place is most pronounced among lower-educated adults.

A critical dimension of place is the US state.[20] The size of disparities in adult disability by education may vary across states for myriad reasons. We focused on 4 demographic and socioeconomic factors that are particularly salient for adult disability. First, low education puts individuals at greater risk for poverty, especially in contexts with weak economic safety nets.[12] Second, individuals' race/ethnic minority status intersects with low education, and jointly they elevate the risk of disability. We also assessed 2 contextual factors: the concentration of low education and poverty in an individual's area of residence. Low education may be more problematic for disability in states where low-educated adults tend to reside in areas of educational and economic disadvantage.

We addressed 3 questions: (1) How does the size of disparities in disability by educational attainment vary across states? (2) Does the size vary across states primarily because the prevalence of disability among low-educated adults varies across states? and (3) How does the variation across states in the prevalence of disability among low-educated adults reflect differences across states in the race/ethnicity and poverty status of low-educated adults and the socioeconomic contexts in which they live? We address these questions for all adults and by gender because previous studies suggest state and local contexts may have different consequences for women and men.[21–23]

METHODS

We analyzed the 2010 to 2014 Public Use Microdata Sample of the American Community Survey (ACS), a nationally representative sample of more than 15 million individuals. The 2010 to 2014 ACS combines 5 annual cross-sectional surveys into 1 data set. Our analytic sample includes 6 090 440 US-born individuals aged 45 to 89 years residing in the 50 states. Focusing on US-born individuals minimizes the chance that they obtained their education abroad, as education obtained abroad generally does not confer the same health benefits as education obtained domestically[24]; it also minimizes confounding stemming from healthy immigrant effects. Setting the lower age limit at 45 years helps ensure that respondents had completed their education and captures aging-related disability; setting the upper limit at 89 years ensures an adequate number of adults in each age–state–education stratum used to estimate age-standardized disability prevalence. In ancillary analyses, we examined age subgroups (45–64, 65–89 years).

Measures

Disability. The 2010 to 2014 ACS contains 6 disability-related measures. Because our objective was to examine how disparities in disability vary across state environments, we assessed the 2 measures that the disablement process asserts depend particularly on the environment.[10] The ACS asked respondents whether, because of a physical, mental, or emotional condition, they had difficulty dressing or bathing (a measure of difficulty with activities of daily living) and difficulty doing errands alone, such as visiting a doctor's office or shopping (a measure of difficulty with instrumental activities of daily living). We designated respondents answering affirmatively to either question as having a disability. In our sample, 4.7% of adults had difficulty with instrumental activities of daily living only, 1.0% had difficulty with activities of daily living only, and 4.5% had difficulty with both.

Educational attainment. Educational attainment is a "fundamental social cause"[25] of a host of health outcomes, including disability. It is typically attained before other socioeconomic resources such as income and occupation; and compared with those resources, it is the most stable across the lifespan, the least affected by declining health, and a particularly meaningful indicator of socioeconomic resources for older adults.[18] We categorized education into no high school credential (low), a high school credential or some college (mid), and a bachelor's degree or higher (high). We combined high school and some college because preliminary analyses showed that these groups had similar probabilities of disability.

Four potential explanations. We examined 2 characteristics of individuals and 2 characteristics of their surrounding contexts. Individual characteristics included race/ethnicity and poverty. We categorized race/ethnicity as non-Hispanic White (reference), non-Hispanic Black, non-Hispanic other, and Hispanic. Poverty status indicates whether the respondent lived in a household with total income below the poverty threshold (as determined by the ACS using the federal threshold for each ACS survey year).[26]

Two contextual characteristics captured the spatial concentration of low-educated adults and poverty in each Public Use Microdata Area. The Public Use Microdata Area is the smallest geographic area in the 2010 to 2014 ACS.[26] Covering the entire nation, the 2378 Public Use Microdata Areas consist of 1 or more contiguous counties or census tracts in a state so that each contains at least 100 000 people. Using the ACS, we estimated the percentage of residents aged 25 years and older in each Public Use Microdata Area without a high school credential and the percentage of residents living below the poverty line. We age-standardized both estimates using the 2010 US population as the standard. We then merged these 2 contextual variables into the ACS data. We used the socioeconomic characteristics of the local area instead of the state to capture the day-to-day proximal environments that individuals navigate.

Analytic Strategy

We first documented the distribution of educational attainment in each state. We then estimated disability prevalence by educational attainment in each state. We age-standardized the prevalence estimates using the 2010 US population.

Next, we estimated a series of logistic regression models. The baseline model is shown in Equation 1. It estimates the log-odds of having a disability for adult, i, from 150 combinations of $j = 50$ states, S, and $k = 3$ education levels, E, controlling for gender (female is the omitted reference) and age (in single years from 45 to 89).

$$(1)\quad ln\left(p_{ijk}/(1-p_{ijk})\right) = b_0 + b_1 age_i + b_2 male_i + \sum_{j=1,k=1}^{j=50,k=3} b_{j,k} S_{i,j} E_{i,k}$$

We progressively added the 4 potential explanatory variables to the model. In

TABLE 1—Distribution of Educational Attainment and Disability Prevalence by Education in US States Among US-Born Individuals Aged 45–89 Years: 2010–2014

		Distribution of Education (Rows Sum to 100%), %			Age-Standardized Prevalence of Disability for All Adults and Within Educational Attainment, %				
State	No.	Low Educated	Mid-Educated	High Educated	All	Low Educated	Mid-Educated	High Educated	Gap (Low - High)
Massachusetts	131 386	8.3	54.6	37.2	8.9	24.4	9.5	4.6	19.7
New Mexico	40 415	12.0	59.2	28.8	10.8	24.6	10.8	4.9	19.6
Kentucky	100 091	19.2	61.7	19.1	13.6	24.8	12.6	5.9	18.9
West Virginia	45 074	18.4	65.5	16.1	13.4	24.8	12.0	6.4	18.5
Michigan	224 255	10.3	66.1	23.6	10.4	23.2	10.3	4.9	18.3
Tennessee	144 683	17.0	61.4	21.7	12.6	24.1	11.7	5.9	18.2
Maine	33 528	9.0	63.8	27.2	9.0	22.5	9.3	4.3	18.2
Connecticut	74 016	9.0	55.1	35.9	8.3	22.2	8.8	4.1	18.1
Mississippi	64 334	20.1	60.8	19.1	14.3	24.6	13.2	6.8	17.8
North Carolina	209 221	14.6	60.0	25.4	11.0	22.5	10.7	4.9	17.5
Alabama	110 673	17.3	61.3	21.4	13.0	23.7	12.3	6.1	17.5
California	504 407	8.5	58.4	33.1	9.5	22.3	10.3	4.9	17.4
Missouri	137 849	12.6	64.0	23.4	10.8	22.4	10.6	5.2	17.2
Arkansas	66 988	16.3	64.6	19.1	12.4	22.3	11.9	5.4	16.9
Washington	135 843	6.7	61.4	31.9	8.9	21.3	9.7	4.5	16.8
Louisiana	96 743	18.2	61.6	20.1	12.7	23.3	11.5	6.5	16.8
South Carolina	106 752	16.0	60.2	23.8	11.5	21.9	11.1	5.2	16.7
New York	337 064	10.9	57.9	31.2	9.3	21.6	9.4	4.9	16.7
Ohio	263 367	12.0	65.7	22.2	10.2	21.6	10.0	5.0	16.6
New Jersey	157 559	9.4	57.6	32.9	8.7	20.9	9.2	4.3	16.6
Rhode Island	21 575	12.3	56.8	30.9	9.1	21.1	9.1	4.7	16.3
Illinois	246 909	9.8	61.8	28.4	9.3	21.3	9.4	5.0	16.3
Indiana	141 964	12.2	67.0	20.8	10.0	21.2	9.6	4.9	16.3
Georgia	188 527	14.8	59.0	26.2	11.1	21.5	10.8	5.4	16.1
Pennsylvania	292 951	11.3	64.8	23.9	9.5	20.8	9.4	4.7	16.1
Hawaii	24 649	6.8	60.6	32.6	8.5	21.0	8.9	4.9	16.0
Texas	430 197	13.0	59.3	27.7	10.6	21.3	10.5	5.3	16.0
Vermont	15 665	8.7	57.8	33.5	8.8	20.3	9.7	4.3	16.0
Kansas	62 799	8.1	63.1	28.8	9.0	20.7	9.3	4.9	15.8
South Dakota	18 953	9.4	66.0	24.6	8.2	21.3	7.5	5.6	15.8
Minnesota	124 172	6.7	63.9	29.4	7.2	19.3	7.5	3.9	15.4
Oklahoma	77 847	12.4	64.6	23.0	11.4	21.5	11.3	6.1	15.3
Oregon	83 870	7.7	63.4	28.9	9.5	20.3	10.2	5.2	15.1
Delaware	20 091	11.5	62.2	26.2	9.2	20.0	8.8	4.9	15.1
Colorado	102 187	6.5	56.2	37.4	7.9	19.4	8.7	4.4	15.0
Arizona	124 083	9.0	62.3	28.7	8.6	19.2	9.0	4.4	14.8
Virginia	162 792	13.2	54.6	32.2	9.2	19.2	9.3	4.6	14.7
Wisconsin	137 846	8.8	66.6	24.5	7.9	19.2	7.7	4.6	14.6
Maryland	114 720	10.2	55.8	34.0	8.7	19.0	9.4	4.4	14.6

Continued

TABLE 1—*Continued*

State	No.	Distribution of Education (Rows Sum to 100%), %			Age-Standardized Prevalence of Disability for All Adults and Within Educational Attainment, %				
		Low Educated	Mid-Educated	High Educated	All	Low Educated	Mid-Educated	High Educated	Gap (Low - High)
Nebraska	41 147	7.0	66.3	26.7	7.6	18.7	7.7	4.4	14.3
Florida	381 549	10.6	62.5	26.9	9.2	19.2	9.4	5.1	14.1
Iowa	71 997	8.0	69.2	22.8	7.9	18.4	7.9	4.3	14.1
Montana	24 199	7.7	64.5	27.8	8.3	18.0	8.8	4.4	13.6
New Hampshire	32 025	8.0	59.3	32.7	7.5	17.3	8.1	4.0	13.3
Idaho	32 156	8.9	65.5	25.6	8.9	18.3	9.1	5.0	13.3
North Dakota	16 775	9.8	66.7	23.5	7.0	16.8	6.8	4.5	12.3
Nevada	47 017	9.0	67.5	23.6	9.1	17.3	9.4	5.1	12.2
Utah	43 291	6.3	62.8	31.0	7.7	16.5	8.5	4.5	12.0
Alaska	11 552	7.5	63.2	29.3	8.7	16.5	9.5	4.5	12.0
Wyoming	12 687	7.4	67.8	24.8	7.4	16.4	7.4	4.6	11.8
United States	6 090 440	11.3	61.3	27.4	9.9	21.5	9.9	4.9	16.6
Range		13.8	14.6	21.3	7.3	8.5	6.3	2.9	7.9

Note. Estimates are weighted. Sample sizes are not weighted. Table is sorted in descending order of last column. Low educated = no high school credential; mid-educated = high school or some college; high educated = bachelor's degree or higher.

ancillary analyses we estimate the models separately by gender and 2 age subgroups. We adjusted all analyses for the ACS replicate weights and analyzed them with Stata MP version 14.1 (StataCorp, College Station, TX). Because of the large number of estimated coefficients, we have displayed the results graphically (full results are available by request).

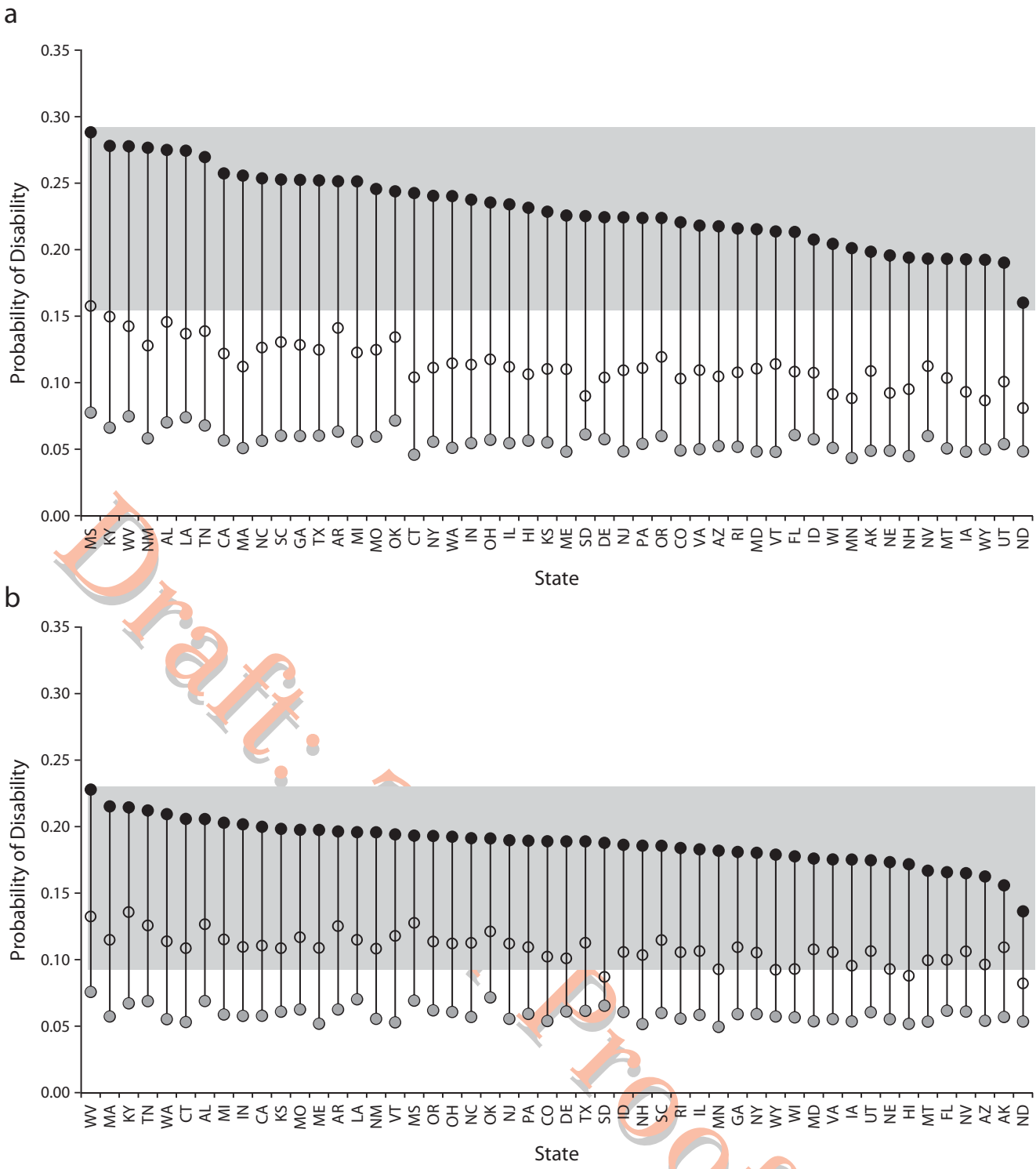
RESULTS

Summary statistics of our sample are shown in Table 1. The left side contains the educational distribution in each state. For instance, in Massachusetts, 8.3% of the sample did not have a high school credential (low educated), 54.6% had a high school credential or some college (mid-educated), and 37.2% had a bachelor's degree or higher (high educated). As expected, educational distributions vary across states. The percentage of low-educated adults ranges from 6.3% in Utah to 20.1% in Mississippi, and the percentage of high-educated adults ranges from 16.1% in West Virginia to 37.4% in Colorado.

The table contains the age-standardized disability prevalence by education level in each state, as well as the disparity in disability prevalence between low- and high-educated adults. Two patterns are striking. First, the size of the disparity varies markedly across states, from 19.7% in Massachusetts to 11.8% in Wyoming. Second, the disparity varies across states mainly because the prevalence of disability among low-educated adults varies across states. This is evident in a couple of ways. To start, disability prevalence among low-educated adults ranges from 16.4% to 24.8% across states (a gap of 8.5 percentage points), whereas among high-educated adults it ranges from 3.9% to 6.8% (a gap of just 2.9 percentage points). It is also evident by the high correlation across the 50 states between the size of the disparity and the prevalence of disability among low-educated adults (correlation = 0.97). By contrast, the correlation between the disparity and disability prevalence is 0.62 for mid-educated adults and 0.38 for high-educated adults.

Next, we used Equation 1 to estimate the probability of disability for all combinations of education level and state, controlling for age and gender. To display the results, the probabilities of disability by education level and state (estimated for women aged 65 years) are shown in Figure 1a. Consistent with the findings shown in Table 1, the probability of disability varies strikingly across states among low-educated adults, whereas it varies considerably less among mid-educated and high-educated adults. The shaded region in Figure 1 encompasses the probabilities of disability for low-educated adults across all 50 states (average = 23.1%; variance = 7.98; coefficient of variation [CV] = 100[SD/average] = 12.2).

We also estimated Equation 1 separately by gender. Like the main analysis, disparities in disability by education vary across states for women and men mainly because disability prevalence of their low-educated peers varies across states (Figure A, available as a supplement to the online version of this article at http://www.ajph.org). Although women have a higher prevalence of disability than do men, the state-level patterns and variation are similar for both genders. Specifically, among the 50 states, the average prevalence of disability among low-educated adults aged 65 years is 22.8% (CV = 13.0) for women and 19.3% (CV = 13.1) for men. In ancillary analyses, we also estimated Equation 1 for 2 age groups: 45 to 64 and 65 to 89 years. We again found that disparities in disability by education vary across states mainly because disability of low-educated adults varies,



Note. We derived the probabilities from logistic regression models predicting disability status from education and the variables listed. The 2 individual factors were race/ethnicity and poverty status; the 2 contextual factors were percentage of residents aged ≥ 25 years without a high school credential and percentage of residents living below the poverty line. We estimated probabilities for US-born women aged 65 years, with other variables at their average. The shaded region in panel a captures the range of probabilities across states for adults without a high school credential. That same region is placed on top of panel b.

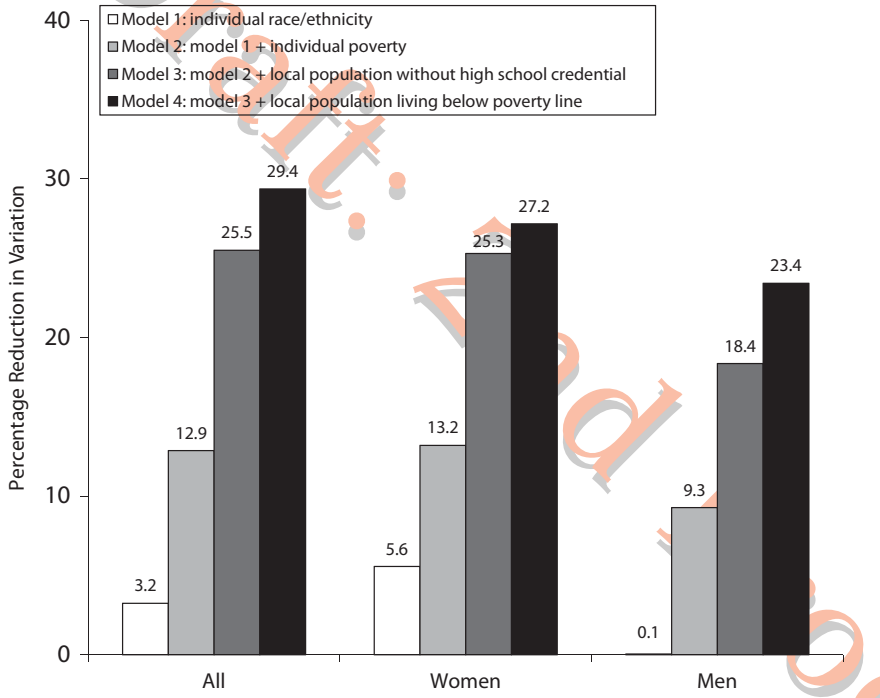
FIGURE 1—Probability of Disability by Education and State, Adjusted for (a) Age and Gender and (b) Age and Gender Plus 2 Individual and 2 Contextual Factors: United States, 2010–2014

and this is especially pronounced among older adults (Figure A).

Next, we examined how the variation in the prevalence of disability among low-educated adults can be accounted for by the race/ethnicity and poverty status of low-educated adults and the socioeconomic contexts in which they live. We progressively added the 4 individual and contextual variables to the models. For each model, we estimated the probability of disability among low-educated adults by state (setting age = 65 years; male = 0; and other variables at their average) and then calculated the CV of these 50 probabilities. We compared the CV across models to assess the extent to which the variables attenuate the CV. We compared the CV instead of the variance because the latter may change across models simply because the average probability changes. The results are summarized in Figure 2.

Accounting for individuals' race/ethnicity reduces the CV by just 3.2%. Accounting for individuals' poverty status reduces it by another 9.7%. Accounting for the spatial concentration of low-educated adults reduces the CV by another 12.6%, and the spatial concentration of poverty accounts for an additional 3.9%. In other words, these 4 factors jointly account for 29.4% of the variation: 44% of that total from the individual characteristics and 56% from the contextual characteristics. The results from the gender-stratified analyses are shown in Figure 2. Although race/ethnicity seems to play a somewhat larger role in the cross-state variation in low-educated disability among women, overall, the importance of individual and contextual socioeconomic factors was similar for women and men.

Figure 1b visually illustrates the variation in disability prevalence of low-educated adults after accounting for the 4 factors. The variation is noticeably attenuated. The shaded region from Figure 1a is overlaid on Figure 1b to illustrate how the final probabilities for low- and mid-educated adults fit within the original range for only low educated.



Note. CV = coefficient of variation. We measured variation by the CV. For each model, we calculated the CV as the SD of the 50 state-level estimates of disability prevalence among adults aged 65 years without a high school credential, divided by the average of the 50 estimates.

FIGURE 2—Percentage Reduction in the Variation Across US States in the Prevalence of Disability Among Adults Without a High School Credential After Adjusting for Race and Socioeconomic Conditions: 2010–2014

DISCUSSION

Studies of disparities in disability by educational attainment among US adults have examined the nation as a single geographic unit. We speculated that the disparities vary considerably across states because states differ in ways that make resources like education more important for avoiding disability risks in certain states than in others. Using nationally representative data of more than 6 million adults spanning all state and local areas, we have provided new information on whether and why disparities in disability by education vary across states. We have shown that the size of the disparity does indeed vary markedly across states. The size varies mainly because the prevalence of disability among low-educated adults varies. Both personal and contextual socioeconomic circumstances of low-educated adults undergird the pattern. Our findings are similar for women and men.

To our knowledge, no previous studies have examined disparities in disability by education level across US states. A few studies have examined disparities in mortality by education or income, but none has examined states. A study of US regions found that disparities in mortality by education are larger in the South than the Northeast.[27] Disparities in men's mortality by education are larger in urban than rural areas.[28] A related study examined mortality disparities by income across commuting zones and found that they vary across zones mainly because the mortality of low-income adults varies.[29]

The dominant view in US studies of disparities in health and longevity by education is that education is a personal resource. Individuals with more education are thought to pursue healthy lifestyles, seek out medical knowledge, avoid financial hardship, and so on.[18] Although these agentic explanations are important, they overlook the fact that individuals are embedded in socioeconomic and policy contexts that strongly influence the extent to which personal resources like education matter for health and longevity. By contrast to US studies, European studies generally view education as a socially embedded resource whose health risks and

rewards are tightly tethered to the broader environment.[7] Our study provides a more nuanced perspective. In the United States, our findings indicate that education is both a personal and social resource, with health risks more tethered than rewards to the environment.

Having low levels of education appears to present a much greater disability risk in some states than others, whereas having high levels of education seems to provide similar protection against disability across states. Interestingly, this pattern is consistent with the theory of fundamental causes.[17] Specifically, higher-educated adults appear to effectively marshal their resources (e.g., cognitive, noncognitive, social, economic) to avoid disease, disability, and premature death across vastly different contexts. Lacking this "personal firewall," their less-educated peers are more exposed, vulnerable, and reliant on resources in those contexts.

Our findings indicate that the disability prevalence of low-educated adults varies across states because the personal and contextual socioeconomic circumstances of these adults vary across states. The personal factors that we considered (race/ethnicity and poverty) accounted for 12.9% of the variation, whereas the contextual factors (spatial concentration of low education and poverty) accounted for another 16.5%. The importance of context is not surprising considering that disability is the intersection between personal capabilities and environmental conditions and that states differ markedly in the latter.

Low education seems particularly problematic for disability in some states because low-educated adults in those states are more likely to be living in poverty and surrounded by others who are similarly disadvantaged. Indeed, states differ in their social and economic safety nets for disadvantaged adults and in the opportunities they provide for good jobs, affordable childcare, and other factors that can lift adults out of poverty. States also differ in contextual characteristics (e.g., concentration of poverty; reliable public transportation; income inequality; housing stock; and physical infrastructure affecting accessibility to employment, communities, and social networks) that can influence whether chronic conditions and functional limitation become a disability.

Limitations

Despite the many strengths of the ACS, it has a few shortcomings. First, the cross-sectional nature of the data has limitations. Some of the most disadvantaged individuals (e.g., low educated, poor) may not have survived long enough to be included in the survey. Consequently, the size of the disparities in disability may be conservative. The cross-sectional data also preclude analyses of cohort effects. However, this is not problematic considering our focus on state-level comparisons: although older birth cohorts were less likely to graduate from college than are recent cohorts, this is true across all states. In addition, because the data are cross-sectional, we cannot establish how education is temporally and causally related to disability.

Although some portion of the education–disability association may reflect the selection of unhealthy persons into low education, prospective studies of older US adults find that education shapes disability status, after controlling for important confounders such as early life health and socioeconomic conditions.[4,5] Moreover, the state patterns we found contradict a pure selection argument. If low-educated adults have higher disability prevalence simply because certain personal characteristics impede educational achievement, then we would not expect to find such dramatic state-level differences in disability prevalence of low-educated adults, with the highest prevalence in states with the largest proportions of these adults.

The ACS does not collect information on other measures that may contribute to the patterns. For instance, it does not collect data on health behaviors. It also does not collect retrospective data such as lifetime income and poverty status and migration histories across state and local areas.

Because of the shortcomings, we cannot definitely rule out the possibility that the high prevalence of disability among low-educated adults in some states reflects a longer survival of disabled individuals in those states or interstate migration. However, the survival explanation is highly improbable because states with high disability also have high mortality.[21] The migration explanation is also highly improbable on the basis of our ancillary analyses of the subset of adults born in their state of residence (Figure B, available as a supplement to the online version of this article at http://www.ajph.org). Their pattern of disability disparities across states is similar to the pattern for all US-born adults.

We encourage studies to build on this work and examine how state and local policies—for example, cigarette taxes, minimum wage, state supplemental earned income tax credits, Medicaid—may shape disparities in disability by education. Recent evidence finds that state-level socioeconomic and policy contexts predict adult disability status,[30] but it is unclear whether they are differentially important for lower-educated adults. Future studies may want to examine other disability-related measures in the ACS and contrast the patterns across population subgroups (e.g., groups by race or immigration status).

Public Health Implications

The large and widening disparities in adult disability by education,[3,6] alongside increasing prevalence of disability among young and middle-aged adults,[31] are troubling public health issues. In fact, all 4 overarching goals of Healthy People 2020 aim to tackle these issues.[32] Our findings indicate that US states play a critical role and point to at least 3 strategies. The first is to reduce poverty among low-educated adults. Reducing poverty is complex and requires multiple approaches. A recent analysis by the Urban Institute found that poverty rates could be reduced by more than 50% through 5 avenues: expanding job opportunities, raising the minimum wage, expanding the state supplemental earned income tax credit, increasing support for recipients of Social Security and Supplemental Security Income, and expanding access to affordable childcare.[33]

To the extent that education has a causal effect on health, a second strategy suggested by our analysis is raising education levels. This would reduce the number of low-educated adults and potentially improve the odds that adults who nonetheless achieve low education live near people with higher education. A third strategy could target the concentration of socioeconomic disadvantage in certain communities by, for example, reducing neighborhood segregation, reducing income

inequality, and incentivizing businesses to build roots in disadvantaged areas.

Lastly, our findings have broader implications for the way that social determinants of health are conceptualized and addressed. These determinants are, by definition, socially manufactured. They are best understood by examining the broader contexts that allow social disparities in health to exist in the first place. AJPH

CONTRIBUTORS

J. K. Montez proposed the research project, conducted the analyses, and drafted the article. A. Zajacova and M. D. Hayward provided substantive insights and editorial feedback on all versions of the article. All authors approved the final version.

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HUMAN PARTICIPANT PROTECTION

Institutional review board approval was not required because the study used a de-identified, publicly available data set.

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