The population health benefits of a healthy lifestyle: life expectancy increased and onset of disability delayed

The Population Health Benefits Of A Healthy Lifestyle:

Life Expectancy Increased And Onset Of Disability Delayed

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ABSTRACT

A key determinant of population health is the behavioral profile of a population. Nearly eighty percent of American adults enter older age having smoked cigarettes or been obese. It is unknown to what extent risky behaviors (e.g., smoking, poor diet and physical inactivity, excessive alcohol consumption) cumulatively are reducing U.S. health and life expectancy and what levels might be achievable in their absence. Using data from the Health and Retirement Study, we studied individuals aged 50+ who never smoked, were not obese, and consumed alcohol moderately. Compared to the U.S. population, those with a favorable behavioral profile have up to seven years longer life expectancy at age 50 and they experience up to six years postponement in the onset of disability. These results provide a benchmark for evaluating the massively damaging effects that behavioral risks have on health at older age and the importance of policy prioritization for behavioral-based interventions.

INTRODUCTION

Older Americans are living longer and are generally healthier than their predecessors.[1,2] In aging societies, the health and functional ability of the elderly is of central policy significance. Nearly all high-income countries subsidize medical and hospice care for the elderly and a healthier older population is more capable of contributing to economic and social roles than an unhealthier one. Actuarial calculations informing Social Security's future solvency rely heavily on the longevity expectations of those who will enter old age in the coming decades.[3]

Research documents strong heterogeneity in healthy aging across individuals—that is individuals appear to "age" at different rates.[4] Among the key determinants of this variation are health-related behaviors whose effects often are realized over the long-term and at older age (e.g., cigarette smoking, diet, physical activity). By ages 50-59, nearly 80% of American adults have either ever smoked or have been obese, a level that has remained remarkably stable since the 1970s (Exhibit 1). While the percentage of Americans who have smoked has been declining over time, the prevalence of obesity has increased markedly, potentially off setting health gains made from reductions in smoking.[5-7]

The combined prevalence of smoking and obesity suggests that these two behavioral factors are key determinants of healthy aging among older Americans (obesity being an indicator for dietary and physical activity behaviors). [ ] Because behavioral factors can be targeted by a wide range of policies, measuring their cumulative impact aids in the prioritization of such policies.[8]

The massively damaging effects risky behaviors are having on population health is increasingly recognized by international bodies outside of the traditional health sector. In 2011, for example, the United Nations General Assembly held a high level meeting on non-communicable disease, of which behavioral interventions were a primary focus. This meeting was the first high-level meeting convened over a health issue since HIV/AIDS.

Against this backdrop, we evaluated the extent to which three major behavioral factors (cigarette smoking, obesity, and unhealthy alcohol consumption) influence the overall and healthy life expectancy of Americans over age 50. *Our contribution is two-fold. First, the focus on life expectancies provide straightforward policy-relevant metrics to assess the population-level effects of behavioral factors. Healthy life expectancy, or how long an individual is expected to live in a healthy state, is particularly relevant because it conveys*

information on the functional capacity of older individuals and is related to productivity and health care costs.

Second, we analyzed sub-groups by behavioral profiles, in addition to addressing each risk factor separately. This approach allows us to assess the total effect of the three risk factors. We gave particular focus to individuals who have a low-risk profile (e.g., individuals who have never smoked, are not obese, and drink alcohol at healthy levels) as the study of these individuals provides insight into how much the three risk factors combined are holding back healthy and overall life expectancy.

METHODS

Data. Data were from the U.S. Health and Retirement Study (HRS), a high-quality on-going longitudinal survey on health among middle- and older-aged Americans that began in 1992 and is supported by the U.S. National Institute on Aging and the Social Security Administration.[9] Respondents were re-surveyed bi-annually with follow-up response levels consistently above 85%.[10] Since 1998, the HRS has been representative of non-institutionalized Americans aged 50+. *After participants enroll in the study, the HRS follows them even if they become institutionalized.* HRS data are linked to the U.S. National Death Index.

Our analytical sample included respondents aged 50-74 in 1998 (N=14,804). Disability transitions and deaths were modeled during 2000-2012. There were 4,305 deaths and 6,795 disability transitions over 153,991 person-years of follow-up (Supplementary Appendix 1).[11] Analyses were conducted with the RAND HRS data, version N.[12]

Measures. Disability was defined by a respondent report of a limitation in at least one of five activities of daily living (ADL):[13] walking, dressing, bathing, getting in/out of bed, or eating. Respondents not reporting any limitations were considered disability-free.

Smoking categories were current, former, or never smoker with never smoker as the low-risk category. Weight status categories, based on Centers for Disease Control definitions, were obese (BMI≥30.0) and non-obese (BMI<30), with non-obese as the low-risk category. Because preliminary models indicated non-significant differences in risk between normal weight (BMI 20.0-24.9) and overweight (BMI 25.0-29.9) respondents these two groups were combined in the non-obese category. Underweight respondents (BMI<18.5) were excluded from the low-risk non-obese group.

Alcohol consumption groups were non-drinker or irregular drinker, moderate drinker, and heavy drinker, with moderate drinker as the low-risk category.[15-17] non-drinkers or irregular

drinkers, moderate drinkers Moderate and heavy drinker categories were defined as drinking alcohol at least one day per week in addition to meeting a threshold for weekly number of drinks: moderate – less than 14 drinks per week for men and less than 7 drinks per week for women and heavy – 14 or more drinks per week for men and 7 or more drinks per week for women.[14] *Individuals who reported drinking alcohol less than one day per week (irregular drinkers), who represented about one-fifth of all drinkers, were classified with non-drinkers because preliminary analyses revealed higher mortality and disability risks in irregular drinkers compared to the low-risk moderate drinkers.*

Low-risk Behavioral Profiles. We examined two low-risk behavioral (LRB) profiles: LRB 1 was individuals who never smoked and were non-obese. LRB 2 was individuals who never smoked, were non-obese, and were moderate alcohol consumers. Individuals at high-risk on multiple behaviors were also evaluated: (1) obese + ever-smoker and (2) obese + ever-smoker + non-moderate drinker.

Control variables were educational attainment (< high school (HS) completion, HS degree/GED/some college attendance, college graduate) and race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, non-Hispanic other race).

Statistical Analysis. We produced two sets of metrics. The first was the mean age of first incident disability conditional on being non-disabled at age 50. The second was life expectancy in disabled and non-disabled states. We measured overall life expectancy, disabled life expectancy, and disability-free life expectancy, all from age 50. We used multinomial logistic regression models used to generate age-and sex-specific transition probabilities across the states of non-disabled, disabled, and dead. We used the transition probabilities in age-, sex-, and state-structured matrix population models to estimate life expectancies at age 50 in the various states (disabled, non-disabled, overall) and mean age of first incident disability. Matrix population models are extensions of multi-state life table techniques.[18,19]

Supplementary Appendix 2 describes the regression and matrix population models and Supplementary Appendix 3 provides coefficients from the regression models.[11]

Our overall life expectancy estimates were similar to U.S. life expectancy from 2005 National Vital Statistics data.[20] Standard errors were estimated using bootstrap procedures. All analyses were conducted using Stata 14. Statistical code is available by request.

Study Limitations. A methodological advantage of our study was that longitudinal data were used to estimate transition

probabilities, avoiding the biases arising from cross-sectional approaches.[21] A limitation is that we were unable to account for the wide number of behavioral factors that affect health. We relied on three behavioral factors that have been shown to have the largest impact on life expectancy in high-income countries. Obesity is an imperfect marker of lifelong dietary practices and physical activity. Sufficient detailed dietary histories are rarely available in health surveys and is not available in our data. The data we use does contain information on physical activity levels. However, physical activity levels will simultaneously be a cause and consequence of health rendering it difficult to infer reliable estimates of the effect of physical activity on health.[22] We were also unable to observe disability incidence for individuals prior to entering our risk set at age 50, thus the estimated age at first onset of disability does not account for disability incidence at a younger age, which may be substantial for some subpopulations.

STUDY RESULTS

Descriptive Characteristics. At study onset, 13% of women and 10% of men were disabled (Approximately 26% of the sample were obese, 62% ever smokers, and 73% non/irregular or heavy drinkers. Twenty-seven percent of the sample were non-obese never-smokers (LRB1). Women (33%) were more likely than men

(20%) to be in this low-risk category. Seven percent of the sample were non-obese never-smokers who drink moderately (LRB 2), with equal percentages of men and women. While individuals from all educational levels are represented among the LRBs, those with higher levels of education were more likely to be LRBs than others (Supplemental Appendix 4).[11]

Disability Onset. As expected, each behavioral risk factor was associated with early disability onset (Exhibit 1). Compared to the average for the entire population, obesity stood out as being the most consequential. On average, obese men became disable at age 63, and obese women at age 65, compared to age 67 for the total population In contrast, the LRBs showed considerable postponement of disability (Exhibit 2). LRB 1 men and women had a mean age of first incident disability above age 70, 3.5 years longer than the total population. LRB 2 men and women displayed the longest postponement with a mean age of first disability incidence of 72.1 for men and 75.2 for women.

Life Expectancies. Life expectancy for the total population at age 50 was 77.7 years for men and 81.4 years for women. (Exhibit 3). Women spent more years of life disabled than men, 4.0 years compared to 5.8 years for men. Obesity had a moderate effect on overall life expectancy, and a more substantial effect on disability-free life expectancy. Non-obese men lived 2.3 years longer without disablement compared to obese men, and non-

obese women lived 4.8 years longer without disablement than non-obese women. disability-free life expectancy compared to the obese. The non-obese also spent less time disabled compared to the obese, 2.2 years less for men and 3.3 years less for women.

Never-smokers had a substantially longer overall and disability-free life expectancy compared to ever-smokers but experienced a longer time living with a disability. Compared to heavy drinkers and non/irregular drinkers, moderate drinkers exhibited the longest overall and disability-free life expectancies.

The life expectancy advantages of the LRB populations is shown in Exhibit 4. LRB men and women lived a 4 (LRB 1) to 7 (LRB 2) years longer than the total population. Importantly, nearly all of this advantage was due to a longer disability-free life. Thus, LRB populations not only live longer, they do so in disabled-free state. In contrast, obese, ever-smoking, non-moderate drinkers lived four to five years less overall than the total population and five to seven years less in a disability-free state. The difference is greater comparing the best to the worst profiles. For example, a 50-year-old woman who never smoked, was never obese, and drinks moderately will live an extra 12 years, on average, than the same-age obese woman who ever smoked and does not drink moderately. The difference in

life expectancy between the two categories was 11.1 years for men.

The exceptional profile of the LRB populations is further borne out through a comparison with life expectancy in 2005 in Japan, a nation known for the long lives of its citizens. (Exhibit 6). Life expectancy at age 50 for the U.S. total population lagged behind life expectancy in Japan by three years for men and five years for women. With the exception of LRB 1 women, the other three LRB groups had a longer total life expectancy compared to Japan. Supplemental Appendix 5 provides 95% confidence intervals for all estimates shown in Exhibits 5-6.[11]

Additional Findings. *In our sample, the dominant smoking group was former smokers (41%) and it is relevant to ask whether individuals who quit early in life can still experience a long and disabled-free life. In separate analyses (data not shown), we found that non-obese individuals who quit smoking ten or more years prior to survey entry and drank alcohol moderately had total and healthy life expectancies only one year shorter than non-obese never-smokers who drank alcohol moderately (LRB2).*

We also explored whether life expectancy at age 50 changed over the period of study. To gain reasonable statistical power, we split the data into two periods – 1998-2004 and 2005-2010 – and compared life expectancy at age 50 across the two periods.

For the total sample, life expectancy at age 50 increased by about 0.60 years, about one-third of this time healthy and two-thirds with disability. Results were similar for the two low risk behavior groups; However, our analysis was likely underpowered to distinguish differences in trends across these subgroups.

DISCUSSION

Sizeable segments of the U.S. population exhibit advantageous behavioral profiles, but little is known about how long they live because prior research is limited to studying the effect of single health behaviors on life expectancy. Studying the effect of multiple health behaviors exercised simultaneously provides new insight into levels of health that are achievable without requiring novel life-extending medical technologies.

We analyzed non-disabled and disabled life expectancy for low-risk behavioral groups, one consisting of respondents who were not obese and never smoked and a similar group whose members also drank alcohol moderately. Compared to the average American, these two low-risk groups had a 4-7 year advantage in life expectancy at age 50 and experienced substantially postponed onset of disability. Strikingly, these populations also experienced a disability-free life expectancy similar to or longer than the overall life expectancy of the average American.

Risk Factor Prevention. *Our findings are best interpreted in the context of population-level risk factor prevention, namely, the potential health gains realizable if more Americans adopted a low-risk behavioral profile. While our study provides novel insight into potential health gains from adopting low-risk behaviors, our study did not address the role of genetic factors, which may simultaneously influence both the presence of a risk factor and its damaging effects.*[24] *For example, a similar set of genes may increase both the risk of becoming obese, given a certain diet, and the negative metabolic consequences of obesity.*[25] In addition, people who refrain from risky behavior may be likely to have other health-promoting traits, and our study could not control for this selection.

Nonetheless, the findings of our study do demonstrate what is being achieved by a sizeable segment of Americans and may be potentially achievable for many others. The low-risk behavioral groups have a life expectancy comparable to other exceptionally long-lived populations. Montez and Hayward[26] examined populations defined by a combination of race, childhood health, socioeconomic adversities, and educational attainment and found that the most advantaged groups—those with favorable childhood health, no socioeconomic adversity, and high educational achievement—had life expectancies of 82 years for men and 86 years for women, similar to our estimates for the low-risk

groups. Immigrant populations also exhibit exceptionally high longevity. Mehta et al.[27] showed that, during 2000-2010, U.S. immigrants had a life expectancy of 84 years for men and 87 years for women. Neither study accounted explicitly for behavioral factors.

Role of Behavioral Change. *Our approach did not lend itself to estimating the benefits of behavioral change among individuals already having a risk factor. However, our study provides some indications of the sizeable benefits achievable through behavioral change. We found that individuals who quit smoking 10 years or more prior to our study experienced an exceptionally long disabled-free life if they also are at low-risk on other behavioral factors. This finding is consistent with prior findings illustrating that quitting smoking and other favorable behavioral changes, even in late-life, enhances longevity.*[28] *Similarly, an emerging body of evidence suggests that obesity exhibits "duration" effects in that reducing the length of time obese may be associated with improved health.*[29]

Disability Postponement. *Our study of the low-risk behavioral groups suggest that these exceptional groups experience substantial disability postponement compared to others. The benefit to society is that postponement will defer disability-associated healthcare costs into older ages and enable opportunities for individuals to work longer.*

Nonetheless, our findings also indicate that low-risk groups live *a similar number of disabled years compared to the total population.* In other words, we did not find evidence of a "compression" of disability among the low-risk groups.

In contrast, those with multiple behavioral risk factors not only have a short life but also experience an extended time disabled, underscoring the large negative effects of risky behavioral factors. Of note is that we found obesity to be strongly associated with years lived with a disability, a finding that has been reported in at least one previous study and is especially concerning given obesity's rising prevalence.[30]

Policy Considerations. As aging nations grapple with the social, economic, and fiscal consequences of a growing elderly population, a key variable is the future health status of the older population.[31] Our findings indicate that the high prevalence of risky behaviors poses a formidable challenge to achieving even larger improvements in population health. Optimistically, evidence supports that population-level behavioral profiles can be responsive to large-scale and high-level policy efforts with some of the most convincing evidence coming from anti-smoking campaigns.[8,32] *The Affordable Care Act made a major step forward in federal support for prevention through its establishment of the Prevention and Public Health Fund of which behavioral improvement is a core focus. Financial*

"sticks" through taxation of cigarettes, alcohol, and potentially beverages and foods associated with obesity also enjoy a solid evidence base.[33] *The success of these and other policies in helping people to maintain a healthy body weight and refrain from smoking and heavy alcohol consumption will largely define whether the future of aging in the U.S. is healthy or disabled.*

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Exhibit List

Exhibit 1 (Figure)
Caption: Mean age of first disability incidence from age 50 by behavioral risk factor.
Data Source: Author analysis of U.S. Health and Retirement Survey, 1998
Notes: Total is entire sample. Obesity is defined as BMI≥30.0 kg/m2. Ever smoker includes former and current smokers. Moderate drinking are individuals who drink and consume <14 drinks/week (men) and <7 drinks/week (women). Heavy drinking is ≥14 drinks/week (men) and ≥7 drinks/week (women).

Exhibit 2 (Figure)
Caption: Mean age of first disability incidence since age 50 by behavioral profile.
Data Source: Author analysis of U.S. Health and Retirement Study (1998-2012)
Notes: Total is entire analytical sample from HRS. Obesity is defined as BMI≥30.0 kg/m2. Ever smoker includes former and current smokers. Moderate drinking are individuals who drink and consume <14 drinks/week (men) and <7 drinks/week (women). Heavy drinking is ≥14 drinks/week (men) and ≥7 drinks/week (women).

Exhibit 3 (Figure)
Caption: Overall, disability-free, and disabled life expectancy at age 50, by behavioral risk factor. Data Source: Author analysis of U.S. Health and Retirement Study (1998-2012)
Notes: X-axis represents number of years from age 50. Total is entire analytical sample from HRS. Obesity is defined as BMI≥30.0 kg/m2. Ever smoker includes former and current smokers. Moderate drinking are individuals who drink and consume <14 drinks/week (men) and <7 drinks/week (women). Heavy drinking is ≥14 drinks/week (men) and ≥7 drinks/week (women).

Exhibit 4 (Figure)
Caption: Overall, disability-free, and disabled life expectancy at age 50 by behavioral profile. Data Sources: Author analysis of U.S. Health and Retirement Study (1998-2012). Human Mortality Database (Japan, 2005).
Notes: X-axis represents number of years from age 50. Total is entire analytical sample from HRS. LRB 1 represents non-obese never smokers

and LRB 2 represents non-obese, never smokers, and moderate drinkers. Shaded grey bar for Japan indicates overall life expectancy at age 50 in 2005 as published in the Human Mortality Database.[34]

Exhibit 2. Sample distribution at baseline wave in 1998, ages 50-74

Characteristic	All (N=14,804)		Men (N=6,657)		Women (N=8,147)	
Health state, %						
Non-Disabled	88.5	[87.7-89.2]	89.6	[88.6-90.5]	87.5	[86.5-88.5]
Disabled	11.5	[10.8-12.3]	10.4	[9.5-11.4]	12.5	[11.5-13.5]
BMI Category, %						
Non-Obese	72.8	[71.7-73.8]	74.3	[72.9-75.6]	71.5	[70.0-72.9]
Obese (BMI≥30)	25.9	[24.9-26.9]	25.2	[23.9-26.5]	26.5	[25.1-27.9]
Cigarette smoking, %						
Never	38.0	[36.6-39.4]	27.8	[26.2-29.4]	47.0	[45.1-49.0]
Former	41.4	[40.2-42.7]	50.7	[49.0-52.4]	33.2	[31.7-34.8]
Current	20.6	[19.4-21.9]	21.5	[20.2-23.0]	19.7	[18.3-21.3]
Alcohol Consumption, %						
Non/Irregular Drinker	65.8	[64.3-67.4]	56.6	[54.9-58.3]	74.0	[72.0 75.9]
Moderate Drinker	27.2	[25.7-28.7]	32.2	[30.7-33.9]	18.7	[17.1 20.3]
Heavy Drinker	7.0	[6.5-7.4]	11.2	[10.3-12.0]	7.3	[6.4 8.4]
Low Risk Behavioral Profiles (LRB), %						
LRB 1	27.1	[26.1-28.2]	20.0	[18.8-21.3]	33.3	[31.9-34.8]
LRB 2	7.0	[6.3-7.8]	6.7	[5.9-7.6]	7.3	[6.4-8.2]
High-Risk Behavioral Profiles						
Obese + Ever Smokers	15.4	[14.5-16.2]	17.5	[16.4-18.7]	13.4	[12.4-14.5]
Obese + Ever Smokers + Non-Moderate Drinkers	11.8	[11.1-12.6]	12.9	[11.9-13.9]	10.9	[9.9-11.9]

Note: *Non/Irregular drinkers are individuals who either report not drinking alcoholic beverages or report drinking alcohol, but report doing so zero or less than one day per week. Moderate drinkers are those that drink <14 drinks/week [men] and <7 drinks/week [women]. Heavy drinkers are those that drink ≥14 drinks/week [men] and ≥7 drinks/week [women].* LRB 1 is non-obese never smokers. LRB 2 is non-obese, never smokers, and moderate alcohol consumers. Estimates reflect HRS provided sample weights. 95% confidence intervals shown in parentheses.

Data Source: Author analysis of U.S. Health and Retirement Survey, 1998