PROGRAM ON THE GLOBAL DEMOGRAPHY OF AGING

Working Paper Series

The Centrality of Variability

How society shapes patterns of aging

Lisa F. Berkman, Ph.D.
Maria Glymour, ScD.

Harvard School of Public Health
677 Huntington Avenue
Boston, MA 02115
lberkman@hsph.harvard.edu
617 432-3915
fax 617 432-3132

mglymour@hsph.harvard.edu
617 998-1022

PGDA Working Paper No. 4: http://www.hsph.harvard.edu/pgda/working.htm

The views expressed in this paper are those of the author(s) and not necessarily those of the Harvard Initiative for Global Health. The Program on the Global Demography of Aging receives funding from the National Institute on Aging, Grant No. 1 P30 AG024409-01.

The Centrality of Variability

How society shapes patterns of aging

Lisa F. Berkman, Ph.D.
Maria Glymour, ScD.

Harvard School of Public Health
677 Huntington Avenue
Boston, MA 02115

lberkman@hsph.harvard.edu
617 432-3915
fax 617 432-3132

mglymour@hsph.harvard.edu
617 998-1022

Increasing variability is a hallmark of aging populations. Although demographic trends are often described in terms of average experiences, in this paper we argue that variability in the health experiences of older men and women is key to understanding aging. The variations in outcomes among older people are not merely nuisances obscuring the more salient averages and trends. The deviations from the mean are a central part of the story: the patterning of these variations reveals factors that influence health for everyone and indicates what sort of advances in healthy aging might be possible under optimal circumstances. Quinn, in an important piece on the economic status of the elderly gave us all sage advice relevant to many issues about the health and well-being of older men and women. "Never begin a sentence with 'the elderly are...or the elderly do'. No matter what you are discussing, some are and some are not, some do and some do not." He went on to warn us not to ignore the enormous diversity that comes with aging and always to "beware the mean" [1].

How will we age 50 years from now? What will we need to do to provide opportunities for more of us, from a population perspective, to experience optimal aging and longevity? While some investigators emphasize individual patterns of aging to point out the idiosyncrasies and complexities of the way people age, we believe that a great deal of what initially may seem like random variability is in fact socially patterned by opportunities for social interaction and intimacy, by economic and educational experiences, by exposure to severe social and physical stresses. We have all seen people who grow old suddenly or seem much older than their chronological age. Conversely, we know people who look and act in vibrant and vital ways, who seem resilient to the challenges they face late in life. Our aim is to show some of the ways in which society has shaped these patterns of aging.

We are going to explore the ways in which social conditions shape variability in two health outcomes we think of as prototypical of the aging process. The first is life expectancy, constructed from birth cohort mortality patterns. We will illustrate how patterns and trends in life expectancy reflect our past social investments in the population health and wellbeing. The second aging outcomes we focus on are classical biomarkers of aging. These are physiologic characteristics that many people think of as the most sensitive indicators of the aging process: among these are measures of metabolic function, glucose metabolism, blood pressure regulation, pulmonary function, and DHEAS. We will discuss findings related to telomere activity and hormonal levels

What will we need to do to provide opportunities for more of us, from a population perspective, to experience optimal aging and longevity?

such as telomerase as an illustration of how social conditions affect individual physiologic aging at the cellular level.

Changes in life expectancy and health expectancy: The demography of survival

One of the most common indicators of health and aging used in epidemiology and demography is life expectancy. Life expectancy measures are derived from applying current death rates for men and women in specific age groups to come up with a summary estimating how long we can expect people to live in the future. The assumption is that death rates today will be applicable in the future. Because death rates historically have changed rather quickly, projections are not always very accurate. For example, demographers debating issues around social security often scramble to get what they believe are accurate projections. However, small differences in death rates or more rapid declines in mortality can lead to rather large differences in projections about the numbers of older men and women in 2010, and are even less reliable when we predict out to 2020 or 2030.

Measures of life-expectancy (LE), however, do give us a relatively straightforward summary statistic that is valuable when compared across countries or populations over time (especially when looking historically or at current patterns). In the US, life expectancy in 2002 was 77.3 years at birth and 18.2 years at age 65. The latter number means that if a person survives to age 65, he or she can expect to live, on average, another 18.2 years. This summary statistic, however, hides large differences in life expectancy across gender, racial and ethnic groups. Life expectancy for white women was 80.3 years at birth and 19.5 years at age 65. For African-American men those same numbers were 68.8 and 14.6. Life expectancies for black women were 75.6 years at birth and 18.0 years at age 65. For white men, LE at birth and age 65 were 75.1 and 16.1 respectively. Thus, even a preliminary "unpacking" of average life expectancy reveals a difference of 11.5 years at birth and about five years of added life at age 65 between white women and African-American men.

To what extent do social and economic investments made at the national level have a major health impact, especially on the current generation of older men and women?

Equally startling are improvements in LE that have occurred over the last century and those predicted based on data from the last decade or two. Life expectancy in the US in 1900 was 47.3 years; by 1950 it leaped 20 years to 68.2; by 2000 it was 76.7, an improvement of almost 30 years. If one looks at the long-term improvements in life expectancy, the majority of "added" years in the first half of the century occurred because of improvements in infant and childhood mortality, maternal mortality and control of infectious diseases as a result of major public health efforts at the turn of the century [2]. However, over the last several decades we have also achieved substantial improvements in life expectancy for older people. Between 1980 and 2000, life expectancy for 65 year-olds improved 1.6 years. In these decades, increases were greatest for men, who gained almost two years These gains narrowed the gender gap slightly, but older women can still expect to live three years longer than men.

Living longer may be problematic if older men and women are spending many of those years disabled or with many chronic conditions. Optimally, we want a high quality of life in later years. Scientific opinion on whether increased life expectancy would translate into increased old-age disability have evolved over time. In the early 1980s, investigators such as James Fries [3] anticipated a "compression of morbidity" accompanying increases in life expectancy. Early responses to this provocative idea contradicted this notion: health surveys indicated that people were living longer but instead had substantial levels of disability for many of those years. In fact, in a well-known Daedelus volume, "Doing better and feeling worse", investigators outlined how life-saving technologies for many diseases produced survivors with serious chronic conditions and disability.

In looking back over the last several decades, demographers have realized that the changes have been complex and trends have actually changed in the last ten years. For instance, Crimmins [4] and Robine [5,6] concluded that across several countries including the US, active life

expectancy had not increased relative to total life expectancy when moderate or light levels of disability were included in disability measures. The opposite was true if investigators used measures of major disability. Using this standard indicated that disability-free life expectancy improved along with life expectancy. Recent data suggest that the percent of men and women ages 30–75 with limitations in activity increased between 1970 and 1980. Changes were not consistent for those 75 and over. In contrast, during the decade from 1980–1990, the percentages of men and women with limitations dropped for almost all age groups. Information on disability and mortality are combined to estimate active or disability-free life expectancy. Crimmins [7] reported that life expectancy free of disability improved more in the decade of the 1980s than the 1970s. This was true looking at life expectancy from birth as well as from age 65, but not for those 85 and over. Active life expectancy among the oldest old apparently changed very little in the decade from 1980–1990. Recent data suggest that rates of cognitive impairment are also decreasing over the last decade or so [8]. These temporal changes have not closed the gender gap: women have both longer disability-free life-expectancy and longer life expectancy with disability. Women are also more likely to spend time in an institution.

There are also marked social inequalities in disability-free life expectancy. Although data are limited, recent studies show that African-Americans, especially those living in urban poverty areas, have strikingly shorter active life expectancy than whites or African-Americans living in non-poverty areas. Geronimous [9] examined life expectancy starting at age 16. Active life expectancy measured by having any limitation was 52 years for US white women and 43 for US black women. However, active life expectancy was only 39 for black women in Harlem, central Detroit, or the south side of Chicago. Even in non-poverty urban areas such as Queens in New York and economically better parts of Detroit and Chicago, the average did not approach that of US whites. White women living in poverty areas generally did better than the US black average of 43. Their active life expectancies ranged from 42 in Appalachian Kentucky to 49 in west North Carolina and south central Louisiana. Thus, both poverty area and race were associated with variations in active life expectancy.

It does not appear that increases in life expectancy have brought us many more years of living with severe disability.

Similar variations in life expectancy have been observed between occupational grades in other countries. Cambois [10] reported that both disability-free and total life expectancy increased in the French population between 1980 and 1991, but improvements in disability-free life expectancy were larger. Increases were relatively similar across socioeconomic groups during this decade, though, so the class differences in health were preserved. The authors note that inequality in mortality risk when coupled with the increased prevalence of disability of manual workers actually heightens life cycle inequalities in health. French men in higher grades of employment have a long life expectancy and a compressed period of disability compared to less advantaged men. Manual workers lived 5.4 years less than managers in 1991 and have 1.4 more years of their lives spent with a disability.

Three important findings emerge from these studies and are generally applicable to the US and to other industrialized countries. First, in recent decades both mortality and disability rates have dropped for older men and women. With the somewhat larger decreases in disability apparent over the last decade or so, disability-free life expectancy has increased at the population level. Secondly, these gains have been experienced by men and women across virtually all social classes and racial/ethnic groups. Often, slightly larger absolute gains have been observed among those in more socioeconomically advantaged groups. Third, while population health has improved, inequality has been maintained across socioeconomic strata with socially and economically disadvantaged men and women persistently worse off. Furthermore, the gap between rich and poor has not narrowed and, depending upon which indicators are used, may actually have increased in both absolute and relative terms.

The good news from the perspective of population aging is that it does not appear that increases in life expectancy have brought us many more years of living with severe disability. Even though the onset of many specific diseases may not have changed dramatically in the last decades, the consequences of disease, e.g. mortality and disability, have decreased [11]. This positive outcome must not mask the variability in outcomes among people with different social and economic positions. In the next section, we explore the extent to which social and

economic investments made at the national level have had a major health impact, especially on the current generation of older men and women. We speculate that much as investments in public health made at the turn of the century helped to control infectious diseases and curb infant and maternal mortality, social and economic investments initiated in the first half of the twentieth century may have had broad impacts on the successful aging of the current generation of senior citizens.

Do public social investments impact health and aging?

The trajectory of health or ill-health experienced by the elderly does not begin at age 65: experiences accumulated throughout life set the stage for well-being in old age. The majority of elderly in America today were born between the two World Wars. They may have been immigrants during the large waves of migration from Europe, crowding into tenements in large cities. Those who celebrate their 80th birthdays in 2005 were born during the presidency of 'Silent Cal' if they were born in the US. This was a time of prosperity for the rich but nascent troubles for farmers, when agriculture still dominated the economy and women were gaining greater formal political power and rights. In the South, mob lynchings of blacks were declining but still constituted an important form of social control [12] and southern blacks responded to changing economic and social conditions by migrating north in record numbers[13]. Older people today may have been mid-western children during the Dust Bowl years when bad weather and planning conspired to deprive millions of their prime livelihood; hunger was a reality for the nation's poor. Today's elders entered adulthood as the nation entered WWII. After the war, they encountered a prosperous economy but many faced continued but increasingly contested discrimination. These people's lives, from infancy, childhood, working years, and into old age, have been shaped by the social upheavals occurring in the US in the twentieth century.

The government responded to many of the social conditions of the time with investments in public education, regulation of working conditions, federal housing initiatives, employment and income insurance programs. Further economic progress and extensions of civil rights reflected both secular developments and government intervention. Good health and long lives may be among the most dramatic and unexpected consequences of these social policies. Although Medicare and Medicaid represent large intentional investments in medical care, the inadvertent health benefits of investments in social goods may be more important factors in shaping how older men and women are aging today.

What were the major health-relevant social changes in the twentieth century? Educational attainment, working conditions, minimum income and income stability, and housing conditions all changed profoundly between 1910 and 1980. Civil rights laws in the second half of the century gave rights and opportunities to many who had been denied earlier benefits. Because there has been so little research directly addressing the health consequences of social policies, we are not in a position to give compelling evidence about which social or economic policies had the largest health effects. One might suspect work related policies could have profound health effects. Working conditions changed substantially during the twentieth century due to both public and private efforts to improve occupational health and safety—many improvements directly and successfully targeting reducing fatalities. Between 1933 and 1997 deaths from unintentional work related injuries declined by 90% [14]. Improvements in working conditions likely also affected long-standing chronic conditions and risk of disability. A number of labor protection policies introduced or universalized in the twentieth century, such as workmen's compensation, unemployment and minimum wage standards, also seem likely candidates for directly affecting health outcomes in workers. Although implemented to buffer workers from poverty, these policies may have long term benefits in terms of survival and freedom from disability in old age. Similarly, we might examine the health impacts of housing policies that regulated physical hazards in homes or promoted homeownership by increasing mortgage availability. Some policies may have been harmful, e.g. home loan programs that served to stabilize racial segregation in neighborhood housing. We believe that the variations in life expectancy and health in old age observed in current cohorts of elderly may reflect the health consequences of differential social investments. Identification of the health impacts of these policies would give us valuable clues as to the social and economic conditions that produce variations in aging, survival to old age and health status of older men and women.

As an illustration of how we might explore such associations, we will focus here on one set of policies, relating to educational attainment. Our goal is to illustrate how the profound changes to such policies

enacted decades ago may continue to reverberate in the patterns of health of today's elderly. Educational attainment in general is a potent predictor of good health. Epidemiologic studies suggest each year of education is associated with decreased risks of death, decreased risks of dementia, better cognitive function, improved physical function and decreased risk of a number of diseases, including cardiovascular disease, the major cause of death in the US. The reasons for this are undoubtedly complex and have often been thought to reflect the intrinsic values, health and intelligence of individuals who continue their education not the benefits of education per se. There is also good reason to believe that there may be a more causal line between education and health and functional outcomes. Education translates into higher incomes (on average) and therefore material improvements in standards of living. People with higher levels of education also tend to have health-promoting behaviors, consume less tobacco and alcohol, get more physical activity, etc.

Educational policies changed drastically in the twentieth century in the US and many other countries. Katz and Goldin have described the first half of the twentieth century as the "second transformation of US education" [15], when high-school completion, previously a rare achievement, became the norm. Changes in average educational attainment partially reflected increases in the demand for schooling. However, there was extensive and explicit government intervention to increase both the demand for and supply of schooling. In the US, educational policy has historically been determined by state and local governments, and the first half of the twentieth century was a time of exceptionally rapid changes in policies and standards relating to schooling. For example, in 1918, six states required students complete six or fewer years of schooling before leaving school, and seven more required only seven years of schooling. By 1939, the lowest state schooling requirement was seven years, and all but four states required eight or more years [16]. At the same time, there was wide variability in compulsory school laws across states and over time. For instance, in 1918, North Carolina mandated enrollment at age eight and permitted 14 year olds to leave school. By 1939, the enrollment age dropped to age seven, effectively adding one year to the compulsory school length. Florida during this time period changed from requiring schooling from ages 8 to 14 (six years) to requiring schooling from ages 7 to 16 (nine years). Iowa, Indiana, Kentucky, and Nebraska already required nine years of schooling by 1918. Significant improvements in the quality of schooling, e.g. extensions of the school year, construction of new buildings, grade separation, increasing teacher qualifications, standardization of curriculum, were also achieved during the first half of the twentieth century by virtue of extensive social investments. The expansion of high-school education was probably quite costly to the communities that accomplished it: direct costs of high-school provision were roughly twice that of elementary school, and indirect costs, in terms of transportation and lost labor from adolescents, were also likely substantial.

We speculate that much as investments in public health made at the turn of the century helped to control infectious diseases and curb infant and maternal mortality, social and economic investments initiated in the first half of the twentieth century may have had broad impacts on the successful aging of the current generation of senior citizens.

On top of local action to build high-schools and enroll students, and state changes in compulsory schooling laws, the GI Bill (formally the 1944 Serviceman's Readjustment Act) represented a tremendous federal investment in increasing educational opportunities. Ultimately, nearly eight million veterans of World War II received benefits under the aegis of the GI Bill. The GI Bill provided unemployment benefits, job search assistance, and loan guarantees for small businesses or home purchases, but it is best known for promoting education via subsidies for tuition and living expenses. The government spent over $14 billion to provide these education benefits. As a result of the GI Bill benefits, participation in World War II probably increased college completion rates by 5–6 percentage points, which represented an increase of roughly 40% over prior college completion rates [17]. Millions more veterans of the Korean War also benefited from subsequent GI Bills.

Social investments such as schooling laws and the GI Bill did not affect everyone in the country equally. Even policies that are de jure race-neutral, such as the GI Bill, translate very differently when superimposed on an already unequal society. Our best evidence suggests that southern blacks

benefited very little from the education provisions of the GI Bill[18,19]. In the post-war period African-American GI's were much less likely to have completed high school and to be eligible for college tuition benefits than white veterans. Southern colleges serving blacks had few seats and many veterans were turned away because of inadequate resources. The GI Bill may be among the most important federal educational policies in the history of the US and it probably reduced educational inequalities for white men. For blacks, however, it may have stabilized or exacerbated inequalities. Compulsory schooling laws similarly did not dramatically help young African-Americans because they were apparently rarely enforced for blacks in many states.

Research explicitly evaluating the effects of twentieth century social policies on health is relatively limited, in part because of the enormous challenges of finding compelling research designs to study these questions. Economists recently developed the idea of exploiting the temporal variation in state changes to schooling requirements, in the US and elsewhere, to examine the effects of education on adult earnings [20]. This work is now being extended to examine the consequences of compulsory schooling and education on health [21]. Initial findings are striking.

Variations in when states enacted or extended compulsory schooling laws represent a 'natural' experiment for the effects of education. Natural experiments are valid if some members of a population receive an exposure (in this case, compulsory schooling regulations) and the mechanism determining each person's exposure is completely independent of the outcome that individual would experience if exposed or not exposed. We often think of natural disasters such as earthquakes or hurricanes as natural experiments but social scientists have employed the concept very effectively to explore the effects of numerous social exposures that are difficult to randomize in a traditional experiment. Because social policies are often implemented differently or at different times by states, they can sometimes be viewed as natural experiments. While exposure or "treatment" is not randomly assigned by an experimenter, the strength of the study design is that individuals are assigned almost randomly to the exposure.

Individuals born into states with varying compulsory schooling requirements have no choice about participating in what amounts to an experiment. While other factors at the state level may occur simultaneously with changes in compulsory school laws, at the individual level, nothing innately individual shapes exposures. Therefore, we can make stronger causal inferences from natural experiments than we can from many observational studies. There are two important limitations to such a research design. First, when state level factors determine exposure, it is difficult to disentangle correlated state characteristics and identify which characteristic is at work. Second, for statistical reasons, results of these studies tend to have wide bounds of uncertainty. Nonetheless, natural experiments represent one of the most promising approaches to understanding how social policies and socioeconomic conditions influence health and strengthening our confidence in the results from observational studies.

Early work suggests that changes in state compulsory schooling laws impact both mortality and cognitive function. Lleras-Muney compared changes in state schooling laws between 1915 and 1939 with census information on education and mortality of people who would have been age 14 (roughly prime age to dropout) during these years. She reported that one additional year of compulsory schooling (or schooling required for a work permit) increased completed years of education for people born in that state by 5% [22]. Each additional year of schooling induced by com-

First, in recent decades both mortality and disability rates have dropped for older men and women. With the somewhat larger decreases in disability apparent over the last decade or so, disability-free life expectancy has increased at the population level. Secondly, these gains have been experienced by men and women across virtually all social classes and racial/ethnic groups. Often, slightly larger absolute gains have been observed among those in more socioeconomically advantaged groups. Third, while population health has improved, inequality has been maintained across socioeconomic strata with socially and economically disadvantaged men and women persistently worse off. Furthermore, the gap between rich and poor has not narrowed and, depending upon which indicators are used, may actually have increased in both absolute and relative terms.

pulsory schooling laws was associated with a 3–6% reduction in risk of death over 10 years (between decennial censuses) [23]. We have recently completed analyses looking at the effects on compulsory schooling laws affecting men and women enrolled in the Health and Retirement Study born between 1900 and 1947. Individuals born in states with high levels of mandatory schooling completed more schooling and performed better on cognitive tests taken many decades after finishing school [24], even after adjusting for demographic characteristics such as race and parental education. We are now extending this work to examine whether other state-level characteristics that changed contemporaneously with schooling policies, such as economic development or the spread of kindergarten enrollment, might account for this relation, and whether schooling appears to have the same effect on other health outcomes. Identifying the most influential policies is an area of active research, but the results highlight the importance of changes in social-environmental conditions of childhood in determining cognitive risk of elders. Although old-age cognitive impairment is often perceived as a function of one's genetic endowment, these results suggest that state policies, perhaps related to schooling, can help protect elders regardless of their individual social or genetic background. We can and do change policies such as schooling requirements or resources in response to evolving social demands; we can similarly change the policies in order to promote healthy aging for future cohorts if such policies play a causal role.

Although old-age cognitive impairment is often perceived as a function of one's genetic endowment, these results suggest that state policies, perhaps related to schooling, can help protect elders regardless of their individual social or genetic background.

Individual characteristics undoubtedly influence how we do in old age. Our genes shape many capacities but the important point of this evidence is that the social environment also exerts strong forces on how we age. The findings indicate that social policies can have an important impact on health and aging. Complicating the picture is that our example of educational attainment indicates that early experiences in childhood and early adulthood shape outcomes in late life. Mark Hayward has referred to this phenomenon as "the long arm of childhood" [25]. Whether this phenomenon occurs because education shapes adult experiences in the labor force, behaviors or economic and social position in a cumulative way producing cumulative advantages and disadvantages or shapes cognition during a critical period of human development is unknown. These questions are among the most challenging for us to answer in the coming decade. We also have only some insights into the biological pathways which might tie social experiences to aging. In the next section, we explore the ways in which both stressful and fulfilling social experiences actually shape the biology of aging.

Accelerated aging: a tale of telomeres

Scientists used to believe that the rate of aging was fixed. Early on, gerontologists thought that perhaps we had a certain number of heartbeats and when we reached that mysterious point, the show was up. Gerontologists then worked hard to slow down the rate of aging, virtually to slow our heart rate. While some intriguing evidence has suggested this is possible (mostly by diet restriction), we seem to be far better at identifying factors that accelerate the aging process. These exposures put us at risk for more precipitous declines in physical and cognitive function and death.

Social and psychological stressors, like certain core health behaviors such as physical activity, have generalized health consequences. These stressors influence a wide array of diseases through a set of physiological pathways that are normally so strongly related to chronological age as to be considered markers of the aging process. We have hypothesized that stresses presented by social disadvantage and social isolation as well as classical life events such as bereavement and loss (chronically stressful situations) impact health because they accelerate the rate of aging [26]. By eroding individual capacity for resilience, these stressors leave people more vulnerable to a host of other intrinsic (genetic predispositions) or extrinsic (environmental) risks. The specific disease developed is determined by the

Our genes shape many capacities, but the important point of this evidence is that the social environment also exerts strong forces on how we age.

combination of additional genetic or environmental risks encountered. That is, the social stress "leans" on the aging body, accelerating the onset of disease, but not necessarily determining which specific disease occurs. Stressful environments and experiences leave people open to infectious diseases such as the common cold, hasten the progression of diseases like AIDS, and may contribute to the development of chronic diseases such as diabetes, hypertension or pulmonary disease.

Although there are several theories compatible with this idea, this theory linking the social environment to accelerated biological aging has been difficult to prove. Weathering is a concept elaborated by Arlene Geronimous[27] to explain the more rapid health deterioration and different reproductive health experiences of African-Americans. She argues that accelerated health deterioration and shortened life expectancy result from the prolonged exposure to discrimination and stress that African-Americans experience throughout their lives. Other work has focused on allostatic load, an idea developed by Bruce McEwen to refer to the cost of adaptation to heightened physiological responses resulting from the repeated or chronic environmental challenges—the wear and tear—on the body[28]. In studies of humans, Seeman and McEwen have initially identified a number of biological parameters composing allostatic load. These include those related to the sympathetic-adrenomedullary system, hypothalamic-pitutary-adrenal axis, cardiovascular metabolic and immune systems. Allostatic load has been linked to socioeconomic conditions, social networks, and mortality. However, in addition to these elegant theories, a recent study of the effect of caring for a seriously ill child on telomere activity has provided us with an incredible insight into how this process might actually work at the cellular level. In this study, a psychologist and a biochemist teamed up to test the hypothesis that stress impacts heath by modulating the rate of cellular aging[29]. Blackburn had been working on cellular aging, specifically a study of telomeres and telomerase, a cellular enzyme, for some time but had never linked it with psychosocial stress. Telomeres are DNA-protein complexes that cap chromosomal ends, promoting chromosomal stability. With age, telomeres shorten in humans and in vitro cells become senescent when telomeres shorten sufficiently. Blackburn has worked on telomere function precisely because telomere shortening may be a key to aging, one of the best available biomarkers of a cell's biological "age". Telomere shortening has been linked in other investigations to higher mortality rates in the elderly and to cardiovascular disease[30, 31]. Telomerase is a cellular enzyme that protects telomeres. Both were hypothesized to be related to stress.

Perceived stress was associated with telomere shortening among all mothers, regardless of whether their children were healthy or ill. Women with the highest levels of perceived stress were comparable to women a decade older in terms of telomere length. Thus, we see the ways in which social stresses influence aging at a cellular level.

Caregiving, especially of long duration, for intimate partners and close family has been related to increased mortality risk and a host of mental and physical problems[32]. In this study, Epels et al followed almost 60 healthy mothers between the ages of 20 and 50 who had either a seriously chronically ill child or a healthy child. Perceptions of stress were assessed in all mothers. Mothers who had been taking care of a chronically ill child for a long time had shortened telomeres, decreased telomerase activity, and higher levels of oxidative stress than either controls with a healthy child or mothers with an ill child who had not been in that caregiving role for long. Perceived stress was associated with telomere shortening among all mothers, regardless of whether their children were healthy or ill. Mothers with chronically ill children did not differ from controls in telomere length or function. Women with the highest levels of perceived stress were comparable to women a decade older in terms of telomere length. Thus, we see the ways in which social stresses influence aging at a cellular level.

In sum, we have the variability in how people age, how long they live, the health outcomes they experience, and their patterns of variability in biological aging processes. This variability linked to social experiences provides us with critical clues as to how we can improve the health and well being of older men and women. We believe that the investments society makes for its citizens all along the life cycle from early childhood to old age accumulate to affect the health of the older population, for good or ill. The degree to which those social investments are unequally distributed will create health inequalities difficult to erase as people age.

REFERENCES

1. Quinn, J., The economic status of the elderly: Beware the Mean. *Review of Income and Wealth*, 1987. 33(March): p. 63-82.

2. Cutler, D. and G. Miller, The role of public health improvements in health advances: the twentieth-century United States. *Demography*, 2005. 42(1): p. 1-22.

3. Fries, J., Aging, Natural Death and the Compression of Morbidity. *New England Journal of Medicine*, 1980. 303: p. 130-35.

4. Crimmins, E.M., Y. Saito, and D. Ingegneri, Changes in Life Expectancy and Disability-Free Life Expectancy in the United-States. *Population and Development Review*, 1989. 15(2): p. 235-267.

5. Robine, J.M. and K. Ritchie, Healthy Life Expectancy - Evaluation of Global Indicator of Change in Population Health. *British Medical Journal*, 1991. 302(6774): p. 457-460.

6. Freedman, V., et al., Resolving inconsistencies in trends in old-age disability: report from a technical working group. *Demography*, 2004. 41(3): p. 417-411.

7. Crimmins, E.M., Y. Saito, and D. Ingegneri, Trends in disability-free life expectancy in the United States, 1970-90. *Population and Development Review*, 1997. 23(3): p. 555-&.

8. Freedman, V., H. Aykan, and L. Martin, Aggregate changes in severe cognitive impairment among older Americans: 1993 and 1998. J of Gerontology: series B Psychological Sciences & Social Sciences, 2001. 56(2): p. S100-111.

9. Geronimus, A.T., et al., Inequality in life expectancy, functional status, and active life expectancy across selected black and white populations in the United States. *Demography,* 2001. 38(2): p. 227-251.

10. Cambois, E., J. Robine, and M. Hayward, Social inequalities in disability-free life expectancy in the French male population, 1980-1991. *Demography*, 2001. 38(4): p. 513-524.

11. Robine, J.M., P. Mormiche, and C. Sermet, Examination of the causes and mechanisms of the increase in disability-free life expectancy. *Journal of Aging and Health*, 1998. 10(2): p. 171-191.

12. Beck, E.M. and S.E. Tolnay, The Killing Fields of the Deep South - the Market for Cotton and the Lynching of Blacks, 1882-1930. *American Sociological Review*, 1990. 55(4): p. 526-539.

13. Tolnay, S.E., The African American "Great Migration" and beyond. *Annual Review of Sociology*, 2003. 29: p. 209-232.

14. Anonymous, Improvements in workplace safety -- United States, 1900-1999. *Morbidity and Mortality Weekly Report*, 1999. 48(22): p. 461-469.

15. Katz, L.F. and C. Goldin, Why the United States led in education: lessons from secondary school expansion, 1910 to 1940. National Bureau of Economic Research, 1997. Working Paper 6144(http://www.nber.org/papers/w6144).

16. Umbeck, N., State legislation on school attendance and related matters - school census and child labor. 1959, US Department of Health, Education and Welfare.

17. Bound, J. and S. Turner, Going to war and going to college: did World War Ii and the G.I. Bill increase educational attainment for returning veterans? *Journal of Labor Economics*, 2002. 20(4): p. 784-815.

18. Turner, S. and J. Bound, Closing the gap or widening the divide: The effects' of the GI Bill and World War II on the educational outcomes of black Americans. *Journal of Economic History*, 2003. 63(1): p. 145-177.

19. Onkst, D., "First a negro...incidentally a veteran": black World War II veterans and the GI Bill of Rights in the deep south, 1944-1948. *J Social History*, 1998: p. 517-543.

20. Acemoglu, D. and J.D. Angrist, How large are the social returns to education? Evidence from compulsory schooling laws. NBER Working Paper Series, 1999. Working Paper 7444.

21. Angrist, J. and A. Krueger, Does compulsory school attendance affect schooling and earnings? *The Quarterly Journal of Economics*, 1991. 106(4): p. 979-1014.

continued

REFERENCES

continued

22. Lleras-Muney, A., Were compulsory attendance and child labor laws effective? An analysis from 1915 to 1939. *Journal of Law & Economics*, 2002. 45(2): p. 401-435.

23. Lleras-Muney, A., The relationship between education and adult mortality in the US. *Review of Economic Studies*, 2005. 72(1): p. 189-221.

24. Glymour, M., Identifying social determinants of old age cognitive function, in Society, Human Development, and Health. 2004, Harvard School of Public Health: Boston, MA.

25. Hayward, M. and B. Gorman, The long arm of childhood: The influence of early-life social conditions on men's mortality. *Demography*, 2004. 41(1): p. 87-107.

26. Berkman, L., The changing and heterogeneous nature of aging and longevity: A social and biomedical perspective. *Ann Rev Ger & Geriatrics*, 1988. 8: p. 37-68.

27. Breeze, E., et al., Do socioeconomic disadvantages persist into old age? Self-reported morbidity in a 29-year follow-up of the Whitehall Study. *American Journal of Public Health*, 2001. 91(2): p. 277-283.

28. McEwen, B.S., Sex, stress and the hippocampus: allostasis, allostatic load and the aging process. *Neurobiology of Aging*, 2002. 23(5): p. 921-939.

29. Epel, E., et al., Stress and Body Shape: stress-induced cortisol secretion is consistently greater among women with central fat. *Psychosomatic Medicine*, 2000. 62: p. 623-632.

30. Cawthon, R.M., et al., Association between telomere length in blood and mortality in people aged 60 years or older. *Lancet*, 2003. 361(9355): p. 393-395.

31. Brouilette, S., et al., White cell telomere length and risk of premature myocardial infarction. *Arteriosclerosis Thrombosis and Vascular Biology*, 2003. 23(5): p. 842-846.

32. Lee, S., et al., Caregiving and risk of coronary heart disease in US women: a prospective study. *Am J Prev Med*, 2003. 24(2): p. 113-119.