Published in final edited form as:

Soc Sci Med. 2015 December ; 146: 75–84. doi:10.1016/j.socscimed.2015.09.029.

Does a College Education Reduce Depressive Symptoms in American Young Adults?

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Abstract

Higher levels of educational attainment are consistently associated with better mental health. Whether this association represents an effect of education on mental health, however, is less clear as omitted variable bias remains a pressing concern with education potentially serving as a proxy for unobserved factors including family background and genetics. To combat this threat and come closer to a causal estimate of the effect of education on depressive symptoms, this study uses data on 231 monozygotic twin pairs from The National Longitudinal Study of Adolescent to Adult Health and employs a twin-pair difference-in-difference design to account for both unobserved shared factors between twin pairs (e.g. home, school, and neighborhood environment throughout childhood) and a number of observed non-shared but theoretically relevant factors (e.g. cognitive ability, personality characteristics, adolescent health). We find an inverse association between possessing a college degree and depressive symptoms in both conventional and difference-in-difference models. Results of this study also highlight the potentially overlooked role of personality characteristics in the education and mental health literature.

Keywords

Depressive symptoms; Education; Causal Inference; Twins

Introduction

Recent estimates suggest depression constitutes a larger disease burden than any other condition in high-income countries (Mathers, Fat, Boerma, 2008). In the United States alone, depression leads to 1,445 fewer healthy years of life per 100,000 people (World Health Organization 2009), as over 25% of U.S. adults experienced symptoms of depression in the last two weeks and nearly 30% will experience depression in their lifetime (Wittayanukorn, Qian, and Hansen, 2014; Kessler et al. 2012). This problem shows few

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signs of abating as levels of self-reported depressive symptomology are increasing over time (Twenge, 2015).

Higher education may be one way to protect against symptoms of depression as a wide body of research finds an inverse association between education and depressive symptoms (e.g. Lorant et al., 2003; Miech, Eaton, Brennan, 2005; Mirowsky and Ross, 2003; Quesnel-Vallee and Taylor, 2012; Ross and Wiligen, 1997). However, despite the noted association between educational attainment and depressive symptoms, it is unclear as to whether and to what extent higher education produces better mental health.

The goal of this study is to assess the relationship between educational attainment and depressive symptoms. The occurrence of identical twins in society represents a natural occurring phenomenon that can be exploited for causal inference, particularly in addressing spuriousness due to social and genetic endowments (Kohler, Behrman, Schnittker, 2011). Analyzing a sample of identical twins from The National Longitudinal Study of Adolescent to Adult Health (Add Health), a U.S. study that followed middle and high school students from 1994-2009, we are able to account for a wider array of potential confounding factors than any work on this topic to date.

This study is of particular importance for at least four reasons. First, prominent conceptual models (Mirowsky and Ross, 2003; Pearlin et al., 2005) assume that education has a causal influence on mental health and our study therefore provides a rigorous test of this assumption. Second, in light of the growing enthusiasm for education as a policy lever to improve population health (House et al., 2009; Montez 2015), our study will inform discussions on whether college enrollment promotion policies are plausible mechanisms for improving population mental health.

Third, we directly account for the “big-five” personality characteristics, a neglected topic in the research on educational attainment and mental health. Personality characteristics, or dispositional patterns of thoughts, feelings, and behaviors, are strongly linked with both educational attainment (e.g., Shanahan et al., 2014) and mental health (e.g., Kendler and Myers, 2010). Given such strong associations, it is surprising that, to our knowledge, no work on education and mental health has directly accounted for personality as a potential form of spuriousness.

Finally, we extend the study of educational effects beyond high school to college. Past research has investigated the mental health benefits to education by exploiting exogenous variation in the mandatory years of education (Sironi, 2012; Crespo, López-Noval, and Mira, 2014), however, as no state mandates post-secondary education, such designs are unable to assess the effect of college education. This limitation is noteworthy as 31% and 87% of young adults now obtain a bachelor's degree or at attend some college classes, respectively (Ryan and Siebens, 2012).

Background

A full body of research has documented that those with higher levels of education tend to have fewer depressive symptoms (e.g. Mirowsky and Ross, 2003; Miech et al., 2005;

Quesnel-Vallee and Taylor, 2012). Education is believed to benefit mental health because it decreases the number and severity of stressors individuals experience and equips the possessor with the resources needed to successfully deal with stressors when they do arise. For instance, education is thought to confer economic, occupational, and status rewards. These types of rewards may reduce financial strain and improve work conditions, including increased autonomy and decreased routinization (Mirowsy and Ross, 2003). Education is also thought to confer psychosocial and cognitive resources, such as learned effectiveness and sense of control, which aid in active and preemptive problem solving and protect against psychological stressors (Mirowsky and Ross, 2003).

Despite the consistency of this association, researchers do not know to what extent the association between education and depressive symptomology represents a causal connection (Kawachi, Adler, and Dow, 2010; Fujiwara and Kawachi, 2008; Boardman, Domingue, and Daw, 2015). Having established an association between education and depressive symptoms, two additional threats to causal association remain (Gangl, 2010): temporal ordering and spuriousness. Past research has shown that only a relatively small proportion of the education and depressive symptom association can be attributed to reverse temporal ordering (i.e., that elevated depressive symptoms precede and influence the attainment of education) (e.g. Quesnel-Vallee and Taylor, 2012; Mezuk, Myers, and Kendler, 2013). Spuriousness, however, represents the central threat to causality as a wide variety of social, genetic, and psychological endowments have been difficult to address in past research.

Figure 1 displays two competing models where (a) presents a spurious relationship between education and depressive symptoms and (b) a causal relationship between education and depressive symptoms. These two models are not mutually exclusive. It is possible, and perhaps likely, that the association between education and depressive symptoms combines both causal and non-causal pathways. We represent this possible uncertainty in magnitude of causation using the differently sized overlapping arrows seen in the causal model. As these models highlight, two uncertainties exist in the current research; whether there is any effect of education on depressive symptoms and, if so, how large it is.

Model (a) suggests that education and depressive symptoms are correlated because of the presence of endowments, as denoted by the dotted line. There are a myriad of early-life endowments (i.e. social, psychological) which may be underlying the association between educational attainment and depressive symptoms (e.g. Conti, Heckman, Urzua, 2010). While past work frequently accounts for relatively easy-to-measure factors (e.g. socioeconomic origins, race, age, and gender), other, more difficult to measure factors that may account for the education and depressive symptoms association are frequently excluded. Three infrequently measured potentially spurious factors include personality characteristics, cognitive ability, and adolescent health. Personality characteristics, such as one's level of conscientiousness, develop in early childhood, are relatively constant over time, and are strongly associated with both educational attainment and depressive symptomology (Shanahan et al., 2012; Caspi and Roberts, 2001; Lleras, 2008). One's cognitive ability may help individuals acquire higher levels of educational attainment as well as preemptively avoid situations and environments that take a toll on their mental health (Link et al., 2008). Compared to their healthier counterparts, adolescents with poor health experience

diminished educational attainment (Jackson, 2009), are more likely to experience poor health as adults (Haas and Fosse, 2008), and are more likely to experience symptoms of depression in adulthood (Katon, 2003).

But while these factors are rarely included in investigations of educational effects, many more potentially spurious factors are difficult to include in most study designs and often go unmeasured. Early life experiences, though difficult to measure, may be important for both educational attainment and later symptoms of depression. For instance, the timing and duration of social exposures across the early life course such as one's family structure, socioeconomic status, school, and neighborhood, can influence both educational achievement and depressive symptoms (Wagmiller et al., 2006; McLeod and Kaiser, 2004; McLeod and Nonnemaker, 2000). Genetic predispositions are also known to influence educational attainment and depressive symptoms but are particularly difficult to measure and model (Boardman et al., 2015). For instance, both educational attainment and depressive symptoms have a meaningful heritable component (e.g., Nielsen, 2006; Kendler et al., 1994) and the specific genes responsible for the heritability of both educational attainment and depressive symptoms overlap (Boardman et al., 2015). These phenomena suggest that genetic endowments may lead to a spurious association between education and depressive symptomology.

In contrast to these omitted variable threats, Model (b) suggests that higher levels of educational attainment protect against depressive symptoms. Education is positively associated with factors thought to protect against symptoms of depression, such as income, occupational prestige, learned effectiveness, sense of control, and family stability (Mirowsky and Ross, 2003). While the links between these factors and depressive symptoms may be indicative of a causal relationship, only three studies examine the effect of college education on depressive symptoms and address most potentially spurious pathways.

Bauldry (2015) used longitudinal data from a sample of young adults born circa 1980 with propensity score matching and provided evidence that higher education was protective over depressive symptoms. While informative, propensity score matching models can only be taken to imply a causal relationship to the extent to which all potential factors that may lead to a spurious association between education and depressive symptoms were measured and included in the construction of a propensity score (Xie, Brand, and Jann, 2012). However, this study did not account for the known predictors of depressive symptoms, such as home environment in early childhood which can influence both educational attainment and mental health in adulthood (Conti et al., 2010). Using a sample of female twins from Virginia in the late eighties, Mezuk, Myers, and Kendler (2012) employed a decomposition of variance approach and showed that individuals with higher levels of education were less likely to suffer from depression than their less educated counterparts. They also, however, found a non-causal negative correlation between the genetic components of major depression and education attainment which suggests educational attainment and depression share a common genetic cause.

Finally, Fujiwara and Kawachi (2008) utilized a discordant twin study design of middle aged Americans to test the relationship between education and various health outcomes,

including depressive symptoms, and showed that education was not associated with depressive symptoms. There were two central limitations to their study pertinent here. First, they measured education in number of years rather than a categorical approach. This is important because the relationship between education and mental health may be sensitive to discrete education categories. While using a continuous variable in regression analysis is typically more appropriate than dichotomizing it (Royston, Altman, Saverbreri, 2006), educational attainment suggest nonlinearities in its returns and influence. Using the same data and methodology, Lundborg (2013) replicated Fujiwara and Kawachi's study using educational categories to test the association between education and physical health (they did not analyze depressive symptoms) and found associations where Fujiwara and Kawachi did not. Second, Fujiwara and Kawachi (2008) did not account for key non-shared characteristics between twin pairs, such as personality characteristics, cognitive ability, and adolescent health, which may have biased the relationship between education and depressive symptoms. Despite these limitations, their approach did account for shared characteristics, like genetic endowment and early life home environment. Because of the strengths of this approach, we will employ a similar twin discordant approach in our current study, while at the same time, addressing the design's weaknesses by including relevant non-shared factors that Fujiwara and others did not.

The Twin Discordant Approach

The discordant twin-pair difference-in-difference research design is better suited to account for potential sources of spuriousness than conventional models (McGue, Osler, and Christensen, 2010). This design leverages the facts that monozygotic (MZ) twins are both genetically identical at conception and typically share a rearing environment to evaluate whether some discordant factors are related to an outcome. Focusing on MZ twins raised in the same household accounts for unobservable common potential causes of the outcome of interest, such as home environment and neighborhood characteristics over the early life course. The ability to account for all shared factors is particularly important because knowledge of factors that can potentially influence both educational attainment and outcomes of interest is developing at a pace that may surpass the measurement capacity of survey-based research (Schnittker and Behrman, 2012).

This method can also account for any non-shared observed factors such as cognitive ability or personality characteristics. Identical twins, while sharing large components of their environment growing up, do experience non-shared environments as well (McGue et al., 2010) and these non-shared environments could influence social and psychological development for one twin but not the other. For example, one twin could invest more heavily in school because he or she had a particularly inspiring teacher. Similarly, non-shared environments could potentially produce dispositions that influence both educational attainment and depressive symptomology in adulthood. For instance, MZ twins often report different levels of personality traits, such as conscientiousness. Those with higher levels of conscientiousness do better in school and have better mental health than their less conscientious counterparts (Stanek, Iacona, and McGue, 2011; Shanahan et al., 2012). For this reason, twin discordant studies that account for relevant non-shared factors are especially suited to address potential spuriousness (Stanek et al., 2011).

Using this method allows us to take into account all shared factors in conjunction with the Add Health twin sample which is rich in measures of potentially non-shared factors, we move closer to an answer to whether the attainment of higher education reduces depressive symptomology.

Data

We use data from Add Health which used a school-based stratified cluster design to construct a nationally representative sample of adolescents in grades 7-12 in the 1994-95 school year and interviewed the adolescents and a parent in an in-home Wave I interview (N=20,745). Original respondents have been followed over time with three follow-up in-home interviews: 1996 (Wave II), 2001-02 (Wave III), and most recently in 2008-09 (Wave IV). For more information on the study design and implementation see Harris et al. (2009).

Our analytic sample is drawn from Add Health's embedded genetic subsample, a supplemental sample based on the genetic relatedness of pairs (see Harris et al., 2006 for details on this sample). The embedded genetic subsample includes individuals in the same household but with varying levels of genetic similarity, ranging from theoretically identical to completely unrelated. Paired respondents share a home, neighborhood, and, in most cases, school environment. In subsequent waves of in-home data collection, high priority was placed on locating and interviewing respondents from the genetic subsample, reducing attrition within this subsample.

In the current paper, we focus exclusively on monozygotic twins. Zygosity status was assessed using a panel of 11 polymorphisms. The criterion used to assign monozygosity to a twin pair was 100% concordance of all genotypes (Harris et al., 2006). Originally, 307 twin pairs were enrolled in the study at Wave I. In 75 of the original pairs, at least one twin was lost to attrition between Waves I and IV. We also removed from the sample a pair in which one twin was an extreme outlier and an overly influential case. All analyses shown in this paper were replicated without dropping this outlier. While, this case is overly influential, its inclusion does not change the results of the difference-in-difference model shown below. Due to the small sample size, we used a regression-based imputation procedure that substituted predicted values from linear regression equations for missing values on control variables (Landerman, Land, and Pieper, 1997). The highest imputation rate was for cognitive ability (12%). Rates of missingness did not exceed 10% on any other measure. The final sample consisted of 462 twins from 231 complete twin pairs. Our final sample was relatively diverse as 61% were white, 17% black, and 22% other race/ethnicity. Age ranged from 24.6 to 32.8 with a mean and standard deviation of 29.1 and 1.6, respectively.

Measures

Depressive Symptoms

Depressive symptomology was measured by a 10 question subset of the Center for Epidemiologic Studies Depression Scale (CES-D) at Wave IV (Radloff, 1977). Consistent with past research (Bauldry 2015), a psychometric confirmatory factor analysis of the 10 CES-D items available at Wave IV for our sample indicated that a subset of 4 items

identified as suitable indicators produced a better fitting model than using all 10 indicators (results available on request). The items begin with the stem “during the past seven days” and included (1) “you could not shake off the blues, even with the help from your family and friends”, (2) “you felt depressed”, (3) “you felt happy”, and (4) “you felt sad.” Responses ranged from (0) never or rarely to (3) most of the time or all of the time. The sum of these items gives a measure of depressive symptoms ($\alpha = .81$) with a 0-12 range.

Educational Attainment

Educational attainment was obtained via an item from Wave IV that asked “What is the highest level of education that you have achieved to date?” We created three dichotomous variables: less than high school or high school education, some college, and a college degree or higher. More detailed education categorizations were utilized in supplementary analyses, but because the results largely reflected a difference between those with some college and those without, we decided to categorize education in this parsimonious manner as have others (Bauldry, 2015).

Controls

Twin discordant studies provide more accurate estimates of the returns to education when potentially non-shared factors that vary between twin pairs are included (Stanek et al., 2011). Three previously mentioned factors, personality, cognitive ability, and health, may be particularly important and are included here as well as several other potential sources of spuriousness. The analysis assesses the “big five” dimensions of personality as potential confounders between education and depressive symptoms. Wave IV of Add Health includes the Mini-IPIP (see Shanahan et al., 2014 for a complete list of items), which is a 20-item short-form version of the International Personality Item Pool designed to measure the five factors of personality (Donnellan et al., 2006). Respondents were read a series of statements and asked to identify to what degree they agreed with statements ranging from (1) “strongly agree” to (5) “strongly disagree”. Answers were summed together by dimension to give five measures of personality: neuroticism, agreeableness, conscientiousness, extraversion, and openness.

The Peabody Add Health Picture Vocabulary Test (AHPVT) from Wave I was used as a measure of verbal cognitive ability. In the AHPVT, the interviewer reads a word and the respondents selects, from among four illustrations, the picture that best matches the meaning of the word. The AHPVT includes 78 items, and raw scores have been standardized by age based on the Add Health sample.

Self-reported health was measured at Wave I by an item that asked “In general, how is your health?” Responses ranged from (1) “excellent” to (5) “poor.” A measure of low self-rated health was constructed by creating a dichotomous variable that identified those that responded with (4) “fair” or (5) “poor.” A control for missing school due to health or emotional problems was created based off an item from Wave I that asked the respondent “In the last month, how often did a health or emotional problem cause you to miss a day of school?” Responses ranged from (0) “never” to (4) “every day.” The same four items from the CES-D from Wave IV were used from Wave I to measure depressive symptomology

during adolescence (Range: 0-12). These items have been validated both as effect indicators of depression and for cross-racial comparisons among adolescents (Perreira et al., 2005).

Other controls indicated whether the respondent had ever been diagnosed with an anxiety disorder, depression, post-traumatic stress disorder, or attention deficit disorder. These measures came from a series of items at Wave IV that asked: "Has a doctor, nurse or other health care provider ever told you that you have or had: anxiety or panic disorder, depression, post-traumatic stress disorder or PTSD, attention problems or ADD or ADHD." Indicators for traumatic events experienced in childhood such as emotional, physical or sexual abuse were also included. At Wave IV, the survey asked a series of retrospective questions about childhood including how often a parent or care giver would: "say things that really hurt your feelings or make you feel like you were not wanted or loved" "hit you with a fist, kick you, or throw you down on the floor, into a wall, or down stairs?", and "touch you in a sexual way, force you to touch him or her in a sexual way, or force you to have sexual relations?" Response ranged from (0) "this never happened" to (5) "more than ten times." These variables were recoded dichotomously to reflect any exposure and ever reporting sexual or physical abuse was collapsed into the same variable. In addition, an indicator of whether the respondent reported that drinking ever interfered with school or work was also utilized.

A measure of adolescent delinquency was assessed using 14 questions that asked adolescents to report how often during the past 12 months they engaged in various delinquent activities such as stealing, fighting, or damaging property ($\alpha = .84$). A full list of items can be found in Hagan and Foster (2003). In Wave I, respondents were asked about their likelihood of attending college. Response ranged from (1) "very unlikely to (5) "very likely." The importance of the respondent's religious beliefs and their frequency of religious attendance were also measured in adolescence with answers varying from (1) "very unimportant" to (5) "very important" for importance of beliefs and from (1) "never" to (4) "more than once a week" for frequency of attendance.

Analytical Strategy

We employ a two-pronged strategy. For ease of interpretation and to match the existing literature (e.g. Mirowsky and Ross, 2003; Miech et al, 2005), all models shown treat depressive symptoms as a continuous variable. However, analysis of negative binomial regressions that treat depressive symptoms as counts yields substantively similar results. First, we investigate the association between education and depressive symptoms using an Ordinary Least Squares (OLS) regression. This type of model, except for being comprised of twins, is what has been represented in the prior literature (e.g. Mirowsky and Ross, 2003) and represents a point of comparison for this study.

Next, the relationship between education and depressive symptoms is reanalyzed using the discordant twin-pair difference-in-difference approach (Gangl, 2010). By design, this model eliminates all factors that twin pairs have in common (e.g. early SES, neighborhood, school environment, genetic endowment). Covariates for education estimate the effects of having

some college or a college degree on depressive symptoms compared to those with a high school degree or less.

The twin-discordant approach can easily be understood by representing the association between depressive symptoms and education for each pair of twins. The first subscript, i , represents the twin pair, and the second subscript represents either twin 1 or 2 in the pair:

$$y_{i1} = \beta_{11}x_{i1} + \beta_{k1}\mathbf{X}_{i1} + g_{i1} + f_{i1} + \varepsilon_{i1} \quad (1)$$

$$y_{i2} = \beta_{12}x_{i2} + \beta_{k2}\mathbf{X}_{i2} + g_{i2} + f_{i2} + \varepsilon_{i2} \quad (2)$$

Where y is depressive symptoms, x is a dichotomous measure that indicates whether the twin completed a discrete level of schooling (e.g. college degree), g and f represent unmeasured factors including genetic endowment and early family environment, respectively, $\mathbf{X}_i$ represents a vector of individual specific covariates, and ε represents a normal error term. β_1 represents the influence of educational attainment on depressive symptoms and β_k represents the influence of k covariates. By subtracting the second equation (2) from the first (1), the effects of shared unmeasured factors cancel out. Because MZ twins share both genetic endowment and early family environment, the second and third terms cancel out. β'_1 and β'_k in (3) represent the influences of educational differences and covariate differences, respectively, on differences in depressive symptoms.

$$y_{i1} - y_{i2} = \beta'_1(x_{i1} - x_{i2}) + \beta'_k(\mathbf{X}_{i1} - \mathbf{X}_{i2}) + (\varepsilon_{i1} - \varepsilon_{i2}) \quad (3)$$

Overall, we estimate four models of depressive symptoms using the twin sample. The first model establishes the baseline relationship between education and depressive symptoms using OLS regression and the second incorporates control variables. While these two models do not address the potential omitted variable bias, they represent important grounds for comparing the results of the current study with existing work on education and mental health. The third utilizes a baseline twin discordant model. The final model adds covariates to the twin discordant model that account for observed within-pair twin differences as represented by equation (3).

Results

Descriptive statistics of our monozygotic twin sample stratified by discordancy on educational attainment are shown in Table 1. In the analytic sample ($N=462$ individuals from 231 pairs), the average level of depressive symptoms is 2.26 ($SD=2.32$). Twin pairs discordant on education had approximately the same average level of depressive symptoms as twin pairs that were not discordant on education. Twin pairs did not differ in the average level of covariates by education discordancy. In the overall sample, 29% ($N=136$) achieved less than a high school or a high school education, 43% ($N=197$) achieved some college, and 28% ($N=129$) achieved a college degree or higher.

Table 2 presents the association between educational attainment and depressive symptoms among monozygotic twins (N=462). In model 1, individuals with a college degree had lower levels of depressive symptoms relative to individuals with a high school degree or less ($\beta = -1.32$; $p < 0.001$). Individuals with some college did not differ in their level of depressive symptoms from individuals with a high school degree or less. Incorporating control variables, we still find that individuals with a college degree had lower levels of depressive symptoms relative to individuals with a high school degree or less, as shown in Model 2. The observed college association with depressive symptoms is relatively large; having a college degree rather than just a high school diploma has a difference in depressive symptoms approximately equal to that seen with a $\frac{1}{2}$ standard deviation reduction in neuroticism, a well-known predictor of depression. Moreover, model 2 accounts for approximately 32% of the variance in depressive symptoms. This high R-squared value may be driven the fact that cases are not independent (i.e. each twin has co-twin in the model) in this model and thus observations have many shared characteristics. The college education coefficient dropped from -1.32 in model 1 to -0.46 (a 65% reduction) in model 2 suggesting that a large portion of the bivariate association between college education and depressive symptoms is due to shared associations with the control variables. Additional analyses showed the inclusion of neuroticism into the model by itself led to a 48% reduction in the college education coefficient.

Model 3 shows the results of the difference-in-difference model which accounts for shared factors among twin pairs. These models show a similar pattern. Having a college degree was inversely associated with depressive symptoms ($\beta = -1.36$; $p < 0.01$). Incorporating all previously mentioned controls, Model 4 accounts for both unobserved shared factors as well as several observed non-shared factors. We again find an inverse association between having a college degree and depressive symptoms ($\beta = -0.90$; $t = 2.21$; $p < 0.05$). This finding can be interpreted to mean a twin with a college degree would be expected to have 0.90 fewer depressive symptoms than a twin with a high school degree or less. The magnitude of this relationship was relatively large compared to the influence of neuroticism. For instance, the influence of having a college degree was approximately equal to that of a 1.25 standard deviation reduction (i.e. $0.90 / (0.27 \times 2.65) = 1.25$) in neuroticism. This coefficient was not statistically different from the college degree coefficient in model 2. Having some college was unrelated to depressive symptoms but the coefficient was negative ($\beta = -0.43$; $t = 1.17$). The inclusion of controls into model 4 increased the proportion of the overall variance explained to approximately twenty-five percent and produced a drop in the college education coefficient from -1.36 in model 3 to -0.90 (a 33% reduction). This drop suggests that part of this association in model 3 was due to spuriousness caused by between twin-pair differences, particularly in neuroticism and history of depression.

Tests for Robustness

For this analysis to be potentially relevant to analysis of the effects of education, an essential assumption is that differences in educational attainment between twins are due to exogenous events that affected the amount of schooling but not depressive symptoms, except through education. If educational attainment differs between the twins due to such events as the random assignment of teachers, then this assumption may be realistic. If, alternatively,

differences in education arise from unaddressed factors which also influence depressive symptomology, then the schooling coefficient in within-MZ-twins estimates will be biased.

A plausible violation of this assumption is that the parents of twin pairs favor one twin over another and the favored twin receives extra instrumental and emotional resources from the parents (Felson, 2014) that lead to higher levels of educational attainment and superior mental health. We partially accounted for this possibility in ancillary models by controlling for twin differences in the mother's perception of her relationship with each child as well as each twins' perception that their counterpart received more love and attention from their parent. The twins' perception that they were equally loved by their parents was constructed using a question from the initial wave. Each twin was asked to think about all the things their parents do for them. They were consequently asked if they thought their twin received more attention and love from their parents. The inclusion of these variables in ancillary models did not affect any of the substantive conclusions.

Another plausible violation of this assumption would be if families with limited economic resources selectively finance the twin with better mental health to attend college. We partially addressed this issue by running a DID logistic regression of college attendance on the interaction between depressive symptoms and household income during adolescence. If the influence of depressive symptoms was stronger for those with lower incomes, a negative interaction would provide some evidence for this scenario. The interaction was not significant. No evidence was found that the association between education and depressive symptoms varied by gender. Because the most common limitation of twin-discordant models is that they can be statistically noisy with relatively small samples, such as the one utilized here, we replicated all analysis with Add Health's dizygotic twins as well. The results of the analysis revealed the same pattern of findings reported here and are shown in the Appendix.

Conclusion

This study tested for an association of college education on depressive symptoms using a discordant twin-pair difference-in-difference approach. Consistent with previous work (e.g., Pearlman et al., 2005; Mirowsky and Ross, 2003), we found those with a college degree had lower levels of depressive symptoms than those without a college education. Having a college degree was inversely associated with depressive symptoms net of all factors shared by twin pairs, such as an early environment, as well as observed non-shared factors including cognitive ability, personality characteristics, depressive symptoms during adolescence, and self-reported health in adolescence. Overall, our results are consistent with the idea that a college degree protects against depressive symptoms.

Our results overlap with two of the three causally-informative studies that also found evidence of an association between education and depressive symptoms or depression (Mezuek et al., 2012; Bauldry, 2015). However, our findings are counter to those of Fujiwara and Kawachi (2008) who used the same twin-based study design and found that educational attainment was unrelated to depressive symptoms. We believe there are at least two potential explanations for this discrepancy. First, Fujiwara and Kawachi analyzed data of middle to

older aged adults while we examined those in young adulthood. In line with the increasing economic benefits of a college education for younger cohorts (Kaymak 2009), the importance of education for health and mortality is increasing for younger cohorts (Masters, Link, and Phelan 2015) and it is possible a similar change is occurring for education and depressive symptoms. Second, as previously stated, Fujiwara and Kawachi (2008) measured education as a continuous variable in years whereas we measured it categorically (i.e. high school degree or less, some college, college degree). Ideally, we would have liked to test the effect of education in years, as well, to examine if the association was sensitive to these measurement decisions, the Add Health study at Wave IV, when respondents were almost universally finished with education acquisition, did not ask respondents to identify the number of years of schooling they completed.

While none of the past literature on education and depressive symptoms accounted for personality characteristics, our results suggested that, neuroticism, conscientiousness, and extraversion were sources of partial spuriousness. Moreover, neuroticism was still associated with depressive symptoms, even after factoring out all shared factors between twin pairs. In other words, neuroticism was not simply a marker for genes or shared environments but rather may have reflected past exposures to non-shared environmental influences (Caspi and Roberts, 2001). In contrast, while those with high levels of extroversion or conscientiousness tended to report fewer symptoms of depression, these associations were explained by unobserved shared factors in the DID models. Overall, these findings highlight the important role of personality characteristics in mental health and should draw consideration in future research as potential sources of spuriousness in the education and mental health relationship.

This study had several limitations that should be acknowledged. First, while employing a sample of monozygotic twins has many advantages, identical twins may not be reflective of the individuals within the broader population. For instance, they may be treated differently by their families, teachers, and society more generally than singletons (Felson, 2014). Furthermore, the demographics of twins tend to differ from the broader population. In other words, by employing a sample of monozygotic twins we gained internal validity at the cost of external validity. While, external validity remains a concern, it should be emphasized that our results before employing the discordant approach approximately align with studies that employ nationally representative samples (Mirowsky and Ross, 2003; Quesnel-Vallee and Taylor, 2012).

Second, despite the fact that MZ twins have identical genotypes, fixing genotype does not necessarily eliminate all genetic influences (Boardman and Fletcher, 2015). Experimental animal models show that even when genotype is fixed (i.e. all animals are identical at the genomic level) and the environment is held strictly constant, genetic influences can still manifest due to stochastic processes in epigenetic responses to the environment (Raj et al., 2010). While we cannot rule out epigenetic mechanisms biasing our results, epigenetic interactions with environments will only bias our estimates if such interactions directly affect both schooling and depressive symptoms (Amin et al., 2015). As more datasets include measurement of epigenetic mechanisms, like methylation, future work should consider how to incorporate this between-twin variation.

Finally, other factors that vary between twin pairs could account for the observed relationship between education and depressive symptoms. As previously mentioned, the key assumption for this study design is that differences in educational attainment between twins are due to exogenous events that affect the amount of schooling obtained, but not directly depressive symptoms. While we cannot control all possible reasons why differences between discordant levels of educations may also be related to depressive symptoms, we were able to account for several important ones (e.g. cognitive ability, personality characteristics, depressive symptoms during adolescence, and self-reported health during adolescence). Indeed, no previous study has included controls for each of these relevant domains together, and as such, this study addresses the most documented potentially spurious threats to our causal pathways of interest.

Our study is consistent with a causal pathway whereby a four-year college degree can reduce depressive symptoms. However, it should be recognized that this effect may depend on the macro-social environmental conditions that structured how respondents in this cohort grew up, pursued their education, and reaped its benefits. With recent attention discussing education as a potential policy lever to improve physical health (Montez, 2015), future work must focus on identifying the social, cultural, and environmental conditions under which educational effects may lead to better mental health outcomes. Extending studies like this one to other cohorts and countries is a necessary step in elucidating the underlying macro-level contextual factors necessary for higher levels of educational attainment to improve mental health. For instance, a recent study using European data suggested that a national labor market must offer sufficient economic returns to education in order for it to be beneficial toward mental health (Bracke, Straat, and Missinne, 2014). By understanding the necessary conditions for education to function as an effective policy lever for improving population mental health, policy makers will be better equipped to know if, when, and how to implement policies that seek to improve population health through increased education.

Our findings provide additional support for past work that argued the positive association between education and depressive symptoms represented a causal connection (e.g., Mirowsky and Ross, 2003). Whether and under what conditions the link between education and mental health represents a causal one should be a key question in the health disparities literature. With recent calls for educational attainment as health policy (House et al., 2009), understanding the causal benefits of educational attainment and the mechanisms by which such benefits are realized remains a crucial area of research.

Appendix

Table 1
Effects of College Education on Depressive Symptoms
among Dizygotic Twins (N=706)

	Model 1	Model 2	Model 3	Model 4
	OLS	OLS	FE	FE
<i><u>Educational Attainment</u></i>				
Some college (ref=no college)	-0.41 * (0.23)	-0.26 (0.20)	-0.27 (0.37)	-0.04 (0.30)

	Model 1	Model 2	Model 3	Model 4
	OLS	OLS	FE	FE
College degree or higher (ref=no college)	-1.03 *** (0.22)	-0.52 ** (0.22)	-1.01 ** (0.41)	-0.74 * (0.35)
<u>Controls</u>				
Neuroticism		0.31 *** (0.03)		0.36 *** (0.05)
Agreeableness		0.08 * (0.04)		0.09 (0.06)
Conscientiousness		-0.06 * (0.03)		-0.11 (0.05)
Extraversion		-0.09 *** (0.03)		-0.04 (0.04)
Openness		-0.01 (0.03)		-0.03 (0.05)
Cognitive ability		-0.01 (0.01)		-0.01 (0.01)
Low self-reported health during adolescence		-0.02 (0.17)		-0.14 (0.26)
Missed school because of health during adolescence		0.08 (0.12)		0.00 (0.19)
Depressive symptoms during adolescence		0.07 * (0.04)		0.00 (0.06)
Ever diagnosed with depression		1.19 *** (0.29)		1.22 *** (0.36)
Drinking ever interfere with home or school		0.43 * (0.21)		0.32 (0.35)
Ever diagnosed with PTSD or anxiety disorder		0.67 (0.63)		1.39 (0.92)
Ever diagnosed with attention deficit disorder		0.94 ** (0.36)		0.62 (0.52)
Ever felt unloved before eighteen		0.18 (0.16)		-0.06 (0.28)
Ever physically or sexually abused before eighteen		0.22 (0.22)		0.30 (0.36)
Delinquency during adolescence		0.10 (0.22)		0.34 (0.42)
Likelihood of attending college during adolescence		0.09 (0.07)		0.02 (0.13)
Importance of religion during adolescence		-0.11 (0.11)		0.01 (0.20)
Religious attendance during adolescence		-0.03 (0.09)		-0.08 (0.22)
Constant	2.73 *** (0.17)	0.53 (1.10)	2.67 *** (0.25)	0.18 (1.60)
R-squared	0.03	0.36	0.02	0.36

p<.001,**
p<.01,*
p<.05 (one-tailed).

Table 2
Effects of College Education on Depressive Symptoms
among both Monozygotic and Dizygotic Twin Pairs
(N=1168)

	Model 1	Model 2	Model 3	Model 4
	OLS	OLS	FE	FE
<u>Educational Attainment</u>				
Some college (ref=no college)	-0.38 * (0.18)	-0.21 (0.15)	-0.41 (0.29)	-0.24 (0.24)
College degree or higher (ref=no college)	-1.11 *** (0.17)	-0.49 *** (0.16)	-1.14 ** (0.31)	-0.84 *** (0.27)
<u>Controls</u>				

	Model 1	Model 2	Model 3	Model 4
	OLS	OLS	FE	FE
Neuroticism	0.32 *** (0.03)			0.33 *** (0.03)
Agreeableness	0.07 * (0.03)			0.05 (0.05)
Conscientiousness	-0.06 ** (0.02)			-0.10 ** (0.03)
Extraversion	-0.09 *** (0.02)			-0.04 (0.03)
Openness	-0.02 (0.03)			-0.05 (0.04)
Cognitive ability	-0.01 ** (0.01)			-0.01 (0.01)
Low self-reported health during adolescence	-0.08 (0.13)			-0.05 (0.19)
Missed school because of health during adolescence	0.09 (0.10)			0.06 (0.15)
Depressive symptoms during adolescence	0.08 ** (0.03)			0.05 (0.05)
Ever diagnosed with depression	1.28 *** (0.21)			1.27 *** (0.27)
Drinking ever interfere with home or school	0.21 (0.17)			0.30 (0.26)
Ever diagnosed with PTSD or anxiety disorder	0.41 (0.67)			0.57 (0.84)
Ever diagnosed with attention deficit disorder	0.45 (0.28)			0.29 (0.41)
Ever felt unloved before eighteen	0.19 (0.12)			0.08 (0.19)
Ever physically or sexually abused before eighteen	0.16 (0.17)			0.15 (0.26)
Delinquency during adolescence	0.23 (0.17)			0.22 (0.28)
Likelihood of attending college during adolescence	0.10 * (0.06)			0.03 (0.10)
Importance of religion during adolescence	-0.15 * (0.08)			-0.05 (0.15)
Religious attendance during adolescence	0.02 (0.07)			0.02 (0.16)
Constant	2.75 *** (0.13)	0.81 (0.82)	2.77 *** (0.18)	1.19 (1.25)
R-squared	0.03	0.36	0.02	0.32

p<.001,
**
p<.01,
*
p<.05 (one-tailed).

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- Whether a college education is protective over depressive symptomology is unclear
- We estimate this association using a monozygotic discordant-twin design
- We find an inverse association net of shared and non-shared controls

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Figure 1. Competing Conceptual Models for the Relationship between Educational Attainment and Mental Health

Notes: Dark lines denote a hypothesized causal relationship while the dotted line represents a correlational but non-causal relationship between education and mental health. These two models are not mutually exclusive. The differently sized overlapping arrows seen in the causal model are meant to indicate that researchers don't know the magnitude of this linkage. The spurious model denotes the case where the magnitude is equal to zero.

Table 1

Descriptive Statistics of Monozygotic Twin Pairs

	All Twins (N=462)		Twin Pairs with Discordant Education (N=154)		Twin Pairs with Same Education (N=308)	
	Mean	Std.	Mean	Std.	Mean	Std.
Depressive symptoms	2.26	2.32	2.44	2.48	2.18	2.24
No college ^a	0.29	0.46	0.36	0.48 *	0.26	0.44 *
Some college	0.43	0.50	0.40	0.49 *	0.44	0.50 *
College degree	0.28	0.45	0.24	0.43 *	0.30	0.46 *
Neuroticism	10.40	2.65	10.44	2.68	10.39	2.64
Agreeableness	15.16	2.35	15.29	2.49	15.10	2.28
Conscientiousness	13.14	3.10	12.99	3.25	13.21	3.02
Extraversion	14.36	2.23	14.47	2.15	14.31	2.27
Openness	14.84	2.67	14.83	2.70	14.85	2.65
Cognitive ability	68.27	12.85	68.49	13.87	68.15	12.33
Low self-rated health during adolescence	0.32	0.47	0.34	0.48	0.31	0.47
Missed school because of health	0.35	0.59	0.32	0.56	0.37	0.61
Depressive symptoms during adolescence	2.41	2.13	2.46	2.18	2.38	2.11
Ever diagnosed with depression	0.15	0.35	0.15	0.36	0.14	0.35
Drinking ever interfere with home or school	0.13	0.33	0.13	0.34	0.12	0.33
Ever diagnosed with an anxiety disorder	0.01	0.11	0.03	0.16	0.01	0.08
Ever diagnosed with ADD or ADHD	0.06	0.23	0.06	0.25	0.05	0.22
Ever felt unloved before eighteen	0.41	0.49	0.47	0.50	0.39	0.49
Ever physically or sexually abused before eighteen	0.16	0.37	0.16	0.36	0.17	0.37
Delinquency during adolescence	0.28	0.39	0.29	0.41	0.28	0.38
Likelihood of college during adolescence	4.13	1.13	4.10	1.19	4.14	1.10
Importance of religion during adolescence	3.13	1.05	3.17	1.00	3.11	1.08
Religious attendance during adolescence	2.75	1.21	2.74	1.20	2.75	1.22

^a Group differences by educational attainment were tested by means of a global Chi-square test which revealed group differences.

* p<.05.

Table 2
Effects of College Education on Depressive Symptoms among Monozygotic Twins
(N=462)

	Model 1	Model 2	Model 3	Model 4
	OLS	OLS	FE	FE
<i>Educational Attainment</i>				
Some college (ref=no college)	-0.34 (0.25)	-0.16 (0.22)	-0.68 * (0.38)	-0.43 (0.36)
College degree or higher (ref=no college)	-1.32 *** (0.28)	-0.46 * (0.26)	-1.36 ** (0.49)	-0.90 * (0.41)
<i>Controls</i>				
Neuroticism		0.32 *** (0.04)		0.27 *** (0.05)
Agreeableness		0.04 (0.04)		-0.06 (0.09)
Conscientiousness		-0.08 ** (0.04)		-0.08 (0.05)
Extraversion		-0.09 ** (0.03)		-0.02 (0.05)
Openness		-0.05 (0.05)		-0.08 (0.08)
Cognitive ability		-0.02 * (0.01)		-0.02 (0.02)
Low self-reported health during adolescence		-0.17 (0.20)		0.16 (0.25)
Missed school because of health during adolescence		0.09 (0.16)		0.19 (0.22)
Depressive symptoms during adolescence		0.10 * (0.05)		0.08 (0.07)
Ever diagnosed with depression		1.35 *** (0.28)		1.13 ** (0.42)
Drinking ever interfere with home or school		-0.16 (0.28)		0.15 (0.38)
Ever diagnosed with PTSD or anxiety disorder		-0.09 (0.81)		-1.45 (1.44)
Ever diagnosed with attention deficit disorder		-0.23 (0.40)		-0.48 (0.68)
Ever felt unloved before eighteen		0.29 (0.20)		0.29 (0.25)
Ever physically or sexually abused before eighteen		-0.01 (0.26)		-0.06 (0.37)
Delinquency during adolescence		0.34 (0.24)		0.03 (0.38)
Likelihood of attending college during adolescence		0.13 (0.09)		0.06 (0.12)
Importance of religion during adolescence		-0.20 * (0.11)		-0.04 (0.19)
Religious attendance during adolescence		-0.03 (0.09)		0.02 (0.16)
Constant	2.78 *** (0.19)	2.32 * (1.27)	2.93 *** (0.27)	4.42 * (2.30)
R-squared	0.05	0.37	0.04	0.30

p<.001,

**
p<.01,

*
p<.05 (one-tailed).