Competing Risks

Investing in Sickness Rather Than Health

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Introduction

Fighting disease is deeply ingrained in American medical culture. The steadfast support for medical research—fewer than one in ten Americans would cut research to reduce the deficit[1]—underpins a national belief that curing cancer and other major diseases today will mean longer, healthier lives tomorrow.

During the last half century, faith in the disease-specific research model has rewarded the U.S. with significant returns on investment in life expectancy and better health. But, there are troubling signs that targeting diseases in isolation may be outliving its usefulness. Prevalence of major chronic conditions—high blood pressure, heart disease, diabetes, cancer, and stroke—is increasing.[2–4] This trend is fueled by a combination of higher rates of obesity and gains in life expectancy, which in turn will be driven by innovations in medical technology that allow people to live longer with chronic conditions.[5]

As a result, disability rates also are increasing, suggesting the average length of a healthy life span—defined as length of life lived without disability—may decrease in the future. For example, the authors estimate that life expectancy for 65-year-olds will grow by about a year between 2010 and 2030 to 20.1 years, but expected years of life with a disability for 65-year-olds during the same time will rise even more, from 7.4 years to 8.6 years.[5]

Likewise, disability rates have increased for younger Americans, especially 30- to 49-year-olds, which could have adverse consequences for public financing of disability insurance, Medicare, and Medicaid.[6] And though attacking diseases individually has extended life for younger and middle-aged people, competing risks from other illnesses make such progress more difficult for older people.[7]

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Is It Time for a New Model?

As people age, they are at less risk of falling victim to a single isolated disease. Instead, competing causes of death more directly associated with biological aging—for example, heart disease, cancer, stroke, and Alzheimer disease—cluster within individuals as they reach older ages. These conditions elevate mortality risk and create the frailty and disabilities that accompany old age.[8]

Nonetheless, most of the U.S. medical research and healthcare delivery system remains focused solely on specific, acute, episodic illnesses. The best metaphor is NIH, which divides its budget among its major institutes by focus on a particular disease or body system. As Americans age, such strategies will yield diminishing returns, because success in areas like heart disease may mean more time lived with cancer, dementia, and disability. This does not imply the disease model is a failure. Rather, Americans are victims of their own success, as they face a future where they live longer with more disease and quality of life impairments.[9]

The point is that the model must change. Continuing the same path of disease-specific biomedical innovation seems likely to lead to a destination where research investments increasingly will yield more sickness and disability and less health. At the same time, recent scientific advances suggest a new research course for consideration: slowing the aging process itself—known as senescence—to extend healthy life spans and compress sickness and disability toward the end of life.

What a Drag It Is Getting Old…

Aging is a major risk factor for most of the chronic conditions—heart disease, cancer, and diabetes, for example—that curtail longevity, self-sufficiency, and health. And, these conditions will become progressively more widespread as the elderly population grows. As discussed earlier, treating chronic diseases in isolation is a losing proposition. New research findings suggest that aging itself is a modifiable risk factor: that it may be possible to moderate the aging process to delay onset of diseases associated with aging.

One possible mechanism is to target cellular senescence to delay or prevent multiple age-related chronic diseases as a group, rather than one at a time; some believe successful translation of research to forestall cellular senescence into clinical treatments could transform health care.[10] The aging field already is successfully experimenting with interventions to delay aging in animals. At the same time, new pharmacologic interventions with the potential to extend healthy life spans and promote resilience in experimental animals are being tested, including rapamycin, JAK1/2 inhibitors, senescence-associated secretory phenotype, and protein aggregation inhibitors.[11]

What this means is that just as the disease model is showing diminishing returns, researchers are starting to make progress in the biology of aging. There are tremendous opportunities for research on the genetics of human aging, particularly given the huge trove of information on human biology and pathobiology and the rapidly developing knowledge of the human genome.[12]

Delayed Aging: Not Just Science Fiction

One can often see the potential of a new medical technology by looking at what the private sector is doing. The who's who of the technology intelligentsia—Larry Page of Google, Arthur Levinson of Apple, J. Craig Venter of Human Longevity, Inc., Larry Ellis of Oracle, to name a few—are investing serious money, hundreds of millions of dollars, to advance promising research to delay aging. And some of that research has moved beyond the realm of science fiction into reality.

Scientists are extending the healthy life span of invertebrates and mammals by manipulating genes, altering reproduction, modulating the levels of hormones that affect growth and maturation, and altering insulin signaling pathways. Although many of these interventions are unlikely to be directly applicable in humans, they may lead scientific inquiry toward effective ways to delay aging in people.

For example, reduced signaling of insulin-like peptides was proven to increase the life span of mammals.[13] Other researchers have concluded that the offspring of parents with exceptional longevity have a lower rate of dementia than offspring of parents with usual survival, opening a promising investigative path into whether genetic factors associated with longevity may protect against dementia and Alzheimer disease.[14]

Most centenarians appear to handle chronic diseases better than others, averting disability until well into their 90s. Several studies have shown that centenarians have many disease-associated protective genomic components, suggesting an important role for protective variants that can possibly slow the rate of aging and decrease the risk of age-related diseases. Such genetic models may aid in discovering new target genes and pathways related to aging and longevity.[15]

Economic and Health Dividends of Delayed Aging

To illustrate the potential impact of innovation to delay aging, simulations are conducted with the Future Elderly Model (FEM), an established economic–demographic microsimulation that has been used to study a wide variety of health policy questions with support from NIH, the Centers for Medicare and Medicaid Services, the MacArthur Foundation, and the Department of Labor.[16–19] The FEM follows the evolution of individual-level health trajectories and economic outcomes, rather than the average or aggregate characteristics of a cohort. This enables assessment of how lifetime health outcomes will change as underlying relationships among disease, disability, and spending are manipulated.

A "delayed aging" scenario that assumes successes with animal models are translated into humans was implemented. In other words, all age-related chronic diseases and disability are delayed simultaneously as a group instead of delaying single diseases one at a time. Specifically, the scenario modifies the health transitions of the FEM to reduce the probability of onset of heart disease, cancer, stroke or transient ischemic attack, diabetes, chronic bronchitis and emphysema, hypertension, all-cause mortality, and disability. This probability reduction is phased in gradually until the full reduction is achieved in 2030.

Lifetime health and spending with these modified health transition parameters and measured outcomes were then simulated at the individual and population levels. This optimistic but plausible scenario implies that scientists could translate research on the biology of aging into therapeutic interventions to extend human longevity and compress disease and disability into a shorter period at the end of life. Such a scenario has been explored in more detail in previous work,[20] and more detail about its assumptions can be found in the Appendix (available online).

Compared with the status quo scenario—leaving current disease incidence and mortality trends unchanged—the delayed aging scenario results in tremendous gains in healthy life spans, slightly lower per capita medical spending, and only modest overall increases in total medical spending in 2030 (Table 1).

For example, under the delayed aging scenario, average life expectancy for 51-year-olds would increase 7.1 years more than under the status quo, from 32.5 years to

Table 1. Health Indicators and Medical Spending Estimates for the Population Aged 51 and Older in 2030 in Various Scenarios

		Difference with status quo	
Variable	**Status quo**	**Delayed aging**	**Exercise intervention**
Life expectancy at age 51	32.5	7.1	0.7
Nondisabled	20.9	6.4	1.7
Disabled	11.6	0.7	−1.0
Total population (millions)	128	134	129
Average age	68.2	1.0	0.1
Chronic disease and disability prevalence (%)			
Heart disease	30.7	−1.0	−1.3
Stroke	11.9	−0.4	−1.1
Diabetes	32.9	−1.7	−1.1
Disabled	27.8	−6.2	−3.8
Living in a nursing home	2.8	−0.2	−0.1
Per capita medical spending ($2014 thousands)			
Medicare	11.7	−0.9	−0.3
Medicaid	3.3	0.0	−0.2
Total spending	26.8	−0.9	−0.6
Population medical spending ($2014 billions)			
Medicare	1,494	−42	−32
Medicaid	419	22	−19
Total spending	3,431	59	−51

Note: The first column of the table presents health indicators and medical spending projected by the Future Elderly Model's baseline scenario in year 2030. The last two columns present differences in these outcomes between two alternative scenarios, the Delayed Aging and Exercise Intervention scenarios, and the baseline projections. Disabled is defined as having one or more limitations in instrumental activities of daily living, having one or more limitations in activities of daily living, living in a nursing home, or a combination of the three.

almost 40 years. Similarly, the share of the disabled population aged 51 years and older would decline more than 6 percentage points to about 22%, down from about 28% under the status quo.

Looked at another way, the number of nondisabled Americans aged 51 years and older in 2030 would increase by more than 23 million people under the delayed aging scenario, from about 83 million people in 2014 to about 106 million in 2030 (Figure 1). By 2030, there would be 13 million more nondisabled Americans in the delayed aging scenario than the status quo. Looking further ahead, the FEM projects that this difference would reach 25 million people by 2050.

On the medical spending side, despite producing a higher average age, the delayed aging scenario would actually decrease per capita medical spending slightly by about $900 (in 2014 dollars) in 2030 from the status quo

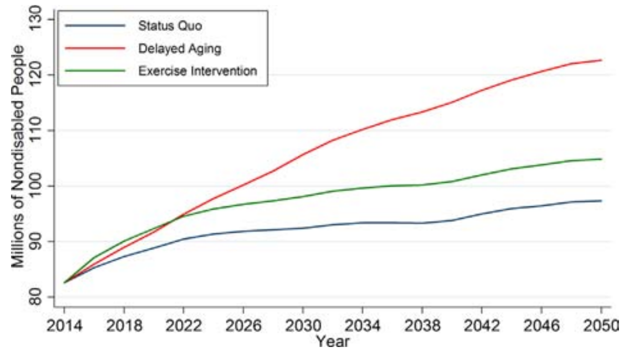

Figure 1. Millions of non-disabled Americans aged 51 and older in various scenarios, 2014–2050.
Note: The figure shows the number of Americans aged 51 years or older projected to be not disabled according to the various scenarios. Disabled is defined as having one or more limitations in instrumental activities of daily living, having one or more limitations in activities of daily living, living in a nursing home, or a combination of the three.

projection of $26,800 annually, whereas population medical spending would increase by about $59 billion from the status quo estimate of $3.43 trillion.

Turning Delayed Aging Into Reality Would Take Time

As is always the case with scientific advances, the trajectory of biomedical innovation to delay aging, even if embraced fully by policymakers and researchers, would be uncertain and uneven. The delayed aging scenario, though based on informed and grounded predictions, provides an optimistic example of possible outcomes from shifting the focus of biomedical research from specific, individual diseases to unraveling, understanding, and, ultimately, delaying the aging process.

And, as the possibilities of delayed aging are explored and pursued as a bold prevention strategy, one shouldn't lose sight of existing low-tech but effective prevention activities that could produce meaningful and almost certain health and economic gains for Americans. In the near term, one of the best investments Americans can make to live longer, healthier lives is as low-tech as it gets—regular physical aerobic and muscle-strengthening activity—otherwise known as exercise!

Exercise Is an Anti-aging Intervention

Compared with what is medically recommended and compared with the rest of the world, Americans simply don't exercise enough. Only about one in five Americans aged 18 years and older in 2013 met physical activity guidelines for both aerobic and muscle-strengthening activity, according to the Centers for Disease Control and Prevention (CDC).[21] And, based on 2011 WHO data, 41% of Americans aged 15 years and older were considered "inactive"—a relatively high level compared with other developed countries like Germany (28%), France (32.5%), and Canada (33.9%).[22]

The lack of exercise in the U.S. has serious individual and population health consequences and economic burden. For example, research[23] shows that a lower level of cardiorespiratory fitness has an inverse impact on health benefit and is significantly associated with higher risk of all-cause mortality and coronary heart disease/cardiovascular disease in healthy men and women. Compared with participants with high cardiorespiratory fitness, those with low cardiorespiratory fitness had higher rates of mortality and coronary heart disease/cardiovascular disease events—up to 1.7-times higher mortality rate and 1.6-times higher rate in coronary heart disease/cardiovascular disease events.[23]

Other research[24] indicates that physical inactivity in the U.S. is responsible for about 7% of the burden of disease from coronary heart disease, 8% of Type 2 diabetes, and 12% of both breast cancer and colon cancer. Moreover, the tremendous health benefits of exercise only increase as people become more active. The American guidelines for physical activity reflect the dose–response relationship concept between volume of completed physical activity and exercise and achieved health benefits, advising that health benefits are gained with 150 minutes a week of mild to moderate physical activity but that more health benefits accrue with 300 minutes a week of moderate physical activity. All adults—regardless of age, race, ethnicity, and weight—benefit from exercise and have lower rates of early death and chronic diseases when they are physically active.[25]

Similar to the delayed aging scenario, an exercise scenario was implemented in the FEM to illustrate the impact of increasing physical activity and the benefits to U.S. population health through reduced risk of chronic diseases and improved physical health status. To implement the exercise scenario, nondisabled individuals aged 51 years or older who are most likely to hardly ever or never take part in sports or vigorous physical activities were first identified in the FEM simulation.

In 2014, this corresponds to 43 million people. The scenario then made them exercise; that is, health transition probabilities were altered to provide them with the benefits of moderate to vigorous exercise identified by large RCTs and observational studies.[26–28] The simulation proceeded similarly for each year, in effect providing low-exercising Americans with the life-time benefits of vigorous exercise. A full review of this scenario and the literature consulted are provided in the Appendix (available online).

As shown in Table 1 and Figure 1, the health and economic benefits of an exercise intervention, although not as great as in the delayed aging scenario, are substantial. For example, when comparing the exercise scenario with the status quo, the number of nondisabled people aged 51 years and older in 2030 would be higher by about 5.7 million, and both per capita and overall total medical spending would decline modestly.

Implications

Despite growing evidence that the disease-specific model of biomedical innovation is reaching its limits, shifting the nation's real and intellectual capital to a delayed aging focus will be no minor task. There are strong vested interests in the current model. With some notable exceptions,[29] the U.S. insurance model is not designed to pay for preventive services—like walks—that might keep people healthy, but rather for treatments when they are sick. In addition, some commentators have inappropriately argued that current life expectancy is long enough: an ironic position given one could have made such an argument when life expectancy was 50 years, not 80 years.

But, the time has come for the U.S. to distance itself from the rhetoric and colored ribbons of conquering individual diseases to begin a real discussion about how best to help Americans achieve longer, healthier, and more productive lives. In the meantime, a brisk, daily, 45-minute walk for about 43 million Americans wouldn't hurt.

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Appendix

Supplementary data

Supplementary data associated with this article can be found at http://dx.doi.org/10.1016/j.amepre.2015.12.005.