the emirate's demographic diversity — composed of Emiratis and a substantial expatriate population — creates an optimal environment for studying varied genetic architectures and validating novel interventions.

## STRATEGIC IMPACT GOALS

Beyond improved patient care, the emirate envisions tangible economic and societal gains emerging from its genomics-driven initiatives. Recent Department of Health Abu Dhabi modeling projects that, by 2040, genomics could realize:

- **US $33 billion** in cumulative GDP contribution in the emirate (2024-2040)
- Over **80 new companies** anchored in genomics and related industries
- Approximately **290 new biotech startups**
- Around **22,000 jobs**, spanning clinical genomics, artificial intelligence (AI) analytics, biotech research and development, and support functions

In parallel, the government has identified equally striking health and societal benefits:

- More than **US $800 million** in productivity gains by reducing chronic disease burdens
- Over **9,000 quality-adjusted life years** improved or saved across three focus diseases — diabetes, cardiovascular disease, and breast cancer — due to earlier detection and precision interventions

These projections underscore how multi-omics not only reshapes healthcare but also fuels broader economic development, fostering a virtuous cycle of innovation, job creation, and improved public health.[2]

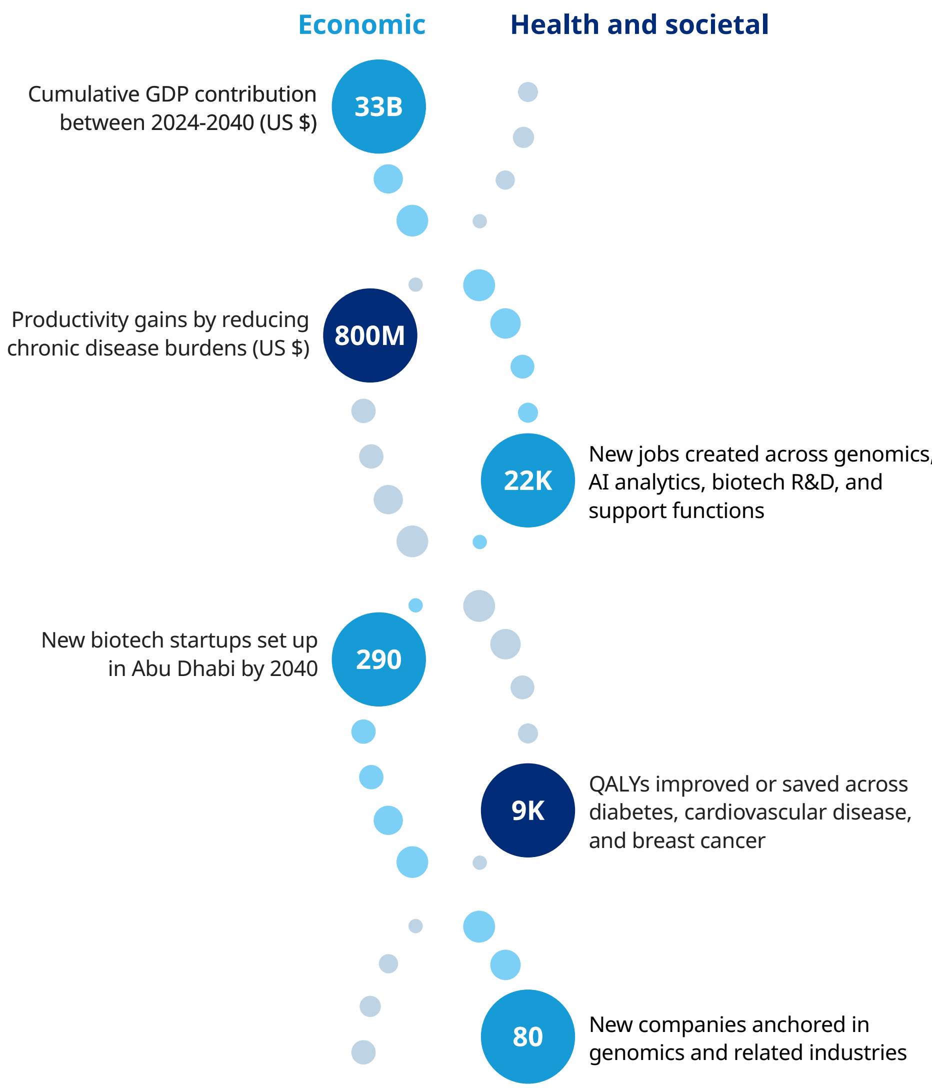
1 Malaffi, About Malaffi, 2025

2 Department of Health Abu Dhabi

Longevity means different things depending on your perspective — are we talking healthspan at an individual level or population-wide strategies? That's why we must unify definitions early, so everyone, from clinicians to regulators, speaks the same language. Once that foundation is set, our frameworks can adapt swiftly to new breakthroughs in genomics, precision medicine, and regenerative technologies

Dr. Asma Al Mannaei, Executive Director of Health Life Science sector, Department of Health Abu Dhabi

**Exhibit 1: Health Life Science Strategic Impact Goals**




Source: Department of Health Abu Dhabi

**In a fast-evolving field like genomics, our policies must be agile and future-proof, striking a balance between safety, innovation, and the constant flow of emerging evidence**

Dr. Asma Al Mannaei, Executive Director of Health Life Science sector, Department of Health Abu Dhabi

# KEY TRENDS IMPACTING THE GLOBAL GENOMICS SPACE

To appreciate any nation or city's future direction, it is useful to consider global trends that currently shape genomics, longevity research, and precision medicine. The section below highlights the most significant developments, with examples from international genomics hubs offering relevant insights.

**Exhibit 2: Key trends impacting the global genomics space**

**Large-scale genomic sequencing**
National programs increasingly move from pilot phases (thousands of genomes) to population-wide efforts (hundreds of thousands or millions)

**Multi-omics integration**
Advanced healthcare systems are merging epigenetic, proteomic, and microbiome data to create holistic patient risk profiles

**AI-enabled risk stratification**
AI platforms rapidly convert large omics datasets into real-time, clinically actionable insights (such as polygenic scores and environment-gene correlations)

**Geroscience and aging research**
Longevity trials increasingly test CRISPR-based therapies, geroprotectors, and senolytic drugs, with integrated "-omics" to track progress

**Emphasis on environment**
Exposome data (pollutants, toxins) merges with genetic predispositions to target community-wide preventive strategies

**Regulatory evolution**
Governments refine data-privacy laws, consent procedures, and approvals for gene-editing to keep pace with surging R&D demand

**Public-private consortia**
Cross-sector consortia expedite clinical trials, reduce duplication, and bolster expertise sharing

Source: Oliver Wyman analysis

## Large-Scale Genome Sequencing

Healthcare systems worldwide have moved from relatively small pilot projects to population-level efforts, often exceeding hundreds of thousands of genomes. This data fuels both translational research and risk stratification at scale.

- *Example:* Genomics England's The 100,000 Genomes Project, which started in 2012, is now leading a new £22 million initiative to sequence genomes from 15,000-25,000 participants.[3]

## Multi-Omics Integration

Beyond basic genetics, modern programs incorporate epigenetics, proteomics, and microbiome data, constructing a holistic view of the gene-environment interplay. These extra layers enhance early detection, refine treatment, and enrich healthy-aging research.

- *Example:* Finland's FinnGen, launched in 2017, has merged genomic data with national registries, proteomic initiatives, and pilot microbiome studies for over 500,000 participants.[4]

## AI-Enabled Risk Stratification

High-performance computing (HPC) and machine learning translate massive omics datasets into near real-time, clinically actionable outputs such as polygenic risk scores or environmental risk correlations.

- *Example:* Singapore's Agency for Science, Technology and Research (A*STAR) established its Institute for High Performance Computing (IHPC) back in 1998 to spearhead innovations across industry verticals, including in healthcare and genomics.[5]

## Geroscience and Aging Research

Trials in this field increasingly target the biological underpinnings of aging — such as senescent cells or epigenetic drift — using CRISPR and senolytic compounds. This approach aims to extend healthspan, not merely lifespan.

- *Example:* The National University Health System's Centre for Healthy Longevity in Singapore is at the forefront of global aging research and geroscience, advancing translational studies that aim to extend healthspan and address the biological underpinnings of aging.[6]

## Regulatory Evolution

Expanding genomic data and emerging technologies (such as gene editing) demand modernized data-privacy laws, consent models, and ethical guidelines. In this context, governments are working to balance innovation with public trust.

- *Example:* The Cooperative Health Research in South Tyrol (CHRIS) is a longitudinal study in Northern Italy that has used dynamic consent since its inception in 2011. Through participant-centered strategies directly linked to participation and communication, research is enabled across broad areas including genomics while complying with high ethical standards.[7]

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3 UK Department of Health and Social Care, Genome UK: 2022 to 2025 implementation plan for England, 2022

4 Finnish Institute for Health and Welfare, Data Resources and Services, 2025

5 Agency for Science, Technology and Research (A*STAR), 2025

6 National University Health System, 2025

7 Nature, Ten years of dynamic consent in the CHRIS study, 2022

### Public-Private Collaborations

Cross-sector alliances — linking government, academia, and industry — share costs, reduce duplication, and can accelerate large-scale clinical trials and HPC expansions.

- *Example:* Genomic Medicine Sweden, founded in 2018, unified healthcare regions, universities, and labs under a single whole-genome sequencing (WGS) platform for leukemia.[8]

### Emphasis on the Exposome

Researchers now overlay environmental exposures (such as pollutants and toxins) and lifestyle factors (including diet and activity) with genomic data to enable "precision public health" at both individual and community levels.

- *Example:* The European Human Exposome Network is a pan-European initiative to systematically measure how environmental exposures interact with our genetics, underscoring that understanding the exposome is critical to fully complement and enhance genomic research.[9]

Embracing such trends — population-scale sequencing, multi-omics, AI-driven risk analysis, and exposome insights, supported by progressive regulation and robust public-private ties — allows a place to move beyond traditional clinical practice. In Abu Dhabi, for example, the promotion of large-scale genomic initiatives, such as The Emirati Genome Program, combined with the integration of epigenetic and environmental data, along with investments in HPC frameworks, will pave the way for a new era of longevity research.

**Because aging isn't recognized as a disease in most regulatory frameworks, many biotech ventures target 'proxy conditions' like metabolic syndrome, obesity, or frailty to gain approvals. Genomics plays a huge role here: it zeroes in on the key pathways that drive both aging and these proxy conditions, allowing trials to be more precise and produce tangible results quicker**

**Ultimately, these proxy diseases become stepping stones, helping researchers validate interventions that may also extend overall healthspan. By focusing on pathways that are measurable and impactful, companies can de-risk their innovations and build a stronger case for future longevity and geroscience breakthroughs**

Marco Janezic, Biotech Entrepreneur and Investor

8 Genomic Medicine Sweden, About Us, 2025

9 The European Human Exposome Network, 2025

# CASE STUDY: SINGAPORE'S CENTRALIZED AI-ENABLED RISK STRATIFICATION

The case study of Singapore's National Precision Medicine initiative serves as a compelling illustration of how centralized, AI-enabled risk stratification can effectively harness vast genomic datasets to enhance clinical outcomes. Singapore took an innovative approach to integrating high-performance computing with genomic data analysis and fostered collaboration between public and private sectors in driving advancements in precision medicine.

## HOW IT CAME ABOUT

Singapore's National Precision Medicine (NPM) initiative, led by the Agency for Science, Technology and Research (A*STAR), identified a critical need for high-performance computing (HPC) to handle vast genomic datasets.

By consolidating efforts under a centralized infrastructure at the National Supercomputing Centre (NSCC), they aimed to streamline bioinformatics and enable real-time AI risk modeling.

## WHAT WAS DONE

**Central HPC Environment:** Researchers and clinicians share supercomputing resources for large-scale genome analysis and machine learning pipelines, avoiding the expense of separate lab clusters.

**Coordinated Pipelines:** A*STAR's Bioinformatics Institute created integrated workflows for variant calling and risk scoring, interfacing directly with hospital electronic health record (EHR) systems.

**Near-Real-Time Predictions:** By streaming new patient data into HPC, clinicians quickly receive updated polygenic risk assessments.

## IMPACT

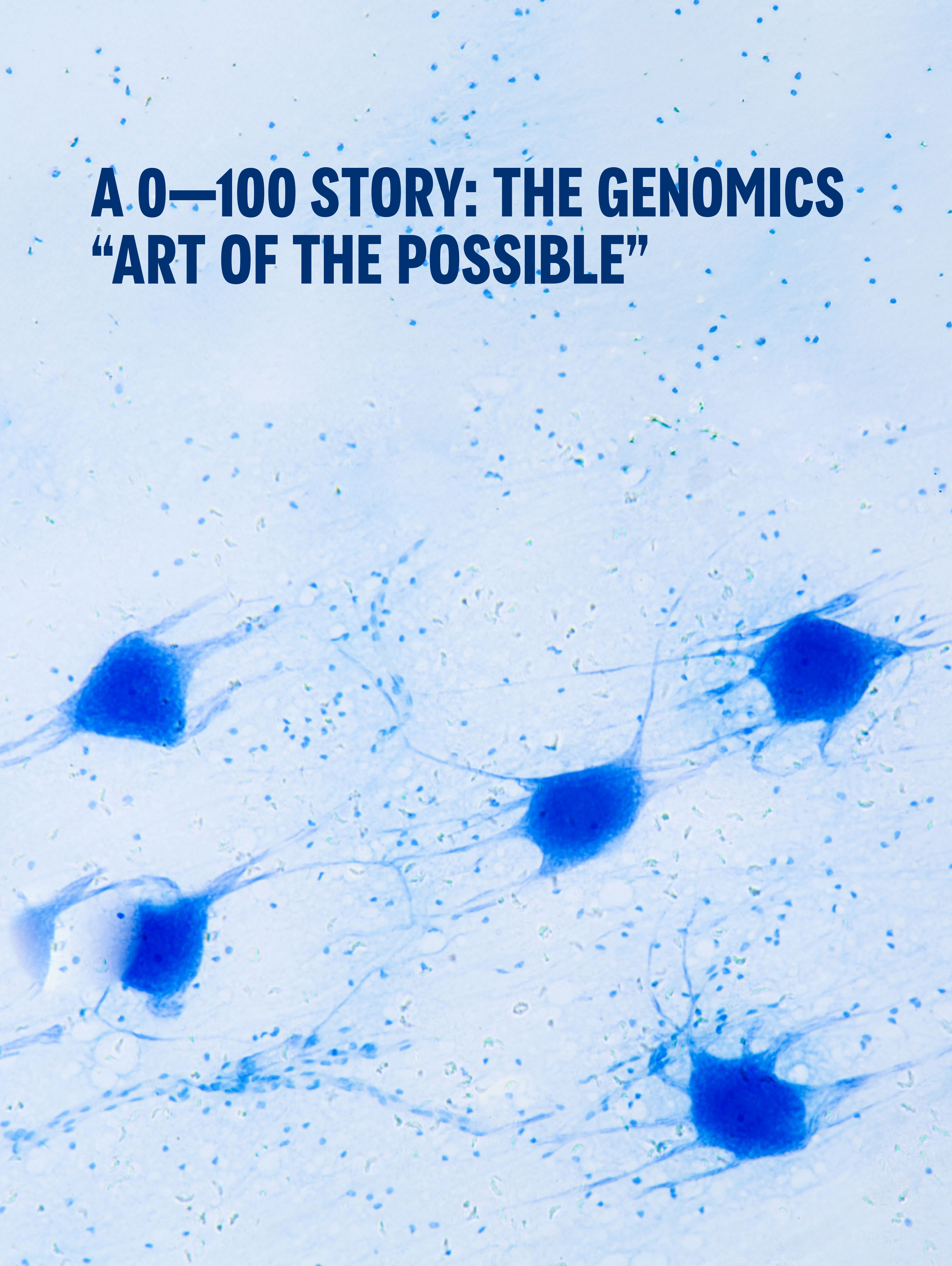
Data-processing timelines dropped, highlighting how a unified HPC strategy can significantly accelerate precision medicine.

**AI Impact:** Accelerated analysis times, near real-time risk notifications, and an intuitive user interface accelerate the transition from research data to proactive clinical care.

This example underscores how pooled computational resources, coordinated governance, and robust AI frameworks can dramatically shrink analysis timelines and boost precision screening. These are lessons other places — such as Abu Dhabi — can integrate as they scale HPC and invest in advanced analytics.[10]

10 Agency for Science, Technology and Research (A*STAR) Singapore, About A*STAR, 2025

# A 0—100 STORY: THE GENOMICS "ART OF THE POSSIBLE"



# SCREENING REIMAGINED

Now let's paint a picture of the potential future of genomics throughout a person's lifespan. Envision the following situation: pre-birth genomics equips parents and clinicians with early, actionable insights — whether it's detecting severe inherited conditions through pre-implantation genetic testing (PGT) or using noninvasive prenatal testing (NIPT) to pinpoint chromosomal anomalies in utero. Additionally, prospective parents can receive valuable information about their genetic compatibility, identifying potential inherited conditions to ensure the necessary clinical support is in place.

A newborn's cord blood then undergoes wide-ranging screening for numerous genetic conditions, well beyond the conventional metabolic panels. By incorporating microbiome and metabolome profiles at this pivotal stage, clinicians can foresee prospective vulnerabilities and implement targeted nutritional or therapeutic strategies — potentially even before hospital discharge.

Progressing through childhood, digital biomarker monitoring and epigenetic assessments guide individualized interventions for metabolic or immunologic risks, significantly attenuating the likelihood of early-onset chronic maladies.

By mid-life, in-depth cardiovascular and oncogenomic screenings reveal susceptibilities to heart disease or malignancies prior to any overt manifestations. Concurrently, pharmacogenomics ensures optimal therapeutic regimens — thereby maximizing efficacy, minimizing adverse reactions, and reducing overall healthcare expenditures. Routine evaluations at specialized clinics integrate genetic data with real-time environmental indices (such as air quality and contaminant exposure) and epigenetic updates, enabling nuanced interventions that can forestall disease progression.

Later, when this person is in their 60s or 70s, the paradigm of inevitable frailty is undermined by breakthroughs in CRISPR-enabled gene therapies, regenerative strategies for musculoskeletal ailments, and epigenetic reprogramming techniques. Aging individuals can thereby preserve mobility, cognitive sharpness, and independence well into advanced age, turning the later decades of life into a stage of productivity and community engagement.

Hospitals evolve into longevity centers, where multi-omics data underpins every therapeutic decision — from novel immunotherapies to epigenetically calibrated regimens for age-associated neurodegeneration.

**Exhibit 3: Genomic interventions across life stages**

**Early life**
(0-10 years old)

**Early detection and planning**
- Newborn Genetic Screening Program
- Childhood Microbiome Development
- Premarital Genetic Screening (for aspiring parents)
- Noninvasive prenatal testing
- Pre-implantation genetic testing (in case of IVF)

**Adolescence to mid-life**
(10-50 years old)

**Prevention and management of healthy life**
- Digital Biomarker Tracking
- Mental Health Genomics
- Premarital Genetic Screening (Reinforcement)
- Pharmacogenomics Program
- Cardiovascular Precision Medicine Program
- Oncology Prevention Program

**Later life**
(50+ years)

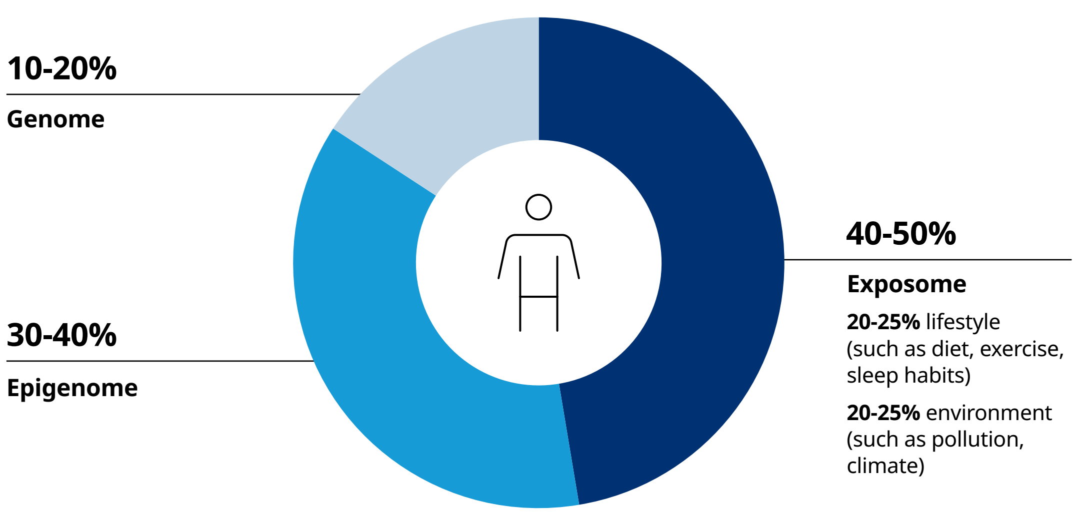
**Better health, quality of care and end of life**
- Oncology Precision Medicine Program
- Frailty and Longevity Trials
- Rare Disease Registry

Note: Not exhaustive
Source: Oliver Wyman analysis

# HOLISTIC BENEFITS BEYOND LIFESPAN

Progress in genomics and precision medicine is rightfully associated with an ambition to extend healthy lifespan. However, these disciplines are also key to unlocking an array of other human, societal, and economic benefits.

**Exhibit 4: The factors that impact lifespan**




Note: Not exhaustive
Source: Nature Review Genetics, USA National Library of Medicine

### Prolonged Healthier Lives (healthspan)

Multiple studies suggest that 10–20% of lifespan variability can be attributed to purely genetic factors (genome),[11] whereas 30–40% may hinge on epigenetic modifications (epigenome),[12] and up to 40–50% can be influenced by environmental or lifestyle exposures (exposome). By mapping these genetic and epigenetic variables, and controlling key environmental risks, debilitating chronic illnesses (such as diabetes and cardiovascular disorders) may be reduced by 20–30% on a population level.[13]

### Cost Efficiency

Proactive interventions generally incur lower expenditures than the extensive management of advanced disease, thus freeing healthcare budgets for further innovation. Genetic variants in an individual can also be used to predict the likelihood that a particular drug will be effective and cause unintended harm through an adverse reaction. In the United Kingdom (UK), admissions related to Adverse Drug Reactions are estimated to cost the NHS an estimated £466m annually.[14]

### Economic Development

Precision medicine catalyzes an ecosystem conducive to biotech ventures, specialized Research and Development (R&D) investments, and high-skill employment. For example, the FinnGen research consortium in Finland attracted approximately €150 million in research funding since its inception in 2007, allowing for the collection and generation of data from more than 500,000 individuals.[15] In this regard, Abu Dhabi aims to achieve a cumulative GDP contribution of US $33 billion from the Healthcare Life Science sector by 2040. This goal includes establishing more than 80 new companies in genomics and related industries, fostering 290 new biotech startups within the ecosystem, and creating approximately 22,000 jobs across various fields, including clinical genomics, AI analytics, biotech R&D, and support functions (see Exhibit 1).

### Proactive Patients

Through access to individualized risk data, patients transition from passive recipients of care to informed and proactive collaborators, fostering a culture of preventive health and psychological well-being. For example, the Estonian biobank established a population-based biobank with a current cohort size of more than 200,000 individuals, reflecting the country's holistic demographic profile. More than 2,000 biobank participants received genetic feedback and were further researched and treated by family doctors, oncologists, and medical geneticists if needed.[16]

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11 DeBord DG, Carreón T, Lentz TJ, Middendorf PJ, Hoover MD, Schulte PA. Use of the "Exposome" in the Practice of Epidemiology, 2016

12 Ho SM, Johnson A, Tarapore P, Janakiram V, Zhang X, Leung YK. Environmental epigenetics and its implication on disease risk and health outcomes, 2012

13 Wu, H., Eckhardt, C.M. & Baccarelli, A.A. Molecular mechanisms of environmental exposures and human disease, 2023

14 Genome UK, The Future of Healthcare, 2020

15 FinnGen, 2025

16 Estonia Institute of Genomics, 2025

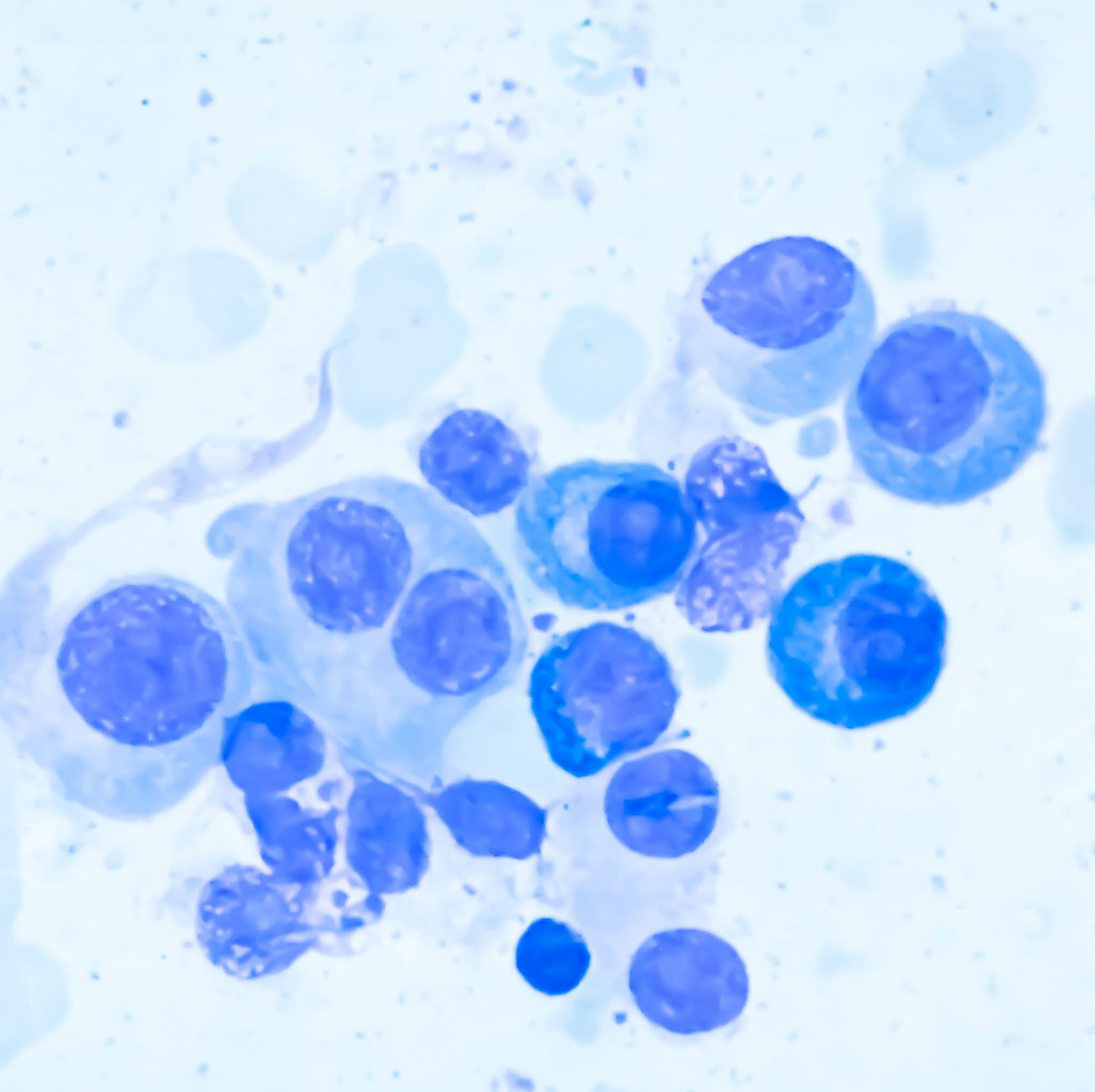
Longevity starts with deeply personalized prevention — integrating advanced multi-omic profiling with clinical, lifestyle, and environmental factors to identify risk factors long before they manifest into disease. In the UAE, where diabetes and cancer often strike early, hyper-personalized interventions can be a game changer

Dr. Nicole Sirotin, CEO of the Institute for Healthier Living Abu Dhabi

Investing in genomics today builds the economic engines of tomorrow — catalyzing innovation, creating high-value jobs, and establishing a sustainable health-driven economy

Dr. Fahed Al Marzooqi, CEO of M42's Integrated Health Solutions platform

# FUTURE PROOFING ABU DHABI: THE GENOME OASIS



# STRATEGIC OBJECTIVES

In its endeavor to prolong healthy lifespan and advance proactive healthcare models, Abu Dhabi's Department of Health (DOH) has initiated the Genome Oasis strategy. This blueprint not only builds upon the achievements of The Emirati Genome Program (with 800,000+ genomes sequenced as of today) but also sets forth a future in which multi-omics insights transform standard clinical workflows and public health policies.

**Key pillars of this strategy include:**

### Integration of Genomics in Clinical Practice

Expand beyond isolated pilots (such as specialized oncogenomics) to universal dissemination of genetic and epigenetic data in primary, specialized, and emergent medical contexts.

### Expansion into Multi-Omics R&D

Deepen research on microbiome, proteomics, exposome, among other omics fields, facilitated by enhancements to the Abu Dhabi Biobank and create a prospective Trusted Research Environment, which is a secure cloud-based environment designed for data analysis.

### Scaling a Public-Private Ecosystem

Establish collaborative frameworks among biotech, pharma, AI, academic institutions, and environmental agencies to accelerate therapy development, reduce costs, and streamline large-scale clinical pilots.

### Positioning Abu Dhabi as a Global Reference Point

Through early disease detection, specialized interventions, and large-scale clinical trials (such as CRISPR-driven anti-aging therapies), Abu Dhabi aspires to serve as a global reference point for longevity research.

Abu Dhabi already has a proven genomic infrastructure, including The Emirati Genome Program, strong government backing, and a vision from the Health Life Science Office for sector-wide coordination. With plans to expand into a Biosciences Park and develop advanced therapy clusters, the emirate can embed multi-omics in daily healthcare. This approach will improve health outcomes while showcasing the effectiveness of large-scale precision medicine.[17]

17 Department of Health Abu Dhabi, Genome Oasis Strategy, 2023

New technologies and trends pop up almost daily, but not all will deliver real impact at scale. We need a robust filter mechanism and strong governance to separate the hype from the genuine breakthroughs. At the same time, our strategy must stay flexible enough to adopt meaningful innovations quickly — serving as a bridge between today's capabilities and tomorrow's discoveries. A clear strategic vision, supported by a foundational operating model, is what keeps us adaptive yet focused on outcomes that truly matter

Dr. Asma Al Mannaei, Executive Director of Health Life Science sector, Department of Health Abu Dhabi

# KEY MILESTONES SO FAR

### The Emirati Genome Program

- It has surpassed 800,000 sequenced Emirati genomes (aspiring for 1 million). This has created a robust, culturally specific dataset for discerning hereditary disorders and fine-tuning local healthcare measures.
- **Potential impact:** Lays the groundwork for population-specific risk modeling, bridging external genomic knowledge and Abu Dhabi's distinct genetic matrix.

### Genetic Screening

- Newborn testing screens for 800+ treatable conditions, expediting immediate interventions for high-risk neonates. Plus, beyond newborn screening more than 570 genes implicated in more than 840 autosomal recessive pathologies have been evaluated as part of the government's pre-marital screening program.
- **Potential impact:** Significantly mitigates chronic morbidity, prevents protracted diagnostic quests, and streamlines paediatric resource allocation.

### Oncology Prevention and Precision Medicine

- Genetic assessment for around 47 high-risk variants (such as BRCA1 and 2), with dedicated high-risk clinics for familial mutation carriers.
- **Potential impact:** Early-stage detection can substantially amplify survival rates in specific cancer types, simultaneously enabling proactive prophylactic strategies.

### Cardiovascular Precision Medicine

- Screens more than 800 genes linked to cardiac conditions and extends screening to relatives of affected patients.
- **Potential impact:** Addresses the emirate's considerable cardiovascular disease load via timely lifestyle adjustments and gene-informed medical protocols.

### Pharmacogenomics Program

- Assesses 22 core pharmacogenes influencing around 180 pharmaceuticals, assisting clinicians in calibrating prescriptions and mitigating adverse responses.
- **Potential impact:** Personalized dosing bolsters medication adherence and alleviates complication rates, thereby significantly reducing hospital readmissions.

### Rare Disease Registry

- Consolidates data on rare hereditary disorders, stimulating targeted research and structured screening protocols.
- **Potential impact:** Hastens diagnoses, nurtures dedicated clinical guidelines, and promotes alliances with global research hubs developing innovative treatments.[18]

18 Department of Health Abu Dhabi, DOH Internal Modeling and Emirati Genome Program Reports, 2023

**Exhibit 5: Key ongoing initiatives in Abu Dhabi**

**Emirati genome program**
800,000+ samples already sequenced, and expanding

**Pharmacogenomics program**
Assesses 22 core pharmacogenes influencing 180+ pharmaceuticals

**Genetic screening**
Ongoing pilot program for genetic screening, such as with newborns

**Cardiovascular precision medicine**
Screening of 800 genes linked to cardiac conditions (including relatives of affected patients)

**Oncology prevention programs**
Genetic assessment for 47+ high-risk genetic variants

**Rare disease registry**
Consolidated data on rare hereditary disorders

Source: Department of Health Abu Dhabi

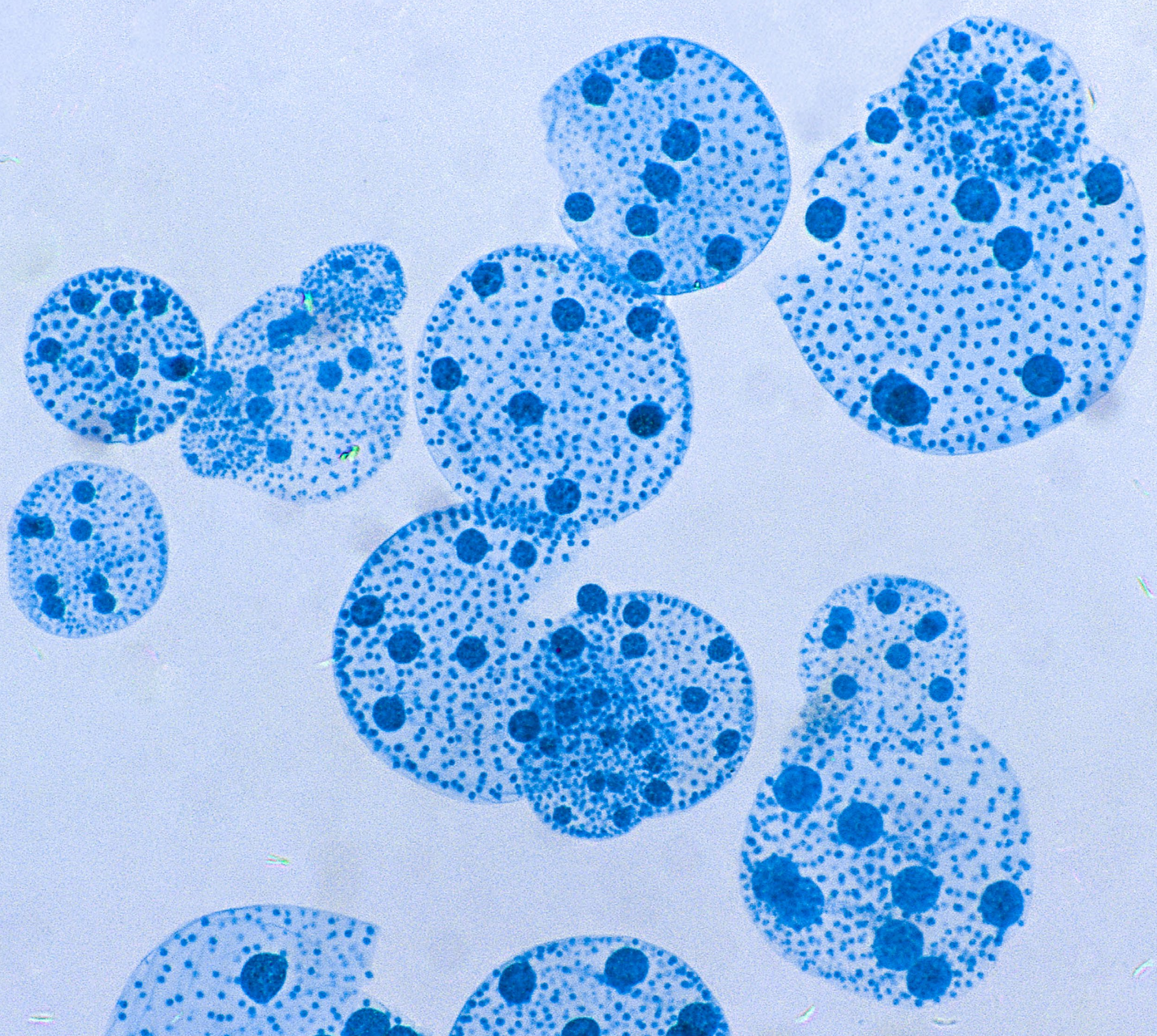
In addition to these important milestones, the Institute for Healthier Living Abu Dhabi (IHLAD) has been licensed by the Department of Health as part of Abu Dhabi's wider ambition to become a global hub for preventive medicine. As the emirate's first science-focused longevity clinic, IHLAD integrates multi-omics data (genomics, metabolomics, microbiome) with advanced AI analytics and lifestyle medicine to deliver comprehensive, evidence-based strategies for extending healthspan.

By conducting randomized controlled trials that measure real-world outcomes, the center aims to validate innovative therapies before weaving them into mainstream care. IHLAD also works closely with regulators to define clinical standards and develop training for a new cadre of "longevity doctors" and health coaches. This fusion of cutting-edge research and rigorous clinical practice exemplifies Abu Dhabi's leading approach to precision, preventive healthcare.

**If we want to compress morbidity — the amount of time people spend sick, and lengthen healthspan — the time people spend healthy, we can't ignore the daily habits that drive outcomes. Genomics only becomes powerful when coupled with precision lifestyle and medical interventions. At IHLAD, we're aiming to deliver hyper-personalized prevention: one individual's risk might hinge on a gene variant, another's on microbiome cues. Multi-omics allows us to see — and act on — those nuances**

Dr. Nicole Sirotin, CEO of the Institute for Healthier Living Abu Dhabi

# UNDERPINNING THE AMBITION: A FOUNDATIONAL LONGEVITY OPERATING MODEL



While these examples from Abu Dhabi constitute a robust foundational framework, achieving a cradle-to-grave multi-omics healthcare continuum necessitates an integrated operating model — one that deliberately merges advanced technological infrastructure, rigorous policy structures, and sustained public engagement. Realizing a truly integrated multi-omics ecosystem can be facilitated by a country or state organizing its Department of Health's operating model into three complementary tiers. Below is a framework that highlights how the three-tier integrated operating model could be carried out in the Abu Dhabi context (see Exhibit 6).

Tier A focuses on the foundational technology and data, such as high-throughput sequencing, advanced omics capabilities, and the HPC-based infrastructure that knits them together. Tier B emphasizes research and clinical integration, ensuring that cutting-edge R&D, environmental data, and clinical workflows form a cohesive pipeline that translates discoveries into real-world care. Finally, Tier C comprises the ecosystem enablers — funding and incentives, policy and regulatory structures, and robust public engagement — that sustain growth, trust, and adoption at scale. By structuring each function within these tiers, multi-omics innovations can be systematically deployed while keeping all stakeholders aligned on data, practice, and societal impact.

Health departments and governments need to clearly delineate which elements they own, lead, or facilitate in this operating model, to not only maximize immediate program efficacy but also to lay the structural groundwork for transformational change. Each building block, from HPC-based analytics to citizen outreach, serves as a critical puzzle piece in constructing a fully realized genomics ecosystem that allows for precision public health and an extended healthy lifespan for all.

**Single-cell multi-omics will be a complete game-changer for how we approach both disease and aging. By analyzing each cell's genomic, transcriptomic, and epigenetic profile in isolation, we see exactly which subpopulations are driving pathology — or resilience — so we can target them with greater precision**

Dr. Nicole Sirotin, CEO of Institute for Healthier Living Abu Dhabi

**Exhibit 6: Integrated longevity operating model**

**Embed multi-omics into every stage of healthcare — enabling early detection, targeted therapies, and prolonged healthy lifespan**

| Improve population health | Catalyze innovation | Build globally recognized success model |
|---|---|---|
| **Tier A: Foundational tech and data** | **Tier B: Research and clinical integration** | **Tier C: Ecosystem enablers** |
| **High-throughput sequencing and bioinformatics**<br>Translate raw genomic data into clinically interpretable outputs | **Research and innovation ecosystem**<br>Speed-up pipeline from lab discovery to clinical practice | **Funding, capital, and incentives**<br>Ensure consistency and foster start-up growth |
| **Advanced omics capabilities**<br>Supplement basic genomics to improve chronic disease prevention, geroscience, and so on | **Clinical integration**<br>Ensure advanced data is used daily | **Regulatory and ethical frameworks**<br>Build trust among citizens, foster cross-border research |
| **Technology backbone (core HPC, EHR integration)**<br>Sustain large volumes of omics data and real-time analytics | **Environment and population-level integration**<br>Expand research beyond individual risk to community-level prevention | **Citizen engagement**<br>Ensure participant buy-in to avoid underutilization of HPC expansions |
| | **Public-private partnerships**<br>Share R&D costs, catalyze biotech growth, foster synergy | |
| | **Workforce and talent**<br>Ensure HPC/omics data is accurately interpreted and integrated into care | |

Source: Oliver Wyman analysis

**With over 85,000 genomes sequenced with methylation data, Abu Dhabi is unlocking the next frontier of precision health — offering unprecedented insights into how genes and environment interact to shape lifelong wellness**

Dr. Fahed Al Marzooqi, CEO of M42's Integrated Health Solutions platform

# TIER A: FOUNDATIONAL TECH AND DATA

### High-Throughput Sequencing and Bioinformatics

- **Description:** Large-scale whole-genome sequencing (WGS), targeted panels, automated variant annotation, and secure data repositories, building upon The Emirati Genome Program.
- **Rationale:** Translates raw genomic data into clinically interpretable outputs, forming the backbone of newborn screenings, oncology risk assessment, and rare disease identification.
- **Potential role of regulator:** Lead on standardizing data formats, variant reporting, and forging a cohesive framework for Genome Program Expansions.
- **Global example:** Genomics England integrated WGS for mainstream NHS care, expediting rare-disease and cancer diagnoses.

### Advanced Omics Capabilities

- **Description:** Epigenetics, microbiome, proteomics, and metabolomics, enabling a holistic view of gene-environment interactions.
- **Rationale:** Supplements basic genomics, improving geroscience (such as aging biomarkers), chronic disease prevention (such as diabetes), and immunological insights (including the microbiome).
- **Potential role of regulator:** Facilitate cross-disciplinary labs, ethical guidelines, and pilot expansions for multi-omics beyond standard WGS.
- **Global example:** Finland (FinnGen) merges epigenetic, proteomic, and EHR data to pinpoint early metabolic risks.

### Technology Backbone

- **Description:** High-performance computing (HPC) clusters, machine learning/artificial intelligence frameworks for risk stratification, and robust EHR interoperability (such as expanding Abu Dhabi's Malaffi system).
- **Rationale:** Sustains large volumes of omics data and real-time analytics. Without scalable HPC and integrated EHR, advanced multi-omics cannot become routine.
- **Potential role of regulator:** Own the HPC architecture or co-fund it with private partners; and mandate EHR compliance across government and private providers.
- **Global example:** Singapore's HPC Ecosystem drastically cut data-processing times, enabling near real-time cancer risk scoring.

# TIER B: RESEARCH AND CLINICAL INTEGRATION

### Research and Innovation Ecosystem

- **Description:** Cultivate a Trusted Research Environment, advanced institutional review boards (IRBs) for gene-editing/longevity trials, academic collaborations, and integration with a Biosciences Park.
- **Rationale:** Speeds the pipeline from lab discovery to clinical practice, ensuring broad synergy among universities, biotech, and environment agencies for multi-omics R&D.
- **Potential role of regulator:** Facilitate synergy via data-access frameworks, IRB standardization, and targeted R&D grants aligned with local disease priorities.
- **Global example:** The UK government's Catapult programs foster collaboration among universities, startups, and large enterprises to accelerate R&D in genomics and related fields. Since their inception in 2011 they have attracted millions of pounds of private investment into UK R&D.[19]

### Environment and Population-Level Integration

- **Description:** Incorporating exposome data (pollution and toxins) with genomic risk for "precision public health." Researchers systematically link environment metrics to clinical datasets.
- **Rationale:** Expands research beyond individual risk to community-level prevention; fosters novel interventions for respiratory and cardiometabolic conditions.
- **Potential role of regulator:** Facilitate environment data-sharing with HPC analytics; embed environment-driven interventions in broader public health strategy.
- **Global example:** The European Human Exposome Network is a pan-European initiative to systematically measure how environmental exposures interact with our genetics, underscoring that understanding the exposome is critical as a complement and enhancement of genomic research.

### Clinical Integration

- **Description:** Incorporating omics data (variant findings, pharmacogenomics) into everyday EHR workflows, e-prescribing alerts, and specialized care pathways (such as oncology and cardiovascular disease).
- **Rationale:** Ensures advanced data is used daily, improving early detection, therapy optimization, and cost-effectiveness.
- **Potential role of regulator:** Lead uniform EHR requirements, cost-benefit studies for omics-based screening, plus design of specialized clinics.
- **Global example:** The US FDA has included more than 600 pharmacogenomic biomarkers on the labels of various drugs across therapy areas, such as oncology, neurology, and gastroenterology.[20]

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19 UK Department of Science, Innovation and Technology, 2025

20 FDA, Table of Pharmacogenomic Biomarkers in Drug Labeling, 2024

### Public-Private Partnerships

- **Description:** Joint programs bridging the Department of Health, private biotech, AI firms, and academic labs to co-develop advanced therapies or large-scale HPC expansions.
- **Rationale:** Shares R&D costs, catalyzes biotech growth, fosters synergy (such as CRISPR-based trials for local diseases).
- **Potential role of regulator:** Lead in forging disease priority, drafting co-funding models, setting partnership frameworks.
- **Global example:** Genomic Medicine Sweden unites regions, universities, and diagnostic labs.

### Workforce and Talent

- **Description:** Building robust pipelines for genetic counselors, data scientists, and geroscience experts. Partnerships with local universities and continuous professional development.
- **Rationale:** Skilled staff ensure HPC and omics data is accurately interpreted and integrated into care.
- **Potential role of regulator:** Own training and certification structures, while awarding scholarships and forging new academic programs.
- **Global example:** The United Kingdom's Genomics Education Programme has funded more than 3,000 NHS staff through its Master's programme.[21]

**You can't run a comprehensive healthy longevity clinic without specialists and AI systems trained in interpreting advanced multi-omic data, in addition to interventions in lifestyle and precision geromedicine. We need new professionals — multi-disciplinary teams including doctors and specialized coaches — to translate multi-omics and targeted, personalized interventions into real practice**

Dr. Nicole Sirotin, CEO of Institute for Healthier Living Abu Dhabi

21 NHS, Genomic Education Program, 2025

To become a magnet for biotech, you need more than raw data — you need a supporting infrastructure of co-investment funds, open-lab facilities, and a frictionless IP environment. When all that comes together, you effectively de-risk the entire start-up journey, and that's what turns a region into a global innovation hub

Marco Janezic, Biotech Entrepreneur and Investor

# TIER C: ECOSYSTEM ENABLERS

### Funding, Capital, and Incentives

- **Description:** Mechanisms for financing HPC, advanced therapies, multi-omics expansions (in Abu Dhabi, this could be co-investment with Mubadala and ADQ, FDI incentives, R&D grants, tax breaks).
- **Rationale:** Genomics at scale demands high capital outlay; robust funding ensures consistency and fosters start-up growth in omics-based sectors.
- **Potential role of regulator:** Lead by structuring "Genome Innovation Funds", awarding R&D grants, shaping tax incentives, and guaranteeing seed funds for advanced therapy pilots.
- **Global example:** Singapore co-funded HPC expansions and AI-driven genomics labs, attracting foreign biotech with joint grants.

**The UAE has the potential to advance significantly in various areas to establish a de-risked environment for genomics startups and venture capitalists. This can be achieved through clear regulatory frameworks for data usage and intellectual property, well-defined licensing requirements, and access to world-class infrastructure, including high-performance computing resources. In addition to these essential elements, the UAE can attract talent by introducing a 'genomics startup visa' and creating necessary liquidity through a dedicated sovereign 'longevity and genomics fund' that co-invests in startups**

Marco Janezic, Biotech Entrepreneur and Investor

### Regulatory and Ethical Frameworks

- **Description:** Comprehensive data privacy, dynamic consent, gene-editing approvals, IP frameworks, and standards for cross-institution data usage.
- **Rationale:** Builds trust among citizens, fosters cross-border research, and ensures advanced therapies (CRISPR) abide by ethical norms.
- **Potential role of regulator:** Lead on national policy, oversee IRBs, align with global best practices to attract international partners.
- **Global example:** The Cooperative Health Research in South Tyrol (CHRIS) is a longitudinal study in Northern Italy, using dynamic consent since 2011 to support ethical research in genomics and other areas.

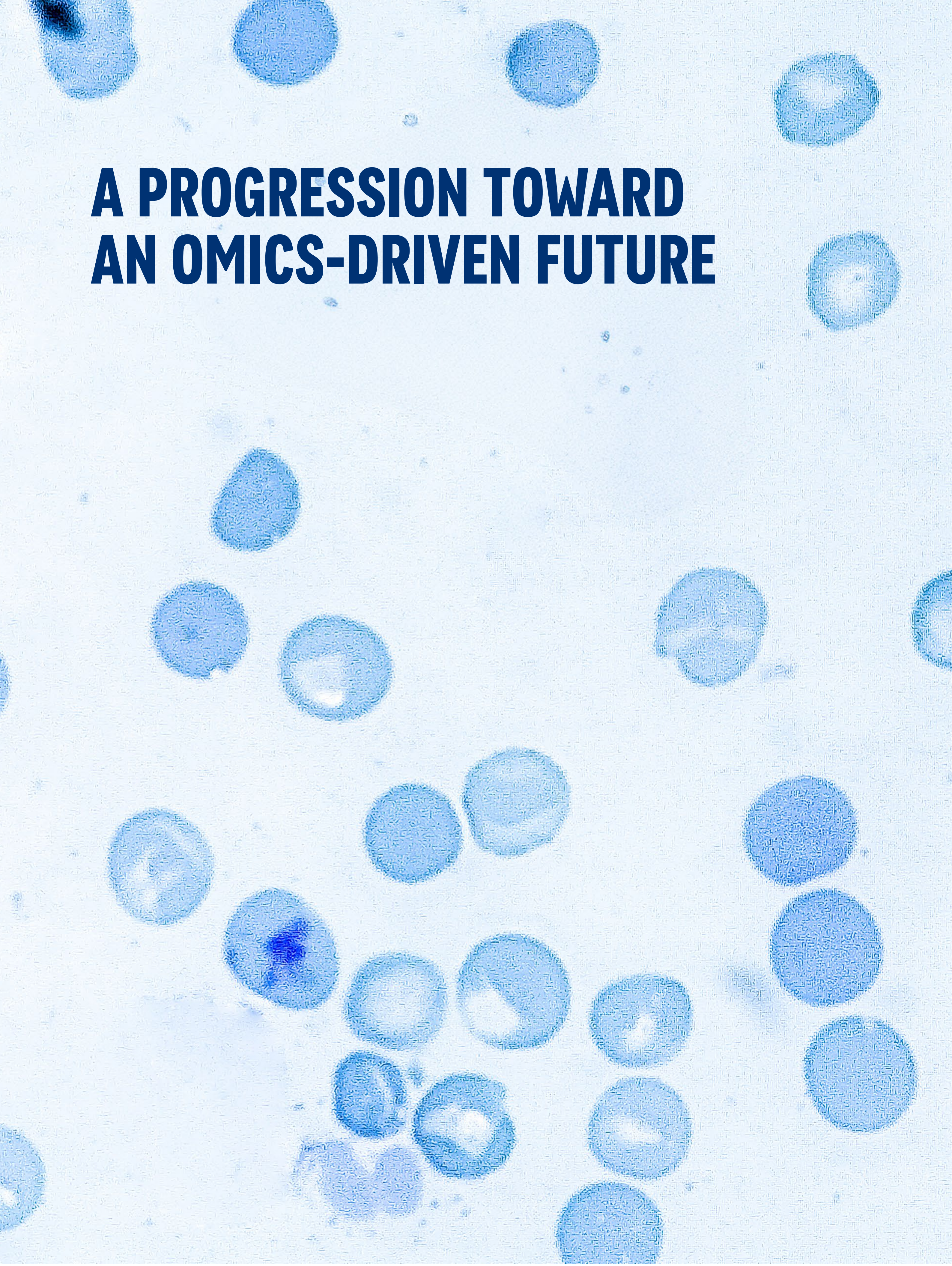
### Citizen Engagement

- **Description:** Proactive outreach explaining genomic benefits, limitations, and data privacy. Culturally sensitive strategies (public events, interactive dashboards) to build widespread participation.
- **Rationale:** Large-scale omics relies on broad enrollment and trust. Without participant buy-in, HPC expansions or environment-driven data sets remain underutilized.
- **Potential role of regulator:** Lead campaigns via local community networks, highlight success stories, and address privacy concerns head-on.
- **Global example:** Iceland’s deCODE Genetics overcame privacy skepticism, achieving near-universal sign-up for national genome projects.

**There is huge potential for our top hospitals, universities and R&D companies to unite more effectively. That is why the Department of Health is working on Nexus, a national network connecting providers, academia, and research entities with incentives to fast-track translational research. Such alignment in a structured ecosystem will allow Abu Dhabi to accelerate breakthroughs in genomic medicine and longevity**

Dr. Asma Al Mannaei, Executive Director of Health Life Science sector,
Department of Health Abu Dhabi

# A PROGRESSION TOWARD AN OMICS-DRIVEN FUTURE



Before embarking on a detailed roadmap, it is important for any global player to recognize that developing a world-class genomics ecosystem is a long-term, capital-intensive undertaking. As with many large-scale transformations, progress must unfold in phases — each contributing to the collective momentum.

In the short term (1-2 years), the priority is to solidify the foundation by expanding select pilots, upgrading infrastructure, and ensuring early successes that reinforce stakeholder confidence. By doing so, government healthcare stakeholders can demonstrate tangible outcomes from existing or newly expanded pilot programs (such as newborn screening enhancements and targeted pharmacogenomics). Quick, visible successes build stakeholder confidence and encourage policy endorsement, establishing the legitimacy of large-scale genomics investments. Concurrently, strengthening core infrastructure (HPC, artificial intelligence, and data management) and upskilling key personnel ensures subsequent expansions do not stall due to technical or human capacity gaps.

The mid-term window (3-5 years) then pursues population-level screening and deeper integration with environmental data and private-sector R&D, moving beyond isolated programs to establish a nationally cohesive, data-driven approach. Any government that has proven certain cost-effective measures and established foundational capabilities should then aim to push beyond small-scale efforts to population-wide screening, deeper environmental correlations, and more ambitious public-private ventures (such as advanced multi-omics trials). By this stage, the focus shifts to systemic integration — ensuring synergy between HPC analytics, clinical EHR systems, and cross-departmental data (such as exposome tracking). Demonstrable success in this window solidifies Abu Dhabi’s claim to national-scale precision medicine, forming a persuasive case for foreign direct investments and multinational R&D partnerships.

Finally, in the long term (5-10 years) the aim should be full multi-omics convergence, advanced gene-editing therapies, and becoming a global reference point for geroscience, precision public health, and longevity innovation. By pacing investments and aligning them with strategic milestones, a country or state can balance near-term achievements against the broader vision — ultimately ensuring the sustainability and global impact of its genomics-driven healthcare model.

**Exhibit 7: A roadmap — from short-term goals to long-term vision**

**Solidify the foundation and demonstrate impact**
**Now (1-2 years)**

- Expand existing screening pilots
- Enhance data and AI foundations
- Refine regulatory and data governance
- Upskill key workforce
- Expand public-private alliances

**Scale and integrate systemically**
**Next (3-5 years)**

- Population wide screening
- Trusted Research Environment
- Advanced multi-omics trials
- Environmental public health 1.0
- Heightened citizen engagement

**Converge to full multi-omics and lead globally**
**Later (5-10 years)**

- Full multi-omics integration
- Gene therapy mainstreaming
- Environmental public Health 2.0
- Global longevity center of excellence
- Increased economic and social impact

Source: Oliver Wyman analysis

**Ultimately, it's not about chasing trends but about building a future-proof strategy that can scale and adapt with each breakthrough in genomics or regenerative therapies. If our regulatory frameworks remain agile — ready to pivot with evolving science — we'll keep innovating without losing sight of long-term goals**

Dr. Asma Al Mannaei, Executive Director of Health Life Science sector, Department of Health Abu Dhabi

# CONCLUSION

The journey of genomics represents a significant leap toward a future where healthcare is proactive and personalized. With robust genomic infrastructures being developed globally, hubs like Abu Dhabi exemplify how advancements in genomics can enhance public health, drive economic growth, and improve quality of life.

The transformative potential of genomics lies in its ability to identify disease risks, tailor treatments, and extend healthy lifespans through multi-omics integration. The anticipated economic impact is substantial, with significant contributions to GDP and the creation of jobs in biotech and related sectors, ultimately enhancing societal well-being.

To fully realize the benefits of genomics-driven precision medicine, it is essential to focus on several key areas: scaling existing programs, such as newborn screening, into population-level multi-omics frameworks; institutionalizing HPC-based analytics that unite environmental and clinical data under robust AI-driven risk models; cultivating a specialized workforce of genetic counselors, bioinformaticians, and geriatric genomics professionals to bridge the gap between research and clinical delivery; strengthening public-private alliances for innovative therapy investigations, including CRISPR applications and exposome-focused longevity; and building public trust through transparent communication of data usage and demonstrable healthcare gains.

Through a judicious amalgamation of technical innovations, a carefully orchestrated operating model, and a tiered roadmap, places such as Abu Dhabi can ascend from current genomics achievements to become globally renowned centers for longevity research and advanced precision medicine. In doing so, they will exemplify how visionary governance can yield not just longer life but a more fulfilling, health-empowered life for their populations, reinforcing economic vitality and setting formidable international standards for 21st-century healthcare.

# GLOSSARY

**Bioinformatics:** The use of computer software and algorithms to analyze and interpret biological data, particularly genomic data, to understand complex biological processes.

**Biological Age:** A measure of how physiologically "old" an individual is, often assessed via biomarkers (epigenetic clocks, telomere length) that reflect cellular or systemic function more accurately than chronological age. Biological age can differ significantly from chronological age, influencing risk for age-related diseases.

**Chronological Age:** The count of years a person has lived, measured from birth to the current date. It is a purely time-based measure, not necessarily indicative of health status or physiological condition.

**CRISPR:** A powerful gene-editing technology that allows scientists to modify DNA sequences in living organisms, enabling precise changes to genes for research and therapeutic purposes.

**Frailty:** A clinical syndrome marked by reduced physiologic reserve and resilience in the face of stressors (such as infection, minor injuries), leading to a heightened vulnerability to adverse health outcomes, hospitalization, or premature death. Frailty often correlates with advanced chronological or biological age.

**Geroscience:** A research field focused on understanding the biological mechanisms of aging (such as cellular senescence, mitochondrial dysfunction) and leveraging that knowledge to delay or prevent age-related diseases, thereby extending healthspan.

**Healthspan:** The period of time during which a person is healthy within his or her lifespan. The healthspan is therefore shorter or at most as long as the lifespan, and a person can fall ill early in life but still live for several years [Kaeberlein 2018]. Healthspan is a key indicator of an individual's well-being, aligning with the WHO's definition of health.

**High-throughput sequencing:** A technology that allows for the rapid sequencing of large amounts of DNA, enabling the analysis of entire genomes quickly and efficiently.

**HPC (High-Performance Computing):** The use of advanced computing systems to process and analyze large datasets quickly, often used in genomics to handle complex calculations and simulations.

**Life expectancy:** The amount of time a person is expected to live based on the year they were born, their current age, and various demographic factors, including gender. It is always statistically defined as the average number of years of life remaining at a given age. So, life expectancy is basically the average lifespan of a population.

**Longevity:** The ability to live a long life beyond the species-specific average age at death [De Benedictis & Franceschi 2006].

**Longevity medicine:** Advanced personalized preventive medicine powered by deep biomarkers of aging and longevity; a fast-emerging field [Bischof et al., 2021]. It aims to optimize health and healthspan by targeting aging processes throughout one's lifespan. This innovative approach combines preventive and therapeutic medical practices, encompassing a broad spectrum of diagnostics and interventions. The importance of longevity medicine lies in its potential to revolutionize healthcare by shifting the focus from disease treatment to proactive health diagnostics, optimization, and age-related disease prevention. Longevity medicine differs from general preventive care by its focus on aging biomarkers, geroscience interventions, and therapies aimed at extending healthspan and delaying the onset of age-related diseases [Department of Health Abu Dhabi, 2024].

**Maximum lifespan:** The maximum time that one or more members of a population have been observed to survive between birth and death. The oldest woman in the world lived to over 122 years old, so the maximum human lifespan is often given as 120 years [Dong et al., 2016].

**Metabolomics:** The comprehensive analysis of metabolites, which are small molecules involved in metabolism, to understand cellular processes and how they relate to health and disease.

**Multi-omics:** An integrated approach that combines data from different biological layers, such as genomics, proteomics, and metabolomics, to provide a comprehensive view of an organism's health and biological functions.

**Oncogenomic:** The study of the genetic changes associated with cancer, focusing on how specific genes contribute to the development and progression of tumors.

**Pharmacogenes:** Genes that influence how an individual responds to medications, helping to tailor drug treatments based on a person's genetic makeup.

**Precision medicine / personalized medicine:** This is recognized by the US National Human Genome Research Institute in its definition of precision medicine: "Precision medicine (generally considered analogous to personalized medicine or individualized medicine) is an innovative approach that uses information about an individual's genomic, environmental, and lifestyle information to guide decisions related to their medical management. The goal of precision medicine is to provide a more precise approach for the prevention, diagnosis, and treatment of disease" [National Human Genome Research Institute, n.d.]. According to the US National Research Council, "personalized medicine is an older term with a meaning similar to precision medicine. However, there was concern that the word 'personalized' could be misinterpreted to imply that treatments and preventions are being developed uniquely for each individual. The Council therefore preferred the term precision medicine to personalized medicine" [Delpierre & Lefèvre, 2023].

**Proteomics:** The large-scale study of proteins, including their functions, structures, and interactions, to understand how they contribute to biological processes and diseases.

**Senolytic:** Refers to a type of therapy or compound that selectively targets and eliminates senescent cells, which are damaged cells that contribute to aging and age-related diseases.

**Senolytics:** A class of interventions (pharmacological or otherwise) designed to selectively eliminate senescent ("zombie") cells — which accumulate with age and drive chronic inflammation — thereby potentially reducing frailty and age-related pathologies.

**Smart healthy city:** A smart health city integrates emerging technologies and innovative strategies to enhance efficiency, focusing on sustainable healthcare delivery and improved quality of life for its residents. By fostering collaboration across government, industry, and academia, such cities aim to create an environment where quality of life is improved through the effective deployment of emerging technologies (such as IoT, IoMT) [Thompson et al., 2023].

# COMMON ABBREVIATIONS

**AI** — Artificial Intelligence

**APPI** — Act on the Protection of Personal Information (Japan)

**BRCA** — BReast CAncer gene (e.g., BRCA1, BRCA2)

**CRISPR** — Clustered Regularly Interspaced Short Palindromic Repeats (genome editing technology)

**CVD** — Cardiovascular Disease

**EGP** — Emirati Genome Program

**EHR** — Electronic Health Record

**HPC** — High-Performance Computing

**HTS** — High-Throughput Sequencing

**IHLAD** — Institute for Healthier Living Abu Dhabi

**IRB** — Institutional Review Board

**NIPT** — Noninvasive Prenatal Testing

**NHS** — National Health Service (UK)

**PGT** — Pre-implantation Genetic Testing

**R&D** — Research & Development

**TRE** — Trusted Research Environment

**VC** — Venture Capital

**WGS** — Whole-Genome Sequencing

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