Published in final edited form as:

Health Aff (Millwood). 2017 April 01; 36(4): 626–635. doi:10.1377/hlthaff.2016.1281.

Preventing Disability in the United States: The Role of Modifiable Risk Factors on State and National Disability Prevalence

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Abstract

Declines in U.S. disability levels have stalled, but much disability could be prevented by reducing lifestyle-related risk factors in the population. We estimated the percentage of national and state disability that could be prevented through reducing five modifiable health risk factors: cigarette smoking, obesity, diabetes, high cholesterol, and hypertension. Data were from the 2013 Behavioral Risk Factor Surveillance System. Taking into account risk factor prevalence and the association between each risk factor and disability, we evaluated the fraction of disability preventable if risk factors were reduced under two scenarios: complete elimination and reduction in all states to lowest levels observed in U.S. states. If all five risk factors were eliminated, fifty-three percent of disability could be prevented nationally. Largest contributors were smoking (17%), obesity (16%), and hypertension (12%). If all states reduced risk factor levels to lowest observed levels, up to seven percent of disability could be prevented nationally. Many states in the South and Mid-West could experience disability reductions of more than 10% by attaining risk factor levels on par with states with the most favorable profiles. Improved risk factor prevention may result in the resumption of longer-term declines in U.S. disability.

Introduction

Disability is a key indicator of population health.^{1,2} It imposes a large burden on the wellbeing of individuals and their families, on health care expenditures, and on economies as a whole.^{3–7} While life expectancy in the United States has continued to improve, prevalence of key disability indicators since the early 2000s has either increased or remained stagnant among those under age 70.^{8–11} These indicators include limitations in the activities of daily living (ADL) and instrumental activities of daily living (IADL). These recent patterns are in contrast to remarkable declines in these and related disability indicators during the 1980s

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and 1990s.^{12–15} The reasons why the declining trend in disability has stalled for large segments of the U.S. population remain unclear.

Five major lifestyle-related factors have been shown to increase the risk of disability for individuals in observational studies: obesity, diabetes, hypertension, high cholesterol, and cigarette smoking.^{10,16–18} *Aside from their association with disability, these lifestyle-related factors themselves are interdependent. Obesity, diabetes, hypertension and high cholesterol are cardio-metabolic conditions. All four risk factors are influenced by dietary intake and physical activity.*¹⁹ *Cigarette smoking is a behavioral risk factor that is also associated with cardio-metabolic morbidity in addition to cancers. Ample evidence indicates that these risk factors are preventable through lifestyle modification.*^{20–24} As such, some proportion of disability at a population-level could be prevented through population-wide reductions of these risk factors. However, there are no estimates as to how large a reduction in disability we would expect if the five risk factors were reduced to target levels.

Our objective was to evaluate the role of the five modifiable risk factors in contributing to population-level disability prevalence in 2013. We do so both at the national-and state-levels using a preventable fraction framework which allows us to describe the percentage of disability that could be reduced if a given risk factor were eliminated or lowered.

Study Methods

Study Data.

We obtained data on disability and risk factors from the 2013 Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is an annual national telephone survey conducted collaboratively by U.S. states and territories and the Centers for Disease Control and Prevention (CDC).²⁵ The BRFSS is the only major U.S. health survey that provides representative population-based data at the state level for all U.S. states. *It collects data on a wide range of health conditions and risk factors including those related to chronic disease, healthcare access and preventive screenings, and immunizations.* We restricted our analysis to adults aged 18–79 years residing in the 50 U.S. states and Washington DC. Of the 443,731 respondents sampled by BRFSS in 2013 who fit these criteria, we analyzed 391,389 respondents with complete data for variables of interest (88% of the age- and residence-eligible sample). We analyzed 340,280 individuals for estimates regarding high cholesterol as data on high cholesterol were only available for individuals who reported having had their cholesterol measured and had information on other covariates.

Study Measures.

We focused on physical disability. In 2013, the BRFSS for the first time included a set of five disability-related questions recommended by the U.S. Department of Health and Human Services.²⁶ We based our definition of disability from answers to three questions that were pertinent to global physical functioning and excluded from analysis two questions regarding vision-related and cognitive disability. The three questions were: “Do you have serious difficulty walking or climbing stairs?”, “Do you have difficulty dressing or bathing?”, and “Because of a physical, mental, or emotional condition, do you have difficulty doing errands

alone such as visiting a doctor's office or shopping?". The first two questions are among Katz's activities of daily living (ADL) limitation items and the third is conventionally used as a measure of instrumental activities of daily living (IADL) to capture independent living.^{21–29} We classified respondents as being disabled if they responded "yes" to at least one of the three questions.

All risk factor data were obtained from questions asked in the 2013 BRFSS. As noted, the five risk factors that we examined were: cigarette smoking, obesity, diabetes, high cholesterol, and hypertension. Following conventional guidelines, we defined obesity as having a body mass index (BMI) of at least 30 kg/m², which was computed from respondent reports of their height and weight. Cigarette smoking was defined based on reports of ever smoking cigarettes. Diabetes, high cholesterol, and hypertension were based on respondents reporting ever being diagnosed with the condition by a health professional. Diabetes excluded gestational diabetes. In addition to examining each of the five risk factors separately, we examined the role of the presence of at least one risk factor (which we term "1+ Risk Factors").

Analytic Approach.

Our goal was to use a preventable fraction framework to estimate the percentage of disability at the national- and state-levels that could be hypothetically prevented if risk factors were reduced under two separate target scenarios: complete elimination and reduction in all states to lowest levels observed in U.S. states in 2013.³⁰ We term the first scenario the "elimination scenario" and the second the "reduction scenario". The elimination scenario uses a risk factor prevalence of 0%, the theoretical minimum exposure, as the target prevalence.³¹ The reduction scenario uses as a target the mean prevalence in the five states that have the lowest prevalence of the risk factor under investigation.

The analysis proceeded in three stages. First, we estimated the prevalence of disability and each of the risk factors, including the 1+ Risk Factor measure, in BRFSS at the national and state levels.

Second, we estimated the magnitude of the association between each risk factor and disability using prevalence ratios. Prevalence ratios are analogous to odds ratios, and they reflect the ratio of prevalence of disability among individuals with a risk factor relative to individuals without that risk factor. We used multi-variable Poisson regression models with robust variance estimation to estimate the prevalence ratios.³² To allow the prevalence ratios to vary by socio-demographic groups we estimated models stratified by age group (18 to 54 years; 55 to 64 years; 65 to 79 years), sex (men; women), and race (non-Hispanic White; Hispanic, and non-Hispanic non-White). We controlled for age in single years, educational attainment (less than high school; high school degree/some college; college graduate or higher), and depression (ever been told that s/he has a depressive disorder). These covariates were included as expected confounders of the association between the risk factors and disability.

We also allowed for regional variations in the prevalence ratios through interaction terms between region of the U.S. (South, Midwest, East, and West) and the risk factors. In the

statistical models, we controlled for the other non-index risk factors (i.e., those not under investigation for a particular model), but avoided over-adjustment for risk factors that were consequences of the index risk factor (e.g., models estimating the prevalence ratio associated with obesity excluded an adjustment for diabetes as diabetes may be on the causal pathway between obesity and disability).

Third, we estimated the preventable fractions. We did so using a standard formula:

$$PF = 1 - \frac{P^*(PR - 1) + 1}{P(PR - 1) + 1}; \text{where PF is preventable fraction, } P \text{ is the prevalence of the risk}$$

factor, P^* is the target prevalence, and PR is the prevalence ratio as described above. For the elimination scenario, P^* was set to 0 (indicating a 0% prevalence); for the reduction scenario, P^* was set to the mean prevalence among the five states with lowest prevalence for the risk factor. Preventable fractions were estimated within age-sex-race strata and scaled up to state and national levels using the weighted-sum approach; see Detailed Method in online Appendix.

Confidence intervals for the preventable fractions were estimated using Monte-Carlo simulations and accounted for the sampling error in both prevalence and prevalence ratio estimation.³³ BRFSS-provided survey weights were incorporated into all estimations. Tests of statistical significance were performed at the $\alpha=.05$ level. Detailed procedures are included in the Detailed Method in the online Appendix.

Study Limitations.

The main limitation was the use of self-reported risk factor data. Reliance on self-reports may under-estimate the actual prevalence of risk factors. Studies report that up to 36% of U.S. individuals with diabetes and 20% of individuals with hypertension are undiagnosed,^{34,35} and obesity is under-estimated using self-reported data.³⁶ Therefore, the prevalence estimates we rely on may be conservative (i.e., an under-estimate). The cross-sectional, observational study design also limits a purely causal interpretation of the estimates. For example, risk factor profiles of adults may both cause or be caused by disability status; therefore, estimated associations may represent the upper-bounds of the true association between risk factors and disability. We did not examine physical inactivity, an important health risk, because of the high potential for reverse causality (i.e., disability status determining activity levels rather than vice versa).

STUDY RESULTS

Descriptive Characteristics.

Fifteen percent of adults aged 18–79 reported a disability (Exhibit 1). As expected, disability prevalence was higher with older age: approximately 11% of those aged 18–54 and 26% of those aged 65–79 reported a disability. At all ages, women reported higher levels of disability compared to men. Exhibit 1 also arrays risk factors in order of their prevalence in the total population. The majority (73%) of the population reported having at least one risk factor. Ever smoking was the most common risk factor (44%). Risk factor prevalence was higher at older relative to younger ages with the exception of obesity, which was lower among those aged 65–79 (30%) compared to those aged 55–64 (34%). Sex-specific

estimates and standard errors for the descriptive characteristics are presented in Appendix Exhibit 1.

Prevalence Ratios.

Prevalence ratios indicate the relative prevalence of disability among those with the risk factor compared to those without the risk factor. Appendix Exhibit 2 shows the prevalence ratios among those aged 50–64 for illustrative purposes. Prevalence ratios for other age groups are available upon request to the author. Those with at least one risk factor (1+ Risk Factor) had about a three-fold prevalence of disability compared to those with no risk factors (Appendix Exhibit 3). *Among the individual risk factors, obesity and diabetes were associated with the highest prevalence ratios, ranging from about 1.4 to 1.8 indicating a 40% to 80% higher disability prevalence among those with the risk factor compared to those without the risk factor.* Having high cholesterol was not associated with a significantly increased disability risk. In general, the prevalence ratios did not statistically differ by geographic region.

National Preventable Fractions.

Exhibit 2 shows the national preventable fractions for each of the risk factors under the elimination and reduction scenarios. With elimination as the target scenario, the preventable fractions for the 1+Risk Factor measure was 53% in the total population - that is, we would expect the prevalence of disability to be reduced by 53% if everyone in the population did not have any risk factors. The preventable fraction for the 1+ Risk Factor measure did not statistically differ by sex (53% for men and 52% for women) or age group, although the point estimate for preventable fractions for the 1+ Risk Factor was higher at older ages, reaching 57% for men and 64% for women (Appendix Exhibit 3). The preventable fractions associated with the individual risk factors among ages 18–79 and both sexes combined were as follows: smoking (17%), high cholesterol (4%; $p = .05$), hypertension (12%), obesity (16%), and diabetes (4%).

With reduction as the target, the national preventable fraction of disability associated with the 1+ Risk Factor measure and for the total population was 7% - that is, we would expect disability to be reduced by 7% if all states had the same percentage of individuals with at least one risk factor as that of the target states (i.e., those with the lowest percentage with 1+ Risk Factor) (Exhibit 2). In the reduction scenario, obesity and next smoking were associated with the highest preventable fractions; the rank ordering of the remaining three factors was similar to that of the elimination scenario. The preventable fractions for the total population were: obesity (5%), ever smoking (3%), hypertension (3%), diabetes (2%) and high cholesterol (1%) (Exhibit 2).

The online Appendix show preventable fractions and associated confidence intervals in table form by sex and age group for the elimination (Appendix Exhibit 3) and reduction (Appendix Exhibit 4) scenarios.

State-level Preventable Fractions.

Exhibit 3 is a color-coded map of age- and sex-adjusted disability prevalence by state. Disability prevalence was generally highest in the South and lowest in the Plains states. In general, the states with the lowest risk factor prevalence were those in the West and Northeast, while the states with the highest risk factor prevalence were in the Midwest (Appendix Exhibit 5). Utah (60%) and California (67%) had the lowest percentage of individuals with 1+ Risk Factor - meaning they had the highest percentage without any of the risk factors. Utah is noteworthy as it ranked as having the lowest prevalence in three of the five risk factors (cigarette smoking, high cholesterol, hypertension). Kentucky (82%) and West Virginia (83%) had the highest percentage with 1+ Risk Factor. Both states were also generally ranked as having the highest prevalence of each of the individual risk factors.

States varied widely in their preventable fractions of disability. Exhibit 4 provides a color-coded map of state-level preventable fractions for the 1+ Risk measure under the elimination scenario. In general, states in the South and Midwest displayed the highest preventable fractions and states in the West and Northeast had the lowest. The lowest state-level preventable fraction was 37% (Utah), and the highest was 66% (South Dakota). The online Appendix lists the state-level preventable fractions and 95% confidence intervals for the elimination (Appendix Exhibit 6) and reduction (Appendix Exhibit 7) scenarios for all risk factors.

Discussion

Comparative assessments of major modifiable risk factors aid in prioritizing public health targets for intervention.³¹ Results from this study specifically inform the population-level role of modifiable, lifestyle-related risk factors in shaping aggregate U.S. disability levels. To our knowledge, this effort is the first to quantify the individual and cumulative burden of modifiable risk factors to U.S. disability levels. We find that approximately one-half of disability levels among U.S. adults in 2013 can be attributed to the presence of at least one of five major modifiable risk factors. Of individual risk factors, cigarette smoking, obesity, and hypertension - in that order — were most consequential.

Although complete elimination of the risk factor from the population is the conventional target for calculating preventable fractions, as a more realistic scenario we also considered as a target the risk factor levels achieved in states with the lowest prevalence.³⁰ This additional target provides a more realistic assessment of disability reductions achievable through health policy. If all states were to reduce risk factor prevalence to the levels observed in the best U.S. states, we would expect national disability reductions of up to seven percent, with the largest expected reduction in disability from bringing national obesity down to the lowest currently observed prevalence in U.S. states.

With respect to the interpretations of the preventable fractions, it is important to note that certain risk factors are on the causal pathway between other risk factors and disability. Cigarette smoking and obesity influence risk of diabetes, high cholesterol, and hypertension. The preventable fractions we estimate reflect these relationships, and our approach did not partial out the various pathways. For example, the preventable fraction associated with

obesity reflects both the effect of obesity on disability independent of diabetes, hypertension, and high cholesterol, and indirect effects of obesity on disability that operate through these risk factors. Similarly, the preventable fraction associated with smoking incorporates both estimated direct and indirect effects of smoking on disability. It is therefore incorrect to add the preventable fractions across the various risk factors. The preventable fractions for smoking also did not differentiate effects of current and former smoking.

Our study examined the contribution of the risk factors to disability levels during 2013. Based on the preventable fraction metric, the two most important risk factors in order of largest contribution to disability were cigarette smoking and obesity. Given continued declines in smoking levels among U.S. adults³⁷ and a persistently high obesity prevalence,³⁸ especially at younger ages, it is conceivable that obesity will surpass smoking as being the single most important risk factor to U.S. disability in the near future. While our study did not assess trends, we draw on prior work that has examined obesity's role. A 2004 study indicated that obesity explained about one-quarter of the growth in disability, measured through limitations in personal care, among those ages 30–39 and one-tenth of the growth among those ages 40–49 during 1984–1996.⁹ A 2014 study indicated that increasing BMI among adults ages 40–64 explained nearly all of the increase in disability, measured by physical functioning and IADLs, for this age group during the 1997–2010 period.³⁹

We found that relative to the other risk factors, diabetes was associated with small preventable fractions. This finding should not be interpreted as diabetes being an unimportant determinant of disability for individuals or populations. In fact, we found the association between diabetes and disability to be as high or higher than the other risk factors (see, for example, prevalence ratios in Appendix Exhibit 2). This finding underscores the high disability risks associated with having diabetes. The relatively small preventable fractions for diabetes is largely a function of its lower prevalence compared to the other risk factors in the age range examined (18–74 years). For example, approximately 10% of men and women aged 18–79 reported being diagnosed with diabetes compared to roughly 30% or more for each of the other risk factors. Diabetes rises sharply across age and analyses limited to older populations (ages 65+) may reveal much larger preventable fractions associated with diabetes than our study. The U.S. Centers for Disease Control and Prevention (CDC) estimated that approximately one-quarter of adults ages 65 years or older had diabetes (including undiagnosed cases).⁴⁰

Also concerning is that among hypertension, high cholesterol, and diabetes, the secular trends for diabetes appear the most unfavorable. Between 1960 and 2000, diabetes was the only risk factor that increased in prevalence among adults aged 20 or older with measured high blood pressure and high cholesterol levels showing substantial declines.⁴¹ The increasing prevalence of diabetes over time appears attributable to the increasing prevalence of obesity over time.⁴² If recent patterns continue into the future, the preventable fractions associated with obesity and diabetes will likely increase.

While cigarette smoking is itself a behavior, the four metabolic risk factors—diabetes, obesity, hypertension, and high cholesterol—share common behavioral antecedents, notably poor diet, low levels of physical activity, and cigarette smoking.^{43,44} Policies aimed at

behavioral change therefore appear to be the most promising at simultaneously preventing multiple risk factors. What types of policies would be most effective? Since the 1960s, levels of cigarette smoking have declined, which has been attributed in large measure to aggressive taxation and national-level health communication campaigns.^{45,46} Regarding the metabolic risk factors, there are several ongoing campaigns. Population-wide examples include: state-level taxation of sugar-sweetened beverages;⁴⁷ steps taken by the Federal Drug Administration to limit trans-fatty acids in processed foods;⁴⁸ state policies promoting school-based physical activity;⁴⁹ and employer-based wellness programs incentivizing preventive healthcare and healthy lifestyle. Other large scale programs, such as the CDC's Diabetes Prevention Program, focus on high risk individuals for targeted lifestyle intervention. Scientific consensus is lacking, however, on the set of policies that are most successful in improving the dietary and physical profile of the U.S. population.^{50–52}

In terms of state differences, disability levels were highest in the southern U.S., Appalachian region, and states surrounding the Great Lakes. Our estimates suggest that many states in these regions would experience the largest proportionate declines in disability, often in excess of 10%, by reducing risk factor levels to those occurring in the states with the best risk factor profiles. Relative to other regions, these regions also exhibit relatively high death rates,⁵³ lower life-expectancy,⁵⁴ high prevalence of risk factors,^{30,55–57} poor risk factor detection and control,⁵⁵ and high levels of poverty.⁵⁸ These burdens combined with socioeconomic deprivation also make these states some of the most challenging for policy intervention.

The validity of the preventable fractions reported here depend in large measure on the validity of the estimated prevalence ratios of disability. Despite reliance on cross-sectional associations, the rank-order and magnitude of prevalence ratios we rely on are largely consistent with measures of associations found in prospective studies. A recent study of the Framingham Offspring cohort identified smoking, obesity, and diabetes as the main predictors for disability defined using an ADL measure in adults aged 45 to 65 years at baseline.⁵⁹ Similar to our results, cholesterol was not as salient a predictor of disability as these other risk factors. Similarly, our estimates for diabetes are of comparable magnitude with findings from a systematic review of 26 studies on the disability risk associated with diabetes.⁶⁰

Conclusion

This analysis provides a benchmark for future national- and state-level monitoring of disability levels in the U.S. population over time and geography. Roughly half of the disability burden in the United States in 2013 can be attributed to the presence of risk factors known to be modifiable, with cigarette smoking, obesity, and hypertension contributing the largest share to overall disability. Further understanding of the wide state-level variation in disability and the prevalence of risk factors may also yield important policy insights.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Exhibit 1.

Prevalence of disability and risk factors among U.S. adults by age group, 2013

Note: Disability is defined as reported difficulty walking, climbing stairs, bathing, or doing errands alone such as visiting a doctor's office or shopping. Smoking includes former and current smokers. Obesity is a body mass index of 30 kg/m² or higher based on self-reported height and weight. Hypertension, diabetes, and high cholesterol are based on being ever diagnosed with the condition. Estimates reflect sample weighting.

Data Source: Behavioral Risk Factor Surveillance System, 2013

Exhibit 2.

National-level preventable fractions (expressed as percentages) of disability associated with risk factors under elimination and reduction scenarios for adults ages 18–74, 2013

Note: Men and women combined. Disability is defined as difficulty walking or climbing stairs; bathing; or independently conducting errands. 1+ Risk Factor category indicates the presence of at least one of the five risk factors. Obesity is a body mass index of 30 kg/m² or higher based on self-reported height and weight. Hypertension, diabetes, and high cholesterol are based on being ever diagnosed with the condition. Estimates reflect sample weighting. 95% confidence intervals shown in parentheses.

Data Source: Behavioral Risk Factor Surveillance System, 2013

Exhibit 3.

State-level disability prevalence among adults ages 18–79, 2013

Note: Age- and sex-standardized to the U.S. population ages 18–79 in 2013. Shading indicates quintile of disability prevalence. Disability is defined as reported difficulty walking, climbing stairs, bathing, or doing errands alone such as visiting a doctor's office or shopping. Estimates reflect sample weighting.

Data Source: Behavioral Risk Factor Surveillance System, 2013