WORKING PAPER SERIES

JUNE 2009 WORKING PAPER No. 09-07

The Effect of Migraine Headache on Educational Attainment

by

Daniel I. Rees and Joseph J. Sabia

DEPARTMENT OF ECONOMICS
UNIVERSITY OF COLORADO DENVER
DENVER, CO 80217-3364

www.econ.cudenver.edu

The Effect of Migraine Headache on Educational Attainment

Abstract

Despite the fact that migraine headache is common and debilitating, very little is known about its effect on educational attainment. Using data drawn from the National Longitudinal Study of Adolescent Health, we estimate the relationship between migraine headache and four outcomes: high school grade point average, years of schooling completed, high school graduation, and college attendance. Across a wide set of empirical strategies designed to control for the influence of unmeasured heterogeneity, our results provide consistent evidence that migraine headache negatively impacts human capital accumulation. The relationship between migraine headache and educational attainment is explained, in part, through its effect on excused school absences and the respondent's self-reported ability to pay attention in class and complete homework.

Keywords: migraine headache, schooling, human capital

"Only if you've had a severe migraine can you appreciate how devastating this is to the life and composure of the victim."

> --Dr. Seymour Diamond, Executive Chairman of the National Headache Foundation.

I. Introduction

The International Headache Society (IHS) classifies headaches as either primary or secondary. While secondary headache can be caused by, for instance, trauma to the head, a sinus infection, or a night on the town, primary headache is by definition not the result of a treatable medical condition or pathology (Gladstein 2006).

There are three types of primary headache. Tension headache is the most common, affecting anywhere between 30 to 80 percent of the North American/Western European population (Kaniecki 2002). Migraine headache is the second most common, affecting between 10 and 12 percent of the population (Breslau and Rasmussen 2001). Cluster headache is the rarest but most severe type of primary headache. It affects approximately 1 out of 500 individuals of European decent (Russell 2004).

Of the three types of primary headache, migraine has received the most attention from medical researchers, and a large number of studies have examined its correlates. For instance, there is evidence that migraine headache is more common among whites as compared to blacks or Asians (Stewart et al. 1996; Lipton et al. 2001), and there is evidence that it is negatively correlated with commonly used measures of socioeconomic status (Breslau et al.1991; Stewart et al. 1992; Stang and Osterhaus 1993; Lipton et al. 2001; Waldie et al. 2002; Waldie and Poulton. 2002; Lipton et al. 2007). Although sufferers will attest to its power to seriously disrupt daily life, no previous study has attempted to assess the causal effect of migraine headache on outcomes of interest to

economists such as educational attainment or earnings.[1] Such an assessment is necessary in order to accurately estimate the full economic cost of migraine headache.

Using data from the National Longitudinal Study of Adolescent Health, this study examines the effect of migraine headache on four measures of educational attainment: high school grade point average, years of schooling, the probability of graduating high school, and the probability of attending college. Ordinary least squares (OLS) and propensity score matching (PSM) estimates suggest that migraine headache is negatively related to all four measures. These estimates, however, could reflect difficult-to-measure factors at the family level. In order to account for the influence of family-level unobservables, we investigate the effect migraine headache on educational attainment through an examination of siblings raised in the same household. Estimates based on sibling data confirm the negative relationship produced by OLS and PSM.

There is evidence that both migraine and tension headache sufferers are more likely to exhibit neurotic tendencies than non-sufferers (Rasmussen 1992; Kentle 1997; Cao et al. 2002), raising the possibility that the negative relationship between migraine headache and educational attainment is driven by personality. In an effort to explore this hypothesis, we estimate the effect of non-migraine headache on educational attainment. The results suggest that, in contrast to migraine headache, non-migraine headache is unrelated to the outcomes under study. We argue that this pattern of results

[1] There has been some research done on migraines and work absences. Migraine sufferers in Western Europe reported an average of 2-9 work days lost per year as a result of attacks (Berg 2004). Twenty-five percent of migraine sufferers in the United States reported losing at least one day work in the past three months (Lipton et al. 2007). Migraine sufferers also report reduced productivity while at work (Clarke et al.1996; Lipton et al. 2001; Waldie and Poulton 2002; Pradalier et al. 2004; Lipton et al. 2007).

can be viewed as evidence against the hypothesis that personality is driving the estimated effect of migraine on educational attainment.

Finally, we pursue an instrumental variables (IV) estimation strategy, using the respondent's biological mother's migraine history as a source of plausibly exogenous variation. IV estimation produces evidence of a negative relationship between migraine headache and educational attainment of a magnitude comparable to that found using OLS, PSM, and sibling comparisons. Controlling for excused absences from school and difficulty paying attention during class and completing homework reduces, but does not eliminate, the estimated effect of migraine headache on educational attainment found using 2SLS. We conclude that estimates of the cost of migraine headache on society should include its impact on human capital accumulation.

II. Background

The Headache Classification Subcommittee of the IHS describes migraine headache without aura, the most common type of migraine, as a recurrent

> disorder manifesting in attacks lasting 4-72 hours. Typical characteristics of the headache are unilateral location, pulsating quality, moderate or severe intensity, aggravation by routine physical activity and association with nausea and/or photophobia.[2]

Migraine attacks can be triggered by stress, fatigue, lack of sleep, hunger, smoke, bright lights, menstruation, and even changes in the weather (Kaniecki 2002). Attacks can also

[2] Migraines with aura typically begin with visual disturbances such as flashes of light or flickering spots. A headache "with the features of migraine without aura usually follows the aura symptoms" (Headache Classification Subcommittee of the IHS 2004, p. 31).

occur without an identifiable trigger, seemingly at random. Although there are a number of over-the-counter and prescription medications that are used to treat migraine headache, sufferers are often forced to retreat to a dark, quiet room.

Almost 20 percent of adult women in the United States report having had at least one migraine headache in the past year (Stewart et al. 1992; Lipton et al. 2001; Lipton et al. 2007). In contrast, on the order of 5 or 6 percent of adult men in the United States report having suffered an attack in the past year (Stewart et al. 1992; Lipton et al. 2001; Lipton et al. 2007). In keeping with evidence that many women experience their first attack when they are in their 20s or 30s (O'Brien et al. 1994), the migraine "gender gap" is much narrower among adolescents. A recent study found that that 7.7 percent of females in the United States between the ages of 12 and 19 reported having had at least one attack in the past year, while the corresponding figure for males belonging to this age group was 5.0 percent (Bigal et al. 2007).

There are a number of reasons to expect migraine headache to be negatively related to educational attainment. To the extent that it makes attending class and studying more difficult, migraine headache can be thought of as increasing the cost of remaining in school beyond the age required by compulsory attendance laws. To the extent that it interferes with learning, migraine headache can be thought of as decreasing the return to remaining in school. Finally, migraine headache may impact occupational aspirations and, as a consequence, educational attainment. For instance, if migraineurs have an incentive to avoid high-stress occupations requiring an advanced degree, the

result may be a negative relationship between migraine headache and educational attainment.[3]

Using simple cross tabulation, medical researchers have, in fact, found that migraine headache is negatively related to years of schooling and grades (Breslau et al.1991; Bigal et al. 2001; Waldie et al. 2002; Waldie and Poulton. 2002). Nevertheless, there is a perception among the general public that migraine sufferers tend to be overachievers, prone to feelings of anxiety and driven to succeed.[4] This perception is perhaps fueled by the fact that stress is an important trigger of both migraine and tension headaches (Kaniecki 2002), and is buttressed by a growing number of medical studies documenting a link between migraine headache and neuroticism (Brandt et al. 1990; Merikangas et al. 1993; Breslau and Andreski 1995; Kentle 1997; Cao et al. 2002).[5] Because there is some evidence that neuroticism can impact academic achievement (De Raad and Schouwenberg 1996; Laidra 2007), disentangling the effect of migraine headache from that of personality becomes a potentially important issue.

[3] Research using twin pairs produced no evidence that migraine headache negatively impacts IQ (Gaist et al. 2005). Nevertheless, we are careful to control for cognitive ability in the empirical analysis below.

[4] Writing for the New York Times, Brody (1988) described migraines as occurring "with disproportionate frequency among high achievers who expect a lot from themselves and accomplish a lot." The overachieving-migaineur hypothesis seems to be common even among medical professionals. In an interview with Vibrant Life, Dr. Seymour Diamond, the Executive Chairman of the National Headache Foundation, was asked if there "is such a thing as a migraine personality." He replied, "[m]any migraine patients are perfectionists. They tend to be intelligent, doers, and achievers." The full text of this interview is available at: http://findarticles.com/p/articles/mi_m0826/is_n4_v9/ai_14022967/?tag=content

[5] It should be noted, however, that the link between migraine and personality is still being investigated and debated. Nylander et al. (1996) found no evidence that migraine sufferers had different "temperaments or characters" than non-sufferers; Mattsson and Ekselius (2002) found no relationship between migraines and personality type among women ages 40-74; and Stronks et al. (1999) found that neither migraineurs nor subjects prone to tension headaches showed higher anxiety levels than members of a healthy control group when confronted with an arithmetic problem.

To date, researchers interested in estimating the impact of migraine headache have generally relied on cross-sectional surveys. For instance, Lipton et al. (2007) obtained their data from a self-administered questionnaire mailed in June of 2004 to a random sample of 120,000 U.S. households. They found that 25.3 percent of migraineurs lost at least one day of school or work in the past three months; and 28.1 percent reported that their productivity at work or school had been reduced by at least half.[6] Based on similarly designed surveys, it has been estimated that the indirect costs to society of migraine headache are much larger than the costs associated with treatment (Berg 2004).[7]

To our knowledge, this is the first study to estimate the relationship between migraine headache and educational attainment using longitudinal data.[8] The advantage of longitudinal data is that we are able to observe the migraine status of respondents before they have completed their desired level of schooling, assuring that our estimates do not

[6] Examples of other studies that have taken a similar approach to assessing the impact of migraines on work productivity include: Clarke et al. (1996), Lipton et al. (2001), Waldie and Poulton (2002), and Pradalier et al. (2004).

[7] After reviewing a number of studies using data from Western Europe, Berg (2004) concluded that the, "vast majority of the total costs, nearly 90%, are due to indirect costs in the form of absenteeism and reduced effectiveness." Direct medical costs were, on average, € 39 per patient per year in Western Europe in (Berg 2004).

[8] Waldie et al. (2002) used longitudinal data to examine the effect of migraine headache on cognitive ability. Controlling for whether a respondent suffered from headaches as a child, they found that diagnosis with migraine headache at age 26 was associated with lower verbal scores at ages 7, 9, 11, 13, 15, and 18. They also reported the results of a cross tabulation showing that diagnosis with migraine headache at age 26 was associated with lower high school grades. Finally, Waldie et al. (2002, p. 907) reported that respondents who were diagnosed with tension-type headache (TTH) at age 26 were

> slightly more likely than those with migraine to have achieved secondary school qualifications (84 versus 82%), but this difference was significant only for men (78 versus 63%; p _ 0.02). A greater number of study members with TTH (26%) and control subjects (22%) had obtained a bachelor degree by age 26 compared with those with migraine (18%).

reflect reverse causality. If, for instance, graduating from college leads to more lucrative, but more stressful employment, then relying on a cross-sectional survey of adults could easily produce an underestimate of the effect of migraine headache on educational attainment.[9]

III. Data and Measures

The data used in this study come from the National Longitudinal Study of Adolescent Health (Add Health), which was conducted by the Carolina Population Center at the University of North Carolina at Chapel Hill. The Add Health data collection effort began with the identification of more than 26,000 high schools from across the United States. Eighty were selected with probability proportional to enrollment, stratified by region of the country, level of urbanization, type (public vs. private), and racial mix. It was determined that 20 of these 80 high schools enrolled 7th graders. If a high school did not enroll 7th graders, it was matched with a "feeder school" (that is, a junior high or middle school), chosen with a probability proportional to the number of students it contributed to that high school. Fifty-two feeder schools were recruited, bringing the total number of participating schools to 132.

The Wave I (baseline) in-home survey was administered between April and December of 1995 to a core sample composed of 12,105 students who were selected at random from the rosters of the 132 participating schools. The core sample was

[9] There are at least two assumptions built into this brief example. The first is that individuals who have had a migraine headache in the past can reduce the probability of suffering a subsequent attack by avoiding stressful situations. The second is that the cross-sectional survey in question asked respondents whether they had an attack in the recent past. A cross-sectional survey could, in theory, mimic a longitudinal study by asking about migraine headaches suffered as an adolescent.

augmented through a special effort to collect information on siblings, half-siblings, and twins living in the same household as one of the 12,105 students selected at random from the school rosters. In addition, the entire population of students in 16 of the 132 participating schools was administered the Wave I in-home survey, and a number of "supplementary samples" were drawn including 1,038 black students with college-educated parents, 334 Chinese students, 450 Cuban students, and 437 Puerto Rican students. All told, the Wave I in-home survey was administered to 20,745 respondents. When weighted, it can be used to produce nationally representative statistics for 7th to 12th graders living in the United States in 1995.[10]

Three follow-ups have been conducted since the initial Add Health data collection effort.[11] The outcome measures used in this study come from the second follow-up, the Wave III in-home survey, which was administered in 2001. The Wave III in-home survey contains information on 15,170 of the original Add Health participants. However, because the analysis below is restricted to respondents who were 21 through 25 years of age when surveyed, our sample sizes are considerably smaller than 15,000. We adopt this age restriction in order to focus on respondents who were old enough to have completed high school and begun college by the time of the Wave III survey. Approximately 3,600 respondents, or 13 percent of the original Wave III respondents, were dropped because they were under 21 years of age at Wave III. Approximately 1,800 were dropped because of missing information with regard to key variables used in the analysis.

[10] Further information regarding the Adolescent Health data collection effort is available from a variety of sources. See, for example, Harris et al. (2008).

[11] Data from the third follow-up survey is not yet available to researchers.

Four measures of educational attainment were constructed. The first, based on student transcripts, is equal the respondent's high school grade point average (GPA); the second is a continuous measure equal to the number of years of schooling completed by Wave III in 2001; the third is a dichotomous variable equal to 1 if the respondent had reported receiving a high school diploma by Wave III, and equal to 0 if he or she failed to complete high school; and the last is equal to 1 if the respondent was attending college at the time of the Wave III survey or had completed at least one year of college prior to being surveyed

The independent variable of interest is *Migraine.* One parent, usually the mother, filled out a 40-minute questionnaire when the Wave I in-home survey was administered. They were presented with a list of "health problems," and asked if their child, the respondent, was currently suffering from any of the problems on the list. *Migraine* is equal to 1 if the parent indicated that the respondent had migraine headaches, and is equal to 0 if the parent indicated that they did not. The parent was also asked if the respondent's biological mother had migraine headaches.

In Table 1A we present unweighted means and standard deviations of the outcome variables and *Migraine* by gender and for males and females combined.[12] According to the information in Table 1A, a little over 10 percent of Add Health males and 14 percent of Add Health females suffered from migraine headache. These figures are considerably higher than those reported by (Bigal et al. 2007), who examined 12 through 19 year-olds, perhaps because Bigal et al. (2007) had enough information to apply the IHS criteria for what constitutes a migraine. If parents had trouble

[12] Appendix Table 1A presents descriptive statistics for the sub-samples used in the IV analysis and the analysis based on sibling data. .

distinguishing between severe tension headaches (or secondary headaches) and migraines, then the estimates below may understate the true effect of migraine headache on educational attainment.[13]

In Table 1B we show the percentage of Add Health respondents with migraine headache by educational attainment. The patterns are pronounced and in keeping with the results of Breslau et al. (1991), Bigal et al. (2001), Waldie et al. (2002), and Waldie and Poulton (2002): respondents whose high school GPA was below 3.5 were more likely to be migraineurs as compared to their counterparts with GPAs above 3.5; high school dropouts were more likely to be migraineurs as compared to their counterparts who graduated high school; and respondents who were not attending college were more likely to be migraineurs as compared to their counterparts who were attending college.

IV. OLS Estimation Results

The negative relationship between suffering from migraines as an adolescent and educational attainment documented in Table 1B could be due to a number of factors. For instance, it could be attributable to socioeconomic status or even be a reflection of factors at the neighborhood or community level.[14] In this section we use standard regression analysis to investigate these hypotheses.

Specifically, we estimate the following equation using OLS:

[13] Distinguishing between migraine and tension headaches can often be difficult. Many migraine headaches are accompanied by tension headache symptoms and vice versa (Kaniecki 2002). Migraineurs often experience frequent tension headache (Lyngberg et al. 2005).

[14] Bigal et al. (2007) found that adolescents from low-income families were more likely to be migraineurs than their counterparts from middle- and high-income families.

(1) $E_i = \beta_0 + \boldsymbol{\beta'_1 X_i} + \beta_2 \, Migraine_i + \varepsilon_i,$

where E_i is a measure of respondent *i*'s educational attainment constructed from answers to the Wave III Add Health survey; $\boldsymbol{X_i}$ is a vector of controls; and $Migaine_i$ is the indicator variable defined above. Our focus is on the estimate of β_2. If β_2 is less than zero this could be interpreted as evidence that, as hypothesized, migraine headache imposes a cost on suffers in terms of reduced human capital accumulation.

We include a large number of individual- and family-level variables in $\boldsymbol{X_i}$. Most are measured at Wave I, including the educational attainment of the parent who answered the parental questionnaire, household income, parents' marital status, the respondent's Peabody Picture Vocabulary Test (PPVT) score (a measure of cognitive ability)[15], race, ethnicity, height, body mass index (BMI), and whether the respondent had an older sibling. A set of age dummies were constructed from information available in the Wave III in-home survey.[16]

OLS results for the full sample and by gender are presented in Table 2. Even controlling for family background and individual characteristics, there is a strong negative relationship between migraine headache as an adolescent and educational attainment. Among males, migraine headache is associated with a 0.099 decrease in high school GPA, 0.187 fewer years of schooling, and a 0.058 decrease in the probability of attending college. Among females, migraine headache is associated with a 0.072

[15] The PPVT measures verbal comprehension and vocabulary. The test is conducted by an interviewer who reads a word to a respondent and then has the respondent choose among four illustrations to determine the picture that best fits the word. The PPVT consists of 78 items (Harris and Thomas 2002). Adolescent Health respondents were administered 39 of these 78 items.

[16] The full list of controls is available in Appendix Table 1B. This table also presents the means and standard deviations of the control variables.

decrease in high school GPA, 0.268 fewer years of schooling, a 0.050 decrease in the probability of graduating high school, and a 0.074 decrease in the probability of attending college.

In terms of magnitude, the impact of migraine headache on educational attainment appears to be substantial. For instance, the average high school GPA of male Add Health respondents in our sample was 2.40. Interpreting the OLS estimates as casual for the moment, they suggest that among males, migraine headache leads to a 4.13 percent reduction (0.099/2.40) in high GPA. Or, to take another example, migraine headache is associated with an almost 12 percent decrease in the probability that female respondents were attending college at the time of the Wave III interview.

Although the OLS estimates in Table 2 are adjusted for a wide variety of individual- and family-level variables, they are not adjusted for community and school characteristics that could potentially be correlated with migraine triggers such as noise, weather, or even florescent lighting.[17] Table 3 presents OLS estimates from a model in which $\boldsymbol{X_i}$ includes school fixed effects, which should capture any environmental influences at the community or school level. Grade effects are also added to the vector $\boldsymbol{X_i}$, intended to capture differences in stress and other environment factors.[18] The results are qualitatively similar to those in Table 2. The relationship between migraine and educational attainment is generally negative and of a similar magnitude to that obtained without the school and grade effects, although the estimated coefficient of $Migraine_i$ is not statistically significant at conventional levels in the female GPA equation.

[17] There is some evidence that community characteristics could be related to the incidence of migraine headache. For instance, Bigal et al. (2007) and Lipton et al. (2007) found that regional population density was related to the likelihood of migraine headache.

[18] The grade effects are five indicators based on the grade of the respondent at Wave I.

V. Propensity Score Matching

One potential concern with regard to the estimates discussed thus far is that migraineurs could look quite different from non-migraineurs in terms of observable characteristics. If respondents from the two groups lack common support, then PSM should produce more reliable estimates of the effect of migraine on educational attainment than the standard regression approach (Rosenbaum and Rubin 1983). Following previous researchers who have employed PSM as an alternative to OLS or other procedures (Mocan and Tekin 2002; Levine and Painter 2003; Michalopoulos et al. 2004; Veiga and Wilder 2008), we begin by estimating a standard probit model of the following form:

$$(2) \qquad P(Migraine_i = 1) = 1 - \Phi(-\beta_0 - \boldsymbol{\beta'_1 X_i} - \boldsymbol{\beta'_2 Z_i}),$$

where $\boldsymbol{Z_i}$ is a set of additional controls designed to capture other characteristics of respondents that could be correlated with both migraines and education. Because there is evidence of an association between depression and migraine headache (Breslau et al.1991; Zwart et al. 2003), we include two measures of psychological well-being in the vector $\boldsymbol{Z_i}$: the Center for Epidemiological Studies Depression (CES-D) score and the Rosenberg Self-Esteem (RSE) score. We also include indicators for whether the respondent suffered from hypertension and whether the respondent reported usually being unable to get enough sleep, both of which have been found to be associated with migraine headache (Kelman and Rains 2005; Scher et al. 2005). Finally, we include indicators of

drunkenness to capture any "hangover effects" that might have been misdiagnosed by parents as migraine headache, and measures of the respondent's closeness with his or her biological mother to capture the quality of the parent-child relationship.

Estimates of equation (2) are found in Appendix Table 2. They indicate that a number of the variables in $\boldsymbol{X_i}$ and $\boldsymbol{Z_i}$ are associated with the probability of migraine headache. Respondents from more highly educated and richer households were less likely to have suffered from migraine headache; those with greater symptoms of depressive symptomotology (higher CES-D scores), greater cognitive ability, more sleep problems, hypertension, and more frequent drunkenness were more likely to have suffered from migraine headache.

After estimating equation (2), we used nearest neighbor matching without replacement to assign migraineurs with a non-migraineur whose estimated propensity score was within 0.002. In a further effort to ensure common support, we dropped migraineurs whose estimated propensity score was higher than the maximum or less than the minimum estimated propensity score of non-migraineurs, and then dropped the 10 percent of migraineurs whose propensity score was furthest from the propensity score of their match. This procedure produced matched samples that appear to be well-balanced across observables.[19]

Table 4 presents estimated differences in educational attainment for the unmatched and matched samples. Although the PSM estimates are generally smaller in magnitude than the unmatched sample estimates, they nevertheless provide evidence of a

[19] Appendix Table 3 shows the mean values of each of the controls for the matched sample of migraine and non-migraine sufferers. The matched samples are similar across the observables. In fact, there were no statistically significant mean differences in means except for *Parent Widowed* in the male sample, and *Drunkenness Less Than Once Per Month*.

negative relationship between migraine headache and educational attainment, especially when male and female respondents are combined into one sample. When the sample is divided by gender, the PSM are less precise, but suggest that the effect of migraine headache is larger for male respondents than their female counterparts. For instance, migraine headache is associated with a 0.086 decline in the probability of attending college for males, and a 0.045 decline for females, a difference which is even larger in percentage terms because females were more likely to attend college than males. In summary, the PSM estimates are consistent with OLS estimates, and show that even after balancing the migraineur and non-migraineur samples based on observable characteristics, the negative relationship between migraine headache and schooling persists.

VI. Sibling Comparisons

Propensity score matching will generate an unbiased estimate of the effect of migraine headache provided that the chosen matching variables adequately capture the influence of confounders. However, we cannot rule out the possibility that difficult-to-measure family-level variables are driving the results presented thus far. For instance, although we controlled for family income in the regression analysis and matched on family income to obtain the PSM estimates presented in Table 4, we do not observe how much support or encouragement the respondent received at home.

In order to address the issue of family-level unobservables, we restrict our sample to siblings raised in the same family and estimate the following equation:

(3) $E_{ij} = \beta_0 + \boldsymbol{\beta'_1 X_i} + \beta_2 \, Migraine_{ij} + \boldsymbol{\kappa_j} + \varepsilon_{ij},$

where $\boldsymbol{\kappa_j}$ is a vector of family fixed effects and the vector $\boldsymbol{X_i}$ includes controls for age (at Wave III), gender, PPVT score, BMI, height, and whether the respondent had an older sibling. The advantage of this estimation strategy is that only the within-family variation is used to estimate the effect of migraine headache on educational attainment. All factors common to both siblings are controlled for by the vector $\boldsymbol{\kappa_j}$, eliminating the need to observe and measure factors having to do with the home environment.

The odd-numbered columns of Table 5 show baseline OLS estimates when the sample is restricted to siblings. The even-numbered columns of Table 5 show what happens to these estimates when family fixed effects are added to the right-hand side of the estimating equation. The results suggest that migraine headache can lead to substantial reductions in educational attainment, although there is evidence that its impact varies by gender and the specific outcome under study.

The first row of Table 5 shows estimates for a combined sample of brothers and sisters.[20] Migraine headache is associated with reductions in high school GPA and the probability of college attendance. However, it is not associated with reductions in years

[20] The sample is restricted to siblings with different migraine histories. If a family contributed information on two siblings to the Adolescent Health data, this restriction means that one sibling suffered from migraine headache, while the other did not. If a family contributed three siblings, then at least one suffered from migraine headache and at least did not. When grades are the dependent variable, the sample is composed of 214 siblings from 105 families (70 of whom were either monozygotic or dizygotic twins or twins of unknown zygoticity). When high school completion or college attendance is on the left-hand side, the sample is composed of 280 siblings from 137 families (85of whom were either monozygotic or dizygotic twins or twins of unknown zygoticity).

of schooling or the probability of high school graduation, perhaps because of the smaller number of observations available for this analysis.[21]

The second row of Table 5 shows estimates for a sample of brothers.[22] Here, fixed effects estimates suggest that migraine headache is associated with reductions in high school grades, years of schooling and the probability of high school graduation. Estimates of the effect of migraine headache on the probability of college attendance are negative but not statistically significant at conventional levels.

Finally, the third row of Table 5 show estimates for a sample of sisters.[23] Fixed effects estimates suggest that migraine headache is associated with reductions in years of schooling and the probability of college attendance. Estimates of the effect of migraine headache on the probability of high school grades and graduation are small in magnitude and are not statistically significant.

To summarize, controlling for family fixed effects does not produce consistently significant estimates of the relationship between migraine headache and educational attainment, although the fixed effects estimates are, with only one exception, negative. Moreover, with perhaps one exception, they are of similar magnitude to OLS estimates obtained using the same sample. We view this pattern of results as evidence that family-level unobservables are not driving the results presented in Tables 2-4.

---

[21] Note that these estimates are not statistically significant with or without controlling for family fixed effects.

[22] When grades are the dependent variable, the sample is composed of 86 brothers from 42 families (23 of whom were either monozygotic or dizygotic twins or twins of unknown zygoticity). When high school completion or college attendance is on the left-hand side, the sample is composed of 73 brothers from 36families (30of whom were either monozygotic or dizygotic twins or twins of unknown zygoticity).

[23] When grades are the dependent variable, the sample is composed of 86 sisters from 42 families (23 of whom were either monozygotic or dizygotic twins or twins of unknown zygoticity). When high school completion or college attendance is on the left-hand side, the sample is composed of 104 sisters from 51families (29 of whom were either monozygotic or dizygotic twins or twins of unknown zygoticity).

VII. Personality and the Impact of Migraine Headache

As noted in the background section, there is evidence that migraine headache is associated with high scores on tests designed to measure neuroticism (Brandt et al. 1990; Merikangas et al. 1993; Breslau and Andreski 1995; Kentle 1997; Cao et al. 2002). Because some studies have shown that individuals with neurotic tendencies tend to receive lower grades than their less anxious counterparts (De Raad and Schouwenberg 1996; Laidra 2007), it is important to distinguish the effect of migraine headache from that of personality.[24]

Breslau and Rasmussen (2001) noted that "most migraineurs also have tension-type headache," and hypothesized that "the high neuroticism score in migraineurs demonstrated in previous studies" could be due to the "high proportion of migraineurs with co-existing tension-type headache."[25] In fact, there is persuasive evidence that the association between tension headache and neuroticism and is at least as strong as the association between migraine headache and neuroticism. Rasmussen (1992) found that tension headache was associated with higher neuroticism scores, but migraine headache was not; Boz et al. (2004) found that tension headache was associated with "harm avoidance," but migraine headache was not; Kentle (1997) and Cao et al. (2002) found that both migraine and tension headache were associated with neuroticism; and Zwart et

[24] It should be noted, however, that the jury is still out with regard to the effect of neuroticism on academic achievement. Halamandaris and Power (1999) and Busato et al. (2000) found no association between neuroticism and academic achievement among college undergraduates. Heaven et al. (2002) found no association among high school students

[25] In one study, 83 percent of migraine sufferers also had tension headaches (Rasmussen et al. 1992).

al. (2003) found that both migraine and tension headache were associated with almost equal increases in the likelihood of anxiety disorder.[26]

This substantial body of research suggests that if the negative relationship between migraine headache and educational attainment is simply a reflection of neuroticism, then we would also expect to observe a negative relationship between tension headache and educational attainment.

To explore whether neuroticism could be driving the relationship between migraine headache and educational attainment, we limit our sample to respondents who did not suffer from migraine headache at Wave I. Approximately 25 percent of non-migraineurs reported having headaches at least once per week, a figure which is consistent with what we know from studies of frequent tension headache (Lyngberg et al. 2005).[27] Table 6 shows estimates of the relationship between suffering from a non-migraine headache at least once per week and the four outcome variables.

The results are striking. The first row Table 6 presents PSM and fixed effects estimates for a combined sample of males and females; the second row of Table 6 presents estimates for male respondents; and the third row presents estimates for female respondents. The estimates of the effect of non-migraine headache are often positive and are consistently insignificant. Moreover, when negative, they are generally much smaller

[26] Many studies on migraine headache and personality ignore the potential role played by tension headache. See, for instance, Passchier and Orlebeke (1985), Brandt et al. (1990), Leijdekkers and Passchier (1990), Breslau and Patricia Andreski (1995), and Abbate-Daga (2007). Passchier et al. (1983) found that both types of headache were positively related to "achievement motivation." Merikangas et al. (1993) is the only study we know of to conclude that migraine headache was associated with neuroticism but tension headache was not.

[27] Although Add Health contained no items specifically about secondary or tension headaches, at Wave I respondents were asked, "[In the last 12 months,] how often have you had a headache? Responses included "never," "just a few times," "about once a week," "almost every day," and "everyday." Respondents who reported having headaches at least once per week were defined as suffering from non-migraine headach.

in absolute magnitude than the corresponding estimate for migraine headache. There is one PSM estimate that is statistically significant at conventional levels, but it is positive: females who reported suffering from non-migraine headaches at least once a week had higher GPAs than their counterparts who did not suffer from frequent non-migraine headaches. We interpret this pattern of results as evidence that the negative relationship between migraine headache and educational attainment is not attributable to neuroticism.

VIII. Instrumental Variables Estimation

An alternative method of disentangling the effect of migraine from that of other difficult-to-measure factors at the family or individual level is through instrumental variables (2SLS) estimation. Drawing on evidence that migraine headache is highly inheritable[28], we estimate the following first-stage equation:

$$(4) \qquad Migraine_i = \alpha_0 + \boldsymbol{\alpha'_1 X_i} + \alpha_2 \, Mother\ Migraine_i + u_i,$$

where $Mother\ Migraine_i$ is equal to 1 if the respondent's biological mother was reported to have suffered from migraine headache at Wave I, and is equal to 0 otherwise, and $\boldsymbol{X_i}$ includes the controls listed in Appendix 1B as well as school and grade fixed effects.

First-stage estimates show that $Mother\ Migraine_i$ is a strong predictor of the probability that a respondent suffered from migraine headache (Appendix Table 4, columns 1-3). The F-statistic for the null hypothesis that $Mother\ Migraine_i$ is unrelated

[28] Russell and Olesen (1995) found that first-degree relatives of migraineurs were at increased risk of migraine headache. For instance, they found that having a first-degree relative who suffered from migraine headache with aura was associated with an almost four-fold increase in the likelihood of suffering from migraine headache with aura. Specific gene mutations have been linked to familial hemiplegic migraine (FHM) and sporadic hemiplegic migraine (SHM), rare and particularly severe subtypes of migraine headache (De Fuso et al. 2003; Vries et al. 2007). See also Anttila et al. (2008).

to the probability that the respondent suffered from migraine headache is over 200 in the full sample, and still easily satisfies the instrument relevance standard proposed by Staiger and Stock (1997) when the sample is split by gender.

The assumption behind the instrumental variables identification strategy is that maternal migraine status is uncorrelated with the error term of equation (1). As an informal test of this assumption, we add $Mother\ Migraine_i$ to the right-hand side of equation (1) and examine whether it has an independent effect on educational attainment controlling for $Migraine_i$. The results provide little evidence that mother's migraine status is related to high school grade point average or years of schooling completed (Appendix Table 4, columns 4-6).

The first row Table 7 presents second-stage estimates for the full sample; the second row presents second-stage estimates for male respondents; and the third row presents second-stage estimates for female respondents. The results provide further evidence that migraine headache imposes a cost in terms of human capital accumulation. In fact, the 2SLS estimates are often larger in absolute magnitude than those obtained using OLS. Specifically, we find that migraine headache is associated with a 0.198-point decrease in high school grade point average, 0.451 fewer years of schooling, a 0.154 decrease in the probability of high school graduation, and a 0.134 decrease in the probability of college attendance. Across these educational outcomes, the estimated migraine effects are larger and more precise when the sample is restricted to females than when male respondents are examined separately.

2SLS estimates are only informative in the absence of other channels through which the biological mother's migraine status could affect the respondent's educational

attainment. One potential concern is that mothers who suffered from migraine headache may also have suffered from other unmeasured health problems that are inheritable. Another potential concern is that mothers with migraine headache may have been unable to devote as much time and resources to the production of child education as their non-migraineur counterparts.

To address these concerns, we experiment with augmenting the vector $\boldsymbol{X_i}$ with indicators of parental health, whether the respondent's family moved to the neighborhood because of the quality of the school system, whether the parent who filled out the Add Health parental questionnaire was a member of the local parent teacher association, the intensity of the parent's desire that their child go to college, and the degree to which the respondent's parents valued scholastic brilliance.[29]

When these controls are added to the vector $\boldsymbol{X_i}$, 2SLS estimates of the effect of migraine headache on school attainment remain negative and significant (columns 4-6 of Table 7), and in some cases are actually larger than the 2SLS estimates produced without the extra controls. We interpret this pattern of results as evidence that mothers' migraine status does not proxy for mother's educational involvement or general physical health.

[29] Indicators of parental health were based on responses to the question, [h]ow is your general physical health? The possible responses were,, "excellent,""very good," "good," "fair," and "poor." A dichotomous measure of whether the respondent moved to the area because of school quality was based on responses to the question, "[y]ou live here because the schools here are better than they are in other neighborhoods?" Parental aspirations with regard to their children's scholastic performance were based on responses to the question, " [i]f {NAME} could be one of the following in high school, which would be most important to you?" Possible responses were, "a brilliant student," "a leader in school activities," "an athletic star," "the most popular," and "(He/she) has already graduated from high school." Parental expectations of college attendance were based on responses to the question, "[h]ow disappointed would you be if {NAME} did not graduate from college?" Possible responses were,"very disappointed," "somewhat disappointed," and "not disappointed." Finally, we assessed involvement in official school organizations using responses to the following question, "[p]lease tell me whether you are a member of any of the following: Parent/teacher organization."

Another method of testing whether unobservables correlated with parental involvement or family background drive the results in Table 7 is through the use of falsification tests. This strategy requires identifying a set of outcomes that could be related to these unobservables, but, in theory, should unaffected by migraine headache.

We examine the relationship between migraine headache and six such outcomes measured at Wave I: an indicator equal to 1 if the respondent reported being suspended from school in the previous year, and equal to 0 otherwise; an indicator of whether the respondent had more than one unexcused school absence in the past year; an indicator equal to 1 if the respondent felt "close" to his or her schoolmates; an indicator for whether the respondent had smoked marijuana in the past 30 days; the log of the number of hours of television watched per week; and an indicator of whether the respondent played 5 or more hours of video games per week. Because there are no studies in the medical literature showing that migraine headache is related to these outcomes, a causal interpretation of the results presented in Table 7 would be called into question if 2SLS produced evidence of migraine effects with these alternative outcomes.

Table 8 shows the falsification test results. Without exception, the estimated effect of migraine headache falls short of statistical significance at conventional levels. Moreover, the estimated coefficient is often of the opposite sign than would be expected if migraine headache were capturing the effect of unobservables. For instance, in the full sample migraine headache is associated with a (statistically insignificant) 0.030 *decrease* in the probability of the respondent had more than one unexcused school absence in the past year and a 0.011 *decrease* in the probability of using marijuana in the last 30 days. This pattern of results bolsters the case for interpreting the results in Table 7 as causal.

IX. School Absences, Difficulty Paying Attention in Class, and Difficulty Completing Homework as Potential Mediators

Each of the identification strategies pursued thus far has pointed to a negative relationship between migraine headache and educational attainment. We turn next to an exploration of whether the effect of migraine headache can be attributable to reduced school attendance and difficulty concentrating. Specifically, we add controls for excused absences from school, difficulty paying attention in class, and difficulty completing homework to the vector $\boldsymbol{X_i}$ in order to examine the change in the estimated migraine effect.

The first column of Table 9 reproduces the 2SLS estimate of the relationship between migraine headache and high school GPA originally presented in Table 7. In column (2) of Table 9, we show what happens to this estimate with the inclusion of a set of indicators based responses to the question, "[h]ow many times have you been absent from school for a full day with an excuse—for example, because you were sick or out of town?" Controlling for excused absences reduces the 2SLS by 27 percent (from -0.209 to -0.153) suggesting that migraine headache impacts high grades, at least in part, through this route.

Column (3) of Table 9 presents 2SLS estimates controlling for the respondent's ability to concentrate through the inclusion of two sets of indicators, the first based on the responses to the question, "[d]uring the school year, how often did you have trouble paying attention in class," the second based on a similarly worded question with regard to "getting your homework done." Adding these controls to the vector $\boldsymbol{X_i}$ reduces the estimated migraine effect from -0.209 to -0.136, a decline of nearly 35 percent. When

excused absences and the concentration measures are included simultaneously as controls (column 4), nearly half of the migraine effect on high school GPA is explained. When this exercise is repeated using the remaining outcome variables, the pattern of results is similar. Excused absences from school and concentration problems explain on the order of 30 to 40 percent of the estimated migraine effects.[30]

X. Conclusion

Migraine headache can make even the simplest of tasks almost impossible to perform. Students who suffer from migraine headaches are often forced to miss school, and, if they attend school, report that their productivity is reduced (Lipton et al. 2007). To the extent that migraines headache makes attendance and studying more difficult, it can be thought of as increasing the cost of remaining in school; to the extent that it inhibits learning, it can be thought of as decreasing the returns to remaining in school.

Using cross tabulation, past studies have produced evidence that migraine headache is negatively related to years of schooling and grades (Breslau et al.1991; Bigal et al. 2001; Waldie et al. 2002; Waldie and Poulton. 2002). However, this relationship could the result of socioeconomic status, unobservable factors at the family level, or even reverse causality. Despite the fact that migraine headache affects approximately one out of ten adults living in the United States (Breslau and Rasmussen 2001), and can clearly be debilitating, there has been no previous attempt of which we are aware to assess the causal effect of migraine headache on educational attainment.

[30] A similar exercise was conducted using the sibling sample and adding family fixed effects. The results are shown in Appendix Table 5. Again, we find that excused absences from school and difficulty paying attention in school and completing homework explain a portion of the estimated migraine effect. For high school GPA, years of schooling completed, and college attendance, the estimated migraine effect is reduced by approximately 20 percent when these mediating variables are included. These mediating factors explain nearly 84 percent of the estimated effect of migraine effect on high school graduation.

This study uses longitudinal data from the Add Health to investigate the effect of migraine headache on educational attainment. The advantage of longitudinal data is that we are able to observe the migraine status of respondents before completing their desired educational attainment, reducing the possibility that reverse causality is driving our results. We pursue a wide range of empirical strategies in order to address potential endogeneity issues. Across these strategies, our results provide consistent evidence that migraine headache is associated with sharp decreases in human capital accumulation.

For instance, when the sample is restricted to siblings and within-family variation is used for identification, migraine headache is associated with a 0.124 decrease in high school GPA, or a 5 percent decrease for the typical Add Health respondent. An instrumental variables approach, which relies on cross-family variation for identification, produces an estimate of comparable magnitude. Our results suggest that the effect of migraine headache is not limited to high school grades. Migraine headache is associated with a .067 to 0.134 decrease in the probability of college attendance, and smaller, less precise decreases in the probability of high school graduation. On average, migraineurs obtained between 0.15 and 0.26 fewer years of schooling than their counterparts who did not suffer from migraine headaches, a decrease of 1.1 to 2.0 percent.

The impact of migraine headache on educational attainment can, in part, be attributed to increased excused absences from school and difficulty paying attention in class and completing homework. Controlling for these factors reduces the estimated effect of migraine headache on high school grades by 27 percent, and the estimated effects of migraine headache on the other measures of educational attainment fall by 30 to 40 percent. This pattern of results suggests that school absences and difficulty

concentrating are important pathways through which migraine headache impacts educational attainment.

These results in this study are based on a sample of individuals who were attending middle or high school in 1995. Since then, a number of new prescription migraine medications from a class of drugs called tripans have come onto the market and are now in wide use. Although no medication is 100 percent effective, the introduction of new, more effective drugs may have altered the relationship between migraine headache and educational attainment observed in the Add Health data.

It should be noted, however, that many sufferers delay taking prescription medications when they sense a headache coming on, and some choose to avoid taking them altogether. For instance, one study found that approximately two thirds of migraineurs delayed or avoided taking prescription drugs due to concerns about their side effects, which include difficulty concentrating, dizziness, nausea, and sleepiness (Gallagher and Kunkel 2003). If these side effects inhibit learning, then aggressively treating a migraine attack may not yield benefits in terms of human capital acquisition. In fact, it is possible that the relationship between migraine headache and educational attainment has become more pronounced in the years since the first wave of the Add Health was administered as migraine sufferers increasingly rely on prescription medications with side effects that are potentially as detrimental to learning as the pain and other symptoms they are intended to treat.

References

Abbate-Daga, Giovanni, Secondo Fassino, Rossana Lo Giudice, Innocenzo Rainero, Carla Gramaglia, Lucrezia Marech, Federico Amianto, Salvatore Gentile, and Lorenzo Pinessi. 2007. "Anger, Depression and Personality Dimensions in Patients with Migraine without Aura." Psychotherapy and Psychosomatics, Vol. 76., No. 2, pp. 122-128.

Anttila, Verneri, Dale R. Nyholt, Mikko Kallela, Ville Artto, Salli Vepsalainen, Eveliina Jakkula, Annika Wennerstro, Paivi Tikka-Kleemola, Mari A. Kaunisto, Eija Hamalainen, Elisabeth Widen, Joseph Terwilliger, Kathleen Merikangas, Grant W. Montgomery, Nicholas G. Martin, Mark Daly, Jaakko Kaprio, Leena Peltonen, Markus Farkkila, Maija Wessman, and Aarno Palotie. 2008. "Consistently "Replicating Locus Linked to Migraine on 10q22-q23." American Journal of Human Genetics, Vol. 82, No. 5, pp. 1051-1063.

Berg, Jenny. 2004. "Economic Evidence in Migraine and Other Headaches: A Review." European Journal of Health Economics, Vol. 5, Supplement 1, pp. S43-S54.

Bigal, E.M., R. B. Lipton, P. Winner, M. L. Reed, S. Diamond, and W. F. Stewart. 2007. "Migraine in Adolescents: Association with Socioeconomic Status and Family History." Neurology, Vol. 69, No. 1, pp. 16-25.

Bigal, Eduardo M., Maciel J. Bigal, Michelle Betti, Carlos A. Bordini, and Jose G. Speciali. 2001. "Evaluation of the Impact of Migraine and Episodic Tension-Type Headache on the Quality of Life and Performance of a University Student Population." Headache, Vol. 41, No. 7, pp. 710–719.

Boz, Cavit, Sibel Velioglu, Mehmet Ozmenoglu, Kemal Sayar, Zekeriya Alioglu, Bulent Yalman, and Murat Topbas. 2004 Temperament and Character Profiles of Patients with Tension-Type Headache and Migraine." Psychiatry and Clinical Neurosciences, Vol. 58, No. 5, pp. 536-543.

Brandt, J., D. Celentano, W. Stewart, M. Linet, and M.F. Folstein. 1990. "Personality and Emotional Disorder in a Community Sample of Migraine Headache Sufferers." American Journal of Psychiatry, Vol. 147, No 3, pp. 303-308.

Breslau, Naomi and Glenn C. Davis. 1992. "Migraine, Major Depression and Panic Disorder: A Prospective Epidemiologic Study of Young Adults." Cephalalgia, Vol. 12, No. 2, pp. 85-90.

Breslau Naomi, Glen C. Davis. 1993. "Migraine, Physical Health and Psychiatric Disorder: A Prospective Epidemiologic Study in Young Adults." Journal of Psychiatric Research, Vol. 27, No. 2, pp. 211-221.

Breslau Naomi, Glen C. Davis, and Patricia Andreski. 1991. "Migraine, Psychiatric Disorders, and Suicide Attempts: An Epidemiologic Study of Young Adults." Psychiatry Research, Vol. 37, pp. 11–23.

Breslau, Naomi and Patricia Andreski. 1995. "Migraine, Personality, and Psychiatric Comorbidity." Headache, Vol. 35, No. 7, pp. 382-386.

Breslau, Naomi and Birthe K. Rasmussen. 2001. "The Impact of Migraine Epidemiology, Risk Factors, and Co-Morbidities." Neurology, Vol. 56, Supplement 1, pp. S4-S12.

Brody, Jane E. 1988. "Personal Health." New York Times, Thursday October 13. Available at: http://www.nytimes.com/1988/10/13/us/health-personal-health.html

Busato, Vittorio V., Frans J. Prins, Jan J. Elshout, and Christian Hamaker. 2000. "Intellectual Ability, Learning Style, Achievement Motivation and Academic Success of Psychology Students in Higher Education." Personality and Individual Differences, Vol. 29, No. 6, pp.1057–1068.

Cao, Ming, Shiyang Zhang, Keyong Wang, Yehan Wang, and Wei Wang. 2002. "Personality Traits in Migraine and Tension-Type Headaches: A Five-Factor Model Study." Psychopathology, Vol. 35, No.4, pp.:254-258.

Clarke, C.E., L. MacMillan, S. Sondhi, and N.E. Wells. 1996. "Economic and Social Impact of Migraine." Q J M, Vol. 89, No. 1, pp. 77–84.

De Fusco, Maurizio, Roberto Marconi, Laura Silvestri, Luigia Atorino, Luca Rampoldi, Letterio Morgante, Andrea Ballabio, Paolo Aridon, and Giorgio Casari. 2003. "Haploinsufficiency of ATP1A2 Encoding the Na+/K+ Pump α^2 Subunit Associated with Familial Hemiplegic Migraine Type 2." Nature Genetics, Vol. 333, No. 2, pp. 192-196.

De Raad, Boele and Henri C. Schouwenburg. 1996. "Personality in Learning and Education: A Review" European Journal of Personality, Vol. 10, No. 5, pp. 303-336.

Fletcher, Jason M. 2008. "Adolescent Depression: Diagnosis, Treatment, and Educational Attainment. Health Economics. Vol. 17, No. 11, pp. 1215-1235.

Gaist, D., L. Pedersen, C. Madsen, I. Tsiropoulos, S. Sindrup, M. McGue, B. Krogh Rasmussen, and K. Christensen. 2005. "Long-Term Effects of Migraine on Cognitive Function: A Population-Based Study of Danish Twins." Neurology, Vol. 64, No. 4, pp. 600-607.

Gallagher, R. Michael and Robert Kunkel. 2003. "Migraine Medication Attributes Important for Patient Compliance: Concerns about Side Effects May Delay Treatment." Headache: The Journal of Head and Face Pain, Vol. 43, No.1, pp. 36-43.

Gladstein, Jack. 2006. "Secondary Headache." Current Pain and Headache Reports, Vol. 10, No. 5, pp. 382-386.

Halamandaris, K. F., and K. G. Power. 1999. "Individual Differences, Social Support and Coping with Examination Stress: A Study of the Psychosocial and Academic Adjustment of First Year Home Students." Personality and Individual Differences, Vol. 26, No. 4, pp. 665-685.

Harris, Kathleen Mullan, Carolyn Tucker Halpern, Pamela Entzel, Joyce Tabor, Peter S. Bearman, and J. Richard Udry. 2008. The National Longitudinal Study of Adolescent Health: Research Design [WWW document]. URL: http://www.cpc.unc.edu/projects/addhealth/design

Harris, David R. and Justin L. Thomas. 2002. "The Educational Costs of Being Multiracial: Evidence from a National Survey of Adolescents," Research Report No. 02-521, Population Studies Center at the Institute of Social Research, University of Michigan.

Heaven , Patrick C. L., Anita Mak, Jocelyn Barry, and Joseph Ciarrochi. 2002. "Personality and Family Influences on Adolescent Attitudes to School and Self-Rated Academic Performance." Personality and Individual Differences, Vol. 32, No. 3, pp. 453–462.

Headache Classification Subcommittee of the International Headache Society. 2004. "International Classification of Headache Disorders, 2nd edition." Cephalalgia, Vol. 24, No S1, pp. 8-160.

Jette, Nathalie, Scott Patten, Jeanne Williams, Werner Becker, and Samuel Wiebe. 2008. "Comorbidity of Migraine and Psychiatric Disorders-A National Population-Based Study." Headache: The Journal of Head and Face Pain, Vol. 48, No. 4, pp. 501-516.

Kaniecki, Robert G. 2002. "Migraine and Tension-Type Headache An Assessment of Challenges in Diagnosis." Neurology, Vol. 58, No. 9, pp. S15-S20

Kelman, Leslie and Jeanetta C. Rains. 2005. "Headache and Sleep: Examination of Sleep Patterns and Complaints in a Large Clinical Sample of Migraineurs." Headache: The Journal of Head and Face Pain, Vol. 45 No. 7, pp, 904-910.

Kentle, Robert L. 1997. "Elements of Neuroticism in Relation to Headache Symptomatology." Psychological Reports, Vol. 80. No. 1, pp. 227-235.

Laidra, Kaia, Helle Pullmann, and Juri Allik. 2007. "Personality and Intelligence as Predictors of Academic Achievement: A Cross-Sectional Study from Elementary to Secondary School." Personality and Individual Differences, Vol. 42, pp. 441–451.

Leijdekkers, M.L. and J. Passchier 1990. "Prediction of Migraine using Psychophysiological and Personality Measures." Headache, Vol. 30, No. 7, pp. 445-53.

Levine, David I. and Gary Painter. 2003. "The Costs of Teenage Out-of-WedlockChildbearing: Analysis with a Within-School Propensity Score Matching Estimator," Review of Economics and Statistics, Vol. 85, No. 4, pp. 884-900.

Lipton, Richard B., Walter F. Stewart , Seymour Diamond, Merle L. Diamond, Michael L. Reed. 2001. "Prevalence and Burden of Migraine in the United States: Data from the American Migraine Study II." Headache, Vol. 41, No. 7, pp. 646-57.

Lipton, R. B, M. E. Bigal, M. Diamond, F. Freitag, M. L. Reed, and W. F. Stewart. 2007. "Migraine Prevalence, Disease Burden, and the Need for Preventive Therapy." Neurology, Vol. 68, No. 5, pp. 343-349

Lyngberg, A. C., B. K. Rasmussen, T. Jørgensen1, and R. Jensen. 2005. "Incidence of Primary Headache: A Danish Epidemiologic Follow-up Study." American Journal of Epidemiology, Vol. 161, No. 11, pp. 1066-1073.

Mattsson, P. and L. Ekselius. 2002. "Migraine, Major Depression, Panic Disorder, and Personality Traits in Women Aged 40-74 Years: A Population-Based Study." Cephalalgia, Vol. 22, No. 7, pp. 543-551.

Merikangas, Kathleen R., Denise E. Stevens, and Jules Angst. 1993. "Headache and Personality: Results of a Community Sample of Young Adults." Journal of Psychiatric Research, Vol. 27, No. 2, pp. 187-196.

Michalopoulos, Charles, Howard S. Bloom, and Carolyn J. Hill 2004. "Can Propensity-Score Methods Match the Findings from a Random Assignment Evaluation of Mandatory Welfare-to-Work Programs?" The Review of Economics and Statistics, Vol. 86, No. 1, Pages 156-179.

Nylander, Per-Olof, Paul Schlette, Sven Brändström, Marita Nilsson, Thomas Forsgren, Lars Forsgren, and Rolf Adolfsson. 1996. "Migraine: Temperament and Character. Journal of Psychiatric Research, Vol. 30, pp. 359–368.

O'Brien, Bernie, Ron Goeree, and David Streiner. 1994. "Prevalence of Migraine Headache in Canada: A Population-Based Survey." International Journal of Epidemiology, Vol. 23, No. 5, pp. 1020-1026

Mocan, H. Naci and Erdal Tekin. 2006. "Catholic Schools and Bad Behavior: A Propensity Score Matching Analysis." Contributions to Economic Analysis and Policy, Vol. 5, No. 1, Article 13.

Passchier, J., H. van der Helm-Hylkema, and J.F. Orlebeke. 1983. "Personality and Headache Type: A Controlled Study." Headache, Vol. 24, No. 3, pp. 140-146.

Passchier, J. and J.F. Orlebeke "Headaches and Stress in Schoolchildren: An Epidemiological Study." 1985. Cephalalgia, Vol. 5, No. 3, pp.167-176.

Pradalier, Andre, Jean-Paul Auray, Abdelkader El Hasnaoui, Kazem Alzahouri, Jean-Francois Dartigues, Gerard Duru, Patrick Henry, Michel Lanteri-Minet, Christian Lucas, Guy Chazot, and Anne-Francois Gaudin. 2004. "Economic Impact of Migraine and Other Episodic Headaches in France: Data from the GRIM2000 Study." Pharmacoeconomics, Vol. 22, No. 15, pp. 985-999.

Rasmussen, Birthe K. 1992. "Migraine and Tension-Type Headache in a General Population: Psychosocial Factors." International Journal of Epidemiology, Vol. 21, No. 6, pp.1138-1143.

Rosenbaum, P. R., and Rubin, D. B. 1983. "The Central Role of the Propensity Score in Observational Studies for Causal Effects." Biometrika Vol. 70, No. 1, pp. 41–55.

Russell, Michael B. 2004. "Epidemiology and Genetics of Cluster Headache. Lancet Neurology, Vol. 3, No. 5, pp. 279-83.

Russell, Michael B. and Jes Olesen. 1995. "Increased Familial Risk and Evidence of Genetic Factor in Migraine." British Medical Journal, Vol. 311, No. 7004, pp. 541-544.

Scher, A. I., G. M. Terwindt, S.J. Picavet, M.M. Verschuren, M. D. Ferrari, and L. J. Launer. 2005. "Cardiovascular Risk Factors and Migraine: The GEM Population-Based Study." Neurology, Vol. 64, No. 4, pp. 614-620.

Schwartz, Brian S., Walter F. Stewart, David Simon, and Richard B. Lipton. 1998. "Epidemiology of Tension-Type Headache." Journal of the American Medical Association, Vol. 279, No. 5, pp. 381-383.

Stang, Paul.E. and Jane.T. Osterhaus. 1993. "Impact of Migraine in the United States: Data from the National Health Interview Survey." Headache, Vol. 33, No. 1, pp. 29-35.

Stewart, Walter F., Martha S. Linet, David D. Celentano, Mark Van Natta, and Dewey Ziegler. 1991. "Age- and Sex-Specific Incidence Rates of Migraine with and without Visual Aura." American Journal of Epidemiology, Vol. 134, No. 10, pp. 1111-1120.

Stewart, Walter F. Richard B. Lipton, David D. Celentano, and Michael L. Reed. 1992. "Prevalence of Migraine Headache in the United States. Relation to Age, Income, Race, and Other Sociodemographic Factors." The Journal of the American Medical Association, Vol. 267, No. 1, pp. 64-69.

Stewart, Walter F., Richard B. Lipton, and Joshua Liberman. 1996. "Variation in Migraine Prevalence by Race." Neurology, Vol. 47, No. 1, pp. 52–59.

Stronks, D.L., J.H. Tulen , L. Pepplinkhuizen , R. Verheij , G.W. Mantel , P. Spinhoven, and J. Passchier. 1999. "Personality Traits and Psychological Reactions to Mental Stress of Female Migraine Patients." Cephalalgia, Vol. 19, No. 6, pp. 566-74.

Veiga, Paula Veloso da and Ronald P. Wilder. 2009. "Maternal Smoking During Pregnancy and Birthweight: A Propensity Score Matching Approach." Maternal and Child Health Journal, Vol. 12, No. 2, pp. 194-203.

Vries, B. de, T. Freilinger, K.R.J. Vanmolkot, J. B. Koenderink, A. H. Stam, G. M. Terwindt, E. Babini, E. H. van den Boogerd, J. J.M.W. van den Heuvel, R. R. Frants, J. Haan, M. Pusch, A. M.J.M. van den Maagdenberg, M. D. Ferrari, and M. Dichgans. 2007. "Systematic Analysis of Three FHM Genes in 39 Sporadic Patients with Hemiplegic Migraine." Neurology, Vol. 69, No. 23, pp. 2170-2176

Waldie, Karen E., Markus Hausmann, Barry J. Milne, and Richie Poulton. 2002. "Migraine and Cognitive Function: A Life-Course Study." Neurology, Vol. 59, No. 6, pp. 904-908.

Waldie, Karen E. and Richie Poulton. 2002. "The Burden of Illness Associated With Headache Disorders Among Young Adults in a Representative Cohort Study." Headache: The Journal of Head and Face Pain, Vol. 42, No. 7, pp. 612-619

Zwart, J.A., G. Dyb, K. Hagen, K.J Ødegård, A.A Dahl, G. Bovim, and L.J. Stovner. 2003. "Depression and Anxiety Disorders Associated with Headache Frequency. The Nord-Trøndelag Health Study." European Journal of Neurology, Vol. 10, No. 2, pp. 147-152.

Table 1A. Means of Outcome Variables and Migraine Status by Gender

	Full Sample		
	All	Males	Females
Dependent Variables			
High School GPA	2.55 (0.828) [7,726]	2.40 (0.834) [3,734]	2.69 (0.796) [3,992]
Years of School Attained	13.4 (2.07) [9,592]	13.2 (2.02) [4,657]	13.6 (2.09) [4,935]
High School Diploma	0.827 (0.378) [9,586]	0.800 (0.400) [4,657]	0.853 (0.355) [4,929]
College Attendance	0.596 (0.491) [9,586]	0.550 (0.498) [4,657]	0.640 (0.480) [4,929]
Key Independent Variable			
Migraine	0.122 (0.328) [9,592]	0.102 (0.302) [4,657]	0.142 (0.349) [4,935]

Notes: All means were obtained using unweighted data drawn from Waves I and III of the National Longitudinal Study of Adolescent Health. Standard deviations are in parentheses and sample sizes are in brackets.

Table 1B. Mean Migraine Headache Rates by Educational Attainment and Gender

	HS GPA ≥ 3.5 (1)	HS GPA < 3.5 (2)	HS Grad (3)	Dropout (4)	College (5)	No College (6)
All	0.095	0.122	0.116	0.155	0.104	0.149
	(0.294)	(0.328)	(0.320)	(0.362)	(0.305)	(0.356)
	[1,055]	[6,667]	[7,928]	[1,658]	[5,716]	[3,870]
Males	0.080	0.097	0.096	0.125	0.084	0.124
	(0.271)	(0.298)	(0.295)	(0.330)	(0.277)	(0.330)
	[377]	[3,357]	[3,726]	[931]	[2,562]	[2,095]
Females	0.104	0.148	0.133	0.194	0.121	0.179
	(0.306)	(0.355)	(0.339)	(0.396)	(0.326)	(0.384)
	[682]	[3,310]	[4,202]	[727]	[3,154]	[1,775]

Notes: Means are based on unweighted data drawn from Waves I and III of the National Longitudinal Study of Adolescent Health. Standard deviations are in parentheses and sample sizes are in brackets.

Table 2. OLS Estimates of the Effect of Migraine Headache on Educational Attainment

	HS GPA	Years of Schooling	HS Diploma	College
	(1)	(2)	(3)	(4)
All	-0.081***	-0.234***	-0.038***	-0.067***
	(0.028)	(0.057)	(0.013)	(0.014)
	[7,726]	[9,592]	[9,586]	[9,586]
Males	-0.099**	-0.187***	-0.021	-0.058***
	(0.040)	(0.073)	(0.019)	(0.018)
	[3,734]	[4,657]	[4,657]	[4,657]
Females	-0.072**	-0.268***	-0.050***	-0.074***
	(0.035)	(0.080)	(0.015)	(0.019)
	[3,992]	[4,935]	[4,929]	[4,929]

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Notes: Estimates are from separate unweighted OLS regressions using data from Waves I and III of the National Longitudinal Study of Adolescent Health. All models include the control variables listed in Appendix Table 1. Standard errors corrected for clustering on the school are in parentheses and sample sizes are in brackets.

Table 3. Estimates of the Effect of Migraine Headache with School and Grade Fixed Effects

	HS GPA		Years of Schooling		HS Diploma		College	
	OLS (1)	SGFE (2)	OLS (3)	SGFE (4)	OLS (5)	SGFE (6)	OLS (7)	SGFE (8)
All	-0.074**	-0.071**	-0.224***	-0.162***	-0.037***	-0.031**	-0.064***	-0.048***
	(0.030)	(0.030)	(0.059)	(0.060)	(0.013)	(0.013)	(0.015)	(0.015)
	[7,518]	[7,518]	[9,269]	[9,269]	[9,263]	[9,263]	[9,263]	[9,263]
Males	-0.086**	-0.095**	-0.191***	-0.131*	-0.021	-0.019	-0.055***	-0.038**
	(0.039)	(0.041)	(0.073)	(0.075)	(0.020)	(0.021)	(0.018)	(0.019)
	[3,642]	[3,642]	[4,516]	[4,516]	[4.516]	[4,516]	[4,516]	[4,516]
Females	-0.068*	-0.060	-0.252***	-0.167**	-0.049***	-0.043***	-0.070***	-0.052**
	(0.036)	(0.037)	(0.080)	(0.079)	(0.015)	(0.014)	(0.020)	(0.020)
	[3,876]	[3,876]	[4,753]	[4,753]	[4,747]	[4,747]	[4,747]	[4,747]

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Notes: Estimates from separate unweighted fixed effects regressions using data from Waves I and III of the National Longitudinal Study of Adolescent Health. Models include the control variables listed in Appendix Table 1 along with school and grade fixed effects. Standard errors corrected for clustering at the school level are in parentheses and sample sizes are in brackets.

Table 4. Propensity Score Matching Estimates of the Effect of Migraine Headache on Educational Attainment

	HS GPA		Years of Schooling		HS Diploma		College	
	Unmatched	PSM	Unmatched	PSM	Unmatched	PSM	Unmatched	PSM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All	-0.099***	-0.090**	-0.403***	-0.257**	-0.054***	-0.009	-0.102***	-0.084***
	(0.029)	(0.044)	(0.066)	(0.105)	(0.012)	(0.017)	(0.016)	(0.020)
	[7,314]	[1,540]	[9,012]	[1,930]	[9,008]	[1,926]	[9,008]	[1,926]
Males	-0.148***	-0.109	-0.461***	-0.166	-0.058***	-0.013	-0.113***	-0.086**
	(0.047)	(0.073)	(0.099)	(0.149)	(0.019)	(0.018)	(0.025)	(0.034)
	[3,342]	[568]	[4,257]	[746]	[4,257]	[746]	[4,257]	[746]
Females	-0.117***	0.035	-0.438***	-0.026	-0.065***	-0.040*	-0.109***	-0.045
	(0.037)	(0.048)	(0.087)	(0.120)	(0.014)	(0.024)	(0.020)	(0.034)
	[3,659]	[918]	[4,594]	[1,114]	[4,590]	[1,112]	[4,590]	[1,112]

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Notes: Estimates from separate unweighted propensity score matching procedures using data from Waves I and III of the National Longitudinal Study of Adolescent Health. All models include the control variables and additional matching variables listed in Appendix Table 1. Bootstrapped standard errors are in parentheses and sample sizes are in brackets. Nearest neighbor propensity score matching was used with propensity scores less than or equal to 0.002. Treatment observations with a propensity score greater than the maximum or less than the minimum propensity score of the control group were dropped from the analysis, as were treatment observations with a propensity score match in the lowest decile. Nearest neighbor matching was conducted without replacement.

Table 5. Family Fixed Effects Estimates of the Effect of Migraine Headache on Educational Attainment

	HS GPA		Years of Schooling		HS Diploma		College	
	OLS	FFE	OLS	FFE	OLS	FFE	OLS	FFE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All	-0.115*	-0.124**	-0.254	-0.222	-0.044	-0.043	-0.077*	-0.079*
	(0.070)	(0.059)	(0.174)	(0.151)	(0.037)	(0.039)	(0.042)	(0.041)
	[214]	[214]	[280]	[280]	[280]	[280]	[280]	[280]
Brother Pairs	-0.241*	-0.258**	-0.371	-0.477**	-0.060	-0.169***	-0.085	-0.085
	(0.127)	(0.108)	(0.237)	(0.221)	(0.057)	(0.061)	(0.064)	(0.064)
	[63]	[63]	[73]	[73]	[73]	[73]	[73]	[73]
Sister Pairs	-0.151	-0.078	-0.582**	-0.418*	-0.009	0.018	-0.180***	-0.168**
	(0.111)	(0.112)	(0.263)	(0.220)	(0.065)	(0.089)	(0.068)	(0.080)
	[86]	[86]	[104]	[104]	[104]	[104]	[104]	[104]

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Notes: Estimates from separate unweighted regressions using data on siblings from Waves I and III of the National Longitudinal Study of Adolescent Health. Fixed effects models control control for age, PPVT score, BMI-for-age percentile, heigh-for-age percentile, whether the whether the adolescent had an older sibling, and gender. OLS models used the controls are listed in Appendix Table 1. Standard errors corrected or clustering at the family level are in parentheses and sample sizes are in brackets.

Table 6. Propensity Score (PSM) and Family Fixed Effects (FFE) Estimates of Effect of Non-Migraine Headache on Educational Attainment

	HS GPA		Years of Schooling		HS Diploma		College	
	PSM	FFE	PSM	FFE	PSM	FFE	PSM	FFE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All	0.020	0.003	0.029	-0.171	-0.014	-0.013	-0.001	-0.016
	(0.034)	(0.065)	(0.060)	(0.143)	(0.013)	(0.026)	(0.002)	(0.037)
	[2,838]	[281]	[3,500]	[414]	[3,496]	[414]	[3,496]	[414]
Males	-0.009	0.226	0.051	-0.018	-0.021	0.002	0.007	0.024
	(0.056)	(0.138)	(0.137)	(0.291)	(0.021)	(0.052)	(0.024)	(0.076)
	[924]	[66]	[1,136]	[100]	[1,142]	[100]	[1,142]	[100]
Females	0.082*	0.036	-0.018	-0.355	0.006	0.011	0.002	0.018
	(0.043)	(0.065)	(0.090)	(0.248)	(0.018)	(0.044)	(0.023)	(0.058)
	[1,748]	[109]	[2,224]	[168]	[2,220]	[168]	[2,220]	[168]

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Notes: Estimates from separate unweighted regressions using data from Waves I and III of the National Longitudinal Study of Adolescent Health. The propensity score matching estimates are obtained using the nearest neighbor matching procedure described in Table 4. Propensity score models are estimated using the full set of control variables and additional matching variables listed in Appendix Table 1. Fixed effects models control for age, PPVT score, BMI-for-age percentile, height-for-age percentile, whether the adolescent had an older sibling, and gender. Bootstrapped standard errors appear in parentheses for propensity score matching models. Standard errors corrected for clustering at the family level are in parentheses for fixed effects models. Sample sizes appear in brackets.

Table 7. Two-Stage Least Squares (2SLS) Estimates of the Effect of Migraine Headache on Educational Attainment

	Panel I: Basic Controls				*Panel II: Added Parental Involvement Controls*			
	HS GPA	Years of Schooling	HS Grad	College	HS GPA	Years of Schooling	HS Grad	College
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All	-0.198*	-0.451*	-0.154***	-0.134**	-0.209*	-0.443*	-0.151***	-0.134**
	(0.120)	(0.249)	(0.047)	(0.064)	(0.120)	(0.249)	(0.047)	(0.063)
	[7,147]	[8,809]	[8,803]	[8,803]	[7,147]	[8,809]	[8,803]	[8,803]
First-Stage F-statistic	F = 212.8	F = 290.1	F = 289.8	F = 289.8	F = 201.3	F = 276.6	F = 276.4	F = 276.4
Males	-0.240	-0.211	-0.144**	-0.098	-0.227	-0.110	-0.137*	-0.079
	(0.189)	(0.398)	(0.073)	(0.101)	(0.186)	(0.397)	(0.073)	(0.103)
	[3,455]	[4,286]	[4,285]	[4,285]	[3,455]	[4,286]	[4,285]	[4,285]
First-Stage F-statistic	F = 80.4	F = 107.4	F = 107.3	F = 107.3	F = 67.5	F = 96.7	F = 96.7	F = 96.7
Females	-0.190	-0.597**	-0.160***	-0.152**	-0.213	-0.650**	-0.159***	-0.161***
	(0.149)	(0.272)	(0.054)	(0.064)	(0.148)	(0.275)	(0.055)	(0.065)
	[3,692]	[4,523]	[4,518]	[4,518]	[3,692]	[4,523]	[4,518]	[4,518]
First-Stage F-statistic	F = 164.8	F = 241.9	F = 242.0	F = 242.0	F = 171.5	F = 246.2	F = 246.2	F = 246.2

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Notes: Estimates from separate unweighted 2SLS regressions using data from Waves I and III of the National Longitudinal Study of Adolescent Health. All models include the control variables listed in Appendix Table 1 along with school and grade fixed effects. Panel II adds the matching variables in Appendix Table 1. Standard errors corrected for clustering on the school are in parentheses and sample sizes are in brackets.

Table 8. Falsification Tests

	Suspenstion from School	> 1 Unexcused School Absence	Close to Schoolmates	Marijuana in last 30 days	Log of TV Hours Per Wk	Play Video Games ≥ 5x Per Wk
	(1)	(2)	(3)	(4)	(5)	(6)
All	-0.001	-0.030	-0.114	-0.011	0.031	0.021
	(0.057)	(0.047)	(0.071)	(0.060)	(0.109)	(0.062)
	[8,805]	[8,790]	[8,803]	[8,668]	[8,795]	[8,812]
First-Stage F-statistic	F = 291.2	F = 293.5	F = 292.8	F = 306.0	F = 292.5	F = 291.2
Males	-0.006	-0.143	-0.152	0.017	0.101	-0.067
	(0.089)	(0.115)	(0.118)	(0.103)	(0.199)	(0.093)
	[4,288]	[4,278]	[4,286]	[4,201]	[4,286]	[4,290]
First-Stage F-statistic	F = 107.5	F = 106.8	F = 107.4	F = 112.0	F = 107.4	F = 107.6
Females	-0.011	0.025	-0.080	-0.026	0.012	0.088
	(0.072)	(0.068)	(0.098)	(0.054)	(0.154)	(0.083)
	[4,517]	[4,512]	[4,517]	[4,467]	[4,509]	[4,522]
First-Stage F-statistic	F = 243.3	F = 246.7	F = 245.8	F = 248.8	F = 248.8	F = 243.2

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Notes: Estimates from separate unweighted 2SLS regressions using data from Waves I and III of the National Longitudinal Study of Adolescent Health. All models include the control variables listed in Appendix Table 1 along with school and grade fixed effects. Standard errors corrected for clustering at the school level are in parentheses and sample sizes are in brackets.

Table 9. Examining Factors that Mediate 2SLS Estimates of Relationship Between Migraine Headache and Educational Attainment [1]

	HS GPA				*Years of Schooling*				*HS Grad*		*College*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Mirgaine Headache	-0.209*	-0.153	-0.136	-0.104	-0.443*	-0.325	-0.331	-0.267	-0.151***	-0.115***	-0.134**	-0.104*
	(0.120)	(0.123)	(0.117)	(0.122)	(0.229)	(0.240)	(0.242)	(0.244)	(0.047)	(0.044)	(0.063)	(0.063)
Exused Absences 1-2X: WI		-0.110***		-0.089***		-0.126**		-0.131**		-0.007		-0.016
		(0.032)		(0.031)		(0.055)		(0.065)		(0.012)		(0.018)
Excused Absense 3-10X: WI		-0.191***		-0.153***		-0.191***		-0.231***		-0.026**		-0.029
		(0.028)		(0.027)		(0.067)		(0.075)		(0.012)		(0.020)
Excused Absense >10X: WI		-0.335***		-0.281***		-0.562***		-0.382***		-0.081***		-0.078***
		(0.049)		(0.046)		(0.076)		(0.087)		(0.014)		(0.020)
Exused Absences 1-2X: WII		-0.135***		-0.119***		-0.145**		-0.101*		0.011		-0.020
		(0.029)		(0.030)		(0.062)		(0.054)		(0.015)		(0.019)
Excused Absense 3-10X: WII		-0.177***		-0.145***		-0.266***		-0.159**		0.023		-0.035
		(0.029)		(0.029)		(0.073)		(0.064)		(0.015)		(0.021)
Excused Absense >10X: WII		-0.313***		-0.248***		-0.462***		-0.509***		-0.004		-0.085***
		(0.045)		(0.044)		(0.082)		(0.074)		(0.021)		(0.023)
Trouble Pay Attention Once in Awhile: WI			-0.018	-0.010			0.020	0.032		0.006		-0.015
			(0.028)	(0.026)			(0.048)	(0.045)		(0.011)		(0.013)
Trouble Pay Attention Once per week: WI			-0.036	-0.017			0.056	0.087		0.003		-0.005
			(0.035)	(0.033)			(0.066)	(0.065)		(0.014)		(0.018)
Trouble Pay Attention Almost Everyday: WI			-0.138***	-0.117***			-0.235***	-0.201**		-0.022		-0.039*
			(0.042)	(0.039)			(0.086)	(0.086)		(0.017)		(0.020)

Table 9, Continued

	HS GPA				*Years of Schooling*				*HS Grad*		*College*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Trouble Pay Attention Everyday: WI			-0.211***	-0.168***			-0.137	-0.063		-0.061**		-0.030
			(0.053)	(0.052)			(0.105)	(0.101)		(0.031)		(0.035)
Trouble Pay Attention Once in Awhile: WII			-0.004	0.002			-0.067	-0.058		-0.016		-0.008
			(0.025)	(0.025)			(0.046)	(0.048)		(0.013)		(0.013)
Trouble Pay Attention Once per week: WII			-0.011	0.009			0.018	0.045		-0.026		0.012
			(0.035)	(0.034)			(0.069)	(0.070)		(0.017)		(0.020)
Trouble Pay Attention Almost Everyday: WII			-0.079**	-0.063			-0.057	-0.031		-0.023		0.017
			(0.040)	(0.039)			(0.095)	(0.093)		(0.019)		(0.021)
Trouble Pay Attention Everyday: WII			-0.056	-0.047			-0.047	-0.039		-0.018		-0.009
			(0.068)	(0.065)			(0.192)	(0.184)		(0.041)		(0.040)
Trouble Complete HW Once in Awhile: WI			-0.137***	-0.125***			-0.116**	-0.106**		-0.014		0.001
			(0.022)	(0.021)			(0.055)	(0.054)		(0.010)		(0.012)
Trouble Complete HW Once per week: WI			-0.255***	-0.247***			-0.238***	-0.216***		-0.024**		-0.011
			(0.030)	(0.028)			(0.060)	(0.058)		(0.011)		(0.015)
Trouble Complete HW Almost Everyday: WI			-0.342***	-0.321***			-0.473***	-0.446***		-0.073***		-0.061***
			(0.036)	(0.035)			(0.098)	(0.096)		(0.018)		(0.022)
Trouble Complete HW Everyday: WI			-0.377***	-0.375***			-0.539***	-0.530***		-0.081***		-0.051*
			(0.050)	(0.050)			(0.101)	(0.100)		(0.025)		(0.029)
Trouble Complete HW Once in Awhile: WII			-0.084***	-0.069***			-0.127***	-0.099**		-0.010		-0.013
			(0.021)	(0.021)			(0.049)	(0.049)		(0.011)		(0.013)

Table 9, Continued

	HS GPA				*Years of Schooling*				*HS Grad*		*College*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Trouble Complete HW Once per week: WII			-0.083*	-0.067			-0.250**	-0.215**		-0.008		-0.040**
			(0.044)	(0.043)			(0.100)	(0.098)		-0.018		(0.013)
Trouble Complete HW Almost Everyday: WII			-0.164***	-0.150***			-0.219**	-0.191*		-0.004		-0.019
			(0.038)	(0.038)			(0.100)	(0.101)		(0.020)		(0.022)
Trouble Complete HW Everyday: WII			-0.222***	-0.203***			-0.414***	-0.373**		0.058		-0.068**
			(0.057)	(0.055)			(0.155)	(0.161)		(0.037)		(0.034)
N	7,147	7,147	7,147	7,147	8,809	8,809	8,809	8,809	8,803	8,803	8,803	8,803

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Notes: Each estimate above comes from a separate unweighted 2SLS regression using data from Waves I and III of the National Longitudinal Study of Adolescent Health. All models include the control variables listed in Appendix Table 1 along with school and grade fixed effects. Standard errors corrected for clustering on the school are in parentheses.

Appendix Table 1A. Means of Outcome Variables and Migraine by Gender

	Family Fixed Effects Sample			IV Sample		
	All	Brothers	Sisters	All	Males	Females
Dependent Variables						
High School GPA	2.59 (0.845) [214]	2.45 (0.797) [73]	2.66 (0.865) [86]	2.57 (0.817) [7,147]	2.42 (0.824) [3,455]	2.71 (0.783) [3,692]
Years of School Attained	13.3 (2.21) [280]	13.0 (2.14) [73]	13.6 (2.39) [104]	13.5 (2.06) [8,809]	13.3 (2.02) [4,286]	13.7 (2.08) [4,523]
High School Diploma	0.796 (0.403) [280]	0.781 (0.417) [73]	0.798 (0.403) [104]	0.838 (0.369) [8,803]	0.810 (0.392) [4,258]	0.864 (0.343) [4,518]
College Attendance	0.539 (0.499) [280]	0.452 (0.501) [73]	0.577 (0.496) [104]	0.609 (0.488) [8,803]	0.562 (0.496) [4,258]	0.654 (0.476) [4,518]
Key Independent Variable						
Migraine	0.489 (0.501) [280]	0.493 (0.503) [73]	0.490 (0.502) [104]	0.122 (0.327) [8,809]	0.102 (0.303) [4,286]	0.141 (0.348) [4,523]

Notes: All means obtained using unweighted data drawn from Waves I and III of the National Longitudinal Study of Adolescent Health. Standard deviations are in parentheses and sample sizes are in brackets.

Appendix Table 1B. Means of Control Variables, Endogenous Matching Variables, Instruments, and Falsification Test Variables

	All	Males	Females
Control Variables			
Female	0.514	--	--
	(0.500)		
Log (household income)	10.5	10.5	10.4
	(0.818)	(0.810)	(0.825)
Parent graduated high school	0.289	0.284	0.294
	(0.453)	(0.451)	(0.456)
Parent attended trade school	0.095	0.099	0.092
	(0.294)	(0.298)	(0.289)
Parent completed some college	0.197	0.205	0.190
	(0.398)	(0.404)	(0.392)
Parent graduated college	0.143	0.147	0.139
	(0.350)	(0.354)	(0.346)
Parent attended grad school	0.092	0.093	0.092
	(0.290)	(0.291)	(0.289)
Black	0.209	0.192	0.225
	(0.407)	(0.394)	(0.418)
Indian	0.016	0.014	0.018
	(0.127)	(0.119)	(0.134)
Hispanic/Other	0.176	0.180	0.172
	(0.381)	(0.384)	(0.378)
Asian	0.061	0.064	0.057
	(0.238)	(0.246)	(0.231)
Age 22	0.260	0.262	0.258
	(0.439)	(0.440)	(0.438)
Age 23	0.256	0.256	0.257
	(0.437)	(0.436)	(0.437)
Age 24	0.199	0.204	0.194
	(0.399)	(0.403)	(0.395)

Appendix Table 1, Continued.

Age 25	0.057 (0.232)	0.063 (0.244)	0.051 (0.220)
Number of biological siblings at WI	1.64 (1.46)	1.66 (1.48)	1.62 (1.44)
Resondent has older sibling	0.505 (0.500)	0.509 (0.500)	0.501 (0.500)
Height-for-Age percentile at WI	56.5 (30.1)	59.4 (30.0)	53.8 (29.9)
BMI-for-Age percentile at WI	59.4 (28.3)	60.7 (28.8)	58.1 (27.7)
PPVT Score at WI	99.9 (14.9)	100.6 (14.8)	99.2 (15.0)
Parent never married	0.050 (0.218)	0.042 (0.201)	0.059 (0.232)
Parent divorced	0.143 (0.350)	0.150 (0.357)	0.137 (0.344)
Parent separated	0.047 (0.211)	0.043 (0.203)	0.050 (0.219)
Parent widowed	0.037 (0.188)	0.033 (0.810)	0.040 (0.825)
N	9,592	4,657	4,935
Additional Matching Variables			
RSE Score at WI	24.5 (3.52)	25.0 (3.36)	24.0 (3.69)
CES-D Score at WI	12.7 (8.26)	11.6 (7.40)	13.7 (8.88)
High blood pressure/hypertension (WIII)	0.061 (0.239)	0.058 (0.234)	0.063 (0.244)
Usually gets enough sleep at WI	0.689 (0.463)	0.730 (0.444)	0.651 (0.477)

Appendix Table 1, Continued.

Drunk every day in last year	0.007	0.009	0.004
	(0.081)	(0.096)	(0.065)
Drunk 3-5 days per week last year	0.014	0.019	0.008
	(0.116)	(0.138)	(0.091)
Drunk 1-2 days per week last year	0.040	0.050	0.030
	(0.196)	(0.218)	(0.172)
Drunk 2-3 days per month last year	0.053	0.061	0.045
	(0.0224)	(0.239)	(0.208)
Drunk once a month or less	0.072	0.076	0.070
	(0.259)	(0.264)	(0.255)
Drunk 1-2 times last year	0.142	0.129	0.154
	(0.349)	(0.335)	(0.361)
Drink but never drunk	0.199	0.181	0.217
	(0.400)	(0.385)	(0.417)
Don't feel at all close to mother	0.006	0.003	0.009
	(0.078)	(0.057)	(0.094)
Feel very little closeness with mother	0.026	0.019	0.032
	(0.159)	(0.138)	(0.177)
Feel somewhat close to mother	0.085	0.063	0.107
	(0.279)	(0.242)	(0.309)
Feel quite a bit close to mother	0.217	0.211	0.222
	(0.412)	(0.408)	(0.416)
No mother in home	0.049	0.050	0.047
	(0.215)	(0.218)	(0.212)
N	9,012	4,257	4,594
Instrument			
Biological mother has migraines	0.271	0.269	0.273
	(0.445)	(0.444)	(0.445)
N	8,809	4,286	4,523

Appendix Table 1, Continued.

Falsification Test Variables

Non-Migraine Headaches	0.254	0.166	0.340
	(0.435)	(0.372)	(0.474)
N	6,521	3,234	3,287
Suspended from school	0.282	0.365	0.204
	(0.450)	(0.482)	(0.403)
N	8,805	4,288	4,517
> 1 Unexcused Absence from school	0.256	0.282	0.232
	(0.438)	(0.450)	(0.422)
	8,790	4,278	4,512
Close to schoolmates	0.654	0.670	0.638
	(0.476)	(0.470)	(0.481)
N	8,803	4,286	4,517
Smoke marijuana in last 30 days	0.161	0.178	0.145
	(0.368)	(0.383)	(0.352)
N	8,668	4,201	4,467

Notes: All descriptive statistics are drawn from data from Waves I and III of the National Longitudinal Study of Adolescent Health. Means are unweighted and standard deviations appear in parentheses.

Appendix Table 2. Probit Estimates of Relationship Between Matching Variables and Probability of Migraines

	All	Males	Females
Female	0.175***	--	--
	(0.037)		
Log (household income)	-0.101***	-0.059	-0.142***
	(0.056)	(0.046)	(0.040)
Parent graduated high school	-0.111**	-0.256***	-0.049
	(0.056)	(0.091)	(0.076)
Parent attended trade school	-0.097	-0.130	-0.108
	(0.075)	(0.117)	(0.104)
Parent completed some college	-0.120*	-0.183*	-0.113
	(0.064)	(0.101)	(0.087)
Parent graduated college	-0.230***	-0.327***	-0.161
	(0.074)	(0.126)	(0.100)
Parent attended grad school	-0.279***	-0.420***	-0.209*
	(0.088)	(0.142)	(0.118)
Black	-0.010	0.054	-0.081
	(0.064)	(0.102)	(0.087)
Indian	0.051	0.023	0.006
	(0.151)	(0.251)	(0.197)
Hispanic/Other	-0.070	-0.142	-0.033
	(0.068)	(0.107)	(0.093)
Asian	-0.071	0.015	-0.201
	(0.101)	(0.149)	(0.145)
Age 22	0.064	-0.002	0.144
	(0.066)	(0.105)	(0.090)
Age 23	0.176**	0.211*	0.190*
	(0.082)	(0.127)	(0.116)
Age 24	0.226**	0.041	0.446***
	(0.098)	(0.152)	(0.138)

Appendix Table 2, Continued.

Age 25	0.349***	0.287	0.490***
	(0.123)	(0.186)	(0.176)
Number of biological siblings at WI	-0.022	-0.027	-0.023
	(0.015)	(0.023)	(0.021)
Resondent has older sibling	-0.014	-0.003	-0.019
	(0.041)	(0.063)	(0.056)
Height-for-Age percentile at WI	0.0003	-0.0003	0.0008
	(0.0001)	(0.001)	(0.0008)
BMI-for-Age percentile at WI	-0.0003	-0.001	0.0006
	(0.0006)	(0.001)	(0.0009)
PPVT Score at WI	0.003**	0.002	0.004**
	(0.002)	(0.002)	(0.002)
Parent never married	-0.101	0.047	-0.160
	(0.092)	(0.148)	(0.124)
Parent divorced	0.081	0.126	0.038
	(0.054)	(0.084)	(0.075)
Parent separated	0.193**	0.254*	0.184*
	(0.083)	(0.136)	(0.110)
Parent widowed	0.067	0.304**	-0.101
	(0.095)	(0.146)	(0.132)
RSE Score at WI	-0.009	-0.018*	-0.003
	(0.006)	(0.010)	(0.008)
CES-D Score at WI	0.008***	0.004	0.010***
	(0.003)	(0.004)	(0.003)
High blood pressure/hypertension (WIII)	0.178**	0.270**	0.079
	(0.071)	(0.109)	(0.099)
Usually gets enough sleep at WI	-0.123***	-0.070	-0.163***
	(0.040)	(0.064)	(0.053)
Drunk every day in last year	0.093	0.431*	-0.698
	(0.213)	(0.256)	(0.537)

Appendix Table 2, Continued.

Drunk 3-5 days per week last year	0.130	-0.258	0.580**
	(0.151)	(0.231)	(0.235)
Drunk 1-2 days per week last year	0.168*	0.327***	0.092
	(0.090)	(0.125)	(0.140)
Drunk 2-3 days per month last year	0.026	-0.029	0.122
	(0.083)	(0.129)	(0.116)
Drunk once a month or less	0.176**	0.230**	0.137
	(0.070)	(0.106)	(0.097)
Drunk 1-2 times last year	0.128**	0.182**	0.098
	(0.054)	(0.087)	(0.072)
Drink but never drunk	0.068	0.230***	-0.027
	(0.048)	(0.070)	(0.065)
Don't feel at all close to mother	-0.069	0.405	-0.221
	(0.219)	(0.403)	(0.278)
Feel very little closeness with mother	0.036	-0.173	0.192
	(0.108)	(0.210)	(0.133)
Feel somewhat close to mother	0.015	-0.104	0.082
	(0.064)	(0.116)	(0.081)
Feel quite a bit close to mother	-0.017	-0.138*	0.070
	(0.045)	(0.078)	(0.061)
No mother in home	-0.204**	-0.335**	-0.105
	(0.071)	(0.109)	(0.122)
N	9,012	4,257	4,594

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Notes: Estimates from separate unweighted probit regressions using data from Waves I and III of the National Longitudinal Study of Adolescent Health. Dummy variables for missing observations on independent variables are included as additional controls. Standard errors appear in parentheses.

Appendix Table 3. Covariate Balance between Treatment and Control Respondents, Means and p-values for Tests of Differences

	All		Males		Females	
	Treated	Control	Treated	Control	Treated	Control
Female	0.576	0.628	--		--	
	p = 0.14					
Log (household income)	10.3	10.5	10.4	10.3	10.4	10.2
	p = 0.58		p = 0.51		p = 0.11	
Parent graduated high school	0.317	0.326	0.297	0.305	0.328	0.331
	p = 0.83		p = 0.90		p = 0.96	
Parent attended trade school	0.108	0.122	0.113	0.102	0.094	0.103
	p = 0.52		p = 0.81		p = 0.73	
Parent completed some college	0.202	0.190	0.209	0.153	0.189	0.214
	p = 0.68		p = 0.32		p = 0.48	
Parent graduated college	0.113	0.127	0.121	0.068	0.119	0.076
	p = 0.58		p = 0.23		p = 0.14	
Parent attended grad school	0.070	0.068	0.066	0.068	0.072	0.055
	p = 0.91		p = 0.96		p = 0.48	
Black	0.205	0.212	0.198	0.250	0.212	0.211
	p = 0.78		p = 0.36		p = 0.97	
Indian	0.017	0.022	0.019	0.033	0.018	0.007
	p = 0.57		p = 0.46		p = 0.33	
Hispanic/Other	0.154	0.128	0.161	0.183	0.163	0.184
	p = 0.32		p = 0.66		p = 0.56	
Asian	0.045	0.044	0.051	0.017	0.040	0.020
	p = 0.93		p = 0.24		p = 0.27	
Age	22.7	22.8	22.7	22.8	22.7	22.8
	p = 0.19		p = 0.87		p = 0.37	
Number of biological siblings at WI	1.55	1.55	1.57	1.54	1.54	1.46
	p = 0.98		p = 0.91		p = 0.51	

Appendix Table 3, Continued.

Respondent has older sibling	0.489	0.466	0.490	0.423	0.488	0.486
	p = 0.55		p = 0.34		p = 0.95	
Height-for-Age percentile at WI	57.4	57.7	61.8	64.4	54.8	55.4
	p = 0.91		p = 0.53		p = 0.84	
BMI-for-Age percentile at WI	59.6	58.6	61.2	63.6	58.9	59.9
	p = 0.64		p = 0.56		p = 0.72	
PPVT Score at WI	103.3	92.0	109.5	118.3	93.3	113.9
	p = 0.39		p = 0.74		p = 0.16	
Parent never married	0.049	0.046	0.049*	0.000*	0.053	0.048
	p = 0.85		p = 0.08		p = 0.81	
Parent divorced	0.166	0.174	0.176	0.254	0.159	0.193
	p = 0.71		p = 0.15		p = 0.34	
Parent separated	0.054	0.066	0.046	0.100	0.059	0.054
	p = 0.46		p = 0.11		p = 0.82	
Parent widowed	0.039	0.032	0.038**	0.102**	0.037	0.034
	p = 0.61		p = 0.03		p = 0.90	
RSE Score at WI	24.2	23.9	24.8	24.3	23.7	23.4
	p = 0.14		p = 0.28		p = 0.39	
CES-D Score at WI	13.4*	14.5*	12.2	12.4	14.8	16.1
	p = 0.06		p = 0.78		p = 0.11	
High blood pressure/ hypertension (WIII)	0.067	0.084	0.070	0.067	0.074	0.068
	p = 0.38		p = 0.93		p = 0.81	
Usually gets enough sleep at WI	0.648	0.615	0.716	0.717	0.594	0.537
	p = 0.36		p = 0.99		p = 0.22	
Drunk every day in last year	0.006	0.009	0.003	0.000	0.002	0.000
	p = 0.66		p = 0.57		p = 0.61	
Drunk 3-5 days per week last year	0.013	0.018	0.016	0.017	0.002	0.007
	p = 0.63		p = 0.97		p = 0.31	
Drunk 1-2 days per week last year	0.051	0.049	0.054	0.050	0.036	0.048
	p = 0.90		p = 0.91		p = 0.51	

Appendix Table 3, Continued.

Drunk 2-3 days per month last year	0.058	0.058	0.056	0.050	0.059	0.054
	p = 0.98		p = 0.84		p = 0.82	
Drunk once a month or less last year	0.080**	0.124**	0.094	0.033	0.079	0.116
	p = 0.04		p = 0.12		p = 0.16	
Drunk 1-2 times last year	0.166	0.190	0.153	0.233	0.172	0.156
	p = 0.38		p = 0.12		p = 0.64	
Drink but never drunk	0.200	0.221	0.204	0.217	0.206	0.218
	p = 0.50		p = 0.82		p = 0.77	
Don't feel at all close to mother	0.006	0.000	0.003	0.000	0.007	0.007
	p = 0.24		p = 0.69		p = 0.96	
Feel very little closeness with mother	0.030	0.031	0.017	0.033	0.040	0.061
	p = 0.94		p = 0.36		p = 0.26	
Feel somewhat close to mother	0.098	0.124	0.067	0.033	0.122	0.116
	p = 0.26		p = 0.32		p = 0.83	
Feel quite a bit close to mother	0.228	0.238	0.204	0.200	0.239	0.279
	p = 0.73		p = 0.95		p = 0.32	
No mother in home	0.041	0.035	0.040	0.033	0.048	0.068
	p = 0.68		p = 0.80		p = 0.35	
N	1,930		746		1,114	

Notes: All descriptive statistics are drawn from data from Waves I and III of the National Longitudinal Study of Adolescent Health. Means are unweighted and based on nearest neighbor propensity score matched samples.

Appendix Table 4. Evidence on Instrument Relevance and Exogeneity

	Panel I: GPA Sample					
	Respondent has migraine (Instrument Relevance)			*HS GPA (Instrument Exogeneity)*		
	All	Males	Females	All	Males	Females
Biological mother has migraine	0.176***	0.144***	0.203***	-0.023	-0.023	-0.027
	(0.012)	(0.016)	(0.016)	(0.023)	(0.028)	(0.034)
F-stat on on instrument	F = 212.8	F = 80.4	F = 164.8			
Respondent has migraine				-0.065**	-0.083**	-0.055
				(0.031)	(0.042)	(0.041)
N	7,147	3,455	3,692	7,147	3,455	3,692
	Panel II: Years of Schooling Sample					
	Respondent has migraine (Instrument Relevance)			*Years of Schooling (Instrument Exogeneity)*		
	All	Males	Females	All	Males	Females
Biological mother has migraine	0.189***	0.157***	0.217***	-0.055	-0.010	-0.098
	(0.011)	(0.015)	(0.014)	(0.059)	(0.067)	(0.063)
F-stat on on instrument	F = 290.1	F = 107.4	F = 241.9			
Respondent has migraine				-0.158**	-0.148*	-0.145*
				(0.064)	(0.083)	(0.083)
N	8,809	4,286	4,523	8,809	4,286	4,523

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Notes: Estimates from separate unweighted OLS regressions using data from Waves I and III of the National Longitudinal Study of Adolescent Health. All models include the control variables listed in Appendix Table 1 and school and grade fixed effects. Standard errors corrected for for clustering at the school level are in parentheses and sample sizes are in brackets.

Appendix Table 5. Examining Factors that Mediate FE Estimates of Relationship Between Migraine Headache and Educational Attainment

	HS GPA		*Years of Schooling*		*HS Grad*		*College*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mirgaine Headache	-0.124**	-0.103*	-0.222	-0.184	-0.043	-0.007	-0.079*	-0.064
	(0.059)	(0.061)	(0.151)	(0.179)	(0.039)	(0.040)	(0.041)	(0.046)
Added Controls for Excused Absences, Trouble Paying Attention in Class and Completing Homework?	No	Yes	No	Yes	No	Yes	No	Yes
N	214	214	280	280	280	280	280	280

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Notes: Estimates from separate unweighted family fixed effects regressions using data from Waves I and III of the National Longitudinal Study of Adolescent Health. All models include the control variables listed in the note to Table 5. Standard errors are in parentheses.