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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 80 percent of Americans reach their fifties having smoked cigarettes, been obese, or both. It is unknown to what extent risky behaviors (for example, smoking, having a poor diet, being physically inactive, and consuming an excessive amount of alcohol) collectively are reducing the health and life expectancy of the US population, or what improvements might be achievable in their absence. Using data from the Health and Retirement Study, we studied people ages fifty and older who had never smoked, who were not obese, and who consumed alcohol moderately. Compared to the whole US population, those with such a favorable behavioral profile had a life expectancy at age fifty that was seven years longer, and they experienced a delay in the onset of disability of up to six years. These results provide a benchmark for evaluating the massively damaging effects that behavioral risks have on health at older ages and the importance of prioritizing policies to implement behavioral-based interventions.

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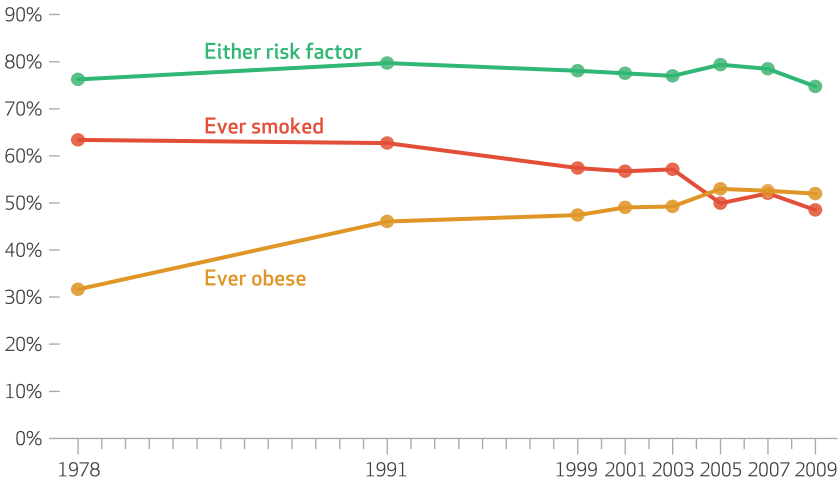
Older Americans are living longer and are generally healthier than their predecessors.[1,2] The health and functional ability of the elderly are key policy concerns because they are critically important in determining the potential productivity and health care costs of aging populations. Nearly all high-income countries subsidize medical and hospice care for the elderly, and a healthier older population may reduce public health care expenditures. Moreover, compared to an unhealthier older population, a healthier one will have greater potential to participate in the labor market and perform social roles such as caring for grandchildren. In the United States, actuarial calculations of Social Security's future solvency rely heavily on the predicted life expectancy of people who will enter old age in the coming decades.[3]

Research has shown 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 (for example, cigarette smoking, diet, and level of physical activity) whose effects often are realized over the long term and at older ages. By ages 50–59, nearly 80 percent of US adults have either smoked, been obese, or both—a level that has remained remarkably stable since the 1970s (Exhibit 1). While the percentage of Americans who have ever smoked has been declining over time, the prevalence of obesity has increased markedly, potentially offsetting health gains achieved from reductions in smoking.[5,6]

The combined prevalence of smoking and obesity (an indicator for dietary and physical activity behaviors) suggests that these two behavioral factors are key determinants of healthy aging among older Americans. An additional behavioral factor is excessive consumption of alcohol. Recent estimates indicate that one in ten deaths

EXHIBIT 1

Percentages of adults ages 50–59 who ever smoked, were ever obese, or ever had either risk factor, selected years



SOURCE Authors' analysis of data from the National Health and Nutrition Examination Survey II (1976–80), III (1988–94), and continuous waves (1999–2010). **NOTES** Survey respondents who reported having smoked at least 100 cigarettes in their lifetime were categorized as "ever smoked." Respondents who reported a maximum lifetime body weight (excluding pregnancy) that resulted in a body mass index of at least 30 kg/m^2 were categorized as "ever obese." Authors used measured height at time of survey along with reported maximum body weight to calculate body mass index. Respondents in either or both of the other two categories were also categorized as having "either risk factor."

among Americans ages 20–64 in the period 2006–10 were attributable to excessive alcohol consumption.[7] Because behavioral factors can be targeted by a wide range of policies, measuring their cumulative impact aids in the prioritization of such policies.

The massively damaging effects that risky behaviors have on population health are 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 noncommunicable disease, with behavioral interventions as a primary focus. This meeting was the first high-level meeting convened about a health issue since AIDS.

Among scientists, there is also long-standing interest in identifying maximum achievable levels of human health and longevity.[8–10] One approach has been the study of "vanguard" populations—groups that exhibit exceptionally favorable health—such as certain religious minority groups (for example, Seventh Day Adventists and Mormons) and scientific elites.[11,12] A key vanguard population that to our knowledge has not been analyzed in this context is people with a favorable profile across multiple behaviors, such as people who have never smoked, who are not obese, and who drink alcohol moderately. A vanguard population defined by a favorable behavioral profile would be drawn broadly from diverse socioeconomic and racial/ethnic groups. Thus, the study of their health would be highly informative about maximum achievable levels of health and longevity in large populations.

Against this backdrop, we evaluated the extent to which three major behavioral factors (cigarette smoking, obesity, and unhealthy consumption of alcohol) influence the overall and disability-free life expectancy (that is, how long a person is expected to live without a disability) of Americans ages fifty and older. Our contribution is twofold.

First, the focus on life expectancies provides straightforward policy-relevant metrics that can be used to assess the population-level effects of behavioral factors. Disability-free life expectancy is particularly relevant because it conveys information about the functional capacity of older people.

Second, we analyzed subgroups by behavioral profiles, in addition to addressing each risk factor separately. This approach allowed us to assess the total effect of the three risk factors. We focused in particular on people with a low-risk profile (that is, people who have never smoked or been obese and who drink alcohol at healthy levels), as the study of this population provides insights into how much the three risk factors combined are restricting overall and disability-free life expectancies.

Study Data And Methods

DATA Our data were from the Health and Retirement Study, a high-quality ongoing longitudinal survey on health among Americans ages fifty and older and their spouses that began in 1992. The study is supported by the National Institute on Aging and the Social Security Administration and is conducted by the University of Michigan.[13] Respondents are surveyed biannually, with follow-up response levels consistently above 85 percent.[14] Since 1998 the study has been nationally representative of noninstitutionalized Americans ages fifty and older. After participants enroll in the study, they are followed even if they become institutionalized. Study data are linked to the National Death Index. We used study data from the RAND Center for the Study of Aging.[15]

Our analytical sample consisted of 14,804 respondents ages 50–74 in 1998. Deaths and transitions across disability states were modeled during the period 2000–12. There were 4,305 deaths and 6,795 disability transitions over 153,991 person-years of follow-up (online Appendix 1 provides descriptive information about deaths and disability transitions).[16]

MEASURES *Disability* was defined by a respon-

The findings indicate the magnitude of health gains that could be achieved if more Americans adopted low-risk behaviors.

dent's report of having a limitation in at least one of five activities of daily living: walking, dressing, bathing, getting in or out of bed, and eating. Respondents not reporting any limitations were considered to be free of disability.

Smoking categories were current, former, or never smoker, with never smoker as the low-risk category. Weight status categories, based on definitions for adults from the Centers for Disease Control and Prevention, were obese (body mass index [BMI] at least 30.0 kg/m^2) and nonobese (BMI less than 30.0), with nonobese as the low-risk category. Because preliminary models indicated nonsignificant differences in risk between normal weight (BMI of 18.5–24.9) and overweight (BMI of 25.0–29.9), respondents in these two groups were combined into the nonobese category. Underweight respondents (BMI less than 18.5) were excluded from the low-risk nonobese group.

Alcohol consumption categories were non- or irregular drinker, moderate drinker, and heavy drinker, with moderate drinker as the low-risk category.[17,18] Moderate and heavy drinkers were defined as people who drink alcohol at least one day per week and who meet a threshold for weekly number of drinks: Moderate is having fewer than fourteen drinks per week for men and fewer than seven drinks per week for women; heavy is having fourteen or more drinks per week for men and seven or more drinks per week for women.[19] People who reported drinking alcohol less often than one day per week (irregular drinkers), who represented about one-fifth of all drinkers, were classified with nondrinkers because preliminary analyses revealed higher mortality and disability risks in irregular drinkers compared to the low-risk moderate drinkers.

BEHAVIOR PROFILES We examined two low-risk behavior (LRB) profiles: LRB1 referred to all people who had never smoked and were not obese; LRB2 (a subset of LRB1) referred to people who had never smoked, who were not obese, and who were moderate drinkers. We also examined two high-risk behavior (HRB) profiles: HRB1 referred to obese people who had ever smoked, and HRB2 (a subset of HRB1) referred to obese people who had ever smoked and who were not moderate drinkers.

Control variables were educational attainment (did not complete high school; had a high school diploma, GED, or some college; or had graduated from college) and race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, or non-Hispanic other race).

STATISTICAL ANALYSIS We produced two sets of metrics. The first was the mean age at the first incident of disability, conditional on not being disabled at age fifty. The second was life expectancy in disabled and nondisabled states. We measured overall, disabled, and disability-free life expectancy, all from age fifty.

We used multinomial logistic regression models to estimate age- and sex-specific transition probabilities across the states of nondisabled, disabled, and dead. We used the estimated transition probabilities in structured matrix population models to estimate overall, disabled, and disability-free life expectancies at age fifty and mean age at the first incident of disability. Matrix population models are extensions of multistate life table techniques.[20]

Appendix 2 describes the regression and matrix population models, and Appendix 3 provides coefficients from the regression models.[16]

Standard errors were estimated using bootstrap procedures. All analyses were conducted using Stata, version 14. Statistical code is available on request.

LIMITATIONS Our study had several limitations. First, we were unable to account for all of the behavioral factors that affect health. We relied on three behavioral factors (obesity, smoking, and drinking) that have been shown to have the largest impact on life expectancy in high-income countries. Obesity is used as an imperfect marker of lifelong dietary practices and levels of physical activity. Sufficiently detailed dietary history is rarely available in health surveys and was not available in our data. While the Health and Retirement Study does contain information on physical activity, we excluded it because physical activity is simultaneously a cause and a consequence of health, which makes it difficult to infer reliable estimates of the effect of physical activity on life expectancy. We also lacked information on obesity earlier in life—which, if accounted for, could have resulted in a larger negative effect of obesity on life expectancy.

Second, we were unable to observe disability incidence for people before age fifty. Because the estimated mean age at first onset of disability does not account for disability incidence before a respondent entered the study, the actual mean age of disability incidence will be lower than that shown in our results.

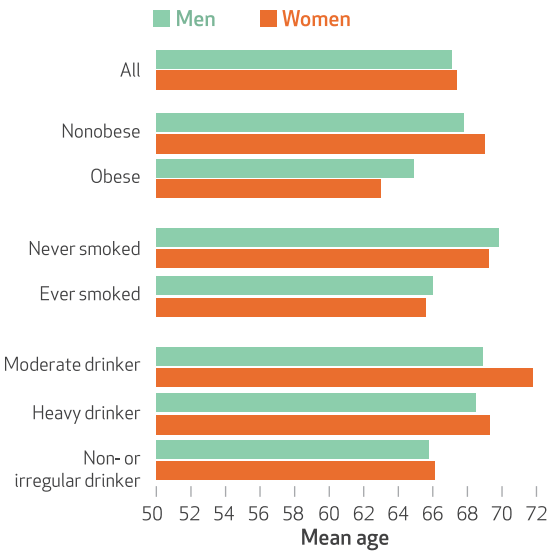
Finally, while our study provides novel insights into the potential health gains of adopting low-risk behaviors, our study did not address the role of genetic factors, which may simultaneously influence both the presence of a risk factor and its damaging effects.[21] For example, a similar set of genes may increase both the risk of becoming obese, given a certain diet, and the negative metabolic consequences of obesity.[22] In addition, people who refrain from risky behavior may be likely to have other health-promoting traits (for example, an optimistic outlook), and our study did not account for such traits.

Study Results

DESCRIPTIVE CHARACTERISTICS OF THE SAMPLE At the beginning of the study period, 13 percent of women and 10 percent of men were disabled (Appendix 4 includes a table of sample characteristics at baseline, in 1998).[16] Approximately 26 percent of the sample were obese, 62 percent had ever smoked, and 73 percent were non-, irregular, or heavy drinkers. Twenty-seven percent of the sample were in the low-risk category LRB1 (all nonobese people who had never smoked), and women (33 percent) were more likely than men (20 percent) to be in this category. Seven percent of the sample were in the low-risk category LRB2 (nonobese people who had never smoked and who were moderate drinkers), which had equal percentages of men and women. While people at all educational levels were represented among the low-risk categories, people with high levels of education were more likely than others to be in these categories (Appendix 5 shows the percentages of people in each low-risk category by educational attainment).[16]

EXHIBIT 2

Mean age of first incident of disability at age 50 or later, by behavioral risk factor



SOURCE Authors' analysis of data for 1998–2012 from the Health and Retirement Survey. **NOTES** Obesity is defined as a body mass index of at least 30.0 kg/m^2. "Ever smoked" includes former and current smokers. "Moderate drinkers" are defined as men who consume fewer than fourteen drinks per week and women who consume fewer than seven drinks per week. "Heavy drinkers" are defined as men who consume at least fourteen drinks per week and women who consume at least seven drinks per week.

DISABILITY ONSET As expected, each behavioral risk factor was independently associated with early disability onset, with obesity the most consequential (Exhibit 2). On average, obese men became disabled at age 64.9 years, and obese women at age 63.0 years—a penalty of 3 years for men and 6 years for women, compared to their nonobese counterparts.

Appendix 6 shows mean age at the first incident of disability at age 50 or later, by behavioral profile.[16] Nonobese men and women who had never smoked had a mean age at the first incident of disability of 71.0 years—3.5 years later than in the whole population. Nonobese men and women who never smoked and were moderate drinkers displayed the longest postponement of disability, with a mean age at the first disability incident of 72.1 for men and 75.2 for women.

LIFE EXPECTANCIES Remaining life expectancy at age 50 was 27.7 years for all men and 31.4 years for all women—or a life expectancy of 77.7 years for men and 81.4 years for women (Exhibit 3). Our life expectancy estimates were similar to US life expectancy from 2005 National Vital Statistics data.[23] (Note that the measure of years lived before disability onset is not the same as the measure of disability-free life expectancy. People can recover from disability, and the latter measure, but not the former one, includes disability-free years after an episode of disability onset and recovery.)

As shown in Exhibit 3, women spent 5.8 years of life disabled, compared to 4.0 years for men. For both men and women, obesity had a small effect on overall life expectancy and a more substantial effect on disability-free life expectancy: Being obese shortened disability-free life expectancy by 2.3 years for men and 4.8 years for women. Nonobese people also spent less time disabled compared to obese people.

Both men and women who had never smoked

had a substantially longer overall and disability-free life expectancy and lived longer with a disability, compared to people who had smoked. Compared to heavy drinkers and non- or irregular drinkers, moderate drinkers had longer overall and disability-free life expectancies.

The life expectancy advantages of the populations with low-risk behavior profiles are shown in Exhibit 4. Compared to all men and women, respectively, nonobese men and women who never smoked (LRB1) live on average about four years longer, and nonobese men and women who never smoked and who were moderate drinkers (LRB2) live on average about seven years longer. Importantly, nearly all of this advantage was due to longer disability-free life expectancy. Thus, the two low-risk behavior populations not only live longer, but they also do so free of disability.

In contrast, obese men and women who had ever smoked and were not moderate drinkers had significantly shorter life expectancies—both overall and disability-free—compared to all men and women. The differences are even greater between the populations with the best and the worst profiles. For example, a fifty-year-old woman who has never smoked, is not obese, and drinks moderately will live until she's almost eighty-nine, roughly twelve years longer than a fifty-year-old obese woman who ever smoked and does not drink moderately. For men, the difference in life expectancy between these two categories is slightly more than eleven years.

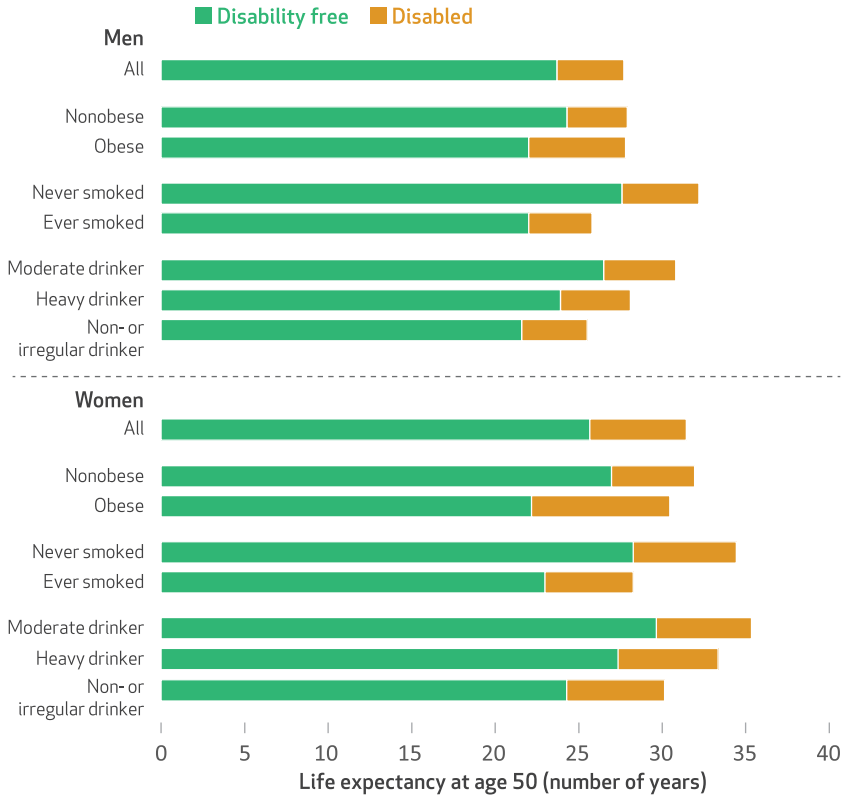
The exceptional advantages of the two low-risk behavior populations are further illustrated through a comparison with life expectancy in 2005 in Japan, a nation known for its citizens' longevity (Exhibit 4). Life expectancy at age fifty for all US men was three years less than for Japanese men, and the difference was five years for women. However, with the exception of LRB1 women, the other three low-risk behavior groups had a longer total life expectancy compared to the Japanese.

ADDITIONAL FINDINGS In our sample, the dominant smoking group was former smokers (41 percent of the total sample), and it is relevant to ask whether smokers who quit early in life can still experience a long and disability-free life. In separate analyses (data not shown), we found that nonobese people who had quit smoking ten or more years before entering the survey and who were moderate drinkers had overall and disability-free life expectancies that were only one year shorter than nonobese people who had never smoked and were moderate drinkers.

We also explored whether the life expectancies at age fifty changed over the study period. We divided the period in two—1998–2004 and 2005–2012—and compared life expectancy at age fifty between the two periods. For the total sample, life expectancy at age fifty increased by about 0.6 year from the earlier to the later period, and about one-third of the increase was disability-free. The results were similar for the two low-risk behavior groups. However, our analysis was likely underpowered to distinguish differences in trends across these subgroups.

EXHIBIT 3

Overall, disability-free, and disabled life expectancy at age 50, by behavioral risk factor



SOURCE Authors' analysis of data for 1988–2012 from the Health and Retirement Study. **NOTES** Obesity, "ever smoked," "moderate drinkers," and "heavy drinkers" are defined in the Notes to Exhibit 2. Appendix 7 shows 95% confidence intervals; see Note 16 in text.

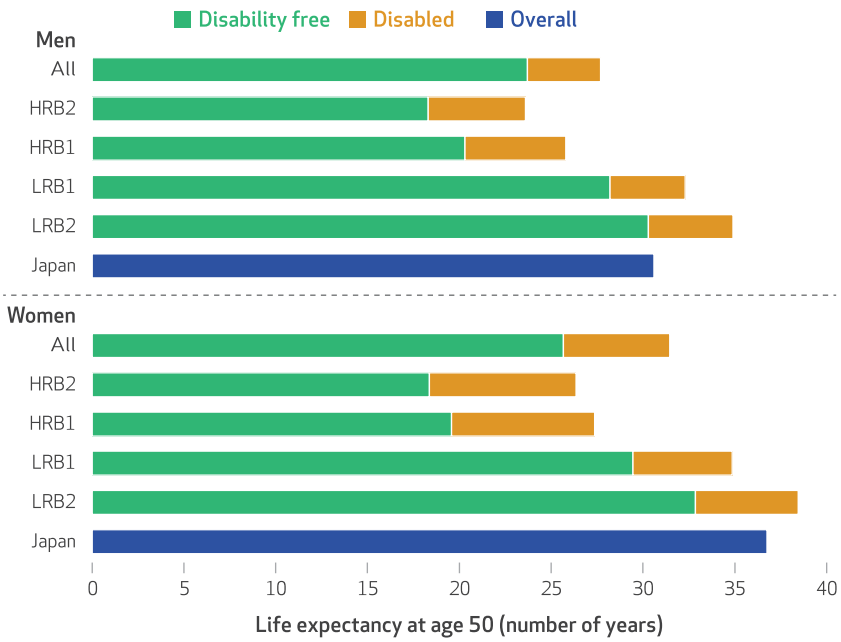
Discussion

Sizable segments of the US population have advantageous behavioral profiles, but little is known about how long people in those groups live because previous research has been limited to studying the effect of single health behaviors on life expectancy. Studying the effect of multiple health behaviors exercised simultaneously provides new insights into levels of health that are achievable without novel life-extending medical technologies.

We analyzed nondisabled and disabled life expectancy for low-risk behavioral groups, one

EXHIBIT 4

Overall, disability-free, and disabled life expectancy at age 50, by behavioral profile



SOURCE Authors' analysis of data for 1988–2012 from the Health and Retirement Study and for 2005 for Japan from The Human Mortality Database [home page on the Internet]. Berkeley (CA): The Database; [cited 2017 May 11]. Available from: http://www.mortality.org. **NOTES** "High-risk behavioral profile (HRB) 1" refers to obese people who have ever smoked. "HRB2" refers to obese people who have ever smoked and were nonmoderate drinkers. "Low-risk behavioral profile (LRB) 1" refers to all nonobese people who never smoked. "LRB2" refers to nonobese people who never smoked and were moderate drinkers. "Japan" refers to all Japanese. Appendix 7 shows 95% confidence intervals; see Note 16 in text.

consisting of respondents who were not obese and had never smoked and a similar group whose members also drank alcohol moderately. Compared to the average American, these two low-risk groups had life expectancy at age fifty that was four to seven years longer and a substantial postponement of the onset of disability. Strikingly, these low-risk populations also experienced a disability-free life expectancy similar to or longer than the overall life expectancy of the average American. A methodological advantage of our study was that we used longitudinal data to estimate transition probabilities, avoiding the biases arising from cross-sectional approaches.[24]

RISK-FACTOR PREVENTION Our findings are best interpreted in the context of population-level prevention of unhealthy and risky behaviors. The findings indicate the magnitude of health gains that could be achieved if more Americans adopted low-risk behaviors. They demonstrate what is being achieved by a sizable segment of Americans and is potentially achievable by many others.

The low-risk behavior groups have a life expectancy comparable to other exceptionally long-lived populations. Jennifer Montez and Mark Hayward 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,[25] similar to our estimates for the LRB1 groups of 82 years for men and 85 years for women. Immigrant populations also exhibit exceptionally high longevity, which has been attributed in part to positive health selection (sometimes referred to as the "healthy migrant effect"), and some immigrant populations have cultural expectations that may discourage risky behaviors. Neil Mehta and coauthors showed that in the period 2000–10, US immigrants who survived to age 65 had a life expectancy of 84 years for men and 87 years for women.[26] However, 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 people who already had a risk factor. However, our study provides some indications of the sizable benefits achievable through behavioral change. We found that people who quit smoking at least ten years before entering the study experienced an exceptionally long disability-free life if they were also at low risk in terms of other behavioral factors. This result is consistent with previous findings that quitting smoking and making other favorable behavioral changes, even late in life, increases longevity.[27] Similarly, an emerging body of evidence suggests that obesity exhibits "duration" effects, in that reducing the length of time a person is obese may be associated with improved health.[28]

DISABILITY POSTPONEMENT Our study of the low-risk behavior groups suggest that these exceptional groups experience substantial disability postponement, compared to other groups. The benefits to society are that postponement will defer disability-associated health care costs until older ages and provide opportunities for people 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, people with multiple behavioral risk factors not only live shorter lives than those without these factors but also experience an extended time disabled, which underscores the large negative effects of risky health behaviors. Of note, we found obesity to be strongly associ-

ated with years lived with a disability, a finding that has been reported in at least one previous study and is especially concerning given the fact that the prevalence of obesity has been rising since at least the early 1980s.[29] As shown in Exhibit 1 and some previous analyses of data from the National Health and Nutrition Examination Survey (NHANES),[30] the increasing prevalence of obesity may have leveled off during the early and mid-2000s. However, we believe that it is premature to infer that the long-term rise in obesity has ended. For example, between 2005–06 and 2013–14 the prevalence of obesity among adult American women increased significantly, according to analyses of NHANES data.[31]

Policy Considerations

As aging nations grapple with the social and economic consequences of a growing elderly population, a key variable is the future health status of the older population.[32] Our findings indicate that the high prevalence of risky behaviors poses a formidable challenge to achieving improvements in population health. Evidence shows that population-level behavior profiles can be responsive to large-scale and high-level policy efforts, with some of the most convincing evidence coming from antismoking campaigns.[33] The Affordable Care Act made a major step forward in federal support for prevention through its establishment of the Prevention and Public Health Fund, which focuses on improvement in health behaviors, among other topics. There is also solid evidence of the effectiveness of financial "sticks" such as taxes on cigarettes, alcohol, and potentially beverages and foods associated with obesity.[34] The success of these and other policies in helping people maintain a healthy body weight and refrain from smoking and immoderate alcohol consumption will largely determine the future health and disability status of the aging US population. ■

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NOTES

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