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Short Report

Anomaly in the education–health gradient: Biomarker profiles among adults with subbaccalaureate attainment levels

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ABSTRACT

This Short Communication builds on recent findings that documented an anomaly in the education–health gradient: adults who attended college but did not earn a BA (the subbaccalaureate group) reported an equal or higher level of health problems than adults with high school (HS) diploma. Our aim is to test whether this anomaly holds when we eliminate potential reporting differences, by examining biomarker levels in the subbaccalaureate vs HS groups.

Using the restricted 1999–2012 NHANES, we estimate models of biomarkers for cardiovascular and metabolic diseases as a function of educational attainment, including three subbaccalaureate levels: "some college", vocational associate degree (AA), and academic AA.

The data show that adults with "some college" or vocational AA have no systematic advantage over HS graduates in most biomarker indices while academic AA is associated with a significantly better risk profile compared to HS. The findings indicate that the adults with some college and vocational AA degrees do not benefit from their college experience in terms of improved physiological risk profile.

This pattern underscores the need to understand and explain the anomalous health pattern that concerns 28% of American adults in the subbaccalaureate group among whom many reap little health payoffs to postsecondary schooling.

Introduction

Questions about the nature of the education–health gradient are central to social epidemiology and population health. The gradient refers to the positive relationship between educational attainment and health (Conti, Heckman & Urzua, 2010) and is thought to be universal across populations, health outcomes, and across the entire range of attainment (Mirowsky & Ross, 2003). A recent study, however, found an intriguing anomaly: subbaccalaureate adults – who attended college but did not earn a bachelor's degree – reported *more* physical health problems and diagnoses than high school (HS) graduates who never attended college (Zajacova, Rogers, & Johnson-Lawrence, 2012). Several other studies also suggested that adults with "some college" did not always compare positively to HS graduates, for instance with respect to health behaviors (Rosenbaum, 2012; Skalamera & Hummer, 2016). This pattern is important because it contradicts the expectation that the college education beyond HS would yield health payoffs. If corroborated, the anomaly may provide valuable clues about the mechanisms of the relationship between educational attainment and adult health. It is also important because the "some college" category is now the modal educational-attainment level for working-age Americans: 28% are college dropouts or have earned associate (AA) degrees (U.S. Census Bureau, 2012).

The studies above that detected the subbaccalaureate anomaly used self-reported health measures, however. This is a potential problem because respondents with different levels of education may also differ in how they report health (Bago d'Uva, O'Donnell & van Doorslaer, 2008). Adults with more education are more likely to have adequate health insurance (NCHS, 2012), receive preventive care (Bennett, Jing, Soroui & White, 2009) and have more health care interactions (Blackwell, Martinez, Gentleman, Sanmartin & Berthelot, 2009), and may thus have a better understanding of their health problems (Kawachi, Adler & Dow, 2010). Previous studies have shown that adults with more education report general health with higher reliability (Zajacova & Dowd, 2011) and higher predictive validity (Zajacova & Woo, In press). If adults at the subbaccalaureate level report their health differently, in particular if they overreport health problems relative to HS graduates, then the findings from self-reports could be biased.

On the other hand, adults who do not complete college may be unable to convert their additional schooling into a significant

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health return. The economic returns to subbaccalaureate schooling are significant for AA degrees but not for "some college" (Belfield & Bailey, 2011). Psychologically, the "college dropout" status may be stigmatizing (Dorn, 1993) and its ongoing psychological burden may gradually damage health (Link & Phelan, 2006). Selection factors into the subbaccalaureate level, such as own cognitive and noncognitive skills or family background, may also play a role: adults who attend college but do not complete a college degree may differ from those who completed college (Hoachlander, Sikora, Horn & Carroll, 2003), but also from those who just completed high school (Rosenbaum, 2012). Such selection factors may also influence health and thus drive the health anomaly among subbaccalaureate adults.

Two competing theories can be used to form hypotheses about the subbaccalaureate patterns. According to the human capital theory (Becker, 1964), any college education should translate to better health compared to just a HS diploma because the additional schooling increase skills and resources. Under the credential model (Collins, 1979), only the attainment of an AA degree should be associated with better health than a HS diploma. An important further nuance exists at the AA level. There are two types of AA degrees, both requiring about 60 credit-hours of study. The technical/vocational AA is a terminal degree that prepares students for specific occupations, such as paralegal, computer technician, or nursing. The academic AA is a stepping stone; it provides a general education applicable toward a BA and thus those who do not complete the additional 2 years toward a BA could be conceptualized as "dropouts". There may be important selection factors into the two AA degrees: those who earn the academic AA may be more similar to those enrolled in 4-year colleges in their intention to eventually earn a BA, compared to the vocational AA students who may be more like HS students in their intention to work in blue-collar or lower-prestige white-collar occupations.

The present study analyzes biological risk marker indices across detailed educational attainment in the working-age U.S. population, using the only nationally-representative data source available to disaggregate the large subbaccalaureate group some college and those with academic and vocational AA degrees. Our aim in this Short Communication is not to explain the patterns but to describe them in detail at the postsecondary level for health measures not affected by reporting tendencies.

Data and methods

Data

The analyses are based on restricted data from the National Health and Nutrition Examination Surveys (NHANES) 1999–2012 (CDC, 2010). These ongoing cross-sectional surveys collect extensive sociodemographic, lifestyle, and health information including biomarkers from a nationally representative sample of the noninstitutionalized civilian US population. Respondents complete a household survey and undergo a 4-hour-long physical examination at a mobile examination center (CDC, 2013).

Sample

The analytic sample is defined as adults age 30–64 whose highest educational attainment is at least 9 years of schooling and no more than bachelor's degree (BA). The age boundaries were selected to capture working-age individuals, excluding younger adults who may not have completed their schooling and older adults from earlier birth cohorts when the average attainment was considerably lower than in the early 21st century and the meaning of college education was correspondingly different.

Variables

Educational attainment

Information about schooling was collected as the highest year of schooling up to 12 years and as the highest earned educational credential for those with more schooling. We retained the detailed educational categories as collected by NHANES at the post-secondary level and only grouped those with less than a high school (HS) diploma into a single category of 9–12 or GED. The General Educational Development diploma (GED) is included in this lowest category because previous studies indicated that GED recipients are comparable to HS dropouts and not HS graduates with respect to health (Zajacova, 2012). The attainment categories are: 9–12 or GED, HS diploma (reference), some college but no degree, technical/vocational associate degree (AA), academic AA, and bachelor's degree (BA).

Health measures

Three clinically defined biomarker-based measures were used to measure biological risk profile: (1) cardiovascular risk (CVD) index; (2) metabolic syndrome; and (3) a cumulative biologic risk measure. The CVD index was calculated based on the Framingham Risk Score (Wilson et al., 1998) using a weighted formula that includes age (weight range of 2–12 units), high density lipoprotein (HDL) cholesterol levels (weight range of −2 to 2 units), total cholesterol (weight range of 0–5 units), high blood pressure (weight range of −3 to 5 units), smoking status (weight range of 0–3 units), and blood glucose levels (weight range of 0–4 units). Higher scores indicate greater CVD risk.

The metabolic syndrome measure was based on the National Cholesterol Education Program's Adult Treatment Panel III report (NCEP-ATP III) criterion (Grundy et al., 2004). It is a count of the presence of five metabolic risk factors: high waist circumference (88 cm (cm) or greater for women or 102 cm or greater for men), low HDL cholesterol (1.04 millimoles per liter (mmol/L) or lower), high triglyceride levels (1.7 mmol/L or greater), high blood

Table 1
Characteristics of the analysis sample, ages 30–64 (N=12,889).

	Men	Women	Total
N	6157	6732	12,889
Age (mean, s.e.)	46.09 (0.16)	46.59 (0.18)	46.34 (0.15)
Female			0.51
Race			
Non-Hispanic White	0.73	0.69	0.71
Non-Hispanic Black	0.11	0.15	0.13
Hispanic	0.11	0.11	0.11
Other or missing	0.05	0.05	0.05
Education			
9–12 or GED	0.20	0.19	0.19
HS Completion	0.27	0.25	0.26
Some College	0.20	0.22	0.21
Vocational AA	0.10	0.11	0.11
Academic AA	0.03	0.05	0.04
BA Degree	0.20	0.18	0.19
Health indices (mean, s.e.)			
Metabolic risk index (n=10,469)	1.85 (0.15)	1.60 (0.02)	1.72 (0.016)
CVD risk index (n=12,310)	8.48 (0.09)	7.04 (0.10)	7.75 (0.079)
Total biological risk index (N=8653)	2.43 (0.03)	2.42 (0.03)	2.43 (0.023)

Adjusted for NHANES 1999–2012 complex sampling design.
s.e.=standard error
Range for the health indices are 0-1 for metabolic risk index, -5 to 26 for cardiovascular risk index, and 0-8 for total biological risk index.

Table 2
Linear regression model results: associations between educational-attainment levels relative to a HS diploma, for CVD, metabolic, and cumulative biological risk indices.

	Metabolic Syndrome B (SE)	CVD B(SE)	Cumulative Biological Risk B(SE)
All sample			
High school diploma (reference)			
9–12 years or GED	0.07 (0.03)*	0.85 (0.11)***	0.24 (0.05)***
Some college, no degree	−0.04 (0.05)	−0.27 (0.11)*	−0.02 (0.07)
Vocational AA	−0.03 (0.04)	−0.32 (0.12)**	−0.01 (0.06)
Academic AA	−0.16 (0.08)*	−0.79 (0.18)***	−0.22 (0.11)†
Bachelor's degree	−0.36 (0.04)***	−1.71 (0.11)***	−0.48 (0.06)***
N	12,484	14,727	10,281
Men			
High school diploma (reference)			
9–12 years or GED	−0.09 (0.06)	0.64 (0.16)***	−0.00 (0.08)
Some college, no degree	−0.08 (0.07)	−0.18 (0.17)	−0.08 (0.09)
Vocational AA	−0.02 (0.07)	−0.19 (0.19)	0.01 (0.11)
Academic AA	−0.30 (0.14)*	−0.62 (0.27)*	−0.38 (0.19)*
Bachelor's degree	−0.31 (0.07)***	−1.51 (0.18)***	−0.39 (0.09)***
N	5993	7057	4903
Women			
High school diploma (reference)			
9–12 years or GED	0.26 (0.05)***	1.09 (0.18)***	0.49 (0.07)***
Some college, no degree	−0.01 (0.05)	−0.32 (0.13)*	0.03 (0.09)
Vocational AA	−0.03 (0.05)	−0.39 (0.18)*	−0.02 (0.09)
Academic AA	−0.05 (0.08)	−0.83 (0.25)**	−0.08 (0.15)
Bachelor's degree	−0.39 (0.04)***	−1.82 (0.13)***	−0.54 (0.07)***
N	6491	7670	5378

Results from OLS models of each index of biological risk. All models control for age, race/ethnicity, NHANES wave, and sex in all-sample models.
The estimation adjusts for the complex sampling design of the NHANES 1999–2012.

† $p<.1$.
* $p<.05$.
** $p<.01$.
*** $p<.001$.

pressure (defined as systolic BP of 140 mmHg or greater or diastolic BP of 90 mmHg or greater), and high blood glucose levels (6.1 mmol/L or greater).

The cumulative biological risk index was based on the count of the presence of eight measures used in previous research on allostatic load and cumulative biological risk (Seeman et al., 2008). The measures included high systolic BP, high diastolic BP, high waist circumference, high blood glucose levels, high triglyceride levels, high cholesterol, low HDL, and high levels of C-reactive protein. The thresholds for elevated levels are the same as used for the metabolic syndrome and CVD risk indices.

Covariates

All models controlled for age (continuous), sex (male is reference), race (non-Hispanic white=reference, non-Hispanic black, and other), and NHANES data collection wave (continuous), ranging from 1 in 1999–2000 to 7 in 2011–2014, to absorb any monotonic temporal changes in the variables in the US population over time.

Analysis

We estimated a series of linear regression models of each biological risk index. Sensitivity analyses used alternative specifications of the indices (dichotomous, ordinal) and appropriate GLM estimations; results yielded comparable substantive findings and are available on request. All models were estimated for the total sample and by gender because men and women differ in biological risk profiles and possibly also in the relationship between educational attainment and health. The estimation adjusted for the complex sampling design of NHANES.

Results

Table 1 summarizes the characteristics of the full sample and by gender.

Table 2 shows results from 9 linear regression models of the three biomarker indices for the full sample and by gender. The coefficients associated with covariates (age, gender, race/ethnicity, and NHANES wave) are omitted for parsimony and are available on request. HS diploma is the reference level of education. In all nine models, BA is associated with a significantly ($p<.001$) and substantially – in terms of absolute size of the coefficients – lower biological risk than HS. At the other end of the education spectrum, the completion of less than HS is associated with significantly higher biological risk in 7 of 9 models. The effects are all significant at $p<.001$ for women; among men, the difference is not significant for metabolic syndrome and cumulative risk indices.

At the subbaccalaureate level, the findings for "some college" and vocational AA groups were rather similar to one another: both groups were statistically indistinguishable from HS in 7 of 9 models (the exception was CVD results for women and the full sample). In contrast, the academic AA was associated with lower biological risk than HS in 7 of 9 models (the exceptions here were results for women with respect to metabolic syndrome and cumulative biological risk). A gender difference emerged in academic AA: this credential was associated with significantly better biomarker profile for men for all three indices while women with an academic AA had only better CVD index, compared to HS graduate women.

Fig. 1 visually summarizes the education-biomarker patterns for the full sample. The plots display the BA biological risk "premium" in terms of significantly lower risk levels for BA relative to HS. The academic AA levels are also significantly lower than HS and the risk is roughly half way between a HS and a BA. Finally, the

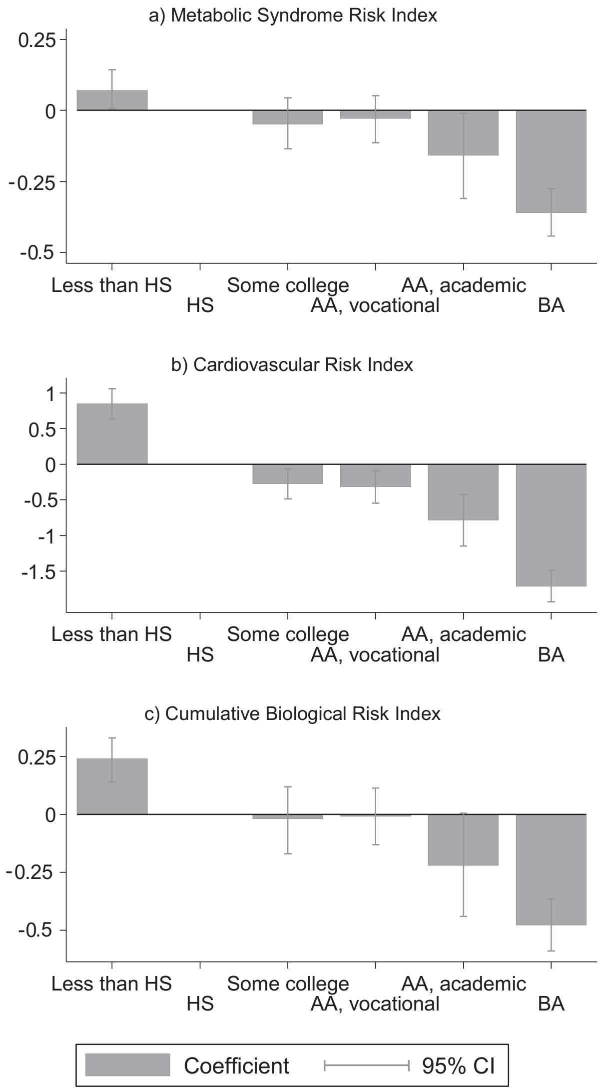

Fig. 1. Biological Risk Levels by Education. Results from regression models of each outcome on educational attainment levels, relative to HS. Y-axis shows adjusted risk difference in each risk index relative to HS graduates.

plots show the largely negligible returns to schooling for those with "some college" and vocational AA.

Discussion

This Short Communication study builds on recent findings that adults with college education but without a BA – the subbaccalaureate group – report *more* health problems than HS graduates, their peers with *less* schooling. To test whether this pattern could be due to reporting differences, we examined biological risk levels at the subbaccaluareate level compared to the HS diploma level, with added "bookends" of less-than-HS and BA levels to frame the sub-BA pattern in a wider set of educational attainment levels.

The data show a large and statistically significant difference between HS and BA in the expected direction for all outcomes and all groups. In most models, there is also the expected difference between HS and less than HS. At the subbaccalaureate level, the academic AA degree is largely associated with a better biological risk profile than HS, in accordance with predictions from the human capital and credential theories. In contrast, the "some college" and vocational AA degrees are rather similar to the HS credential; in most models these two subbaccalaureate groups have statistically equivalent biomarker profiles as HS graduates. This is an important finding because it indicates that these two groups of college-goers do not have better health despite their additional schooling and, for the vocational AA group, a postsecondary credential.

We found no instances where the subbaccalaureate group had significantly worse biological risk profile than the HS group. This is in contrast to the self-reports (Zajacova, Rogers & Johnson-Lawrence, 2012) and suggests that some of the sub-BA health penalty stemmed from differential reporting of health conditions by HS graduates versus those who attended college. However, our findings corroborate other studies where health returns to subbaccalaureate education were modest or not significant (Skalamera & Hummer, 2016).

The basic findings of this Short Communication suggest several promising directions to explore in future studies. First, the key strength of the biomarker indices in this project was eliminating potential reporting bias. However, we did not disaggregate the indices into their individual components because of some instabilities in estimates given the relatively modest sample sizes of the subbaccalaureate groups and the dichotomous nature of the individual biomarkers. While the biomarkers and their indices tend to be moderately positively related (correlations available on request), they are not fungible and they tap into different biological mechanisms. Future studies may find it useful to hypothesize specific biological mechanisms and focus on individual relevant markers of the underlying physiology. Moreover, health is a complex and multidimensional process. The physiological risk indices are related to, but not perfectly correlated with, levels of other health dimensions, such as mental health, functional limitations and disability, and mortality. These additional dimensions need to be explored as well, in order to obtain a complete picture of the health profile of adults in the subbaccalaureate group.

Another important open question pertains to population heterogeneity in the health of the subbaccalaureate groups. In our Short Communication, we analyzed men and women separately and found some differences; in particular, men appeared to benefit more from academic AA than women relative to their HS graduate peers. This pattern could be due to gender differences in the health returns to education (Ross, Masters & Hummer, 2012) or due to general gender differences in physiological dysregulation (Yang & Kozloski, 2011). To understand the subbaccalaureate patterns well, it will be necessary to further explore potential gender, as well as race/ethnic, heterogeneity.

Finally, the nature of postsecondary education, especially at the subbaccalaureate level, has changed considerably in recent decades (Schofer & Meyer, 2005). In our study, we did not take into account the respondents' birth cohort directly (beyond the joint effects of age and NHANES wave) – however, it is possible that the subbaccalaureate education may have smaller returns to health in more recent cohorts when the expectation of a BA has become rather normative and consequently the some-college experience may be less beneficial. This question is critical in order to predict the payoffs to subbaccalaureate education in the future. After establishing the observational associations for the different dimensions of health in the total population, across major population groups, and by cohorts, it will be crucial to examine the causes of the patterns in order to understand why subbaccalaureate education offers little health payoffs from their additional schooling, and why there is such a pronounced difference between the two types of AA degrees.

The findings suggest that people who attend college but drop out or earn a vocational AA benefit little with respect to their biological risk profile from their postsecondary schooling. These findings have implications for population health research and also for health policy. About 28% of American adults age 25 and older, or about 54 million people, fall into the subbaccalaureate category (U.S. Census Bureau, 2012). Poorer health than expected among this group must be addressed in health care and educational policy and planning. For population health research, understanding *why* a large proportion of the adult US population fails to follow the health gradient can provide critical new knowledge toward understanding the relationship between education and health in general.

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