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The relationship between educational attainment and hospitalizations among middle-aged and older adults in the United States

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ABSTRACT

Background: There has been little research on the relationship between education and healthcare utilization, especially for racial/ethnic minorities. This study aimed to examine the association between education and hospitalizations, investigate the mechanisms, and disaggregate the relationship by gender, race/ethnicity, and age groups.

Methods: A retrospective cohort analysis was conducted using data from the 1992–2016 US Health and Retirement Study. The analytic sample consists of 35,451 respondents with 215,724 person-year observations. We employed a linear probability model with standard errors clustered at the respondent level and accounted for attrition bias using an inverse probability weighting approach.

Results: On average, compared to having an education less than high school, having a college degree or above was significantly associated with an 8.37 pp (95% CI, −9.79 pp to −7.95 pp) lower probability of being hospitalized, and having education of high school or some college was related to 3.35 pp (95% CI, −4.57 pp to −2.14 pp) lower probability. The association slightly attenuated after controlling for income but dramatically reduced once holding health conditions constant. Specifically, given the same health status and childhood environment conditions, compared to those with less than high school degree, college graduates saw a 1.79 pp (95% CI, −3.16 pp to −0.42 pp) lower chance of being hospitalized, but the association for high school graduates became indistinguishable from zero. Additionally, the association was larger for females, whites, and those younger than 78. The association was statistically significantly smaller for black college graduates than their white counterparts, even when health status is held constant.

Conclusions: Educational attainment is a strong predictor of hospitalizations for middle-aged and older US adults. Health mediates most of the education-hospitalization gradients. The heterogeneous results across age, gender, race, and ethnicity groups should inform further research on health disparities.

1. Introduction

The uneven distribution of health across the socioeconomic spectrum is one of the most recognized and well-established facts (Ettner, 1996; Grossman, 2006; Montez et al., 2012). Social conditions such as lack of education have been considered the fundamental causes of disease by medical sociologists and social epidemiologists (Link & Phelan, 1995). It is because such social factors embody access to resources (e.g., money, knowledge, power) that help people avoid diseases. It is also because the health effects of social factors cannot be eliminated by addressing the mechanisms linking them to diseases. As a marker of socioeconomic status, educational attainment has certain advantages over other measures such as income, occupation, and social support. Education is established early in life and is not subject to the same fluctuations over the life course, particularly for middle-aged and older adults (Hummer & Lariscy, 2011). An extensive literature has found that the gradient in health by education is particularly robust, although there is still controversy over whether socioeconomic differences in health are causal or due to selection (Galama et al., 2018; Grossman, 2015; Hamad et al., 2018).

However, rigorous evidence on the relationship between education and healthcare utilization (e.g., hospitalizations) is currently limited.

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Ceteris paribus, individuals having higher educational attainment typically have lower needs for medical services, but they have more resources such as income and generous health insurance that could make them use more. Most prior studies included educational attainment as a proxy for socioeconomic control rather than examine education's independent/total effects. Results from this literature are mixed. Some showed that higher education levels were associated with lower odds of readmissions and hospitalizations (Arbaje et al., 2008; Assari & Bazargan, 2019; Maniar et al., 2014). In contrast, others found the low education was not significantly associated with readmission for elderly adults in particular geographic regions (e.g., Georgia or Indiana), and not related to preventable hospitalizations for ambulatory care sensitive conditions (Bernheim et al., 2007; Iloabuchi et al., 2014; Sattler et al., 2015). These findings are important and provocative, but we also see reasons for skepticism; the authors failed to account for common causes (e.g., early-life health and socioeconomic situation) shared by education and healthcare outcomes; these studies simultaneously adjusted for health and income, which might mediate a substantial portion of education's total effect on healthcare utilization. Our study aimed to examine the relationship between educational attainment and hospitalizations based on a pre-set conceptual framework (described in the following paragraphs), investigate the mediation effects of health and income, and disaggregate the association by gender, race, ethnicity, and age groups.

Recent studies have tried to estimate the causal effects of education on health and healthcare by leveraging school reforms or educational legislation as a natural experiment and conducting within-twin comparisons to purge out factors such as early-life environment and genetics. Results from these studies are inconclusive (Arendt, 2008; Behrman et al., 2011). In the US, compulsory schooling laws and child labor laws have been used as instrumental variables to examine the causal effect of education on health outcomes, particularly mortality (Lleras-Muney, 2005). Results from these studies are contentious, primarily due to such laws' limited impacts on years of schooling (Fletcher, 2015; Lleras-Muney, 2002; Mazumder, 2008). More importantly, these laws were only effective for a particular subpopulation (e.g., whites born in the early 1900s for the US laws), which prohibits the authors from including racial/ethnic minorities (e.g., African Americans, Hispanics) and those born in other cohorts in the analyses.

As the US healthcare system is shifting focus to addressing social factors to achieve the triple aims (improving the experience of care, improving the health of populations, and reducing per capita costs of health care) and promote health equity, there is an urgent need for rigorous evidence on the relationship between social factors and healthcare utilization (Berwick et al., 2008; National Academies of Sciences & Medicine, 2017; National Quality Forum, 2017). Our findings will contribute to the literature by providing new and solid evidence for the association between education and hospitalizations, especially for the minority groups in the US. Rigorous research to characterize such relationships accurately is critical to inform policy-making decisions about addressing social determinants of health both within the healthcare system (e.g., payment reforms accounting for social factors) and beyond (e.g., public policies).

2. A conceptual framework for the relationship between educational attainment and healthcare utilization

This section lays out a conceptual model to clarify the relationship between educational attainment and health care utilization based on prior theories and empirical evidence. It helps researchers and policy-makers to understand the education effect better. For example, studies that failed to account for early-life health and the socioeconomic situation would have omitted variable bias. Estimates from studies adjusting for health and income should be interpreted as the residual effect of education on health, excluding the indirect effects through health and income.

Conceptual models and theories explain the relationship between education and health status have been established in various disciplines, such as the Grossman model of health demand and Link and Phelan's work on social conditions as fundamental causes of disease—theory of fundamental causes (Grossman, 1972b; Hayward et al., 2015; Link & Phelan, 1995). From the Grossman model, those with more years of education would demand a larger optimal stock of health because education improves the production efficiency of health capital. The theory of fundamental causes argues that higher socioeconomic status allows access to resources (e.g., money, knowledge, power, prestige, and social network) that can be used to avoid risk factors or minimize the consequences of a disease once it occurs. More importantly, social conditions affect multiple risk factors and disease outcomes through numerous mechanisms. All of these contribute to the enduring association between SES and health outcomes.

The Grossman model also provides theoretical foundations for the demand for medical care (Grossman, 1972a). In the Grossman model, education is considered an important environmental variable that improves the efficiency of the household production function. The education effect on the demand for medical care includes both investment and consumption aspects. In the pure investment model that assumes only investment returns from health, the correlation between medical care demand and education depends on "the percentage change in gross investment in health for a one-unit change in education (γ_H)" and "the elasticity (ε) of the marginal efficiency of capital (MEC) schedule." If $\gamma_H > 0$ and $\varepsilon < 1$ (demand for health is less responsive to the cost), the more educated would demand less medical care since they would offset part of the increase in health caused by higher education (a more efficient production function or lower marginal cost in improving health) by reducing medical services use. It also stipulates that if $\varepsilon < 1$, demand for medical care and need or illness is positively correlated. The less the ε, the stronger the correlation. The demand curve for medical care is a function of four exogenous variables: the wage rate, the price of medical care, the stock of human capital, and age. In the pure consumption model that only considers the consumption effects of health, assuming education's productivity effect is the same for health and wealth, education and medical care would be negatively correlated unless the wealth elasticity of demand for health (η_H) ≥ 1.

Built upon these theories along with the Andersen Healthcare Utilization Model (Kominski, 2013) that summarizes multilevel factors influencing people's access to healthcare services, we propose a conceptual framework, depicted in Fig. 1, to illustrate the education-healthcare relationship via a life-course perspective. Starting from the left of Fig. 1, individual's education (E), as one of the individual predisposing characteristics, provides individuals with resources to cope with health risks and can influence people's adult health (AH), elderly health (EH), and subsequently elderly healthcare utilization (EHU). Educational attainment is commonly considered a form of human capital (Becker, 2009; Mirowsky & Ross, 2003). That says, as an upstream/distal factor, education shapes adult socioeconomic status, SES, in adulthood (AS) and then elderly SES (ES), improves health status, fosters the development of health literacy (L), and eventually influences the use of health services in later life (EHU).

We define SES broadly in the conceptual model to include individuals' modifiable socioeconomic status variables and socioeconomic positions that have likely been shaped by education. As education allows individuals to learn new skills and knowledge, it is one of the most influential factors. People with higher educational levels are more likely to have a high-salary job, have more occupational choices, and are less likely to suffer from health conditions or symptoms that result in hospitalization.

Associations between educational attainment and healthcare utilization could also arise if the two share common causes that induce a spurious relationship. As depicted on the top of Fig. 1, potential confounders include people's opportunities and constraints for schooling (O), individual tastes and preferences (P) such as time preference, and

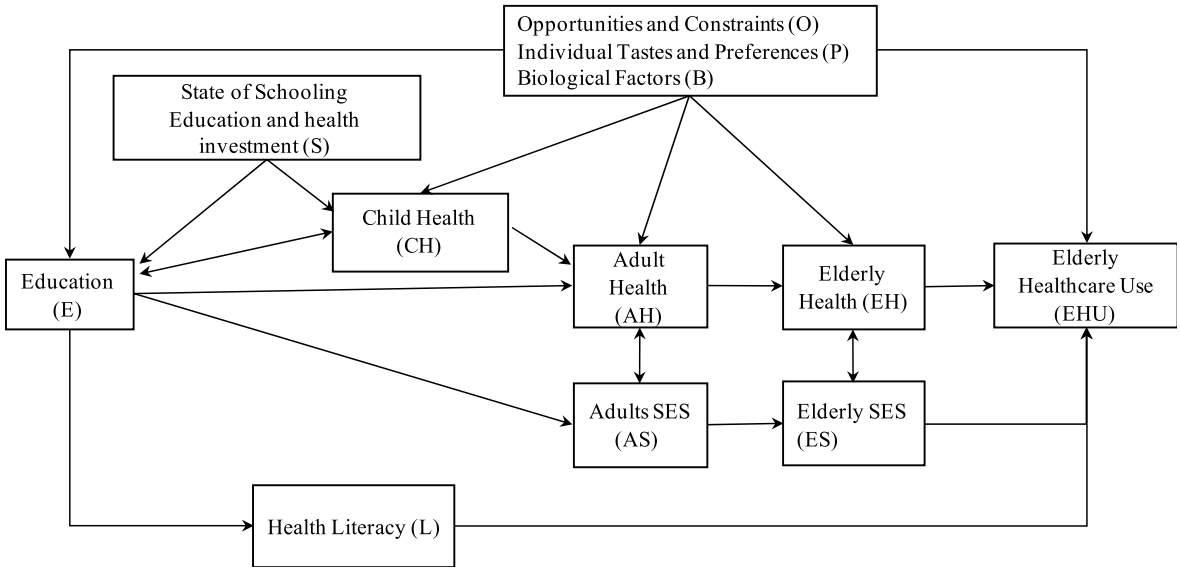


Fig. 1. A conceptual framework of the relationship between educational attainment and healthcare utilization among middle-aged and older adults.

biological factors (B) such as gender (Bailey & Dynarski, 2011; Fuchs, 1980). For instance, race/ethnicity, as a proxy for both O and P, has historically influenced individuals' education opportunities, especially for the blacks in the early 1900s due to segregation (Frisvold & Golberstein, 2011). It is also one of the individual predisposing characteristics in the Andersen healthcare utilization model that facilitate or impede access to health services (Kominski, 2013). These confounds also include education and health investment in the states where people went to school (S). Moreover, childhood health (CH) is another potential confounding factor as it predicts education and influences EHU via its enduring health effects over the life course. Yet, staying in school is also good for childhood health. The double arrow between E and CH reflects this bidirectional relationship.

The education effects on healthcare utilization are not the same for all groups. Prior theories on the educational gradients on physical health offer competing predictions. On the one hand, the biggest health returns to education could go to the most socially disadvantaged as their socioeconomic status heavily relies on educational attainment, such as the resource substitution theory (Catherine E Ross & Mirowsky, 1989). On the other hand, larger health returns to education might go to the more advantaged individuals as they could better leverage and consolidate multiple resources provided by education. It is typically referred to as the resource multiplication hypothesis (Andersson & Vaughan, 2017; C. E. ; Ross & Mirowsky, 2011). For instance, whites who usually held more advantageous structural positions may experience more health benefits from educational attainment. As health is a critical determinant of healthcare utilization, these hypotheses could be applied in the relationship between educational attainment and health services use.

Based on the conceptual framework, we hypothesized that 1) low education is associated with more hospitalizations; 2) the education-hospitalization relationship varies across racial/ethnic, and gender groups; and 3) health and income mediate a substantial portion of the relationship.

3. Methods

3.1. Data and study sample

We drew data from the RAND Health and Retirement Study (HRS) Longitudinal File 2016 (V1), a user-friendly version of a subset of the HRS constructed by the RAND Center for the Study of Aging (Health and Retirement Study, 2020). It contains cleaned and processed variables with consistent naming conventions across waves. We further linked it to the 1992–2016 HRS restricted data with state identifiers to gain information on respondents' state of birth (Health and Retirement Study, 2019). We extracted respondents' childhood health status and childhood family financial situation variables from the RAND Fat files.

The study sample was limited to those born in the US, considering the heterogeneous educational systems across countries. We excluded those who were born outside of the US or unaware of their birthplaces or missing either state-of-birth or year of birth. We further restricted to those with valid state of birth information to link early-life environment, leading to an analytic sample consisting of 35,451 respondents with 215,724 person-year observations. Our regression analyses included those complete cases (29,020 persons and 192,521 person-years) without missing values in both outcomes and independent variables (Fig. S1).

3.2. Measures

The primary outcome is hospitalization, which is used as a proxy for healthcare use. Hospitalizations have low demand elasticities (Manning et al., 1987), and as such, are more likely to reflect changes in health status and corresponding healthcare use than outpatient care. Hospitalizations also capture the demand for healthcare and access to hospitals. The wave-specific hospitalization indicator (1 = hospitalized; 0 = not hospitalized) is available for all waves and represents whether the respondent reports any overnight hospital stay since the last interview. As an example, in 2010, the question was asked as "(Since R's LAST IW MONTH, YEAR/In the last two years), have you been a patient in a hospital overnight?"

The primary independent variable is educational attainment measured in categories (less than high school, high school, and college or above). We combined "some college" and "high school" into one group since those with an educational level of some college have almost the same trend in hospitalization as those with a high school degree (Fig. S2). We included several variables as proxies for concepts that jointly affect both education and hospitalizations identified in the conceptual framework, including self-reported child health status (excellent, very good, good, fair, and poor), parents' highest years of schooling (a continuous variable ranging from 0 to 17), family financial situation in childhood (well off vs. poor), race (White/Caucasian, Black/African American, and other racial groups that include American Indian, Alaskan Native, Asian, and Pacific Islander), ethnicity (Hispanic/Latino or

not), gender (female vs. male), state-of-birth effects, and year-of-birth effects. We also included adult health and income measures available in the HRS baseline survey (respondents were about 50 years old). We included three measures for health: self-reported health status (excellent, very good, good, fair, and poor), "Ever had severe disease" that is set to 1 if a respondent was ever diagnosed with any of the following conditions: a) cancer or a malignant tumor of any kind except skin cancer; b) heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems; c) stroke or transient ischemic; and d) chronic lung disease (except asthma) such as chronic bronchitis or emphysema attack. We grouped these conditions as severe diseases because they are more likely to cause hospitalizations. "Ever had mild disease" is coded to 1 if the respondent was ever diagnosed with any of the following conditions: a) high blood pressure or hypertension; b) diabetes or high blood sugar; and c) emotional, nervous, or psychiatric problems. Regarding income, we use four quintiles of total household income that includes the sum of respondent and spouse earnings, pensions, government transfers, and other incomes.

3.3. Statistical analyses

Fig. 2 illustrates the analytical process. We first illustrated the probability of being hospitalized by educational level and age. We then used a linear probability model (pooled ordinary least square) to examine the education-hospitalization relationship. A linear probability model is better suited for analyzing short panel data with fixed effects and estimating models with interactions (Yue & Ponce, 2021). We estimate the following equation.

$$y_{it} = \alpha + \beta^{*} Edu_i + X_i\theta + c_i + s_i + \lambda_{it} + \varepsilon_{it} \cdot (\text{Base Model})$$

Where y_{it} denotes whether being hospitalized. Edu_i includes three categories: less than high school (as reference), high school graduates, and college graduates. X_i includes child health status, the family financial situation in childhood, parents' highest years of schooling, race, ethnicity, and gender. s_i represents state-of-birth, c_i denotes year-of-birth, and λ_{it} represents state-of-birth specific linear trends. Coefficients (β) on educational categories are of interest; 100* β is interpreted as the percentage point (pp) changes in the probability of being hospitalized.

Since respondents with lower educational levels were more likely to drop out of the HRS longitudinal survey due to death or non-death reasons, estimates from longitudinal analyses using HRS panel data would be biased (Cao & Hill, 2005; Kapteyn et al., 2006; Dahai Yue, 2020; Zhivan et al., 2012). We adjusted for the attrition bias using an inverse-probability-weighting (IPW) approach (Weuve et al., 2012; Wooldridge, 2010). This approach helps to obtain estimates that would have been observed had dropouts remained in the survey with healthcare utilization similar to respondents with comparable demographic, health, and socioeconomic characteristics. Briefly, we separately estimated the probabilities of being alive and uncensored in hospitalizations based on wave-specific predictors including individual demographics, health outcomes, and socioeconomic status. We multiplied the probabilities and took the inverse as weights adjusting for attrition bias (see appendix). Individual-level analyses accounted for within-person correlation with clustering at the respondent level; the fully robust standard errors are robust to arbitrary correlation and arbitrary heterogeneity without making assumptions on covariance structures (Wooldridge, 2010).

We explored the mediation effects of adult health and income in the education-hospitalization relationship by controlling for them in the statistical model. We also examined the modification effects by gender, age, and racial/ethnic groups.

Several robustness checks were performed. To extract hospitalizations from those related to terminal conditions that led to imminent death, we constructed an alternative outcome as ever being hospitalized two years before death and re-estimated our primary analyses. To capture the immediate effects of health and income, we controlled for one-wave lagged health and income variables. We also estimated a logit regression model for the binary outcome. Lastly, we conducted multiple imputations to assess potential selection bias from missing values (See Appendix Section 1 for more details.).

4. Results

4.1. Descriptive statistics

Table 1 displays descriptive statistics of respondents' baseline characteristics by educational attainment. The overall sample was predominately white (77.0%), non-Hispanic (94.7 %), and with childhood health status self-rated as good or above (93.5%). More than half of the

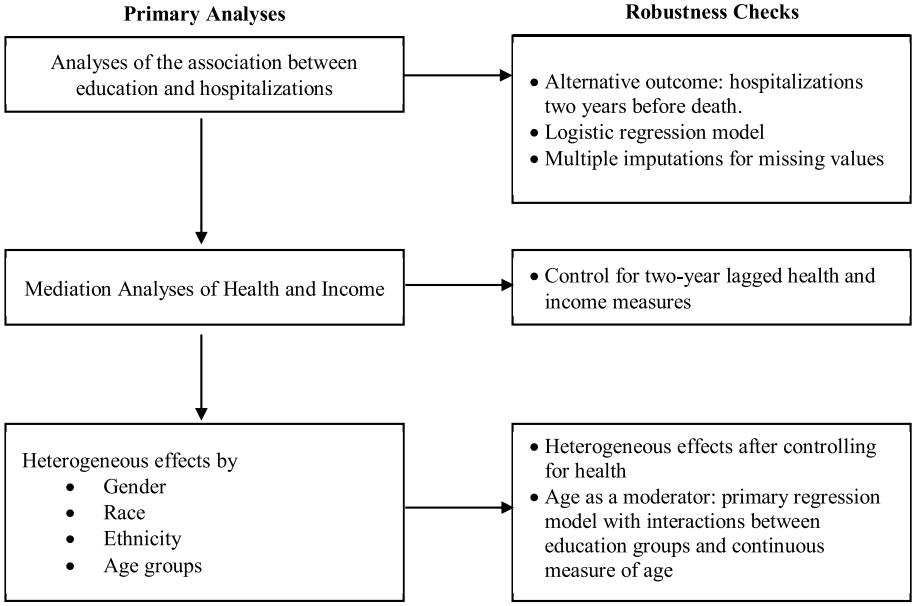


Fig. 2. Flowchart of the analyses process.

Table 1
Descriptive statistics of respondents' characteristics by educational attainment.

	Less than high school (N = 5357)	High school graduates (N = 17,339)	College graduates (N = 6324)	Total (N = 29,020)
Demographics				
Female (%)	57.0	59.1	50.7	56.9
Race (%)				
White	66.7	77.7	83.9	77.0
Black	27.6	17.8	12.7	18.5
Other	5.7	4.4	3.4	4.4
Hispanic (%)	10.0	4.8	2.8	5.3
Childhood Conditions				
Self-rated child health (%)				
Excellent	39.6	51.8	61.9	51.7
Very good	26.1	26.7	23.5	25.9
Good	24.3	15.3	10.5	15.9
Fair	7.1	4.8	3.3	4.9
Poor	2.8	1.4	0.8	1.5
Childhood family financial situation (%)				
Pretty well off financially	55.1	71	79.6	69.9
Poor	44.9	29	20.4	30.1
Parents' highest education (SD)	8.0(3.1)	10.6(3.0)	12.6(3.2)	10.6(3.4)
Adult Health				
Self-reported health in baseline (%)				
Excellent	8.7	16.3	28.1	17.5
Very good	18.3	29.7	36.8	29.2
Good	29.6	31.4	24.6	29.6
Fair	27.1	16.5	8.3	16.7
Poor	16.3	6.0	2.2	7.1
Ever had severe diseases in baseline (%)	31.8	24.0	17.8	24.1
Ever had mild diseases in baseline (%)	54.2	46.9	40.1	46.8
Adult Income				
Household total income in baseline (%)				
Quintile 1 (lowest)	46.3	17.9	5.4	20.4
Quintile 2	31.6	25.1	10.6	23.1
Quintile 3	15.6	29.3	22.7	25.3
Quintile 4 (highest)	6.5	27.7	61.4	31.1

Baseline refers to when the time when respondents first entered the Health and Retirement Study (respondents were about 50 years old).

included respondents were female (56.9%) and rated their childhood financial situation as pretty well off or above the average (69.9%) and reported adult health in the baseline survey as good or above (76.3%). The average year of schooling of the best-educated parent was 10.6 years. Respondents differ in all characteristics across educational categories. The percentage of females among those with college or above (50.7%) was lower than that among those with less than high school (57.0%) and those with high school graduates (59.1%). A total of 83.9% of college graduates were white respondents, whereas only 77.7% of high school graduates and 66.7% of those in the group of less than high school were whites. More than half (61.9%) of college graduates rated their health status in childhood as excellent, while only 39.6% of respondents among the less than high school group did so. Similar patterns were found for the childhood family financial situation, parents' years of schooling, self-reported health in the baseline, and total household income in the baseline.

Fig. 3 shows that, in general, the likelihood of being hospitalized increases as respondents age, regardless of their educational levels. Those with education less than high school had a persistently higher likelihood of being hospitalized than those with education beyond high school, whereas college graduates had the lowest likelihood. The education-hospitalization gradient is stable before age 65, then starts decreasing, and becomes indistinguishable after age 78. For instance, the difference in the probability of being hospitalized between high school graduates and college graduates is, on average, 9.5 percentage points (pp) across ages 48–64, 7.0 pp across ages 65–77, and 4.1 pp between ages 78–93. The difference between those having less than high school and high school graduates also decreases from 4.3 pp during ages 48–64 to 0.6 pp after age 78.

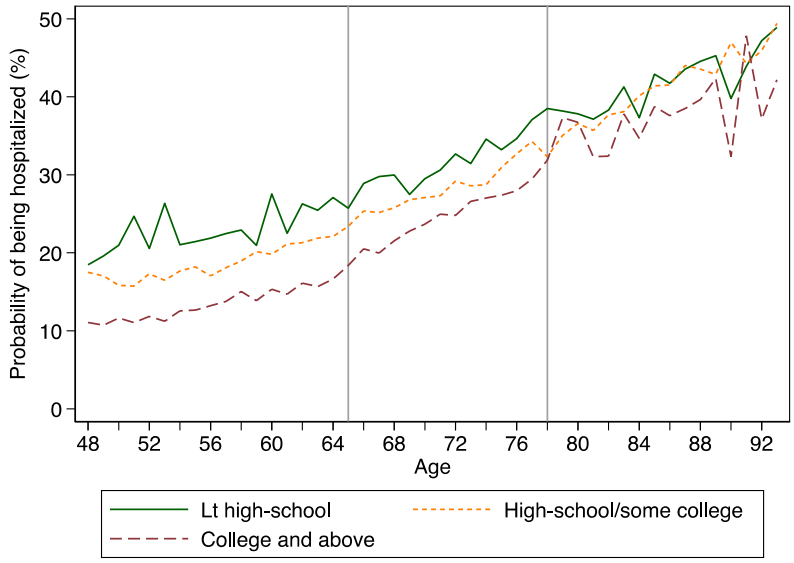
4.2. The association between educational attainment and hospitalization with and without adjusting for health and income

Results from regression models with different sets of controls are reported in Table 2. Column (1) reports the raw differences in hospitalizations by educational levels with no controls. Column (2) presents estimates from the base model before accounting for attrition bias. It shows that, on average, having a college degree or above was significantly associated with a 5.84 pp (95% CI, −6.85 pp to −4.83 pp) lower probability of being hospitalized, and having education of high school or some college was related to 2.04 pp (95% CI, −2.89 pp to −1.19 pp) lower probability, compared to having an education less than high school. Column (3) reports a larger association between education and hospitalizations after accounting for attrition bias. Column (4) added adult health measures to the controls to explore the mediation effects of adult health status. We found that the education-hospitalization gradient substantially diminished; given the same health status and childhood environment conditions, compared to those with less than a high school degree, college graduates saw a 1.79 lower chance of being hospitalized, which is statistically significant. But the gradient for high school graduates became indistinguishable from zero and insignificant. Column (5) additionally included total household income in control. The association only slightly attenuated. Lastly, Column (6) additionally adjusted for both adult health and income. The results are like those in Column (4); a degree of college or above was associated with a 1.24 pp lower probability of getting hospitalized, but it is no longer statistically significant. These results are robust to using an alternative outcome that extracts hospitalizations from terminal conditions (Table S1), alternative model specifications with a logit model (Table S2) or with one-wave lagged health and income controls (Table S3), and missing values in the analytic sample (Table S4).

4.3. Subgroup analyses by gender, race, ethnicity, and age groups

Table 3 reports the relationship between education on hospitalizations without adjusting for health and income by subgroups. We found a greater association for females than males, especially for college education. Female college graduates were 9.59 pp less likely to get hospitalized, whereas male college graduates were 6.92 pp less likely to do so; the difference (2.75 pp) is statistically significant. In terms of racial disparities in the education-hospitalization relationship, we found a smaller association for blacks. Having a high school degree was associated with a 3.94 pp ($p < 0.01$) lower probability of being hospitalized for whites, but the association becomes smaller and insignificant for blacks (−2.04 pp) and other racial groups (−1.04 pp). Particularly the association between college education and hospitalization was statistically lower for blacks (−5.11 pp, $p < 0.01$) compared to that for whites (−9.16, $p < 0.01$). We did not find significant differences in the association by Hispanic ethnicity.

In addition, we found that the education-hospitalization gradients significantly decreased after age 78, consistent with the trends shown in Fig. 3. Specifically, having a high school degree is associated with a 4.57 pp ($p < 0.01$) reduction in the probability of being hospitalized before 78, but it became close to zero after age 78. Having education beyond college is related to a significantly lower likelihood of being hospitalized



Notes: Respondents aged 48 to 93 were included to make sure at least 100 observations available in each education-age cell. The average probability of being hospitalized for those with less than high school, high school/some college, and college or above is 22.7%, 18.4%, and 13.2% over ages 48-64; is 31.2%, 28.1%, and 24.2% over ages 65-77; is 41.6%, 41.0%, and 37.5% after age 78.

Fig. 3. The Probability of Hospitalizations over Age by Educational Attainment. Notes: Respondents aged 48 to 93 were included to make sure at least 100 observations available in each education-age cell. The average probability of being hospitalized for those with less than high school, high school/some college, and college or above is 22.7%, 18.4%, and 13.2% over ages 48–64; is 31.2%, 28.1%, and 24.2% over ages 65–77; is 41.6%, 41.0%, and 37.5% after age 78.

both before (−9.77 pp, $p < 0.01$) and after (−5.67 pp, $p < 0.01$) age 78; the difference is also statistically significant. We also formally tested how the gradient evolves over age groups by estimating the base model with interactions between educational levels and age; Table S5 shows that coefficients on the interactions are positive and statistically significant, which corroborates our results.

Table S6 displays results after adjusting for respondents' baseline adulthood health status. The education-hospitalization association decreases dramatically, but the estimates for college education remain significant for females (−2.53 pp), whites (−2.54), non-Hispanics (−1.72 pp), and respondents younger than 78 (−2.79 pp). Similarly, we still found that even holding health constant, education was associated with greater reductions in the probability of hospitalizations for white college graduates than black college graduates; the difference in the association is 4.30 pp, which is statistically significant.

5. Discussion

In this paper, we found that a higher level of education is associated with a lower probability of two-year hospitalizations among middle-aged and older US adults. The association slightly attenuated after controlling for income but dramatically reduced once holding health constant. The association also varies across gender, racial/ethnic, and age groups; the association between education and hospitalizations was larger among females, whites, and those younger than 78. Our results control for a range of theoretically important confounders—childhood health and childhood socioeconomic conditions.

Our results confirm prior theories and studies that educational attainment has a protective effect on health and reduces the probability of getting hospitalizations in older ages (Arendt, 2008; Link & Phelan, 1995). Our results also indicate that a majority of the association could be explained by health status, regardless of whether health is measured at age 50 or two years prior to hospitalization. Once health was held constant, the impact of a college degree or above on hospitalization dropped by 78.6%, whereas the favorable effect of high school diminished to null. Based on our conceptual framework, it indicates that given the same health need, education has limited impacts on individual's access to hospital care ("access effect") through SES factors (e.g., higher income, more generous health insurance, and better access to healthcare) and health literacy. In addition, considerable research shows that inequalities in primary care go away after controlling for health, but inequalities remain for special care (van Doorslaer et al., 2004, 2006; Woods et al., 2005, p. 272012). Most of these studies focus on adults of all ages from Europe, making it different from our study looking at middle-aged and older Americans. In our study, the diminished education impacts after controlling for health are partly due to the universal access to Medicare after age 65 improves access to and affordability of healthcare (Jacobs, 2021).

Furthermore, based on the Grossman model, since education improves health production function, more educated people can offset part of increased health by reducing the use of medical care. However, when holding health and income constant, then for one unit increase in education, the percentage change in investment in health (γ_H) and percentage change in full wealth (γ_E) become much smaller. In other words, when individuals with different educational levels have the same health status and income, the difference in investment in health (e.g., purchase of medical care) is small. It is particularly true for Medicare beneficences facing the similar price of medical care. As such, both the pure investment model and pure consumption model predict a weak correlation between education and demand for medical care after controlling for health and income.

We found the education-hospitalization gradients substantially diminished after age 78. These results are consistent with the education-health literature and support the age-as-levelers hypothesis, which posits that health is more age-dependent at older ages than at younger ages (House et al., 1994; Lynch, 2003). Thus, education gradients in health should be larger at younger ages. For example, Elo and Preston (1996) show the largest effects of education on mortality occur among persons of working ages. Similarly, our results also show an attenuated effect of education on hospitalizations as people age, but those with a college degree or above still saw a significantly decreased probability of being hospitalized.

Table 2
Associations between educational attainment and hospitalizations.

	(1) No Control	(2) Base Model	(3) Base Model (IPW)	(4) Base Model + Adult Health (IPW)	(5) Base Model + Adult Income (IPTW)	(6) Base Model + Adult Health + Adult Income (IPTW)
Education (ref: Less than high school)						
High school graduates	−0.0592*** (-0.0673, −0.0512)	−0.0204*** (-0.0289, −0.0119)	−0.0335*** (-0.0457, −0.0214)	0.0056 (-0.0060, 0.0172)	−0.0172*** (-0.0297, −0.0047)	0.0084 (-0.0035, 0.0202)
College graduates	−0.1095*** (-0.1186, −0.1004)	−0.0584*** (-0.0685, −0.0483)	−0.0837*** (-0.0979, −0.0695)	−0.0179** (-0.0316, −0.0042)	−0.0541*** (-0.0691, −0.0392)	−0.0124* (-0.0265, 0.0018)
Female		−0.0173*** (-0.0230, −0.0117)	−0.0224*** (-0.0303, −0.0145)	−0.0141*** (-0.0214, −0.0067)	−0.0276*** (-0.0355, −0.0198)	−0.0152*** (-0.0226, −0.0079)
Race (ref: White)						
Black		0.0101** (0.008, 0.0195)	0.0170** (0.0037, 0.0303)	−0.0044 (-0.0170, 0.0082)	0.0062 (-0.0071, 0.0195)	−0.0065 (-0.0191, 0.0061)
Other		0.0303*** (0.0116, 0.0490)	0.0264** (0.0024, 0.0504)	0.0051 (-0.0171, 0.0274)	0.0214* (-0.0024, 0.0452)	0.0042 (-0.0181, 0.0264)
Hispanic		−0.0134 (-0.0298, 0.0030)	−0.0108 (-0.0337, 0.0120)	−0.0109 (-0.0317, 0.0098)	−0.0173 (-0.0403, 0.0056)	−0.0121 (-0.0329, 0.0087)
Self-rated Child Health (ref: Excellent)						
Very good		0.0086** (0.0020, 0.0153)	0.0088* (-0.0006, 0.0181)	−0.0060 (-0.0148, 0.0029)	0.0074 (-0.0020, 0.0167)	−0.0061 (-0.0150, 0.0027)
Good		0.0231*** (0.0149, 0.0313)	0.0295*** (0.0182, 0.0408)	−0.0012 (-0.0118, 0.0094)	0.0253*** (0.0140, 0.0366)	−0.0017 (-0.0123, 0.0089)
Fair		0.0623*** (0.0477, 0.0769)	0.0674*** (0.0493, 0.0855)	0.0119 (-0.0054, 0.0292)	0.0611*** (0.0434, 0.0788)	0.0113 (-0.0059, 0.0285)
Poor		0.1028*** (0.0750, 0.1306)	0.1069*** (0.0727, 0.1412)	0.0344* (-0.0023, 0.0712)	0.0998*** (0.0653, 0.1342)	0.0339* (-0.0030, 0.0708)
Childhood Family Financial Situation (Ref: Well-off)						
Poor		0.0093*** (0.0029, 0.0156)	0.0129*** (0.0041, 0.0218)	0.0052 (-0.0031, 0.0136)	0.0115** (0.0026, 0.0203)	0.0050 (-0.0033, 0.0134)
Parents' highest years of schooling		−0.0007 (-0.0018, 0.0003)	−0.0014** (-0.0028, −0.0000)	−0.0001 (-0.0014, 0.0011)	−0.0010 (-0.0024, 0.0004)	−0.0001 (-0.0013, 0.0012)
Self-report Health Status (Ref: Excellent)						
Very good				0.0249*** (0.0162, 0.0335)		0.0246*** (0.0159, 0.0333)
Good				0.0702*** (0.0604, 0.0800)		0.0692*** (0.0593, 0.0791)
Fair				0.1455*** (0.1320, 0.1589)		0.1426*** (0.1289, 0.1563)
Poor				0.2168*** (0.1972, 0.2364)		0.2126*** (0.1927, 0.2326)
Ever had severe diseases				0.0826*** (0.0727, 0.0924)		0.0826*** (0.0728, 0.0925)
Ever had mild diseases				0.0504*** (0.0426, 0.0582)		0.0501*** (0.0423, 0.0579)
Household Total Wealth (ref: lowest quintile)						
Quintile 2					−0.0413*** (-0.0538, −0.0288)	−0.0110* (-0.0228, 0.0008)
Quintile 3					−0.0575*** (-0.0699, −0.0450)	−0.0102* (-0.0219, 0.0016)
Quintile 4					−0.0793*** (-0.0919, −0.0667)	−0.0188*** (-0.0307, −0.0069)
State of Birth Effects	No	Yes	Yes	Yes	Yes	Yes
Year of Birth Effects	No	Yes	Yes	Yes	Yes	Yes
State of Birth specific linear trends	No	Yes	Yes	Yes	Yes	Yes
Constant	0.3112*** (0.3040, 0.3183)	0.0737 (-0.1034, 0.2507)	−0.1266 (-0.3591, 0.1058)	−0.2518** (-0.4666, −0.0370)	−0.1081 (-0.3419, 0.1258)	−0.2651** (-0.4830, −0.0472)
Persons	29,020	29,020	29,020	29,020	29,020	29,020
Person-years	192,521	192,521	192,521	192,521	192,521	192,521
R-squared	0.0063	0.0270	0.0424	0.0807	0.0452	0.0808
Accounting for Attrition Bias using IPW	No	No	Yes	Yes	Yes	Yes

Notes: Baseline refers to when the time when respondents first entered the Health and Retirement Study (respondents were about 50 years old). In parentheses are 95% confidence intervals. All models account for attrition bias using an inverse probability weighting approach. Standard errors were clustered at the respondent levels to accommodate for within-subject correlation over time in the survey. *p < 0.1, **p < 0.05, ***p < 0.01.

Table 3
Differential impacts of educational attainment on hospitalizations by gender, race, ethnicity, and age groups.

	High School Graduates		College Graduates	
	Estimates	Differential impacts	Estimates	Differential impacts
Gender				
Males	−0.0220** (−0.0405, −0.0035)	(reference)	−0.0692*** (−0.0897, −0.0488)	(reference)
Females	−0.0416*** (−0.0565, −0.0266)	−0.0196* (−0.0424, 0.0032)	−0.0959*** (−0.1133, −0.0784)	−0.0275** (−0.0526, −0.0024)
Race				
White	−0.0394*** (−0.0530, −0.0257)	(reference)	−0.0916*** (−0.1071, −0.0762)	(reference)
Black	−0.0204 (−0.0460, 0.0052)	0.0190 (−0.0093, 0.0473)	−0.0511*** (−0.0849, −0.0173)	0.0405** (0.0047, 0.0764)
Other	−0.0104 (−0.0656, 0.0449)	0.0290 (−0.0275, 0.0855)	−0.0619** (−0.1229, −0.0009)	0.0298 (−0.0324,0.0919)
Ethnicity				
Non-Hispanics	−0.0326*** (−0.0452, −0.0201)	(reference)	−0.0833*** (−0.0979, −0.0688)	(reference)
Hispanics	−0.0465** (−0.0853, −0.0078)	−0.0139 (−0.0539, 0.0261)	−0.0734*** (−0.1260, −0.0209)	0.0099 (−0.0436, 0.0634)
Age				
Above 78	−0.0076 (−0.0290, 0.0138)	(reference)	−0.0567*** (−0.0847, −0.0286)	(reference)
Under 78	−0.0457*** (−0.0594, −0.0321)	−0.0381*** (−0.0618, −0.0144)	−0.0977*** (−0.1133, −0.0822)	−0.0411*** (−0.0709, −0.0113)

Notes: In parentheses are 95% confidence intervals. All models account for attrition bias using an inverse probability weighting approach. All models account for attrition bias using an inverse probability weighting approach. Standard errors were clustered at the respondent levels to accommodate for within-subject correlation over time in the survey. *p < 0.1, **p < 0.05, ***p < 0.01.

Our findings on education differentials in hospitalizations across gender and racial groups have many contributions to health equity literature. We found a greater association for females than for males, which aligns with the resource substitution theory that larger health returns to education could go to the socially disadvantaged groups (Catherine E Ross & Mirowsky, 1989). It is also fairly consistent with prior empirical studies. For example, many studies have found that the impacts of education on earnings and longevity are greater for women than for men (Dougherty, 2005; Lleras-Muney et al., 2020). Possible explanations include women with higher education are more capable of resisting discrimination, more willing to seek better-paid employment that fully values their characteristics (Dougherty, 2005). Moreover, in terms of differential impacts by racial groups, we found a greater association for whites than blacks, which is in line with prior relevant studies (Assari, 2018; Assari & Bazargan, 2019). It supports the resource multiplication hypothesis that larger health returns to education might go to the more advantaged individuals as they could better leverage and consolidate multiple resources provided by education (Andersson & Vaughan, 2017; C. E. Ross & Mirowsky, 2011). Previous studies point out that structural racism and residential segregation could be parts of the difference (Assari, 2018). Moreover, some of these differences remain after holding health status constant suggests disparities in access to healthcare still exist across these subgroups. Unfortunately, our analysis cannot distinguish these two hypotheses.

5.1. Limitations

First, although we included several childhood environment variables, our study cannot control all the confounding variables such as genetics and time preference. However, prior estimates of education effects on longevity using a within-twin design were robust to the adjustment of these variables (Halpern-Manners et al., 2020; Van Der Pol, 2011). Second, similar to other studies based on self-reported survey data, our measurements might suffer from recall bias; respondents were asked to recall their childhood situations. Since it is difficult to follow individuals over the life course, these childhood variables are not even available in many other health surveys. These variables are worth collecting for future studies, however, as most health and economic outcomes have their roots in childhood health and living conditions. Third, the IPW approach used to correct attrition bias relies on the conditional ignorability assumption that attrition is not related to education and/or hospitalizations conditional on observed variables included in the model. Selection bias could still be present if there are unobservables (e.g., time preference, personality, genetics) affecting education, the risk of hospitalization, mediating pathways, and sample attrition. Moreover, there have been debates on how to handle death in longitudinal analyses of health effects. McWilliams and colleagues consider death as attrition and support the use of the IPW approach to deal with death, but Polsky and colleagues argue that we should treat death as a health state (McWilliams et al., 2010; D. , 2007; Polsky et al., 2009; Daniel Polsky et al., 2010). Nonetheless, our primary focus in this paper is healthcare utilization, not health effects, which precludes us from incorporating death into the categories of hospitalizations.

6. Conclusion

In conclusion, we found that higher education is strongly associated with a lower probability of hospitalizations. The association is largely mediated by health status, but college graduates still experienced significantly lower rates of hospitalizations given the same health status. These results should inform policymakers and suggest that greater attention should be paid to social conditions to maximize health effects and reduce expensive healthcare utilization. It also offers evidence for healthcare payment reforms that consider incorporating education into the risk-adjustment models; controlling health is insufficient to account for the education-hospitalization gradient. Lastly, our findings on differential returns to education by gender and racial groups should inform future work to explore potential reasons and craft interventions to achieve health equity.

Ethics approval

The Health and Retirement Study was approved by the University of Michigan Health Sciences Human Subjects Committee. The UCLA Institution Review Board has approved the current study.

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None.

CRediT authorship contribution statement

Dahai Yue: Conceptualization, Methodology, Software, Formal analysis, Data curation, Writing – original draft, Visualization, Writing – review & editing. **Ninez A. Ponce:** Data curation, Writing – review & editing. **Jack Needleman:** Methodology. **Susan L. Ettner:** Conceptualization, Writing – review & editing.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2021.100918.

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