



# Prevalence And Domains Of Disability Within And Outside Appalachian North Carolina: 2013–2016 Behavioral Risk Factor Surveillance System

By: **Erin D. Bouldin**, Andrew Vandenberg, Manan Roy, **Adam Hege**,  
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## Abstract

**Background:** The health and social conditions of the Appalachian region generally are poorer than in the US overall, and this gap is widening, suggesting disability may be higher in Appalachia. **Objective:** To describe the prevalence of disability overall and by domain in Appalachian and non-Appalachian regions in North Carolina (NC) and describe the characteristics of people with and without disability in each region. **Methods:** We conducted a cross-sectional study using data from the NC Behavioral Risk Factor Surveillance System from 2013 to 2016 which assessed disability in five domains: vision, cognitive, mobility, self-care, and independent living. We calculated weighted proportions and age- and sex-adjusted prevalence using direct standardization to the 2010 Census. **Results:** The prevalence of disability in Appalachian NC was significantly higher than in non-Appalachian NC after standardizing by age and sex (26.6% in Appalachia, 24.1% outside Appalachia,  $p < 0.001$ ). In both regions, mobility disability was most common and self-care disability was least common. People within Appalachia more frequently reported disability in all domains compared to people outside Appalachia. **Conclusions:** More than one in four adults in Appalachian North Carolina experience disability in at least one domain and one in eight experiences disability in multiple domains. The high prevalence of disability should be considered when planning programs and services across the spectrum of public health. Understanding common disability domains present in populations can inform public health agencies and service providers and help them develop programs and messaging that meet the needs of residents in Appalachia and are accessible to people with disabilities.

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## A B S T R A C T

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**Objective:** To describe the prevalence of disability overall and by domain in Appalachian and non-Appalachian regions in North Carolina (NC) and describe the characteristics of people with and without disability in each region.

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**Results:** The prevalence of disability in Appalachian NC was significantly higher than in non-Appalachian NC after standardizing by age and sex (26.6% in Appalachia, 24.1% outside Appalachia,  $p < 0.001$ ). In both regions, mobility disability was most common and self-care disability was least common. People within Appalachia more frequently reported disability in all domains compared to people outside Appalachia.

**Conclusions:** More than one in four adults in Appalachian North Carolina experience disability in at least one domain and one in eight experiences disability in multiple domains. The high prevalence of disability should be considered when planning programs and services across the spectrum of public health. Understanding common disability domains present in populations can inform public health agencies and service providers and help them develop programs and messaging that meet the needs of residents in Appalachia and are accessible to people with disabilities.

**Keywords:**  
Disability  
Appalachia  
Function  
Rural  
Surveillance

## Introduction

Disability is a relatively common experience in the United States; approximately one in four adults live with some form of disability.<sup>1</sup> Disability results from an interplay between personal and environmental factors, and is influenced by health conditions, social structure, and available support systems.<sup>2</sup> Because these factors change, disability itself is not static. Furthermore, disability and health are not mutually exclusive but, rather, exist on a continuum.<sup>2</sup> Nonetheless, there are well-documented relationships

between disability, social determinants of health, and health status. For example, people with a disability in the US more frequently live in poverty than people without a disability,<sup>3</sup> and people with a disability generally report having a chronic health condition more frequently than people without a disability.<sup>4</sup>

The health and social conditions of the 13-state Appalachian region generally are poorer than in the US overall.<sup>5</sup> Social determinants of health are those factors within individuals' environments which they cannot change but that have important effects on their opportunities and quality of life, such as the availability of high quality education, safe neighborhoods, clean air and water, and meaningful interactions with others.<sup>6,7</sup> People living in Appalachia have more opportunities for meaningful social interactions than people in the US overall, but otherwise have poorer social determinants of health.<sup>5</sup> Mortality rates for major chronic conditions, depression prevalence, and physically and mentally

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unhealthy days all are higher in Appalachia than in the US overall.<sup>5</sup> Furthermore, over the past 20 years the gap between Appalachia and the rest of the nation has widened on eight measures of social determinants and health outcomes: poverty; education; heart disease, cancer, and stroke mortality; infant mortality; primary care physician supply; and years of potential life lost.<sup>5,8</sup> North Carolina is part of the South Central subregion of Appalachia, which has moderate rates of mortality and social determinants of health compared to the other 4 subregions. North Carolina has some of the smallest disparities between Appalachian and non-Appalachian parts of the state in heart disease, stroke, and cancer mortality; in some cases, the Appalachian region of the state has more favorable rates than the rest of the state.<sup>5</sup> However, disparities in injury and poisoning mortality rates and in years of potential life lost between the Appalachian and non-Appalachian portions of the state are similar to those for the region overall. North Carolina has among the highest disparities in diseases of despair (alcohol and substance use mortality, suicide, and liver disease) when comparing the Appalachian and non-Appalachian regions of the state.<sup>9</sup>

Given the substantial risk factors for disability present in Appalachia, the variability across states, and the lack of information about disability in the region, we sought to assess disability in the Appalachian and non-Appalachian portions of one state. The aims of this study were to: 1) describe the prevalence of disability overall and by domain in Appalachian North Carolina, including evaluating combinations of disability domain, 2) compare crude and adjusted disability prevalence among adults in the Appalachian region of North Carolina to the rest of the state, and 3) describe the demographic, health status, and health care access characteristics of people with and without disability in the Appalachian and non-Appalachian regions of North Carolina. We hypothesized that disability prevalence would be higher in Appalachia than in the rest of the state and that the demographic and health characteristics of people with disability would vary across the two regions, consistent with previous studies (e.g., people in Appalachia would more frequently be non-Hispanic white, have chronic health conditions, and have lower income than people outside Appalachia). We also hypothesized that differences in age and sex would explain some, but not all, of the variation in disability prevalence within and outside Appalachia. We also expected that people living in Appalachia would more frequently experience disability in multiple domains since environmental barriers to activities and participation in the Appalachian region increase the risk of disability.

## Methods

### Data source

We used data from the North Carolina (NC) Behavioral Risk Factor Surveillance System (BRFSS) from 2013 to 2016. The BRFSS is a cellular and landline telephone survey conducted annually in all US states and territories to assess a variety of health-related topics including diet, physical activity, health care access, health conditions, and disability among a representative sample of community dwelling adults age 18 and older.<sup>10</sup> All data collected through the BRFSS are self-reported. Data are aggregated across states by the Centers for Disease Control and Prevention (CDC) and made available to the public on their website; this public dataset does not include county of residence. In order to compare Appalachian and non-Appalachian counties, we requested a dataset from the NC BRFSS coordinator that included an indicator variable for residence in one of the 29 counties that are part of Appalachia based on the Appalachian Regional Commissions' definition: Alexander, Alleghany, Ashe, Avery, Buncombe, Burke, Caldwell, Cherokee, Clay, Davie, Forsyth, Graham, Haywood, Henderson, Jackson, McDowell,

Macon, Madison, Mitchell, Polk, Rutherford, Stokes, Surry, Swain, Transylvania, Watauga, Wilkes, Yadkin, and Yancey.<sup>11</sup> There were 6,001 respondents from Appalachian and 23,383 respondents from non-Appalachian regions of the state across the four years of data. The BRFSS response rates in North Carolina during these years ranged from 37.5 [2014] to 42.9 [2015] and was generally slightly lower than the mean across all states based on BRFSS data quality reports. We were not able to compare response rates in Appalachian and non-Appalachian counties since these are not calculated by CDC. There is a disposition code variable in the public BRFSS dataset that indicates complete or partial complete surveys, and respondents in Appalachia were less likely to have a partially complete survey than respondents in the rest of the state (10.2% versus 15.3%,  $p < 0.001$ ).

### Measures

In 2013, the BRFSS began including questions to capture disability that have been used on the US Census.<sup>12–14</sup> This set of five questions asks respondents if they have difficulty with specific tasks or activities, enabling respondents to be classified as having a mobility, self-care, independent living, vision, or cognitive impairment/limitation/restriction. There is a sixth item assessing a hearing impairment, but because it was included on the BRFSS beginning in 2016, we did not have an adequate sample size to include it in this analysis. The questions and corresponding disability domains are:

- Are you blind or do you have serious difficulty seeing, even when wearing glasses? (vision impairment)
- Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions? (cognitive impairment)
- Do you have serious difficulty walking or climbing stairs? (mobility limitation)
- Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping? (independent living restriction)
- Do you have difficulty dressing or bathing? (self-care restriction)

We classified respondents as having or not having each domain of disability noted above and created a variable to indicate whether they reported any disability versus no disability. We did not require that respondents answer all five questions in order to be included in this measure: if a respondent reported difficulty in at least one domain we classified them as having a disability ( $n = 28,613$ ). We also evaluated combinations of disability domains. We created a variable with mutually-exclusive classifications of disability based on the domain(s) in which a person experienced difficulty (e.g., vision only; vision and cognitive only; vision, cognitive, and mobility; etc.). For this variable, respondents must have responded to all five questions in order to be classified ( $n = 28,474$ ; see [Supplemental Figure 1](#)).

For Objective 3, we used demographic and household characteristics to describe people with and without disability in each region of the state. We categorized respondents as age 18–44 years, 45–59 years, 60–79, or 80 + years old to reflect young adulthood, middle age, early older adulthood, and older adulthood.<sup>12</sup> We classified respondents' sexual orientation using a state-added question available in all years that asked if respondents identify as heterosexual; homosexual, gay, or lesbian; bisexual; or something else. We dichotomized marital status as married or a members of an unmarried couple and not married/coupled. We classified respondents' highest level of education as less than high

school, high school or equivalent, some college, and college degree or higher. Annual household income categories included <\$15,000, \$15,000-\$24,999, \$25,000-\$49,999, \$50,000-\$74,999, and  $\geq$ \$75,000. We classified race and ethnicity together as white, non-Hispanic; Black, non-Hispanic; other race, non-Hispanic; multiple races, non-Hispanic; and any race, Hispanic. Employment status categories included employed or self-employed, out of work, student, homemaker, retired, and unable to work. We created a dichotomous indicator for whether there were any children under age 18 in the household.

We also included health status and health care access variables in our descriptive analysis. We classified general health status as excellent, very good, or good versus fair or poor.<sup>15,16</sup> We measured mental health using the question, “Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?” Consistent with previous research and recommendations from the CDC, we classified respondents as experiencing frequent mental distress if they reported  $\geq$ 14 days of poor mental health in the past 30 days.<sup>15</sup> We created dichotomous variables to indicate whether respondents had ever been diagnosed with one of the following chronic health conditions: heart disease (coronary heart disease, myocardial infarction, or angina), stroke, current asthma, cancer (other than skin cancer), lung disease (chronic obstructive pulmonary disease, emphysema or chronic bronchitis), arthritis (arthritis, gout, lupus, or fibromyalgia), and diabetes (other than gestational diabetes). We also created a dichotomous variable to represent whether the respondent had ever been diagnosed with depression; the BRFSS does not include details about treatment or current depression status. We created indicator variables for whether respondents had any health insurance coverage at the time of the interview, whether they reported they had at least one personal health care provider, and whether they reported they could not see a doctor in the past year because of cost. We report the timing of the last visit to a healthcare provider for a routine check-up as collected. For each question, respondents who said they did not know or were not sure of the answer or refused to answer the question were classified as missing.

#### Data analysis

We included all NC BRFSS respondents who had non-missing values for disability status (yes/no), sex, age, and Appalachian residence since we included these variables in our primary adjusted prevalence estimates. From the original 29,384 respondents, we retained 28,279 (96.2%); 771 of these were missing information on disability and the remaining 334 were missing information on at least one covariate (3 missing sex, 332 missing age, 0 missing region). We compared the prevalence of disability in the full sample to the prevalence in this restricted sample and found very small differences (0–0.2% points).

We calculated the weighted proportion of respondents with a disability and with disability in a given set of domains in Appalachian and non-Appalachian regions of the state (Objective 1). We also calculated the percentage of people with a disability in one domain who reported a disability in each other domain. We calculated age- and sex-adjusted disability prevalence estimates by directly standardizing the data to the 2010 US Census population using the same age groups used in the rest of our analyses: 18–44, 45–64, 65–79, and 80+ (Objective 2). We used the methodology recommended on the National Health and Nutrition Examination Survey website<sup>17</sup> and counts posted in the US Census Bureau Brief on Age and Sex<sup>18</sup> for these standardization calculations. We calculated weighted percentages to describe the characteristics of people with and without disability both within and outside of

Appalachia (Objective 3). All prevalence comparisons between Appalachian and non-Appalachian regions of the state were made using chi-square tests. When comparing the characteristics of people with and without disability in Appalachia and with disability across Appalachian and non-Appalachian regions we again used a chi-square test and excluded people with missing values since we were more interested in understanding if differences existed between groups than in understanding if response patterns (missingness) differed. We used a p-value of <0.01 to indicate statistical significance based on a Bonferroni correction given that there are 5 domains of disability compared in our analyses.

For all analyses, we used the appropriate weight variable in the BRFSS file via survey (svy) commands with subpopulation statements in Stata 13.1 (College Station, TX), consistent with BRFSS guidance.<sup>19</sup> We also did not report any results when the unweighted denominator was smaller than 50 or the relative standard error, calculated as the weighted standard error divided by the weighted point estimate multiplied by 100, was greater than 30.0 since both of these represent potentially unstable estimates.

This study was reviewed by XXX University’s Institutional Review Board and was classified as exempt (IRB #18–0071).

## Results

### Disability prevalence

The prevalence of disability in Appalachian North Carolina was 28.2%, significantly higher than the 24.0% in the non-Appalachian region of the state ( $p < 0.001$ ; Table 1). After standardizing by age and sex, the disability prevalence in Appalachia declined to 26.6% but remained significantly higher than the prevalence outside Appalachia (24.1%,  $p < 0.001$ ). In both regions, mobility disability was most common and self-care disability was least common. People within Appalachia more frequently reported disability in all domains compared to people outside Appalachia after accounting for age and sex.

Fig. 1 illustrates that disability generally increases with age and the domain in which people most commonly experience disability changes with age. Among young adults, cognitive impairment is most common. Beginning in middle age and throughout the remainder of the life span, mobility limitations become more common. The prevalence of disability in each domain increased from the 18–44 year old group to the 45–64 year old group. However, in all domains other than mobility, the prevalence of disability trended lower for 65–79 year olds in the sample than among 45–64 year olds (no formal statistical tests done). Disability was more common in all domains for respondents age 80 and older than for respondents 45–64. In general, the oldest age group had the highest prevalence of disability in each domain; however, in Appalachia, the highest prevalence of vision and cognitive disability occurred among middle-aged adults.

### Disability in multiple domains

As reported in Table 1, 12.7% of adults in Appalachia and 11.1% of adults outside Appalachia experienced disability in two or more of the five domains assessed. A substantial majority of people with a self-care disability or independent living disability also had a mobility disability (self-care: 93% in Appalachia and 85% outside Appalachia also had mobility disability; independent living: 79% in Appalachia and 73% outside Appalachia also had mobility disability; Table 3). About two-thirds of adults with a self-care disability reported a co-occurring independent living disability. Around half of adults with a self-care or independent living

**Table 1**Crude and age- and sex-adjusted<sup>1</sup> estimates of disability prevalence (weighted) within and outside the Appalachian regions of North Carolina, BRFSS 2013–2016.

Disability Domain	Crude Estimate		p-value <sup>2</sup>	Age & Sex-Adjusted Estimate		p-value <sup>2</sup>
	Within Appalachia	Outside Appalachia		Within Appalachia	Outside Appalachia	
	% (95%CI)	% (95%CI)		% (95%CI)	% (95%CI)	
Vision	6.3 (5.5–7.1)	4.8 (4.5–5.2)	<0.001	5.9 (5.1–6.7)	4.8 (4.5–5.2)	<0.001
Cognitive	13.0 (11.9–14.2)	11.1 (10.6–11.6)	0.002	13.0 (11.8–14.2)	11.2 (10.6–11.7)	0.002
Mobility	19.1 (17.9–20.4)	15.5 (14.9–16.0)	<0.001	17.3 (16.1–18.5)	15.5 (14.9–16.0)	<0.001
Self-care	5.5 (4.8–6.4)	4.5 (4.2–4.9)	0.012	5.2 (4.5–6.0)	4.6 (4.2–4.9)	0.009
Independent living	9.0 (8.1–10.0)	7.5 (7.1–7.9)	0.004	8.6 (7.7–9.6)	7.6 (7.2–8.0)	0.003
Any disability	28.2 (26.7–29.7)	24.0 (23.4–24.7)	<0.001	26.6 (25.2–28.2)	24.1 (23.4–24.7)	<0.001
Disability in multiple domains	13.5 (12.4–14.7)	11.0 (10.5–11.5)	<0.001	12.7 (11.6–13.9)	11.1 (10.6–11.6)	<0.001

<sup>1</sup> Adjusted using direct standardization to the 2010 US Census population counts for ages 18–44, 45–64, 65–79, and ≥80 years by sex.<sup>2</sup>p-value compares within Appalachia to outside Appalachia using a chi-square test of weighted proportions.

disability also had a cognitive disability.

When we classified people in mutually-exclusive categories based on the domain(s) in which they experienced disability (Table 4), we found that mobility disability alone was the most common category (6.1% of adults in Appalachia and 6.2% of adults outside Appalachia experienced mobility disability only, after standardizing by age group and sex), followed by cognitive disability only (4.7% in Appalachia and 4.1% outside Appalachia, standardized) and cognitive and mobility disability together (2.0% in Appalachia and 1.5% outside Appalachia, standardized). In both regions, 0.5% of the population experienced disability in all five domains.

#### Characteristics of people with disability

Within the Appalachian region, people with a disability were more likely to be older; have lower levels of education and household income; be out of work, unable to work, or retired; and have no children living in their household compared to people without a disability (Table 2). People with a disability also were more commonly women and less frequently married or partnered than people without a disability. Overall in the Appalachian region self-rated health was more often fair or poor among people with disabilities than among people without, and people with a disability also were more likely to have any of the chronic conditions evaluated. Frequent physical distress, frequent mental distress, and depression were also more common among people with a disability. The proportion of people with any health insurance was similar regardless of disability status and people with a disability were more likely to report having a personal doctor and having a routine check-up more recently, but also were more likely to say they had not visited a doctor in the past year when they needed to because of cost compared to people without a disability.

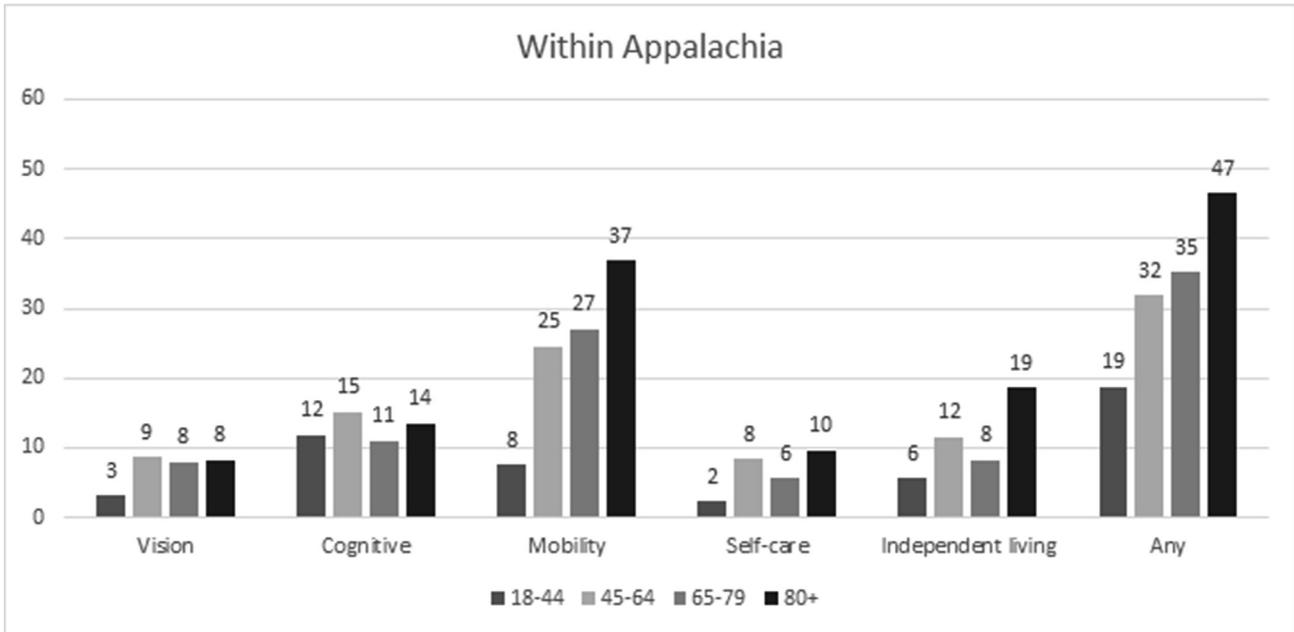
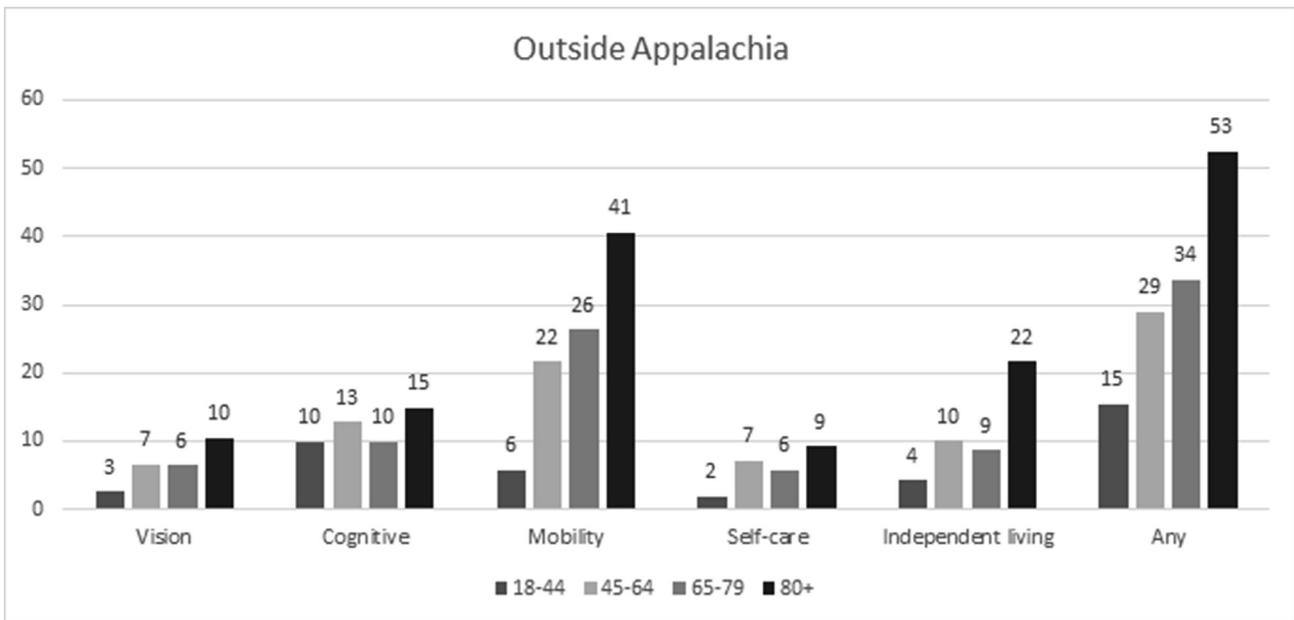
In general, people with a disability were similar across the state whether they lived in Appalachia or not, including in terms of their health conditions and health care access. However, people with a disability in Appalachia were more likely to report their race and ethnicity as white, non-Hispanic and less likely to report being black and non-Hispanic, another race and non-Hispanic, or any race and Hispanic than people with a disability outside Appalachia, which reflects differences in race/ethnicity between Appalachia and the rest of the state. People with a disability in Appalachia were less likely to have children in their home and more likely to have lower household income than people with a disability outside Appalachia. Also, people with a disability in Appalachia rated their health in general more poorly than people with a disability outside Appalachia.

#### Discussion

More than one in four adults in Appalachian North Carolina experience disability in at least one domain and one in eight experiences disability in multiple domains. Further, disability is more common in the Appalachian region of North Carolina than in the rest of the state, even after accounting for differences in the age and sex distributions of the two regions. The difference in prevalence is relatively small – 2.5% – but translates to about 34,000 additional people living with disability in the region than if the entire state had the same experience of disability. (This calculation is based on estimates from the 2011–2015 American Community Survey which indicated the number of adults living in Appalachian North Carolina was about 1.36 million.<sup>20</sup>) The prevalence of disability is also higher in Appalachian North Carolina than the US and state overall based on 2013 BRFSS data.<sup>12</sup> Regardless of region, adults with disability in North Carolina most commonly experienced mobility limitations and least commonly reported self-care restrictions, which is consistent with the US overall and generally with other states.<sup>12</sup>

Overall, disability tended to increase with age, consistent with previous studies,<sup>12</sup> though there were substantial levels of variation within domains, which also has been observed and investigated before.<sup>12,21,22</sup> Within the Appalachian region, middle-aged adults (45–64 years old) had the highest prevalence of vision impairment and cognitive impairment. We did not perform statistical tests for effect modification by region, but we did not observe this pattern outside of Appalachia: in no disability domain was the prevalence point estimate highest for middle-aged adults in the non-Appalachian region of the state. Zajacova and Montez suggest that economic factors, particularly lower family income, may be a driving factor behind the increasing prevalence of disability in middle age.<sup>22</sup> Given that the Appalachian region tends to fare worse economically, this could explain the difference observed in North Carolina. Alternatively, the higher observed prevalence might be a result of selective mortality: people with disabilities living in Appalachia may have higher mortality earlier in life relative to people in the rest of the state. These mechanisms were not investigated in this study, however, so additional research is needed to better understand why middle-aged adults in Appalachia experience higher disability prevalence than older adults.

Mobility limitations and cognitive impairment alone were the most common domains of disability reported. They also were among the most common in combination with one another and with independent living and self-care restrictions. These restrictions very commonly co-occurred with mobility limitations in particular, suggesting that reducing mobility limitations may be an effective way to increase participation among people with disabilities. We are not aware of previous studies that have investigated the combinations of disability domains and so cannot

**a****b**

**Fig. 1.** Disability prevalence (weighted percent of adults with disability) by domain and age group in the Appalachian and non-Appalachian regions of North Carolina, BRFSS 2013–2016.

compare our results to other parts of Appalachia or the country more broadly.

The strengths of this study include the large population-based sample and a measure of disability that focuses on specific impairments, activity limitations, and participation restrictions and aligns with a biopsychosocial concept of disability, similar to the ICF model.<sup>2</sup> We included two distinct age groups of older adults since the experience of disability varies with age and, as evidenced in these data, occurs more frequently and in different domains for people age 80 and older than among people age 65–79. Limitations of this study include the sampling frame and cross-sectional design. The BRFSS does not include institutionalized adults, such as those

living in long-term care facilities, among whom the prevalence of disability may be higher. Also, because the study was cross-sectional, we did not have information on the duration of disability and were therefore unable to evaluate the impact of duration or disability transitions on HRQOL and other measures of health status. Finally, the measures of disability used were not exhaustive and also do not fully consider the impact of the environment on people's experiences.<sup>14</sup> It is not clear whether the results in North Carolina would be similar to those of other states within the Appalachian region.

**Table 2**  
Demographic and health characteristics of people with and without a disability in the Appalachian<sup>1</sup> and non-Appalachian regions of North Carolina, BRFSS 2013–2016.

Variable	Category	Appalachian Region		Non-Appalachian Region	
		People with a Disability (N = 1,816)	People without a Disability (N = 3,991)	People with a Disability (N = 6,285)	People without a Disability (N = 16,187)
		Weighted % (95%CI)	Weighted % (95%CI)	Weighted % (95%CI)	Weighted % (95%CI)
Sex*	Women	57.5 (54.5–60.5)	50.7 (48.7–52.7)	56.9 (55.3–58.5)	50.4 (49.5–51.4)
	Men	42.5 (39.5–45.5)	49.3 (47.3–51.3)	43.1 (41.5–44.7)	49.6 (48.6–50.5)
Age group*	18–44	26.0 (23.2–29.1)	44.4 (42.4–46.4)	30.6 (29.0–32.2)	53.3 (52.4–54.3)
	45–59	40.5 (37.6–43.5)	34.0 (32.2–35.8)	40.1 (38.6–41.7)	31.3 (30.4–32.1)
	60–79	23.9 (21.7–26.3)	17.3 (16.1–18.5)	20.8 (19.6–22.0)	12.9 (12.4–13.5)
	80+	9.5 (8.1–11.1)	4.3 (3.7–5.0)	8.5 (7.8–9.4)	2.4 (2.2–2.7)
Highest level of education*	<High school	28.7 (25.7–31.9)	13.4 (11.9–15.1)	26.6 (25.0–28.1)	11.3 (10.6–12.0)
	High school or equivalent	30.2 (27.6–33.0)	28.8 (27.0–30.7)	31.0 (29.6–32.5)	25.6 (24.8–26.5)
	Some college	28.4 (25.8–31.1)	33.1 (31.2–35.0)	30.7 (29.3–32.3)	33.2 (32.2–34.1)
	College degree or higher	12.5 (11.0–14.2)	24.6 (23.1–26.1)	11.4 (10.6–12.2)	29.8 (29.0–30.6)
	Missing	0.2	0.1	0.3	0.2
Employment status	Employed or self-employed*	25.0 (22.4–27.7)	60.7 (58.7–62.6)	27.4 (25.9–28.9)	64.7 (63.8–65.6)
	Out of work*	8.3 (6.5–10.4)	4.6 (3.7–5.7)	8.5 (7.6–9.5)	5.7 (5.2–6.2)
	Homemaker	4.4 (3.2–6.2)	5.7 (4.8–6.6)	4.3 (3.7–5.0)	5.9 (5.5–6.4)
	Student*	2.2 (1.3–3.5)	5.3 (4.3–6.5)	3.1 (2.5–3.9)	6.5 (6.0–7.2)
	Retired*†	29.8 (27.4–32.4)	21.4 (20.1–22.8)	26.2 (24.9–27.5)	15.1 (14.6–15.7)
	Unable to work*	30.0 (27.2–32.9)	2.1 (1.6–2.9)	30.2 (28.7–31.7)	1.6 (1.4–1.9)
	Missing	0.3	0.2	0.3	0.4
Sexual orientation	Heterosexual or straight	84.2 (81.7–86.3)	84.0 (82.4–85.5)	81.3 (79.9–82.5)	78.6 (77.8–79.4)
	Homosexual, gay, or lesbian	0.9 (0.6–1.6)	1.1 (0.7–1.9)	1.2 (0.9–1.7)	1.1 (0.9–1.4)
	Bisexual	1.9 (1.1–3.2)	1.1 (0.7–1.7)	1.6 (1.2–2.1)	0.8 (0.6–1.0)
	Something else	–	–	0.5 (0.3–0.9)	0.1 (0.1–0.2)
	Missing	12.1 (10.2–14.3)	13.5 (12.2–15.0)	15.4 (14.2–16.6)	19.4 (18.6–20.1)
Marital status*	Married/Coupled	47.2 (44.2–50.3)	59.6 (57.6–61.6)	46.1 (44.5–47.7)	58.7 (57.8–59.7)
	Not married/coupled	52.6 (49.6–55.7)	40.2 (38.2–42.2)	53.7 (52.1–55.3)	40.9 (40.0–41.9)
	Missing	0.1	0.3	0.2	0.4
Children in household*‡	At least one child <age 18	19.9 (17.5–22.6)	31.4 (29.5–33.4)	25.6 (24.1–27.1)	36.5 (35.5–37.4)
	None	80.0 (77.3–82.4)	68.4 (66.5–70.3)	74.2 (72.6–75.7)	63.0 (62.1–64.0)
	Missing	0.1	0.2	0.2	0.5
Household Income*‡	Less than \$15,000	23.3 (20.8–26.0)	7.0 (6.0–8.2)	20.0 (18.7–21.3)	6.1 (5.6–6.6)
	\$15,000–\$24,999	27.5 (24.8–30.4)	15.6 (14.2–17.1)	24.0 (22.6–25.4)	13.7 (13.1–14.4)
	\$25,000–\$49,999	19.1 (16.9–21.5)	24.1 (22.5–25.8)	19.2 (18.0–20.6)	21.0 (20.2–21.8)
	\$50,000–\$74,999	5.4 (4.3–6.8)	15.2 (13.8–16.7)	7.4 (6.6–8.3)	14.0 (13.3–14.7)
	\$75,000 or more	5.6 (4.6–6.9)	20.0 (18.6–21.6)	8.8 (7.9–9.8)	27.6 (26.7–28.4)
	Missing	19.0	18.1	20.6	17.7
Race/ethnicity	White, non-Hispanic‡	83.2 (81.0–85.2)	82.4 (80.8–83.9)	61.2 (59.6–62.8)	63.8 (62.8–64.7)
	Black, non-Hispanic‡	9.2 (7.7–10.9)	8.0 (6.9–9.3)	27.0 (25.6–28.5)	21.4 (20.6–22.2)
	Other, non-Hispanic‡	1.7 (1.1–2.9)	1.8 (1.3–2.5)	3.6 (3.1–4.3)	4.6 (4.2–5.1)
	Multiple races, non-Hispanic*	1.4 (0.9–2.1)	0.6 (0.4–0.8)	1.1 (0.8–1.4)	1.0 (0.8–1.1)
	Any race, Hispanic*‡	3.2 (2.3–4.3)	6.6 (5.7–7.6)	5.9 (5.2–6.7)	8.5 (7.9–9.0)
	Missing	1.6	0.6	1.2	0.8
General health*‡	Excellent, very good, or good	45.9 (42.9–49.0)	89.8 (88.6–90.9)	50.9 (49.2–52.5)	91.1 (90.5–91.6)
	Fair or poor	53.7 (50.7–56.7)	10.0 (8.9–11.2)	48.3 (46.7–49.9)	8.7 (8.2–9.2)
	Missing	0.3	0.2	0.8	0.2
Poor physical health in the past month*	<14 days	58.4 (55.4–61.3)	93.8 (92.8–94.6)	60.0 (58.4–61.5)	94.5 (94.1–94.9)
	≥14 days	37.7 (34.8–40.6)	5.2 (4.4–6.1)	36.4 (34.9–38.0)	4.3 (4.0–4.8)
	Missing	4.0	1.1	3.6	1.1
Poor mental health in the past month*	<14 days	68.3 (65.3–71.1)	92.6 (91.5–93.6)	69.7 (68.1–71.1)	92.9 (92.4–93.4)
	≥14 days	28.3 (25.6–31.1)	6.7 (5.7–7.8)	28.0 (26.6–29.5)	6.2 (5.7–6.7)
	Missing	3.4	0.7	2.3	0.9
Coronary Heart Disease (CHD)*	History of myocardial infarction or angina	17.5 (15.4–19.8)	4.5 (3.9–5.3)	17.1 (16.0–18.3)	95.7 (95.4–96.0)
	No history	81.0 (78.7–83.1)	94.8 (94.0–95.6)	81.5 (80.2–82.6)	3.9 (3.6–4.2)
	Missing	1.5	0.6	1.4	0.4
Stroke*	Ever diagnosed	10.2 (8.6–12.0)	2.0 (1.5–2.6)	10.4 (9.5–11.4)	1.5 (1.3–1.7)
	No history	88.9 (87.0–90.6)	97.9 (97.3–98.4)	89.1 (88.1–90.1)	98.4 (98.2–98.6)
	Missing	0.9	0.1	0.5	0.1
Asthma*	Current	15.5 (13.3–17.9)	5.4 (4.6–6.5)	16.4 (15.2–17.6)	5.5 (5.1–6.0)
	Not current	83.7 (81.3–85.9)	94.2 (93.2–95.1)	82.8 (81.5–84.0)	94.0 (93.5–94.4)
	Missing	0.8	0.3	0.9	0.5
Cancer, non-skin*	Ever diagnosed with cancer, excluding skin cancer	12.7 (11.0–14.7)	6.1 (5.3–7.0)	12.0 (11.1–13.0)	4.4 (4.1–4.8)
	No history or skin cancer only	86.8 (84.9–88.6)	93.8 (9.9–94.6)	87.5 (86.5–88.5)	95.5 (95.1–95.8)
	Missing	0.4	0.1	0.4	0.1
Pulmonary Disease*	Ever diagnosed with COPD, emphysema or chronic bronchitis	20.2 (18.0–22.7)	3.8 (3.2–4.5)	19.9 (18.7–21.2)	3.3 (3.0–3.7)
	No history	78.8 (76.3–81.1)	96.1 (95.4–96.8)	79.3 (78.0–80.6)	96.4 (96.1–96.8)
	Missing	1.0	0.1	0.7	0.2
Arthritis*	Ever diagnosed with arthritis, gout, lupus, or fibromyalgia	56.2 (56.1–62.1)	20.2 (18.8–21.7)	55.0 (53.4–56.6)	16.7 (16.1–17.4)
	No history	40.1 (37.1–43.1)	79.6 (78.1–81.0)	44.4 (42.8–46.0)	83.0 (82.3–83.6)

**Table 2** (continued)

Variable	Category	Appalachian Region		Non-Appalachian Region	
		People with a Disability (N = 1,816)	People without a Disability (N = 3,991)	People with a Disability (N = 6,285)	People without a Disability (N = 16,187)
		Weighted % (95%CI)	Weighted % (95%CI)	Weighted % (95%CI)	Weighted % (95%CI)
Diabetes*	Missing	0.8	0.2	0.6	0.3
	Ever diagnosed, except during pregnancy; pre- or borderline diabetes considered no diabetes	23.8 (21.4–26.4)	7.0 (6.2–8.0)	22.4 (21.2–23.7)	7.2 (6.8–7.6)
	No history or gestational diabetes only	76.1 (73.5–78.6)	92.9 (91.9–93.8)	77.4 (76.1–78.6)	92.7 (92.3–93.1)
Depression*	Missing	0.1	0.1	0.2	0.1
	Ever diagnosed	44.5 (41.5–47.5)	13.8 (12.4–15.3)	40.9 (39.3–42.5)	10.9 (10.3–11.5)
	No	54.8 (51.8–57.8)	85.8 (84.3–87.2)	58.5 (56.9–60.1)	88.8 (88.2–89.4)
Health insurance	Missing	0.7	0.4	0.6	0.3
	Any coverage	84.1 (81.6–86.4)	85.0 (83.4–86.4)	81.9 (80.5–83.2)	83.7 (82.9–84.4)
	None	15.4 (13.2–17.9)	14.9 (13.4–16.5)	17.9 (16.6–19.3)	15.8 (15.0–16.5)
Personal doctor*	Missing	0.4	0.1	0.1	0.5
	One or more	84.7 (82.1–86.9)	78.5 (76.7–80.2)	82.7 (81.4–84.0)	73.7 (72.8–74.5)
	None	15.3 (13.1–17.9)	21.4 (19.7–23.2)	17.1 (15.8–18.4)	26.0 (25.2–26.9)
Medical costs*	Missing	0.01	0.1	0.2	0.3
	Did not see a doctor because of cost in the past year	28.6 (25.8–31.5)	12.2 (10.9–13.7)	29.2 (27.7–30.7)	12.4 (11.8–13.1)
	No cost barrier reported	71.0 (68.1–73.8)	87.6 (86.1–88.9)	70.5 (68.9–72.0)	87.3 (86.7–88.0)
Last routine medical check-up*	Missing	0.4	0.2	0.4	0.2
	Within the past year	77.7 (75.1–80.2)	72.1 (70.2–73.9)	76.3 (74.8–77.7)	72.4 (71.5–73.2)
	1-<2 years ago	10.5 (8.5–12.8)	12.5 (11.2–13.9)	9.1 (8.2–10.2)	11.7 (11.1–12.3)
	2-<5 years ago	4.6 (3.4–6.1)	7.3 (6.3–8.5)	6.1 (5.4–7.0)	7.3 (6.8–7.9)
	>5 years ago	5.0 (3.9–6.4)	6.5 (5.5–7.6)	6.0 (5.2–6.9)	6.4 (5.9–6.9)
	Never	–	0.7 (0.5–1.2)	1.0 (0.7–1.4)	1.0 (0.9–1.3)
	Missing	1.6	0.9	1.4	1.3

– Estimate not reported because the relative standard error is > 30.0.

CI: Confidence interval.

\*Indicates  $p < 0.001$  comparing people with a disability to people without a disability in Appalachia using a chi-square test of weighted proportions.

‡Indicates  $p < 0.01$  comparing people with a disability in Appalachia to people with a disability outside of Appalachia using a chi-square test of weighted proportions.

## Conclusion

Adults in Appalachian North Carolina experience disability more commonly than adults in the rest of the state or in the US overall. Differences in sociodemographic characteristics between people with and without disability suggest that in order to achieve high quality of life and health among all people we should consider addressing inequities in social determinants of health like education, income, and employment. Impairments and limitations were reported more commonly than restrictions. If people with impairments and limitations are not adequately supported, they may begin to experience self-care and independent living restrictions,

which may both reduce their quality of life and increase demand for formal and informal caregiving services. Environments and policies that facilitate participation among people with disabilities could reduce restrictions. The high prevalence of disability should be considered when planning programs and services across the spectrum of public health, from emergency preparedness to health behavior interventions and the types of health services. The multiple disability domains examined can inform public health agencies and service providers who are developing programs, messaging, and other content for communities so they meet the needs of residents in Appalachia and also are developed to be accessible to people with disabilities.

**Table 3**

Percent of people with disability in a given domain who have co-occurring disability in other domains, by Appalachian region of North Carolina, BRFSS 2013–2016.

Within Appalachia					
Disability Domain	Percent with Co-occurring Disability in Other Domains				
	Vision	Cognitive	Mobility	Self-care	Independent Living
Vision		40.2%	56.1%	21.1%	33.8%
Cognitive	19.3%		55.2%	22.6%	36.7%
Mobility	18.5%	37.6%		26.8%	37.0%
Self-care	23.9%	52.7%	92.7%		67.3%
Independent Living	23.6%	53.0%	78.7%	41.5%	
Outside Appalachia					
Disability Domain	Percent with Co-occurring Disability in Other Domains				
	Vision	Cognitive	Mobility	Self-care	Independent Living
Vision		41.9%	51.1%	18.2%	36.1%
Cognitive	18.2%		47.5%	20.4%	36.5%
Mobility	15.9%	34.2%		24.9%	35.5%
Self-care	19.3%	49.9%	85.1%		64.6%
Independent Living	23.2%	53.7%	73.1%	38.8%	

Example interpretation: Among people with vision impairment in Appalachia, 40.2% also reported cognitive impairment.

**Table 4**

Prevalence of disability in mutually exclusive categories of disability domain in the Appalachian and non-Appalachian regions of North Carolina, BRFSS 2013–2016.

Disability Domain(s)	Crude Estimate		Age & Sex-Adjusted Estimate	
	Within Appalachia	Outside Appalachia	Within Appalachia	Outside Appalachia
	%	%	%	%
No disability	72.1	76.3	73.6	76.2
Mobility only	7.0	6.3	6.1	6.2
Cognitive only	4.4	4.1	4.7	4.1
Cognitive & mobility	2.2	1.5	2.0	1.5
Vision only	2.0	1.4	1.9	1.4
Cognitive, mobility, self-care & independent living	1.6	1.2	1.6	1.2
Mobility & independent living	1.4	1.2	1.3	1.2
Mobility, self-care & independent living	1.2	0.9	1.1	0.9
Cognitive, mobility & independent living	1.0	0.9	0.9	0.9
Vision & mobility	0.8	0.6	0.7	0.6
Cognitive & independent living	0.7	0.8	0.8	0.8
Independent living only	0.7	0.6	0.8	0.6
Vision, cognitive, mobility & independent living	0.7	0.4	0.7	0.4
Mobility & self-care	0.6	0.6	0.6	0.6
Vision, cognitive, mobility, self-care & independent living (all)	0.5	0.5	0.5	0.5
Vision & cognitive	0.4	0.5	0.4	0.5
Vision, cognitive & mobility	0.4	0.4	0.4	0.3
Cognitive, mobility & self-care	0.4	0.3	–	0.3
Vision, mobility & independent living	0.3	0.3	–	0.3
Self-care only	–	0.3	–	0.3
Vision & independent living	–	0.2	–	0.2
Vision, mobility, self-care & independent living	–	0.2	–	0.2

– Estimate not reported because the unweighted cell denominator is &lt; 50 and/or the relative standard error is &gt; 30.0.

Note: Combinations not shown in the table had unreported estimates in all columns.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.dhjo.2019.100879>.

## References

- Centers for Disease Control and Prevention NC on BD and DD. Disability and health data system (DHDS) | CDC. centers for disease control and prevention. <https://www.cdc.gov/ncbddd/disabilityandhealth/dhds/index.html>; May 20, 2019. Accessed October 19, 2019.
- World Health Organization. *Towards a Common Language for Functioning, Disability, and Health: The International Classification of Functioning, Disability, and Health*; 2002. <http://www.who.int/classifications/icf/icfbeginnersguide.pdf>. Accessed June 5, 2019.
- Houtenville AJ, Boege S. *Annual Report on People with Disabilities in America: 2018*. Durham, NH: University of New Hampshire, Institute on Disability; 2019: 25. [https://disabilitycompendium.org/sites/default/files/user-uploads/Annual\\_Report\\_2018\\_Accessible\\_AdobeReaderFriendly.pdf](https://disabilitycompendium.org/sites/default/files/user-uploads/Annual_Report_2018_Accessible_AdobeReaderFriendly.pdf). Accessed June 5, 2019.
- Gulley SP, Rasch EK, Bethell CD, et al. At the intersection of chronic disease, disability and health services research: a scoping literature review. *Disabil Health J*. 2018;11(2):192–203. <https://doi.org/10.1016/j.dhjo.2017.12.012>.
- PDA, Inc. *The Cecil G. Sheps Center for Health Services Research, University of North Carolina at Chapel Hill, Appalachian Regional Commission. Health Disparities in Appalachia*; August 2017. [https://www.arc.gov/research/researchreportdetails.asp?REPORT\\_ID=138](https://www.arc.gov/research/researchreportdetails.asp?REPORT_ID=138). Accessed June 5, 2019.
- Centers for Disease Control and Prevention. *Social Determinants of Health | Healthy People*; 2020. <https://www.healthypeople.gov/2020/topics-objectives/topic/social-determinants-of-health>. Accessed August 27, 2019.
- World Health Organization. WHO | about social determinants of health. WHO. [http://www.who.int/social\\_determinants/sdh\\_definition/en/](http://www.who.int/social_determinants/sdh_definition/en/). Accessed August 27, 2019.
- Singh GK, Kogan MD, Slifkin RT. Widening disparities in infant mortality and life expectancy between Appalachia and the rest of the United States, 1990–2013. *Health Aff*. 2017;36(8):1423–1432. <https://doi.org/10.1377/hlthaff.2016.1571>.
- Meit M, Heffernan M, Tanenbaum E, Hoffman T. *Appalachian Diseases of Despair*. Bethesda, MD: The Walsh Center for Rural Health Analysis, NORC at the University of Chicago; 2017:23. [https://www.arc.gov/assets/research\\_reports/AppalachianDiseasesofDespairAugust2017.pdf](https://www.arc.gov/assets/research_reports/AppalachianDiseasesofDespairAugust2017.pdf). Accessed June 5, 2019.
- Mokdad AH. The behavioral risk factors surveillance system: past, present, and future. *Annu Rev Public Health*. 2009;30:43–54. <https://doi.org/10.1146/annurev.publhealth.031308.100226>.
- Counties in Appalachia - Appalachian regional commission. [https://www.arc.gov/appalachian\\_region/CountiesinAppalachia.asp](https://www.arc.gov/appalachian_region/CountiesinAppalachia.asp). Accessed June 18, 2018.
- Courtney-Long EA, Carroll DD, Zhang QC, et al. Prevalence of disability and disability type Among adults—United States, 2013. *MMWR Morb Mortal Wkly Rep*. 2015;64(29):777–783.
- US Census Bureau. How disability data are collected from the American community survey. <https://www.census.gov/topics/health/disability/guidance/data-collection-acs.html>. Accessed June 5, 2019.
- Altman BM. Definitions, concepts, and measures of disability. *Ann Epidemiol*. 2014;24(1):2–7. <https://doi.org/10.1016/j.annepidem.2013.05.018>.
- Centers for Disease Control and Prevention. *Measuring Healthy Days: Population Assessment of Health-Related Quality of Life*. Atlanta, GA: US Department of Health and Human Services; 2000:44. <https://www.cdc.gov/hrqol/pdfs/mhd.pdf>. Accessed July 12, 2019.
- Zhao G, Okoro CA, Hsia J, Town M. Self-perceived poor/fair health, frequent mental distress, and health insurance status among working-aged US adults. *Prev Chronic Dis*. 2018;15:E95. <https://doi.org/10.5888/pcd15.170523>.
- Continuous NHANES web tutorial: age standardization: task 1c. <https://www.cdc.gov/nchs/tutorials/NHANES/NHANESAnalyses/AgeStandardization/Task1c.htm>. Accessed June 5, 2019.
- Howden Lindsay, Meyer Julie. *Age and Sex Composition: 2010. C2010BR-03*. May 2011:16.
- The BRFSS Data User Guide*; August 2013. [https://www.cdc.gov/brfss/data\\_documentation/pdf/UserguideJune2013.pdf](https://www.cdc.gov/brfss/data_documentation/pdf/UserguideJune2013.pdf). Accessed June 5, 2019.
- Pollard K, Jacobsen LA. *The Appalachian Region: A Data Overview from the 2011–2015 American Community Survey – Population Reference Bureau*. Washington, DC: Appalachian Regional Commission & Population Reference Bureau; 2017: 108. <https://www.prb.org/economic-recovery-in-appalachia/>. Accessed October 19, 2019.
- Freedman VA, Martin LG, Schoeni RF, Cornman JC. Declines in late-life disability: the role of early- and mid-life factors. *Soc Sci Med*. 2008;66(7): 1588–1602. <https://doi.org/10.1016/j.socscimed.2007.11.037>.
- Zajacova A, Montez JK. Explaining the increasing disability prevalence among mid-life US adults, 2002 to 2016. *Soc Sci Med*. 2018;211:1–8. <https://doi.org/10.1016/j.socscimed.2018.05.041>.