UC DAVIS Innovation Institute for Food and Health

UC DAVIS GRADUATE SCHOOL OF MANAGEMENT

Barnstorm Foundry

PERSONALIZED NUTRITION FOR LONGEVITY

MARKET DISCOVERY PAPER
MAY 2023

INTRODUCTION

This white paper focuses on:

- Which consumers are most interested in personalized nutrition for longevity.

- How businesses have taken different approaches to offer products that support longevity, focusing on nutritional and lifestyle related interventions. This paper specifically excludes companies taking a medical or drug development approach to longevity (of which there are also many players).

- Which key factors will affect the future of the personalized nutrition for longevity industry.

Longevity can mean many different things to different individuals. To some, it is simply living longer. To others, it is how long they can look a certain way, or do certain things. A few people even view longevity as the search for immortality. Longevity is closely tied to a person's health span, the length of time a person can do the things they wish to do in life unassisted, be it holding their grandchildren or climbing Mt. Kilimanjaro. These two adjacent concepts have been the root cause for many changing the way they eat, exercise, and live their day-to-day life. General recommendations for improving one's healthspan and resulting longevity have been widely popular throughout human history. Examples such as the Mediterranean diet, drinking a glass of wine a day, and consuming more yogurt are all ubiquitous approaches to improving health and extending life. However, research has shown that when individuals are treated as individuals, with differing nutritional,

lifestyle, and cultural needs, superior results ensue. This has promoted the rise of personalized nutrition.

Personalized nutrition is the application of an associated individual's genetic, phenotypic, microbiomic, medical, nutritional, or habitual data and other important information towards establishing healthier eating patterns, nutritional guidance, lifestyle changes, or disease treatment and prevention.[1] Early researchers in this field focused on treating acute and chronic conditions related to nutrient deficiencies in the body. In the early 1920s, Dr. Thomas Addis coined a personalized therapeutic diet using a strategy of low salt, low protein, and vitamin supplementation to treat the renal condition, Bright's disease. His research opened the door for future nutrigenomic research that shows optimal nutrition varies enormously between individuals.[2] Since then, diets have evolved and proved that nutrition has the power to not only help manage chronic conditions but also optimize a healthy lifespan. A number of distinct cellular mechanisms have now been shown to have an effect on how long people can live.

These mechanisms of biological aging are: telomere attrition, genomic instability, loss of proteostasis, epigenetic alterations, deregulated nutrient sensing, mitochondrial dysfunction, cellular senescence, stem cell exhaustion, and altered intercellular communication.

We analyze how various personalized nutrition companies are incorporating these discoveries on longevity to create value for their customers and what critical factors they should consider for future growth.
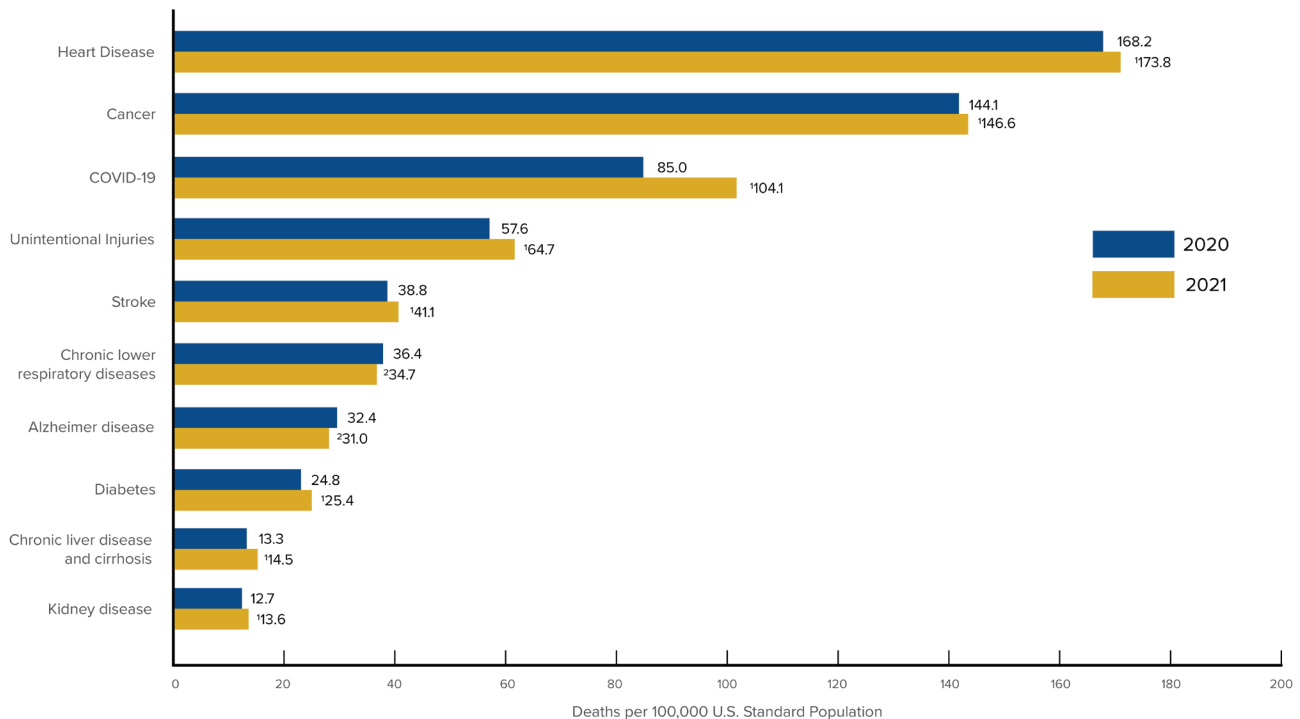
CONTENT

CDC MORTALITY IN UNITED STATES 2021

To begin the discussion on longevity, it is important to frame what the existing causes of mortality are in the United States. Linkages between these causes of mortality and diet and lifestyle should be continually explored in order to create successful and efficacious longevity solutions. In addition, targeting the greatest causes of mortality (such as heart disease) may help emerging companies find faster product adoption and create outsized impact.

Age-adjusted death rate for the 10 leading causes of death in 2021: United States, 2020 and 2021

Cause	2020	2021
Heart Disease	168.2	[1]173.8
Cancer	144.1	[1]146.6
COVID-19	85.0	[1]104.1
Unintentional Injuries	57.6	[1]64.7
Stroke	38.8	[1]41.1
Chronic lower respiratory diseases	36.4	[2]34.7
Alzheimer disease	32.4	[2]31.0
Diabetes	24.8	[1]25.4
Chronic liver disease and cirrhosis	13.3	[1]14.5
Kidney disease	12.7	[1]13.6

Deaths per 100,000 U.S. Standard Population

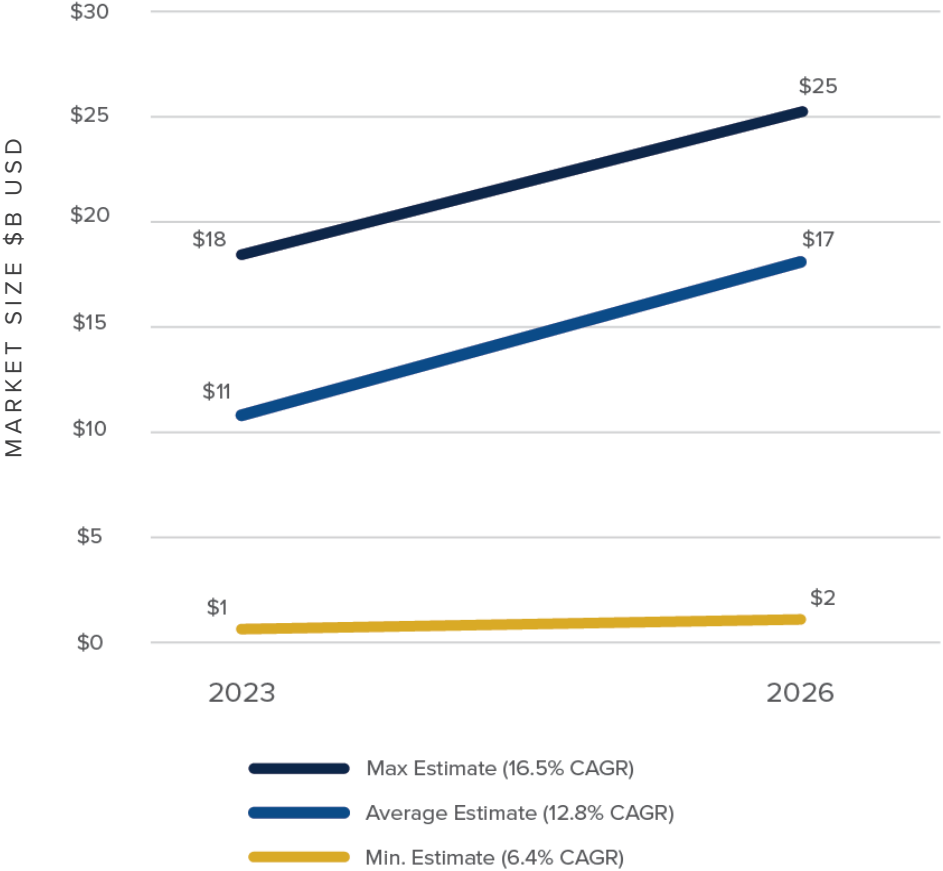[1]Statistically significant increase from 2020 to 2021 (p < 0.05)
[2]Statistically significant decrease from 2020 to 2021 (p < 0.05)

Notes: A total of 3,464,231 resident deaths were register in the United States in 2021, The 10 leading causes of death accounted for 74.5% of all U.S. deaths in 2021. Causes of death are ranked according to number of deaths. Ranking for 2020 data are not shown. Data for Figure includes the number of deaths for leading causes and the percentage of total deaths.
Source: National Center for Health Statistics, National Vital Statistics System, Morality

MARKET SIZE

Global Market Size Estimations

Chart: Global Market Size Estimations. Y-axis: MARKET SIZE $B USD. X-axis: 2023 to 2026.

- Max Estimate (16.5% CAGR): $18 (2023) to $25 (2026)
- Average Estimate (12.8% CAGR): $11 (2023) to $17 (2026)
- Min. Estimate (6.4% CAGR): $1 (2023) to $2 (2026)

On average, the global market size for personalized nutrition is expected to be $11B growing to $17B by 2026, registering a CAGR of 12.8%.[4] Within this broader personalized nutrition market, businesses that position themselves as specifically targeting longevity make up a small percentage. However, there has been a clear increase in interest in the past 10 years as the number of active biotech companies targeting longevity has increased from 44 in 2013 to 163 in 2023, a 13.99% CAGR (AgingbioTech.info).

CUSTOMER SEGMENTATION

Consumer segments in relation to personalized nutrition for longevity can be broken down into three main target categories (see figure 2). These are technologically savvy self-optimizers (known colloquially as "bio-hackers"), health-conscious young professionals, and older professionals/retirees. These three groups' motivations towards food choice are driven by goals of living a healthier life for longer periods of time. The central hurdle to ultimately translating these segments into personalized nutrition customers will be bridging the gap between their immediate dietary goals and longevity. Keeping them engaged through product offerings that match their goals, meet their needs, and connect them to like minded individuals will be key to the success of a new company in this space.

We gain further insights into the trajectory of the longevity market by analyzing early adopters' motivations and demographics. The biohacker community is the earliest adopter of new longevity-related health products.[5] A biohacker refers to individuals who are passionate about optimizing their physical and mental health through biological information to improve their performance. These practices range from strict diets and supplements, to exercise regimens, ice baths, and other physical therapies. The biohacker market, for all health goals, not just longevity-related products, was estimated at $15.41 billion in 2020, with a CAGR of 19.4%.[5A]
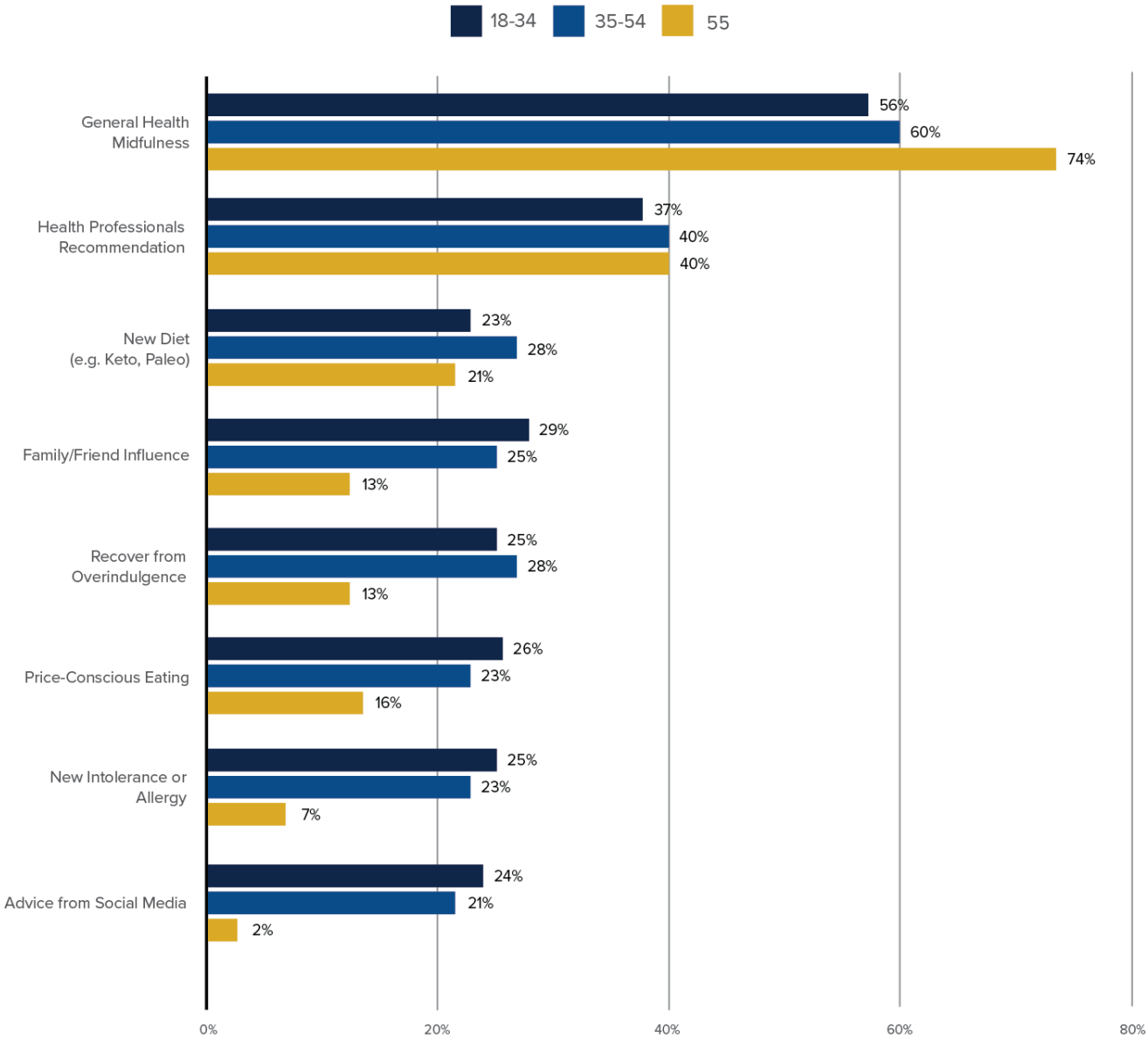
	BOBBY BIOHACKER	**WILLOW WELLNESS**	**MARY MEDICAL**
DESCRIPTION	Technologically savvy self-optimizers	Young health conscious professionals	Older professionals and retirees
MARKET SHARE	$15.41B (2020) CAGR: 19.14% (2021-2028)[5A]	$43.B (2022) CAGR: 15.0% (2023-2030)[5B]	$2.2B (2021) CAGR: 11.2% (2022-2027)[5C]
GOALS	Athletic enchancement, fix flaws, live forever	Better health, fitness, nutrition, apperance, sleep, and mindfulness	Aging with grace, staying healthy, addressing exisiting ailments, spending time with family, and being physical and independent
PRODUCT OF INTEREST	Wearables, Implants (chips), Smart Drugs, Supplements, Mobile Apps, Gene Modification Kits, and Other Early Stage Products[5A]	Nutraceuticals, Anti-Aging, Beauty Supplements, Memory/ Brain Enhancers, Nutrition (juice cleanses, nutrition coaches, fortified foods, and sports nutrition), Personal Coaching, Meditation and Mindfulness Products[5B]	Nutrient Dense Foods, Legacy Brands, Chronic Disease Treatment, Low Sodium, Slow Sugar, Health Improving, Stress Reduction[5D]

Looking closer at recent trends in consumer attitudes toward the relationship between health and food yields important implications for the potential of personalized nutrition for longevity. Consumer motivations towards choosing food based on real or perceived health effects is complex and often dependent on multiple subjective lenses that can make generalizations difficult. A recent report from Mintel

suggests that consumers make the choice to restrict, eliminate, or choose certain foods based on immediate aspirations such as general health mindfulness. Similarly, recent studies have shown that consumers choose healthy foods when the health claim of the product directly relates to an immediate perceived benefit (i.e. being able to eat more of a traditionally "unhealthy" food). Adding further complexity to the situation, a recent study conducted by McKinsey & Company found that fifty percent of consumers prioritize healthy eating, but most of those consumers are confused about what is healthy.[35]

Restrictive Eating Habit Reasoning, by Age 2020

Legend: ■ 18-34 ■ 35-54 ■ 55

Reasoning	18-34	35-54	55
General Health Midfulness	56%	60%	74%
Health Professionals Recommendation	37%	40%	40%
New Diet (e.g. Keto, Paleo)	23%	28%	21%
Family/Friend Influence	29%	25%	13%
Recover from Overindulgence	25%	28%	13%
Price-Conscious Eating	26%	23%	16%
New Intolerance or Allergy	25%	23%	7%
Advice from Social Media	24%	21%	2%

Despite this focus on the immediate effects of nutritional choices people view healthier eating in the context of supporting their health in the future. This segment increases drastically as individuals begin encountering the deleterious effects of aging. Indeed, a recent report of senior lifestyles from Mintel shows that 84% of respondents listed "Taking care of my health" as having the greatest impact on their quality of life, with "spending time with family" coming in at a close second. These motivators speak to an inward turn of conceptions of health as people age. Wellness at later stages of life are no longer driven by body image, but rather more fundamental aspects of health and function.

While an aging population may appear to be the greatest driver of the longevity market, other key factors likely supersede it in importance. It is paramount that longevity businesses understand consumers' consciousness of the future and their attitudes toward aging. Consumers' consciousness of the future, and motivation to plan for it, varies based on age and life experience. A Forbes survey conducted by OnePoll revealed that for people who acknowledged a fear of aging, 63% of those cited declining health as their primary concern. Loss of family/ loved ones and financial concerns were the next most common worries.

U.S. Population in 2021 (in millions)

	Gen Z	Millennials	Gen X	Baby Boomer
U.S. Population in 2021	68	71	65	69
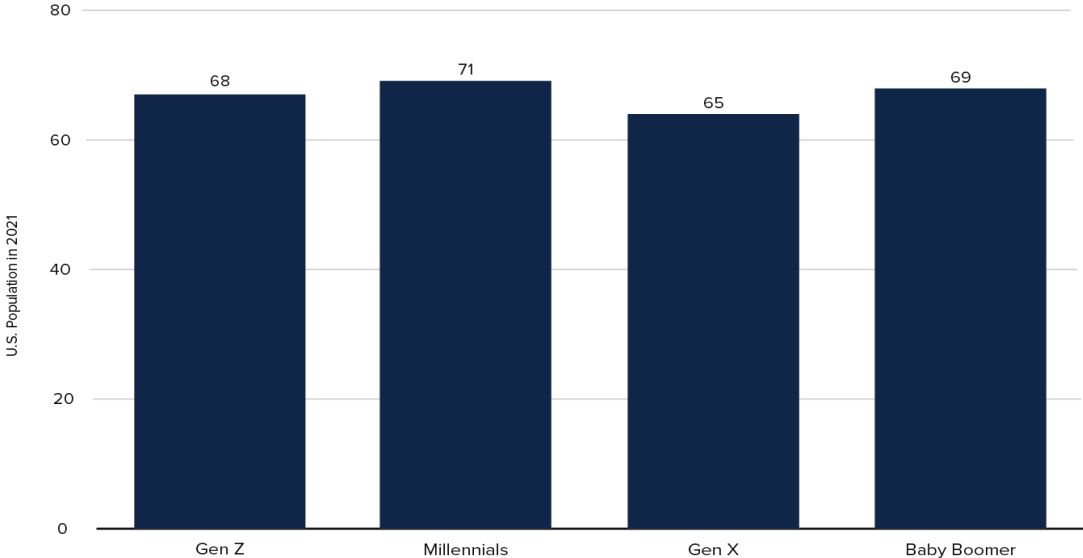
These concerns typically arise after triggering life events such as: turning 30, a diagnosis of a specific health condition, witnessing the experience of older family members (especially parents), and the birth or loss of loved ones.[8]

Within the United States, generational sizes are staying relatively consistent. However, as more people are living longer the proportion of the population 65 and above is anticipated to jump from 9% in 2018 to 16% by 2050.[6]

In a study conducted by Mintel, two thousand individuals were asked to rank what was most important in a typical day for healthy eating. In the 55+ age group 43% of respondents ranked "eating to support healthy aging" and 37% ranked "limiting harmful foods in excess" as their top priorities. Whereas younger groups such as the 18-34 age group value "adding foods with health benefits" and "eating to support mental health" as their most important eating ideals.[34]

There is another aspect of planning for later life that serves as a useful proxy for consumer interest in longevity-based nutrition products, and that is retirement planning. This is an instance of consumers showing interest and most importantly being willing to spend money on their future. This appears to be happening earlier and earlier for subsequent generations. According to a national survey.[9] Gen Z begins saving for retirement around 20, millennials around 25, Gen X at 30, and baby boomers around 35.

Comparing consumers' attitudes toward aging leads to insights on potential in this market. A survey conducted on the subject of longevity indicated greater concerns surrounding quality of life over lifespan alone. This emphasis focuses on maintaining cognitive health, mobility, and physical appearance. It also found that the fear of aging decreases over one's life. Data sourced from OnePoll via Forbes Health.[8]

Do you fear aging?
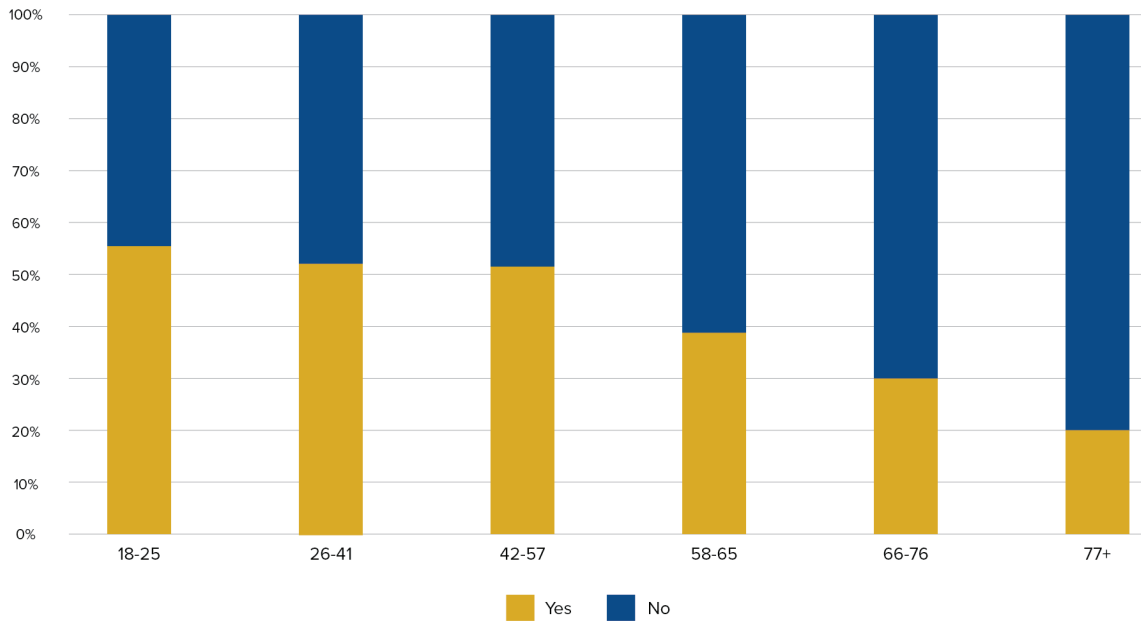
The above trends suggest that the most valuable customers may be within the 30 to 50-year-old range where a higher concern about aging coincides with a greater average disposable income.[10]

Lastly, longevity-focused companies should consider that converting one-time customers to repeat customers in their earlier years of life leads to improved efficacy and a greater lifetime value for the customer. By intervening at an earlier age (30 vs 65 years old), longevity companies will be able to best create good habits and lifestyle changes in their customers that support their product claims.

BUISNESS MODEL DISCUSSION

Businesses in the precision nutrition for longevity space fall into three categories with a significant amount of crossover. In order to distinguish the factors affecting each segment, summaries are provided as well as specific considerations.

Longevity Buisness Models
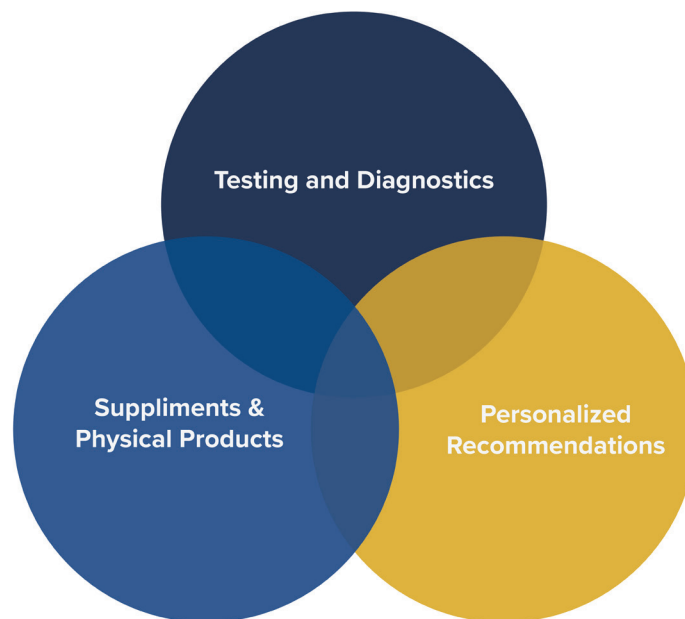
The first product category is testing and diagnostic products which range from self-reported data through apps and surveys, to wearable devices and laboratory analysis of biological samples. These bioassays include blood and urine tests, microbiome mapping from fecal samples, and genetic testing. This business model is predominantly based on a one-time transaction, leaving the customer with a wealth of diagnostic data to help them make their own dietary and health decisions. Many customers show interest in the information itself to have improved knowledge of their own bodies and health.

The second product category is personalized recommendations of diet and nutritional supplements tailored to the individual. These are often based on specific testing or self-reported data. The detail, accuracy, and value of the personalized recommendations seem to vary enormously across products with some being based on lab testing and AI analysis of test results while others simply have customers self-sort through a questionnaire into categories of age, activity level, and current dietary habits. Some companies provide a set of general dietary recommendations in the form of a target balance of macronutrients. This can be delivered in a number of ways including menu and recipe planning or a potential shopping list from the customer's local grocery store or grocery delivery service of choice. This category also includes 1:1 coaching of customers with fitness or nutrition professionals.

The third category of product is the delivered nutrition itself such as consumable personalized supplement products. These companies offer supplements, personalized to varying degrees, for individuals from nutrients like nicotinamide adenine dinucleotide (NAD+) and nicotinamide mononucleotide (NMN). NAD+ and its biological precursor, NMN, are associated with a range of biological processes in cellular aging[11] and have shown therapeutic potential in reducing the physiological symptoms of aging in tests conducted with mice and humans.[12]

An emerging category that is not covered further in this paper includes the market for precision nutrition products aimed at longevity for pets. For example, the firm Loyal,[13] sprung from Cellular Longevity. Inc conducts research on canines to help understand cellular mechanisms of aging in humans. This research has become a veterinary pharmaceutical product for dogs that is marketed as a longevity treatment.

Testing and Diagnostics

The Testing and diagnostic segment is a major part of the longevity market. In essence, each company in the space is claiming that their testing method and resulting data bank is superior to others at predicting long-term health trends for individuals. However, what data is being collected for longevity predictions varies widely. Data collection ranges from simple lifestyle surveys (such as those done by Habit[14]), to self-administered blood tests that are analyzed for Aging Biomarkers (such as those done by Jinfiniti[15]), to DNA methylation analyses (such as those done by AgeRate[16]).

Typically, data is self-collected at home. However, wearable integration and partnership with some healthcare providers have broadened the geographic footprint. The timing of testing is typically on a quarterly to an annual basis, however, some companies stand out such as Vivoo which is a weekly urine test, and Inside Tracker which utilizes continuous wearable data in conjunction with biannual biomarker data. Pricing per test ranges from $5 (Vivoo urine tests), to $248 (Jinfiniti Intracellular NAD+), to $499 (TruDiagnostic's complete collection of tests featuring epigenetic biological age, telomere length, and the Dunedin PACE test). Tests are sold by unit or on a subscription model.

As a segment, testing and diagnostic companies have made great strides in both the speed of data collection and analysis. They also have taken a proactive approach to reassuring consumers that their data will remain private as most in the sector have some sort of privacy claim/policy readily available to customers. This is an important part of the business model for attracting new customers, as 97% of consumers say data privacy is important to them.[16B]

Some weaknesses to the segment are that there are some concerns with sample stability and treatment from collection to testing[21], that consumers may not be receptive to invasive at-home testing[5], and that longevity itself is affected by an indeterminate number of variables which may be hard to prioritize and lead to inaccurate predictions.[17]

There also exist several opportunities for the segment. The greatest opportunity is expected advancements in wearable technology capable of conducting continuous non-invasive monitoring. These technologies will allow companies to collect more robust data sets to feed into their models and analyze correlations between multiple variables and longevity.

Personalized Recommendations for Longevity

In general, customers value personalization, as it is clear that the issue of nutrition is complex and marginally managed by generalized guidelines.[18] Different individuals exhibit large variations in their response to the same dietary input due to genetic and epigenetic factors, and even the composition of the individual's gut microbiome.[19]

Companies that are emerging to create these personalized recommendations for longevity fall into two main categories: AI recommendations and personal coaching.

In AI recommendations, customers are given lifestyle and wellness advice based on comparing test results with scientific literature, bioinformatics analysis, and nutritional databases. These recommendations can take the form of supplement suggestions, diet changes, recipes, and fitness ideas. InsideTracker is an example of a company providing AI personalized recommendations utilizing the

information from blood testing, DNA, and (if incorporated) wearable fitness tracking data. Recommendations from their app can be customized based on your personal goals and completion of daily actions.

In personal coaching, a professional works one on one with you to create a model that works for your lifestyle. This is already a commonly accepted model to achieve health goals such as weight loss and fitness training. One of the strengths of this model is that a subject matter expert is providing recommendations based on test results and is able to adapt to feedback from the patient to factor in aspects of their personal preferences and life situation. Another strength is that because it does not necessarily require cost-intensive technology such as AI systems it can be made available to a wider range of people. There is also potential for business models where this coaching is done remotely thus increasing customer access by becoming geographically independent. There are examples of this type of remote model in industries from fitness training to psychotherapy.

Some companies, such as Thriva[20] have created a modified version of personal coaching where a professional looks over the data from testing and then determines a plan for the consumer but there is no one-on-one aspect with their business model.

A weakness of this segment is that customer adherence to the prescribed product or diet plan is usually quite low. According to Dr. Angelina Zivkovic[21], Associate Professor at UC Davis and Associate Nutritionist, she has seen about 10% adherence to personalized nutrition advice with her personal clients. Her research suggests that people are more likely to continue diet and health recommendations when diagnosable health conditions confront them, often far past the point where these dietary changes could be considered preventative. This may

be particularly difficult for companies who are only conducting quarterly or less regular tests and may not be able to show perceivable effects on customers' longevity scores until years or more have passed.

Advancements in wearable technologies could help address the adherence problem as the technology may soon have the potential to provide real-time longevity recommendations based on daily actions. This real-time feedback often increases customer satisfaction and use.[23]

Moreover, wearables are becoming increasingly commonplace. According to a national survey conducted by the National Cancer Institute about 4,000 participants, roughly 26% of the US population used wearable devices to monitor health and activity in 2019. This increased to approximately 30% in 2020 with 70% saying they used their device either everyday or every other day. Consumers of wearable technology are typically young, educated, tech literate, and with higher incomes[23], which aligns with the demographic discussed in the consumer segmentation section above. That being said, there is serious competition in health and wellness-related applications. As reported by The Economist, there are > 400,000 health and wellness-related applications currently on app stores, with around 5 million downloads per day. Data further suggest that around 95% of the applications downloaded are deleted within 24 hours.[24] Therefore, full integration with applications that consumers already use such as Fitness Apps (Ex: Strava), Shopping (Amazon.com), Meal Planning (Ex: Noom), and Healthcare (Ex: GoodRx Care or Kaiser Permanente) is important. Gamification of the product experience may also help drive adherence to lifestyle or nutrition recommendations.[25]

Overall, customers will need to be convinced that the recommendations they pay for are differentiated and superior to simple generalized guidelines such as eating more vegetables, getting more exercise, and reducing stress.

Dietary Supplements

Dietary supplements targeting longevity make up a major segment of the market. While only a small component of the larger supplement market, which was valued at $111.9 B in 2021 alone, supplements offer a relatively familiar and regulatory-permissive form of treatment.[26] Some firms are solely producers of these supplements while others offer supplements in combination with their diagnostic and recommendation/coaching services.

Many supplements targeting longevity involve the compounds NMN (Nicotinamide mononucleotide) and NAD+ (Nicotinamide adenine dinucleotide) which have shown promise in improving cell health. NMN is a precursor to the formation of NAD+ in the body.[27] Both compounds have been shown to decrease with age and low levels are correlated with various symptoms of aging including cognitive impairment, inflammation, mitochondrial damage, and low energy levels.[28]

Companies that offer NMN in their supplements are facing an increased regulatory burden as of October 2022 when the FDA announced that NMN is to be investigated for approval to be classified as a drug. This has revoked its NDI (New Dietary Ingredient) status. Thus, prohibiting its sale in the US as a nutritional supplement. The request received by the FDA came from MetroBiotech International in 2021 which has invested heavily in research and development of NMN for use in its products.[29] This regulatory action will make supplement companies rethink the future of their offerings and other ingredients. Many retailers hope that the policy of "enforcement discretion" adopted for NAC (N-Acetyl-L-Cysteine) gets extended to NMN too.[29B] The wearables industry can face an NMN-like fate as regulatory frameworks for wearable technology are

under development. Wearables are monitored for ethical data collection and prevention of misuse by the FTC (Federal Trade Commission). So far, this industry has minimal to no liability exposure to the HIPAA and FD&C act. As of now, the FD&C has not classified wearables as medical devices. They are currently categorized as low–risk general wellness products. And HIPAA won't regulate them until they directly engage with customers without providing healthcare services or reimbursement for healthcare services. This may change as wearables hold the promise of non-invasive monitoring that can be integrated with the healthcare industry to offer healthcare services.

A handful of companies are also targeting longevity specifically but not personalizing the supplements to individual customers. NOVOS is an example of a firm that is not investing in significant personalization but rather offering supplement products that address the common factors of aging across all people. This business model differs from others in the space as it assumes that the factors of cellular aging are common across individuals and thus investment in the personalization of the product is not necessary in terms of adding value to their product. By eschewing a high degree of personalization, these companies may enjoy cost reductions from economies of scale, but risk weakening their underlying value proposition compared to more personalized products elsewhere in the market.

Business Model Summary and Comparative Analysis

There is clearly a wide range of business models and product features that have been assembled to target longevity through personalized nutrition. The selected companies below represent a segment of the market players who offer such services, have garnered funding, intellectual property, and their own unique approach. By better understanding where current players exist in the market, new entrants or incumbents may be better positioned to build a superior business strategy.
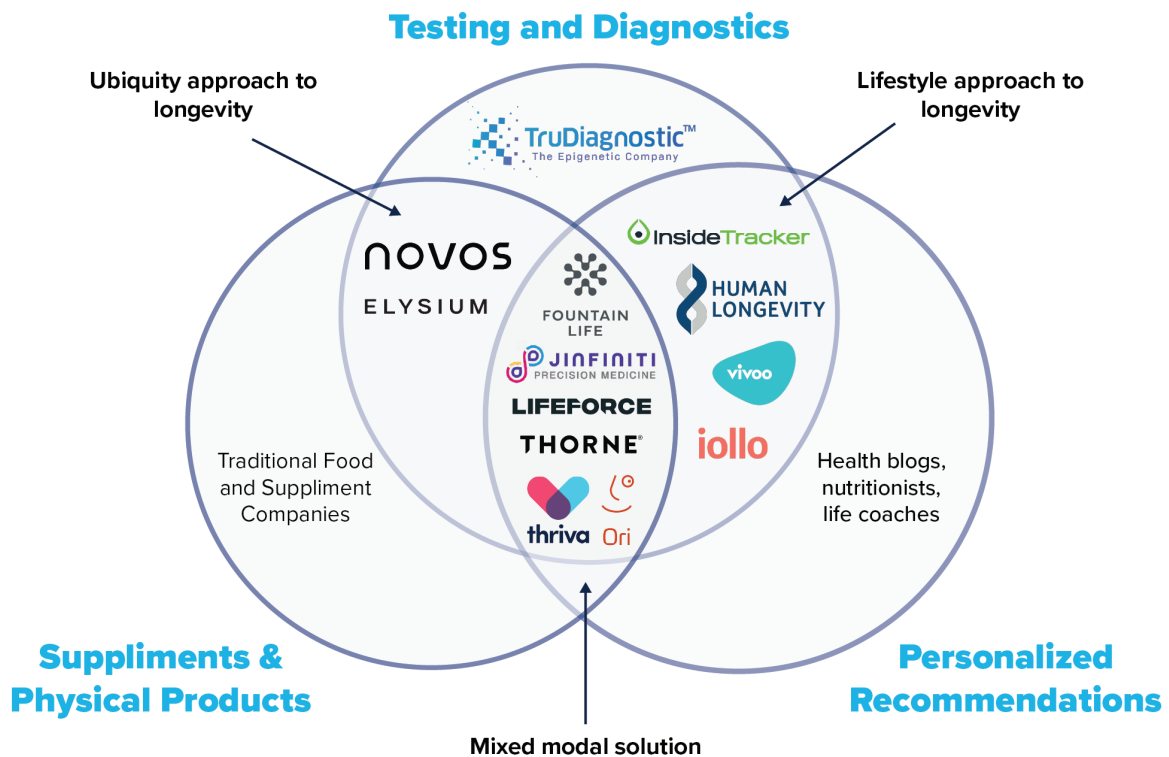
Selected Companies	Headquarters	Most Recent Valuation	Annual Customer Value*	Test Type	Human Interface	Supplements	Ai/Ml Recommendations	App Enabled	Wearable Intergration	Active Patents
INSIDERTRACKER	Cambridge, MA	$65M	$2,199	Blood	No	No	Yes	Yes	Yes	1
TRUDIAGNOSTIC	Lexington, KY	-	$499	Blood	No	No	No	No	No	-
JINFINITY	Augusta, GA	-	$2,400	Blood	Yes	Yes	No	No	No	-
IMAGENE LABS (ORI)	Singapore	-	$960	Saliva	No	Yes	Yes	No	No	2
IOLLO	San Francisco, CA	$7.14M	$1,308	Blood	No	No	Yes	Yes	Yes	-
THRIVA	London, UK	$32.57M	$326	Blood	Yes	Yes	No	Yes	No	Pending
VIVOO	Palo Alto, CA	$0.21M	$239	Urine	No	No	Yes	Yes	Yes	1
NOVOS	New York City, NY	$11.15M	$1,684	Blood	No	Yes	No	No	No	Pending
ELYSIUM	New York City, NY	$240M	$2,887	Saliva	Yes	Yes	No	No	No	5
THORNE (NAS:THRN)	New York City, NY	$247M	$560	Blood	Yes	Yes	Yes	Yes	No	4
HUMAN LONGEVITY	San Diego, CA	$45M	$25,000	MRI & Blood	Yes	No	Yes	Yes	No	3
FOUNTAIN LIFE	Naples, FL	$32.14M	$11,700	MRI & Blood	Yes	No	Yes	Yes	No	-
LIFEFORCE	Santa Monica, CA	$16M	$1,548	Blood	Yes	Yes	No	No	No	-

*Annual Customer Value (ACV) is used to express the expected revenues generated by a customer if they were to purchase the company's leading product at the recommended frequency over a year. These values serve as a baseline for understanding the affordability of the product/programs to the customer.

**Information is sourced from companies' websites and Pitchbook.com.

The subset of companies shown above have an impressive combined valuation of >$695M.

Expected annual spend for customers who remain on the product plans for an entire year (ACV) ranges from $239/yr (Vivoo) to $25,000/yr (Human Longevity). Most of the selected companies appear to have a mix of testing, recommendation, and product offerings, with testing methods primarily based off of blood tests for certain sets of biomarkers. The companies who appear to be charging the most (Human Longevity and Fountain Life) also include MRI scans in their product offering mix.

Personalized one-on-one coaching is provided by six of the thirteen companies selected, ranging from help lines to routinely scheduled sessions. Seven out of the thirteen companies offer supplement products that improve nutrition for the sake of longevity. These range from vitamin and mineral supplements to NAD+, NMN, and sirtuins. Only six companies provide AI derived recommendations and out of those only three have wearable integration.

Based on this comparative analysis, wearable integration and app enablement are the features most underserved in the market. In addition, all of the selected companies appear to be conducting their own testing in-house. It may be wise for a company to spin-off this capability to other players so to invest more aggressively in developing differentiated personalized recommendations or personalized physical products.

ETHICAL CONSIDERATIONS FOR THE FUTURE

Longevity and the dynamics of a longer-lived population is a major topic in the field of bioethics.[32] There are various concerns at the societal/population level and at the individual level. These range from customer concerns about data privacy, connecting lifespan with healthspan, to the possible repercussions of inequitable access to issues of sustained social support and financial planning for a longer-lived population. There are three areas where a developing business should target an answer to these concerns as the industry grows to maturity. First, longevity companies should focus on developing business models that provide wide access to a diverse range of customers. Second, companies should develop products that address quality of life combined with healthspan as a primary motivator for consumers. Third, firms must maintain transparent management of customer data privacy.

Equitable access is a major concern given the current high cost of these products. Although price is likely to come down in time (a common trajectory for many new products), many worry that only the wealthiest and most influential individuals or only certain demographics will be able to access longevity-enhancing treatments. With almost exclusive access, the wealthy could live longer and accumulate even more wealth - so-called "designer elderly" aptly named by Christopher Wareha, a bioethicist at Utrecht University.[30] This concern is shared by Dr. Mariette Abrahams, CEO of Qina, an online hub for data and insights on personalized nutrition, who said,

> " The challenge around affordability and accessibility
> always needs to be highlighted or we will risk worsen-
> ing health inequality."
> -Dr. Mariette Abrahams, Qina

Genomic Study Participation by Region
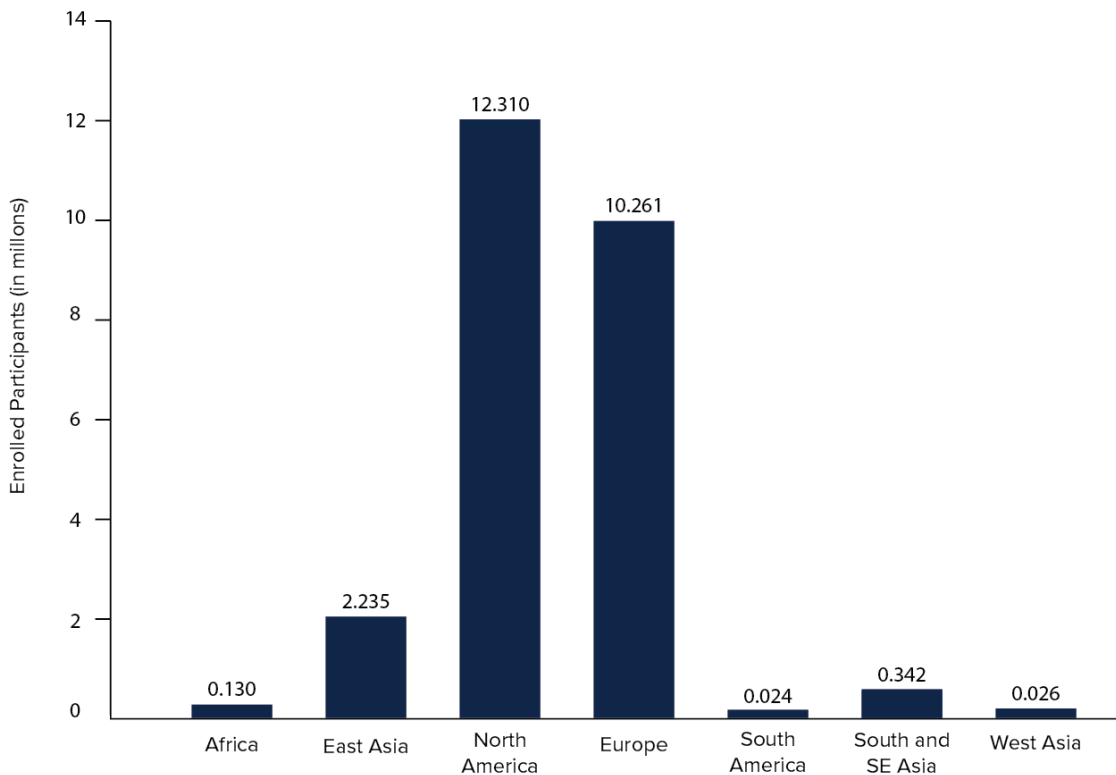
Another concern is that there is a lack of diversity in genomic research studies. The overwhelming majority of genomic research to date has been conducted with participants of North American and European ancestry. This leaves an enormous gap in the data set and undermines the basis of the predicted benefits from genomic medicine (and personalized nutritional research based on it) being used equitably to develop solutions for and provide access to all peoples of the world.[34]

There are also a number of ethical concerns tying lifespan with healthspan. First and foremost are quality of life and support needs. If healthspan, in terms of being mentally and physically able, becomes disjointed from longevity we risk sustaining life without ensuring quality of life. This leads to the issue of support for an aging population. It is possible that we could exacerbate the issue of a growing population of
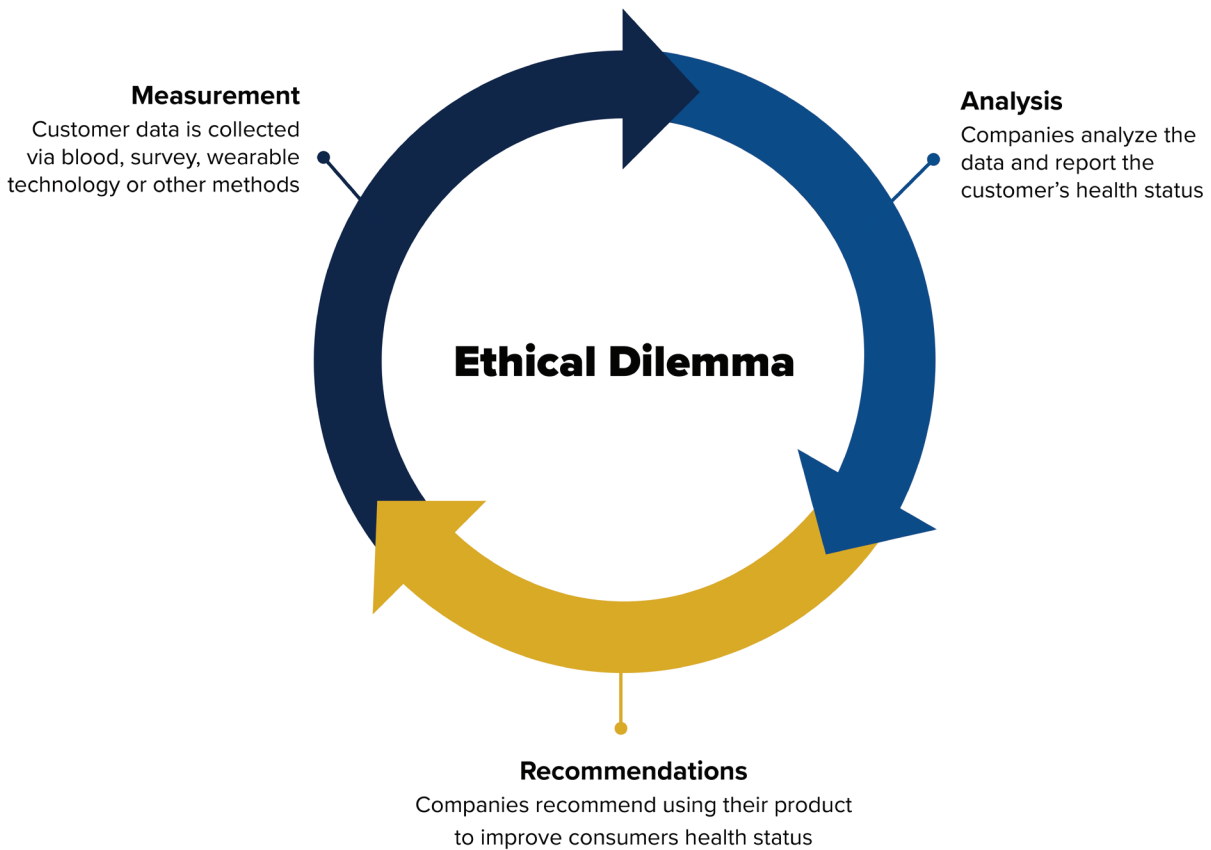
seniors without a large enough younger population to support and care for them. It is not clear that existing support infrastructure, from the modern healthcare system to financial planning such as social security and pension funds, has the capacity to support a larger population of longer-lived people while also providing dignity and a decent quality of life.[35]

Given the number of issues involved in the personal and society wide experience of supporting longer-lived populations, it is not clear that it would be ethically or practically justifiable to separate lifespan from healthspan and to market treatments that increase lifespan without accounting for healthspan. Fortunately, most treatments offering an extension of life do so through improving the health of the individual and thus inherently tie healthspan and lifespan together.

Integration with the healthcare system is an opportunity for longevity companies to provide personalized solutions hand in hand with physicians to improve both healthspan and lifespan. TruDiagnostic, Fountain Life, and Human Longevity, are great examples of companies already taking this approach. Health insurers could be interested in cost savings associated with promising methods for improving one's longevity, which often involves decreasing the likelihood of chronic diseases and subsequent medical costs. Furthermore, health insurers may also be able to exploit advances in diagnostic capabilities, enabling more accurate and precise measures of an individual's health risks.

There is promising potential for preventative healthcare through effective personalized nutrition to greatly benefit public health by easing the burden of the enormous cost of non-communicable diseases such as cardiovascular disease, cancer, and diabetes. These diseases contribute to approximately 70% of annual deaths and associated costs of $17 trillion. More than 50% of an individual's healthcare expenses are incurred in the final quarter of life as health deteriorates with age.[36]

Use in healthcare and insurance, however, raises significant questions around data privacy. This is a special concern for cloud based applications and wearable products but is common to all. Personalization to any degree requires measuring and storing vast quantities of personal health data. This is a major consumer pain point resulting in a barrier to the adoption of a product. A 2022 survey conducted by the American Medical Association reported that 92% of customers believe that their medical data is private and should not be for sale without their consent to third parties such as corporations or insurance providers. A further 75% of customers reported being seriously concerned about their ability to protect the privacy of their personal health data. 59% of respondents also cited a concern that their personal health data could be used to discriminate against them. Consumers reported being much less comfortable giving their data to a technology company than to their health provider. The idea that businesses that collect, store, and use personal health data should be accountable to the law was also supported by 94% of respondents.[37]

Measurement
Customer data is collected via blood, survey, wearable technology or other methods

Analysis
Companies analyze the data and report the customer's health status

Ethical Dilemma

Recommendations
Companies recommend using their product to improve consumers health status

Another question that arises is how companies will address the ethical quandary of selling products while they are still testing the products' efficacy. The value of personalized recommendations for longevity is a challenging claim to verify because studies on longevity are incredibly expensive, risky, and take many years to complete. In addition, the presence of "bad apples", i.e. companies that lack true expertise, and thus make poor products and recommendations could damage public opinion of the market. More ethical dilemmas arise if a company is responsible for and profits from all steps in the process. From analyzing and diagnosing the issues affecting longevity, selling its own product to fix the problem, and then taking the measurements which purportedly gauge the effectiveness of the said product. This is a central reason

drug companies cannot prescribe their own medicines to would-be patients. This is where the potential value arises in establishing a form of third-party validation.

One group taking on this role is Rejuvenation Olympics which works in partnership with TruDiagnostic to independently verify data analysis through tracking data submitted by program participants as well as long-term studies such as the DunedinPACE study.

It is important to be conscious of these ethical questions and new ones that are sure to arise as these technologies and markets develop. To address these, a longevity company should focus on providing wide access, address quality of life and healthspan as a primary motivator for consumers, and ensure transparent management of customer data privacy.

Ethical Issues of Longevity Enhancing Products and an Aging Population

Issue	Ethical Question
ACCESS DISPARITY AND ITS SOCIAL REPERCUSSIONS	• How can equitable access to these benefits be ensured? • What could be the effects of some nations/demographics outpacing others in health outcomes?
ECONOMIC BURDEN AND THE INCREASED NEED FOR LIFESPAN INFRASTRUCTURE	• As the population of individuals over 65 increases, will there be sufficient social and infrastructure support to sustain the quality of life? • Can financial instruments like pension plan funds and social security support people living longer lives?
IF QUALITY OF LIFE ≠ LENGTH OF LIFE	• Is it ethical to increase lifespan without increasing healthspan?
DATA PRIVACY	• A critical consumer pain point and potential basis for discrimination.
POTENTIAL ECONOMIC BENEFIT OF IMPROVED HEALTHSPAN	• Potential to alleviate issues of autonomy, consent, dignity, reduce support costs and burden on the healthcare infrastructure of aging individuals.

SUMMARY

Our understanding of the cellular mechanisms of aging has advanced significantly in recent years and led to the creation of a personalized nutrition for longevity market.

The current market for personalized nutrition aimed toward longevity is in its infancy and is seeing a myriad of companies joining with various approaches. Some provide metabolite and biomarker testing, others generate actionable recommendations, and others offer physical products or supplements to achieve the goal of extending life.

It is clear the greatest value-generation component of a longevity company is its ability to create personalized recommendations based on biological testing. Biological data alone is difficult for consumers to take action on, limiting adoption. Testing also lacks defendability as many players have emerged offering identical measures. Firms offering supplements for longevity will not see mass-market adoption due to the supplement market already being well-developed and affected by negative consumer perceptions and regulatory pressures. Furthermore, the manufacturing of personalized supplements faces significant operational challenges of scale. Therefore, businesses in the space should focus on developing the core competency of recommendation creation and making it as easy as possible for customers to stay engaged with their data and take action based on it.

To do this, longevity businesses should:

- Target customers earlier in life (30-50 years old).

- Address the primary motivations of the target consumer personas.

- Drive consumer adoption and continued adherence through testing and monitoring solutions that are robust, non-invasive, and easily accessed.

- Create truly differentiated recommendations for customers via protected business processes and data analytics. To drive adherence, customers need to experience better outcomes from personalized recommendations than general dietary guidelines.

- Integrate with existing applications and healthcare providers.

- Build consumer trust through strong IP, third-party verification of claims and transparent management of data privacy.

Overall, consumer interest in personalized nutrition for longevity will continue to see growth and become an important part of a new paradigm shift in preventative healthcare. There is a clear market opportunity for businesses offering solutions in this space.

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