Education, race/ethnicity, and multimorbidity among adults aged 30–64 in the National Health Interview Survey

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ABSTRACT

Keywords: Multimorbidity Education Race Ethnicity Non-elderly Working adults

Background: Demographic risk factors for multimorbidity have been identified in numerous population-based studies of older adults; however, there is less data on younger populations, despite the fact that approximately 24% of US adults age 18+ have multimorbidity. Understanding multimorbidity earlier in the life course is critical because of the increased likelihood of long-term disability and loss of productivity associated with chronic disease progression.

Objective: To examine the associations of education and race/ethnicity with multimorbidity among adults aged 30–64 using cross-sectional data from the 2002–2014 National Health Interview Surveys.

Design: Multimorbidity was defined as having at least 2 of 9 self-reported health conditions. Educational attainment was categorized as less than high school (HS), completed HS or some college, and bachelor’s degree or higher. Logistic regression models of multimorbidity controlled for time since last doctor’s visit, demographic and socioeconomic measures.

Results: Compared to having a bachelor’s degree or higher, completing less than HS (OR=1.58, 95% CI = 1.50–1.66) or HS/some college (OR=1.32, 95% CI = 1.27–1.37) were both associated with increased odds of multimorbidity net of all included covariates. Non-Hispanic Blacks had greater odds of multimorbidity (OR=1.07, 95% CI = 1.02–1.11) compared to Non-Hispanic Whites with comparable characteristics.

Conclusions: Epidemiologic and demographic research on the burden of multimorbidity among non-elderly adults is limited, but warrants renewed attention given the potential for long-term loss of quality of life, productivity, and well-being for non-elderly adults. Reducing multimorbidity through health promotion efforts across the socioeconomic spectrum and earlier in the life course will be a requirement to age successfully and support overall well-being in the aging US population.

Introduction

Multimorbidity (i.e. the presence of multiple chronic conditions) has been associated with numerous adverse outcomes, including greater risk of disability, hospitalization, and death (see review by Marengoni et al., 2011). Most studies of multimorbidity have focused on older adults, despite the high prevalence of chronic illnesses among non-elderly individuals. An analysis of the 2012 National Health Interview Survey (NHIS) showed that approximately 25% of US adults age 18+ have multiple chronic conditions (Ward, Schiller, & Goodman, 2014). Among adults ages 45–64, 18.5% had 2 chronic conditions, and 13.8% had 3 or more chronic conditions (Ward et al., 2014). Trend data indicate that the co-occurrence of chronic conditions among the non-elderly has increased in recent years (Ward & Schiller, 2013). These findings all suggest that studying multimorbidity among non-elderly adults is important for researchers who wish to understand chronic disease burden in populations.

Understanding multimorbidity at earlier stages of the life course is important for a number of reasons. Early and middle adulthood are periods often marked by exposure to change and psychological stress in numerous social domains (Lachman & James, 1997; Lowenthal, Thurner, & Chiriboga, 1975). During these developmental periods, individuals typically handle often demanding and conflicting social roles as they manage careers, romantic partnerships, parenthood, and caring for older relatives (Greenhaus & Beutell, 1985; Miller, 1981). Strain from managing these multiple social roles could increase vulnerability to chronic illnesses, or it could make the management of existing chronic conditions more difficult.
Studying multimorbidity early in the life course also has implications for health service delivery. Because existing health care delivery models are often specialized and disease-specific, managing multiple chronic conditions is often difficult and inefficient (Valderas, Starfield, Sibbald, Salisbury, & Roland, 2009). Identifying individuals with multimorbidity early in the life course may allow for the development of integrated, comprehensive services to assist individuals in the earliest stages of disease. This could ultimately make disease management less burdensome and more efficient in the long term.

Understanding multimorbidity at younger ages also allows for the development of health behavior interventions early in the disease process when they are most likely to be effective. For example, improvements in physical activity can lower blood pressure (Fagard, & Cornelissen, 2007) and improve glucose control (Boulé, Haddad, Kenny, Wells, & Sigal, 2001), which can decrease risk of cardiovascular disease and/or diabetes-related complications (Kelly et al., 2009; Sowers, Epstein, & Frohlich, 2001). Some forms of physical activity, however, may be more difficult for older adults due to greater frailty and/or more functional disability at advanced ages (frailty: Fulop et al., 2010; functional disability: U.S. Census Bureau, 2008) Thus, targeting behavior-related interventions to individuals at younger ages may prove more effective in reducing disease burden and progression.

We are particularly interested in how socioeconomic status (SES) is associated with multimorbidity earlier in the life course. Low SES has been linked to greater occurrence of numerous individual chronic conditions, including hypertension (Vargas, Ingram, & Gillum, 2000) heart disease (Thurston, Kubzansky, Kawachi, & Berkman, 2005) diabetes (Borrell, Dallo, White, & White, 2005) and asthma (Cutler & Lleras-Muney, 2006). This relationship may reflect inequities in access to health care, engagement in fewer health promoting behaviors, and/or more stress-related risk factors that contribute to chronic disease (Cutler & Lleras-Muney, 2006). The relationship between low SES and multimorbidity, however, has not been consistently demonstrated. While international work among older adults has shown that higher education is associated with less multimorbidity (Taylor, Sculati, & Fox, 2006; Nagel et al., 2008), we are interested in whether higher education is associated with less multimorbidity (Barnett et al., 2012; Nagel et al., 2008; Tucker-Seeley et al., 2011) or other SES indicators such as marital status, age, and gender. A study of Non-Hispanic Black, White, and Mexican adults aged 51 and older also indicated racial/ethnic disparities in multimorbidity, as Blacks had consistently greater multimorbidity over an 11-year period when compared to Whites. Mexican Americans, however, had lower multimorbidity prevalence and incidence over the same period than both Non-Hispanic Blacks and Non-Hispanic Whites (Quiñones, Liang, Bennett, Xu, & Ye, 2011). Beyond SES, racial differences in health may reflect cultural differences in health practices (Berkman & Mullen, 1997) or greater psychological distress associated with perceived or experienced discrimination (Kessler, Mickelson, & Williams, 1999; Williams, Yu, Jackson, & Anderson, 1997). In the United States, racial/ethnic disparities persist across most major chronic conditions (U.S. Department of Health and Human Services, 2013). Data from the 2010 NHIS showed that among adults aged 18–44, 8.8% of Non-Hispanic Black men and 11.7% of Non-Hispanic Black women had two or more chronic conditions, compared to only 6.4% of Non-Hispanic White men and 8.9% of Non-Hispanic White women (Ward & Schiller, 2010).

We are also interested in the association between race and multimorbidity early in the life course, even after controlling for socioeconomic indicators.

We address our research questions using cross-sectional data from the 2002–2014 waves of the National Health Interview Survey (NHIS), a large, nationally-representative survey of community-dwelling U.S. adults. Because we are interested in studying individuals before retirement age, we restrict our analyses to adults ages 30–64 who provided information on both educational attainment and chronic health status at the time of interview.

**Methods**

**Data**

This is a cross-sectional study based on person-level data collected in the National Health Interview Surveys (NHIS) from 2002 to 2014. The NHIS is an ongoing annual household health survey conducted through face-to-face interviews by U.S. Census Bureau interviewers. The NHIS uses a complex multistage stratified sampling design to obtain a sample representative of the civilian non-institutionalized U.S. population. We obtained the data through the Integrated Health Interview Surveys (IHIS), a consolidated source of NHIS data compiled by the Minnesota Population Center (Wouts et al., 2008). Since a major redesign in 1997, the basic set of health and sociodemographic questions (the Core) have remained the same from year to year. The Core comprises family information on every member of the household and additional information like health conditions for a random subsample of one adult per family (the Sample Adult Core). The unconditional Sample Adult response rate declined over time from 74% in 2002 to 61% in 2013 (National Center for Health Statistics, 2010, 2013, 2014).

The analytic sample was selected from the Sample Adult Core and defined as adults aged 30 to 64 at the time of the interview who provided valid education information and reported at least one chronic
condition. Fewer than 1% (1806 individuals) of adults in the 30–64 age range were missing education information, so their exclusion from the analysis sample is unlikely to bias results. The lower age boundary of 30 years represents a threshold below which over 15% of adults (age 18–29) are still enrolled in school (National Center for Education Statistics, 2016; Planty et al., 2008). The upper boundary is the typical age of transition to retirement; moreover, excluding older adults considerably reduces bias due to selective mortality (Lynch, 2003; Zajacova, Goldman, & Rodriguez, 2009). Jointly, these age boundaries define working-age adults with mostly completed schooling. To focus on multimorbidity, we further restricted our analyses to respondents with at least one chronic condition, in order to minimize variation in the models attributable to differences in health care treatment for those with and without chronic diseases (N=115,097).

**Variables**

**Multimorbidity**

We used information on 9 self-reported health conditions or problems that were collected continuously and identically since 2002 to define multimorbidity. The measures were comparable with those used in a previous study of multimorbidity in NHIS (Ward & Schiller, 2010), but we included additional measures that have been considered in other studies of multimorbidity (Qin et al., 2015). The health conditions were based on respondent self-report of a having ever been told by a doctor that they have each condition, including asthma, arthritis, heart disease (including angina pectoris, heart attack, coro

-nary heart disease, and ‘other’ heart disease), stroke, chronic obstructive pulmonary disease (COPD; including emphysema and chronic bronchitis), hypertension, cancer, diabetes, and kidney failure (weak or failing kidneys during the past 12 months). Multimorbidity was defined as having two or more conditions. The reference category, as noted above, was respondents with one condition.

**Educational attainment**

Information about schooling was collected as the highest completed grade up to 12th grade and as educational credentials for those who completed at least high school. During the interview, respondents were handed a card with a list of educational categories and asked to select the one that best represented their highest completed level. We categorized education as less than high school completion, high school diploma or some college including an associate degree, and a bachelor degree or higher. The lowest attainment category (less than high school) included the GED, which previous studies have found comparable to high school dropout level in terms of health outcomes (Zajacova, 2012).

Race/ethnicity was categorized as Non-Hispanic White (reference), Non-Hispanic Black, Hispanic, and Non-Hispanic Other.

**Additional covariates**

We incorporated key demographic measures to account for potential confounding by these variables. Age was measured in years and centered on the sample mean of 46 years. We adjusted for age because multimorbidity prevalence increases steeply across age (Ward & Schiller, 2010). The sex of the respondent was defined as male (reference) vs. female. Evidence from existing literature has shown marital status as a correlate of chronic disease (Umberson, Williams, Powers, Lin, & Needham, 2006; Schwandt, Coresh, & Hindin, 2010). Here it was defined as married (reference), living with partner, single, separated/widowed/divorced, and unknown. Models also included the region of residence (Northeast as reference, Midwest, South, and West), given variation in particular chronic diseases (i.e. hypertension) across the U.S. (Obisesan, Vargas, & Gillum, 2000). We also controlled for whether the respondent was born in a foreign country, as the “healthy migrant hypothesis” suggests that immigrants to the United States experience better health outcomes than U.S. born individuals in part because healthier people may be more likely to migrate than less healthy people (Markides & Coreil, 1986). This effect has been tested in several studies (Janevic, Savits, & Janevic, 2011; Lu & Qin, 2014). Further, we control for the time since last doctor’s visit (within the past year as reference, 1–2 years ago, 2–5 years, more than 5 years, or never), as more frequent utilization of ambulatory and primary care services has been previously associated with both higher SES (Aday & Andersen, 1984; Feinstein, 1993) and fewer chronic conditions (van Oortom et al., 2014). Interview year was included as continuous and was centered on the grand mean of 2008. We also included additional measures of socioeconomic status, including employment status categorized as employed (reference), unemployed, and not in labor force, home ownership as owner (reference) or renter, and household family income categorized in tertiles (highest tertile as reference). For the latter three variables, we also included category for “unknown/missing” for individuals who did not answer the question.

**Analysis**

Descriptive characteristics, including means and standard errors for continuous variables and frequencies and standard errors for categorical variables, were calculated first. Next, we estimated a set of logistic regression models of multimorbidity versus one condition as a function of select covariates: the first model included education plus basic demographics; the second model included race/ethnicity and basic demographics. The third model joined education and race/ethnicity. Finally models 4 and 5 also controlled for other correlates of health, including marital status, time since the respondent last saw a doctor, Census region where the respondent lived at the time of the survey, and whether the respondent was born in the United States. The potential confounding by age, sex, and interview year was controlled in all models. All analyses were performed in Stata 14.1 and all descriptive and regression estimations were adjusted for the complex sampling design of NHIS (Hahs-Vaughn, McWayne, Bulotsky-Shearer, Wen, & Faria, 2011) using the svy suite in Stata, resulting in estimates representative of the non-institutionalized United States population.

**Results**

**Sample characteristics**

The final analysis included 115,097 adults age 30–64 with at least one chronic condition. Of these, 23.7% had 2 or more chronic conditions. In Table 1, we provided demographic measures for those with 1 or 2+ conditions. Those with 2+ conditions were more likely to have less than a college credential, to be Non-Hispanic Black, slightly older, widowed or divorced/separated, live in the south region of the country, and to have seen a doctor within the past year. Those with 1 condition were more likely to have a college credential or more, report being Hispanic or other race/ethnicity, be married or never married, live in the northeast or the west, were foreign born, and report their last doctor visit as being 1+ years prior.

**Logistic regression results**

Results of the models of multimorbidity (2+ vs 1 conditions) are shown in Table 2. Compared to having a bachelor degree or higher, having less than a HS credential (OR=2.16, 95% CI = 2.07–2.26) or having a HS credential/some college (OR=1.54, 95% CI = 1.49–1.59) were associated with increased odds of multimorbidity, controlling for age, gender, and interview year (Model 1). Model 2 examined the association between race/ethnicity and multimorbidity, controlling for age, gender, and interview year. When compared to Non-Hispanic Whites, Non-Hispanic Blacks had greater odds of multimorbidity (OR=1.30, 95% CI = 1.25–1.35), while Hispanics (OR=0.96, 95% CI = 0.92–1.00) and Non-Hispanics of other race/ethnicities had lower odds of multimorbidity (OR=0.86, 95% CI = 0.79–0.92).
used in existing literature to reflect socioeconomic status – employment status, home ownership, and family income. While the magnitudes of the effects were smaller, the associations between multimorbidity and both education and race/ethnicity were consistent with Model 4.

**Discussion**

Our study suggests that lower educational attainment is associated with increased odds of multimorbidity in a U.S. population-based sample of adults ages 30–64. Specifically, individuals with less than a high school degree as well as those with a high school degree or some college demonstrated greater multimorbidity than their counterparts with at least a bachelor’s degree. This finding is consistent with previous studies showing that less education is linked to numerous individual chronic conditions (Borrell, Dallo, White, & White, 2005; Cutler & Lleras-Muney, 2006; Thurston et al., 2005; Vargas, Ingram, & Gillum, 2000). It is also consistent with work from European samples that have evaluated links between SES and multimorbidity and found a consistent negative correlation (Marengoni et al., 2008; Nagel et al., 2008; van den Akker, Buntinx, Metsemakers, Roos & Knootnerus, 1998). Importantly, the links between education and multimorbidity persisted after controlling for a host of covariates, including age, marital status, gender and race/ethnicity. This suggests the other factors likely mediate the association of education with multimorbidity. Having limited education may contribute to poorer social conditions (e.g. employment without sufficient and affordable health insurance, lower income, unsafe housing and neighborhood conditions) and/or greater psychological stress (Ross & Wu, 1995). Both may result in poorer health practices (e.g. physical inactivity, unhealthy diet, low use of preventive care services), which may in turn increase chronic disease risk (Ross & Wu, 1995). Future studies should explore potential mediators.

We also observed that race/ethnicity was associated with multimorbidity. In all models, Non-Hispanic Blacks demonstrated greater odds of multimorbidity than Non-Hispanic Whites. This finding is also consistent with existing literature. Ward and Schiller (2013) descriptively showed that a greater proportion of Non-Hispanic Blacks had two or more chronic conditions than Non-Hispanic Whites aged 18–44 and 45–64 using 2010 NHIS data. This analysis, however, did not control for education or other demographic indicators. In our sample, the relationship between Non-Hispanic Black ethnicity and multimorbidity persists even after controlling for education and other sociodemographic characteristics. This suggests that other factors are potential mechanisms through which racial/ethnic differences in multimorbidity operate. These may include cultural differences in health practices or social support, greater psychological stress due to perceived discrimination, poorer mental health, or other factors not explored here. Future studies should explore factors that mediate this association.

Associations between race/ethnicity and multimorbidity among Hispanics and Non-Hispanics of other races were more complex. In initial models evaluating the association between race/ethnicity and multimorbidity, we observed that Hispanic adults and Non-Hispanics of other races had decreased odds of multimorbidity when compared to Non-Hispanic Whites. This finding is consistent with work from Quiñones et al. (2011) in which Mexican Americans had a lower multimorbidity burden compared to Whites. In our study, these effects were even stronger when controlling for education. Previous studies suggest a Hispanic paradox in epidemiological research, with Hispanics often having health outcomes comparable to or better than those of Non-Hispanic Whites, even when education and other socioeconomic factors are considered (Crimmins, Kim, Alley, Karlamangla, & Seeman, 2007; Markides & Corell, 1986). Many researchers propose that this paradox is confounded by immigrant status, as the healthy migrant hypothesis suggests that healthier individuals are more likely to originate from healthier populations.

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**Table 1**

Sample Characteristics, US adults 30–64, NHIS 2002–2014 (n=115,097).

| Variable                      | 1 condition | 2+ Conditions |
|-------------------------------|-------------|---------------|
| **Proportion with multimorbidity** | 23.7%       |               |
| **Education**                 |             |               |
| Less than HS credential       | 13.7%       | 20.2%         |
| HS or some college            | 54.6%       | 57.8%         |
| College credential or more   | 31.7%       | 22.1%         |
| **Race**                     |             |               |
| NH White                      | 73.8%       | 73.6%         |
| NH Black                      | 12.6%       | 15.1%         |
| Hispanic                      | 9.5%        | 8.1%          |
| Other                         | 4.0%        | 3.2%          |
| **Basic control variables**   |             |               |
| Age – mean (s.e.)             | 47.7 (.04)  | 52.1 (.05)    |
| Female                        | 54.1%       | 57.1%         |
| Interview year– mean (s.e.)   | 2008.1 (.02)| 2008.3 (.02) |
| **Marital status**            |             |               |
| Married                       | 54.5%       | 48.7%         |
| Widowed                       | 3.4%        | 6.0%          |
| Divorced/separated            | 24.3%       | 30.0%         |
| Never married                 | 17.4%       | 15.0%         |
| Marital status unknown        | 0.4%        | 0.3%          |
| **Region of residence**       |             |               |
| Northeast                     | 18.3%       | 16.8%         |
| Midwest                       | 24.4%       | 25.2%         |
| South                         | 36.4%       | 39.4%         |
| West                          | 20.9%       | 18.6%         |
| Foreign-born                   | 12.4%       | 8.4%          |
| **Last doctor visit**         |             |               |
| Within the past year          | 86.5%       | 93.7%         |
| 1–2 years ago                 | 6.2%        | 2.7%          |
| 2–5 years ago                 | 3.6%        | 1.4%          |
| 5 or more years or never      | 3.6%        | 2.2%          |

Descriptives were adjusted for NHIS complex sampling design. Standard errors for each of the estimates in Table 1 are less than 0.0003.
to immigrate to the United States than their less healthy counterparts (Markides & Coreil, 1986). Our findings seem to support this, as the association between race/ethnicity and multimorbidity among Hispanics does not persist after controlling for foreign-born status.

While our findings contribute to this relatively recent body of work around multimorbidity across the life course, they should be interpreted in context. The NHIS is a nationally representative sample that allows a population-level examination of correlates of multimorbidity. The cross-sectional nature of the data, however, limits our ability to make causal interpretations of the findings. Our work represents a snapshot of the associations between social factors like race/ethnicity and education with multimorbidity. Longitudinal studies and studies of long-term outcomes like mortality are needed to understand the true consequences of multimorbidity identified early in the life course.

Further, our multimorbidity measure is not without limitations. We used a dichotomized variable based on an unweighted count of self-reported measures that did not account for the severity, complexity, or duration of the chronic conditions studied, a standard approach that has been used in other studies of multimorbidity (Nagel et al., 2008; Quiñones et al., 2011; Tucker-Seely et al., 2011; van den Akker, 1998; Ward & Schiller, 2013). The self-reported measures lack clinical precision, but likely indicate the conditions that most influence the respondent’s daily life. Several measures, including those that categorize multimorbidity by organ system (Fortin et al., 2004) could possibly be differentially associated with education level. Only recently has the collection of socioeconomic data become more common in clinical data sources and population level data with diagnostic information comparable to clinical data are few. Future work, using national data sources like the National Health and Nutrition Examination Surveys, may allow for more nuanced multimorbidity measures in nationally representative data that incorporate both clinical indicators and self-reports of diagnosed conditions.

 Ideally, data should capture the clinical severity of the condition, details regarding disease severity, complexity, and treatment choices and burdens that affect the individual. Other clinical data sources, including administrative insurance claims data, for example, may also provide an alternative type of data source for multimorbidity research.

### Table 2

Odds Ratios and 95% Confidence Intervals of Multimorbidity on Select Predictors, NHIS 2002–2014, Adults 30–64 with one or more conditions (n=115,097).

|                         | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|-------------------------|---------|---------|---------|---------|---------|
|                         | OR      | 95% CI  | OR      | 95% CI  | OR      | 95% CI  | OR      | 95% CI  | OR      | 95% CI  |
| **Education (College degree = ref.)** |         |         |         |         |         |         |         |         |         |         |
| LT HS credential        | 2.16    | 2.07,2.26 | 2.21    | 2.11,2.31 | 2.27    | 2.16,2.37 | 1.58    | 1.50,1.66 |         |         |
| HS or some college      | 1.54    | 1.49,1.59 | 1.53    | 1.48,1.59 | 1.52    | 1.47,1.58 | 1.32    | 1.27,1.37 |         |         |
| **Race/Ethnicity (NHW = ref.)** |         |         |         |         |         |         |         |         |         |         |
| NH Black                | 1.30    | 1.25,1.35 | 1.20    | 1.15,1.25 | 1.15    | 1.10,1.20 | 1.07    | 1.02,1.11 |         |         |
| Hispanic                | 0.96    | 0.92,1.00 | 0.89    | 0.82,0.96 | 1.16    | 1.07,1.25 | 1.11    | 1.03,1.21 |         |         |
| Non-Hispanic Other      | 0.86    | 0.79,0.92 | 0.89    | 0.82,0.96 | 1.16    | 1.07,1.25 | 1.11    | 1.03,1.21 |         |         |
| Age                     | 1.05    | 1.05,1.06 | 1.05    | 1.05,1.05 | 1.05    | 1.05,1.05 | 1.05    | 1.05,1.05 |         |         |
| Female                  | 1.17    | 1.14,1.20 | 1.16    | 1.13,1.20 | 1.16    | 1.13,1.20 | 1.10    | 1.07,1.13 | 1.03    | 1.00,1.06 |
| Interview Year          | 1.01    | 1.01,1.02 | 1.01    | 1.01,1.02 | 1.01    | 1.01,1.02 | 1.01    | 1.00,1.01 |         |         |
| **Region of residence (NE = ref.)** |         |         |         |         |         |         |         |         |         |         |
| Midwest                 | 1.11    | 1.07,1.16 | 1.11    | 1.07,1.16 |         |         |         |         |         |         |
| South                   | 1.13    | 1.09,1.18 | 1.12    | 1.07,1.16 |         |         |         |         |         |         |
| West                    | 1.02    | 0.97,1.06 | 0.99    | 0.95,1.04 |         |         |         |         |         |         |
| Foreign-born (US-born = ref.) | 0.63   | 0.60,0.67 | 0.63    | 0.59,0.66 |         |         |         |         |         |         |
| **Marital status (married/living with partner = ref.)** |         |         |         |         |         |         |         |         |         |         |
| Widowed                 | 1.26    | 1.18,1.34 | 1.10    | 1.03,1.18 |         |         |         |         |         |         |
| Divorced/separated      | 1.29    | 1.25,1.33 | 1.16    | 1.12,1.20 |         |         |         |         |         |         |
| Never married           | 1.18    | 1.14,1.24 | 1.04    | 0.99,1.08 |         |         |         |         |         |         |
| Unknown                 | 0.74    | 0.59,0.94 | 0.71    | 0.56,0.90 |         |         |         |         |         |         |
| **Last Dr. visit (within 1 year = ref.)** |         |         |         |         |         |         |         |         |         |         |
| 1–2 years ago           | 0.42    | 0.39,0.45 | 0.43    | 0.40,0.46 |         |         |         |         |         |         |
| 2–5 years ago           | 0.36    | 0.32,0.40 | 0.35    | 0.31,0.39 |         |         |         |         |         |         |
| 5+ years or never       | 0.53    | 0.49,0.58 | 0.52    | 0.47,0.57 |         |         |         |         |         |         |
| **Employment (empl. = ref.)** |         |         |         |         |         |         |         |         |         |         |
| Unemployed              |         |         | 1.18    | 1.10,1.26 |         |         |         |         |         |         |
| Not in labor force      |         |         | 1.83    | 1.77,1.90 |         |         |         |         |         |         |
| N/A                    |         |         | 1.13    | 0.71,1.82 |         |         |         |         |         |         |
| **Home owner (owns = ref.)** |         |         |         |         |         |         |         |         |         |         |
| Rents                   |         |         | 1.19    | 1.15,1.24 |         |         |         |         |         |         |
| N/A                    |         |         | 1.14    | 1.05,1.25 |         |         |         |         |         |         |
| **Family income (high tertile = ref.)** |         |         |         |         |         |         |         |         |         |         |
| Bottom tertile          |         |         | 1.45    | 1.38,1.53 |         |         |         |         |         |         |
| Middle tertile          |         |         | 1.11    | 1.07,1.15 |         |         |         |         |         |         |
| N/A                    |         |         | 1.05    | 1.00,1.11 |         |         |         |         |         |         |
| Adjusted F [39]         | 4063.5  | 3280.3  | 3948.9  | 3931.2  | 3938.1  | 3938.1  | 3938.1  | 3938.1  | 3938.1  | 3938.1  |

Models adjusted for complex sampling design of the 2002–2014 NHIS; OR= Odds ratio; CI=Confidence interval; LT HS=less than high school; NHW=Non-Hispanic White; NH=Non-Hispanic; NE=Northeast; Div=Divorced; Empl=Employed.
particularly if extensive sociodemographic and health behavioral data are also available. Further, the absence of diagnosed mental illness in the NHIS limited our ability to account for mental illness in our analyses. Finally, our study may not capture the complete role of education in multimorbidity. In these analyses, education is operationalized into broad categories, and data reflecting educational quality is not available in the NHIS. Previous research suggests that educational quality may vary with race/ethnicity, (Boozer, Krueger, & Wolkon, 1992) and thus may be an underlying component of education that contributes to the observed relationship between race/ethnicity and multimorbidity among Non-Hispanic Blacks and Whites. Future studies should consider education quality as a factor.

Although our study has some limitations, it has significant merits. We utilized a population-based sample of U.S. based non-elderly adults to address independent associations of race/ethnicity and education with multimorbidity in a non-clinical population. Additionally, we controlled for a host of covariates not considered in previous studies of race/ethnicity and socioeconomic status with multimorbidity, including foreign born status, region, and time since last doctor’s visit. Further, we consider both education and race/ethnicity in the same model, which allowed us to test for the independent associations of these variables with multimorbidity.

Epidemiologic and demographic research on the burden of multimorbidity among non-elderly adults is limited, but warrants renewed attention given the potential for long-term significant loss in quality of life, financial productivity, and well-being for non-elderly adults. Identifying sociodemographic characteristics that are associated with multimorbidity early in the life course is crucial for understanding (and ultimately reducing) the burden of multimorbidity as the U.S. population continues to age.

Conflicts of interest

We have no conflicts of interest to declare, and no financial disclosures.

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References

Aday, L. A., & Andersen, R. M. (1984). The national profile of access to medical care: Where do we stand? American Journal of Public Health, 74, 1313–1339.

Barnett, K., Mercer, S. W., Norbury, M., Watt, G., Wyke, S., & Guthrie, B. (2012). Multimorbidity: The prevalence of comorbidity in adult patients with diabetes in primary care. Diabetes Care, 35, 250–255.

Berkman, L. F., & Mullen, J. M. (1997). How health behaviors and the social environment contribute to health differences between black and white older Americans. Racial and Ethnic Differences in the Health of Older Americans, 163–182.

Boozer, M. A., Krueger, A. B., & Wolkon, S. (1992). Race and school quality since Brown vs. Board of Education (No. w4109). National Bureau of Economic Research.

Borrell, I. N., Fallo, F. J., & White, K. (2006). Education and diabetes in a racially and ethnically diverse population. American Journal of Public Health, 96, 1637–1642.

Boule, N. G., Haddad, E., Kenny, G. P., Wells, G. A., & Sigal, R. J. (2001). Effect of exercise on glycemic control and body mass in type 2 diabetes mellitus: A meta-analysis of controlled clinical trials. JAMA, 286, 1218–1227.

Crimmins, E. M., Kim, J. K., Alley, D. E., Karlamangla, A., & Seeman, T. (2007). Chinese paradox in biological risk profiles. American Journal of Public Health, 97, 1205–1210.

Cutler, D. M., & Lleras-Muney, A. (2006). Education and health: Evaluating theories and evidence (No. w12352). National Bureau of Economic Research.

Fagard, R. H., & Cornelissen, V. A. (2007). Effect of exercise on blood pressure control in hypertensive patients. European Journal of Cardiovascular Prevention Rehabilitation, 14, 12–17.

Feinstein, J. S. (1993). The relationship between socioeconomic status and health: A review of the literature. The Milbank Quarterly, 71, 279–322.

Fortin, M., Lapointe, L., Hudon, C., Vanasse, A., Ntufu, A. L., & Maltais, D. (2004). Multimorbidity and quality of life in primary care: A systematic review. Health and Quality of Life Outcomes, 2, 51.

Kessler, R. C., Mickelson, K. D., & Williams, D. R. (1999). The prevalence, distribution, and internal migration in China. Demography, 40, 309–331.

Lynch, S. M. (2003). Cohort and life-course patterns in the relationship between education and health: A hierarchical approach. Demography, 40, 430–439.

Marrongini, A., Angleman, S., Melis, R., Mangialasche, F., Karp, A., Aarmen, A., & Fratiglioni, L. (2011). Age, multimorbidity and mortality: A systematic review of the literature. Ageing Research Reviews, 10, 430–439.

Marrongini, A., Winblad, B., Karp, A., & Fratiglioni, L. (2008). Prevalence of chronic diseases and multimorbidity among the elderly population in Sweden. American Journal of Public Health, 98, 1198–1208.

Markides, K. S., & Corell, J. (1986). The health of Hispanics in the southwestern United States: an epidemiologic paradox. Public Health reports, 101(3), 253, Miller, D. A. (1981). The ‘sandwich’ generation: Adult children of the aging. Social Work, 26, 419–425.

National Center for Health Statistics (2016). Enrollment trends by age, 2016, US Department of Education. Retrieved from [http://nces.ed.gov/programs/coe/indicator_cse.asp]

National Center for Health Statistics (2010). . 2009 National Health Interview Survey (NHIS) Public Use Data Release: Survey Description. Retrieved from [ftp.cdc.gov/pub/health_statistics/nchs/Data_Bulletin_NHIS/2009/surveydesc.pdf].

National Center for Health Statistics (2013). 2012 National Health Interview Survey (NHIS) Public Use Data Release: Survey Description. Retrieved from [ftp://ftp.cdc.gov/pub/health_statistics/nchs/Data_Bulletin_NHIS/2012/surveydesc.pdf].

National Center for Health Statistics (2014). 2013 National Health Interview Survey (NHIS) Public Use Data Release: Survey Description. Retrieved from [ftp://ftp.cdc.gov/pub/health_statistics/nchs/Data_Bulletin_NHIS/2013/surveydesc.pdf].

Nagel, G., Peter, R., Braig, S., Hermann, S., Rohrmann, S., & Linieisen, J. (2008). The impact of education on risk factors and the occurrence of multimorbidity in the EPIC-Heidelberg cohort. BMC Public Health, 8, 384. http://dx.doi.org/10.1186/1471-2458-8-384.

Obisesan, T. O., Vargas, C. M., & Gillum, R. F. (2000). Geographic variation in stroke risk in the United States. Stroke, 31, 19–25.

Plants, M., Hussar, W., Snyder, T., Provanski, S., Kena, G., Dinkes, R., & Kemp, J. (2008). . The Condition of Education 2009 (NCES 2009-081). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, US Department of Education. http://nces.ed.gov/programs/coe/indicator_cse.asp

Quin, J., Theis, K. A., Barbour, K. E., Helmeric, C. G., Baker, N. A., & Brady, T. J. (2015). Impact of arthritis and multiple chronic conditions on selected life domains—United States, 2013. Morbidity and Mortality Weekly Report, 64, 578–582.

Quitones, A., R. L., Liang, J., Bennett, J. M., Xu, X., & Ye, W. (2011). How does the trajectory of multimorbidity vary across Black, White, and Mexican Americans in middle and old age? The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 66, 739–749.

Schärer, J., Hansen, H., Schiöth, A., Holfels, S., Altiner, A., Dahlhaus, A., & König, H. H. (2012). The influence of age, gender and socio-economic status on multimorbidity patterns in primary care. First results from the multicentre cohort study. BMC Health Services Research, 12, 89.

Schwarz, H. M., Corsh, J., & Hindin, M. J. (2010). Marital status, hypertension, coronary heart disease, diabetes, and death among African American women and men: Incidence and prevalence in the Atherosclerosis Risk in Communities (ARIC) study participants. Journal of Family Issues, 31, 1211–1229.

Sjostrom, P., Hanzer, S., & Janiuk, S. (2008). Stroke and acute myocardial infarction in the Swedish Sami population: incidence and mortality in relation to income and level of education. Scand J Public Health, 36(1), 94–91. http://dx.doi.org/10.1177/1403494807087305.

Sowers, E. A., Epstein, M., & Forbich, E. D. (2001). Diabetes, hypertension, and cardiovascular disease. Hypertension, 37, 1055–1059.

Stewart, J. (2009). . Economic Status. Social Environment Notebook. MacArthur Research Network on SES and Health. Retrieved from [http://www.macses.ucsf.edu/].
Tooth, L., Hockey, R., Byles, J., & Dobson, A. (2008). Weighted multimorbidity indexes predicted mortality, health service use, and health-related quality of life in older women. *Journal of Clinical Epidemiology, 61*, 151–159.

Thurston, R. C., Kubzansky, L. D., Kawachi, I., & Berkman, L. F. (2005). Is the association between socioeconomic position and coronary heart disease stronger in women than in men? *American Journal of Epidemiology, 162*, 57–65.

Tucker-Seeley, R. D., Li, Y., Sorensen, G., & Subramanian, S. V. (2011). Lifecourse socioeconomic circumstances and multimorbidity among older adults. *BMC Public Health, 11*, 313. http://dx.doi.org/10.1186/1471-2458-11-313.

Umberson, D., Williams, K., Powers, D. A., Liu, H., & Needham, B. (2006). You make me sick: marital quality and health over the life course. *Journal of Health and Social Behavior, 47*(1), 1–16.

U.S. Department of Health and Human Services (2013). CDC health disparities and inequalities report—United States, 2011. *Morbidity and Mortality Weekly Report, 60*, 1–113.

Valderas, J. M., Starfield, B., Sibbald, B., Salisbury, C., & Roland, M. (2009). Defining comorbidity: Implications for understanding health and health services. *The Annals of Family Medicine, 7*, 357–363.

van den Akker, M., Buntinx, F., Metsemakers, J. F., Roos, S., & Knottnerus, J. A. (1998). Multimorbidity in general practice: prevalence, incidence, and determinants of co-occurring chronic and recurrent diseases. *Journal of Clinical Epidemiology, 51*(5), 367–375. http://dx.doi.org/10.1016/S0895-4356(97)00306-5.

van Oostrom, S. H., Picavet, H. S. J., de Bruin, S. R., Stirbu, I., Korevaar, J. C., Schellevis, F. G., & Baan, C. A. (2014). Multimorbidity of chronic diseases and health care utilization in general practice. *BMC Family Practice, 15*, 61.

Vargas, C. M., Ingram, D. B., & Gillum, R. F. (2000). Incidence of hypertension and educational attainment: The NHANES I epidemiologic followup study. *American Journal of Epidemiology, 152*, 272–278.

Ward, B. W., & Schiller, J. (2013). Prevalence of multiple chronic conditions among US adults: Estimates from the National Health Interview Survey, 2010. *Preventing Chronic Disease, 10*, 120203. http://dx.doi.org/10.5888/pcd10.120203.

Ward, B. W., Schiller, J., & Goodman, R. (2014). Multiple chronic conditions among US adults: A 2012 update. *Preventing Chronic Disease, 11*(30389). http://dx.doi.org/10.5888/pcd11.130389.

Williams, D. R., Yu, Y., Jackson, J. S., & Anderson, N. B. (1997). Racial differences in physical and mental health: Socio-economic status, stress and discrimination. *Journal of Health Psychology, 2*, 335–351.

Wouts, L., Voshaar, R. C. O., Bremmer, M. A., Buitelaar, J. K., Penninx, B. W., & Beekman, A. T. (2008). Cardiac disease, depressive symptoms, and incident stroke in an elderly population. *Archives of General Psychiatry, 65*, 596–602.

Zajacova, A. (2012). Health in working-aged Americans: Adults with high school equivalency diploma are similar to dropouts, not high school graduates. *American Journal of Public Health, 102*, S284–S290.

Zajacova, A., Goldman, N., & Rodriguez, G. (2009). Unobserved heterogeneity can confound the effect of education on mortality. *Mathematical Population Studies, 16*, 153–173.