

THE EFFECT OF CHILDHOOD CONDUCT DISORDER ON HUMAN CAPITAL

DINAND WEBBINK^{a,*}, SUNČICA VUJIĆ^b, PIERRE KONING^c and NICHOLAS G. MARTIN^d

^a*Erasmus School of Economics Rotterdam, Tinbergen Institute, Rotterdam, The Netherlands*

^b*London School of Economics and Political Science, London, United Kingdom*

^c*CPB Netherlands Bureau for Economic Policy Analysis and IZA, The Netherlands*

^d*Queensland Institute of Medical Research, Brisbane, Queensland, Australia*

SUMMARY

This paper estimates the longer-term effects of childhood conduct disorder on human capital accumulation and violent and criminal behavior later in life using data of Australian twins. We measure conduct disorder with a rich set of indicators based on diagnostic criteria from psychiatry. Using ordinary least squares and twin fixed effects estimation approaches, we find that early-age (pre-18) conduct disorder problems significantly affect both human capital accumulation and violent and criminal behavior over the life course. In addition, we find that conduct disorder is more deleterious if these behaviors occur earlier in life. Copyright © 2011 John Wiley & Sons, Ltd.

Received 12 April 2010; Revised 26 April 2011; Accepted 5 May 2011

JEL classifications: I1; I2; K42

KEY WORDS: conduct disorder; human capital; twins

1. INTRODUCTION

Many children have mental health problems, which hinder their normal development and functioning. Anxiety, conduct, attention, and depressive disorders are the most common. For example, up to 500,000 (14%) of Australian children between the ages of 4 and 18 years have significant mental health problems (Australian Centre for Community Child Health, 2006); up to 50% of ‘hard-to-manage’ pre-school children are likely to have continuing hardships requiring professional help; approximately one in five children and adolescents in the USA may have a mental health disorder (Currie and Stabile, 2006). Despite these large numbers, little is known about the longer-term effects of these mental health problems of children. Currie and Stabile (2009) note that most studies ‘assume that early mental health problems will have negative effects and focus on the efficacy of specific interventions’.

This paper analyses the longer-term effects of childhood conduct disorder on human capital accumulation and violent and criminal behavior later in life using data of Australian twins. If someone shows ‘a repetitive and persistent pattern of behavior in which the basic rights of others or major age-appropriate societal norms or rules are violated’, then he/she falls into a category of individuals with a conduct disorder problem. Conduct disorder is known as a ‘disruptive behavior disorder’ because of its impact on children and their families, neighbors, and schools and is largely associated with delinquent or criminal activity. We measure conduct disorder using diagnostic criteria from the American Psychiatric Association (APA, 1994). In line with Currie and Stabile (2009) we estimate effects on positive human capital, including measures such as grade repetition, marks in

*Correspondence to: Erasmus School of Economics Rotterdam, Tinbergen Institute, Rotterdam, The Netherlands.
E-mail: webbink@ese.eur.nl

high school and high school graduation, and on 'negative' human capital, including measures such as being arrested, spent time in jail, and physically attacking others.

The two main challenges in estimating the longer-term effects of childhood conduct disorder on human capital are the measurement of conduct disorder and omitted variable bias. This paper contributes to the economic literature by addressing these two main challenges. First, it is easy to know when a child has a fever but a child's mental health problem is harder to identify. Typically, mental health problems in children are diagnosed by asking a child's parents and teachers a series of questions about their behaviors. For instance, Currie and Stabile (2009) use six questions to form a conduct disorder scale. In this study, we can employ a much richer set of conduct disorder indicators. We use self-reports of adult twins on 21 statements that follow the definition of conduct disorder according to the APA criteria. In addition, the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) emphasizes that there should be at least three specific conduct disorder behaviors present within the same 12 month period to make the diagnosis of conduct disorder (APA, 1994). Our data include self-reports on a question that exactly matches this definition. Moreover, we have information whether the twin saw a doctor, psychologist or other professional for these behaviors. We used this information for constructing three measures of conduct disorder. Another contribution of this study is that we also have information on the age at which the conduct disorder behaviors occurred. We use this information to investigate the effects of the timing of the problem behaviors on human capital.

Second, estimates of the effect of conduct disorder on human capital might be confounded by unobserved differences between children and their families. For example, in Australia the incidence of mental health problems is even higher in disadvantaged children, such as Aboriginal children (24%), children residing in 'out-of-home care' (55–60%) and children with a disability, who are up to four times more likely to have mental health problems than children without a disability (Australian Centre for Community Child Health, 2006). Parental substance abuse, marital conflict, psychiatric illness, and child abuse and neglect have been identified as risk factors for conduct disorder (Searight *et al.*, 2001). Previous studies on the effects of childhood mental health problems mainly used cross-sectional and within-sibling estimation (Currie and Stabile, 2006, 2009; Fletcher and Wolfe, 2008).

In this paper, we estimate within-family models using the data of (identical) twins. We are aware of only one previous study (Le *et al.*, 2005) that also uses data on twins. The advantage of using twins instead of siblings is that the family circumstances for twins will typically be more similar than with siblings. More importantly, identical twins are genetically identical, whereas siblings on average only share half of their genetic endowments. Therefore, using data on twins, particularly those that are genetically identical, may reduce the bias caused by heterogeneity within families. In addition, we can further reduce this bias by controlling for differences in birth weight within pairs of identical twins. Recent research has shown that birth weight is an important predictor of later outcomes in life (Black *et al.*, 2007).

In the economic literature, several recent studies investigate the longer-term effects of mental health problems on human capital. Most papers find that mental disorders, and especially ADHD, have large negative effects on human capital accumulation. Currie and Stabile (2006) examine the relationship between hyperactivity (ADHD) symptoms and short-term human capital outcomes (test scores, grade repetition, special education, and delinquency). Using ordinary least squares (OLS) and within-sibling estimation, they find large negative effects on test scores and schooling attainment. Fletcher and Wolfe (2008) estimate the effect of ADHD on human capital. Their OLS results imply that children with ADHD face longer-term educational disadvantages. Once family fixed effects are controlled for, standard errors become larger, thus rendering insignificant estimation results. However, they find evidence for spill-over effects within families. Fletcher and Wolfe (2007) also investigated the effect of ADHD on self-reported crime. Controlling for sibling fixed effects, they find that both inattentive and hyperactive symptoms during childhood increase the likelihood of criminal behavior. Currie and Stabile (2009) address the effects of depression and conduct disorder (antisocial behavior/aggression). For the USA, they find that conduct disorder has negative effects on various human capital outcomes, whereas for Canada, they only find negative effects on the probability that 16- to 19-year-old youths are in school (fixed effect estimates for the other outcomes suggest negative effects but are statistically insignificant).

Le *et al.* (2005) investigated the effect of childhood conduct disorder on early school leaving and labor market outcomes in Australia, such as employment and earnings. Their findings suggest that individuals who experienced conduct disorder problems are more likely to leave school early, have poorer employment prospects and lower earnings. However, the within-twin estimates of the effect of conduct disorder on early school leaving conducted on the sample of identical twins are statistically not significant. They therefore conclude that genetic factors are responsible for the positive link between conduct disorder and early school leaving.

In this paper, we use the same data as Le *et al.* (2005) and also investigate the impact of conduct disorder on early school leaving (high school graduation). However, we address a broader range of outcomes. In addition to high school graduation, which can be seen as an indicator of the quantity of human capital, we also investigate the effects on grade repetition and marks in high school. These variables are related to other dimensions of human capital accumulation such as the time needed to attain a certain education level and the quality of the performance in high school. Moreover, we also focus on a set of indicators of negative human capital, such as aggressive and criminal behavior. This might be important because conduct disorder is largely associated with delinquent or criminal activity. Finally, by using three different measures, instead of one measure, of conduct disorder (see next section) we might improve the measurement of conduct disorder. This seems important as mental disorders typically are difficult to observe.

We find deleterious effects of conduct disorder on positive and especially on negative human capital, even within pairs of identical twins. For instance, within pairs of identical twins we find that conduct disorder reduces the probability of being arrested by 7 to 16% points. Another important finding is that the effect of conduct disorder on human capital is more deleterious if these behaviors occur earlier in life. A wide range of robustness checks suggest that our main estimates may be lower bounds of the true effect of conduct disorder on human capital. We conclude that childhood mental health problems have high human and financial costs for families and the society at large.

The remainder of this paper is organized as follows. The next section describes the data. Section 3 explains the methodology. Section 4 shows the main estimation results. Robustness checks are presented in Section 5. Section 6 concludes and discusses some policy implications.

2. DATA

In this study, we analyze data from the so-called younger cohort of twins of the Australian Twin Register (ATR), which were gathered in two surveys, in 1989–1990 and in 1996–2000. The surveys gathered information on the respondent's family background (parents, siblings, marital status, and children), socio-economic status (education, employment status, and income), health behavior (body size, smoking and drinking habits), personality, feelings, and attitudes. More details about the collection of the data can be found in Le *et al.* (2005) and in Appendix A1 in this paper.

2.1. Conduct disorder

The measurement of conduct disorder is crucial for our analysis. The American Psychiatric Association (APA) has defined a set of criteria for the diagnosis of conduct disorder such as: often initiated physical fights; has deliberately destroyed others' property; has broken into someone else's house, building, or a car; has often been truant from school, and so on (for a full definition, see Table A1 in the Appendix). Our data contains self-reported information (when twins were on average 30 years old) on 21 statements, which reflect these behavioral problems before the age of 18 years.

In the empirical analysis, we will use three measures of conduct disorder:

1. *Conduct disorder score* sums up occurrences of 21 behavioral statements above;
2. *APA Definition* is based on the question 'Did you do at least 3 of these things within the same 12-month period?';

- 2a. We use answer to the question 'How old were you the first time you did at least 3 of these things within the same 12-month period?' to investigate the effect of the timing of conduct disorder.
3. *Professional help* is based on the question 'Did you ever see a doctor, psychologist, social worker or any other professional like that because of these behaviors?'

The psychiatric handbook (APA, 1994) emphasizes that at least three conduct disorder behaviors should occur within the same 12-month period to make the diagnosis of conduct disorder. Because 'APA Definition' perfectly matches the definition of conduct disorder according to the American Psychiatric Association, we will use it as our main measure in the analysis. For a more detailed description on how these measures of conduct disorder are constructed, see Appendix A2.

2.2. Positive and negative human capital

In line with Currie and Stabile (2009), we distinguish between 'positive' and 'negative' human capital. Positive human capital is the type of human capital that is generally accumulated through schooling. Negative human capital is related with criminal, antisocial and violent activities. We use three measures of positive human capital: grade repetition, marks in high school, and high school graduation. Marks in high school are measured with a three-point scale (below average, average, better than average). High school graduation is a dummy variable for completing at least 11.5 years of education. We also use three measures of 'negative' human capital: 'physically attacking others'; 'being arrested since you were 18'; and 'spent time in jail'. All three negative human capital variables are dichotomous variables. Unfortunately, because of the routing of the questionnaire twins with a conduct disorder score of zero did not answer several questions on human capital. As this may bias the estimates downward, we checked the sensitivity of the results by imputing mean values on these outcomes for twins with no childhood conduct disorder (see Section 5.2). In the analysis, we use as covariates: mother's and father's education, age, age squared, gender, and birth weight.

The main variables in our analysis (conduct disorder, positive and negative human capital) are all based on self-reports. The reliability of these self-reported data is an important issue. In this paper, we use three different measures of conduct disorder, and one of our measures is based on 21 statements. We expect that the use of such a rich set of indicators improves the reliability of the data. Self-reports on conduct disorder have been shown to have acceptable reliability (Slutske *et al.*, 1997). In criminology, a large literature shows that self-reported data have consistently acceptable reliability and validity. Many studies find high correlations of self-reported data with other criterion-related measures of criminal frequency and arrest histories (Farrington, 1973; Maddux and Desmond, 1975; Huizinga and Elliott, 1986; Mieczkowski, 1990; Horney and Marshall, 1992; Hardt and Hardt, 1997; Weiss *et al.*, 1998). Thornberry and Krohn (2000) conclude that 'self-reported measures of delinquency are as reliable as, if not more reliable than, most social science measures'.

2.3. Descriptive statistics

Table I reports means of all measures for pairs of twins with non-missing information on conduct disorder symptoms. Column 1 (3) shows means for complete pairs of all (identical) twins. Column 2 (4) shows the number of twins with a within-family difference in the variable in question for the sample of all (identical) twins. The top panel shows that the average conduct disorder score is nearly 2. Currie and Stabile (2009) report averages of nearly 5 for the USA and 1.5 for Canada using a scale from 0 to 16. Hence, our Australian sample seems more comparable to the Canadian sample than to the US sample. The second row of Table I shows that 13 percent of our sample would be diagnosed as having conduct disorder according to the APA Definition; for men and women this is respectively 20 and 8 percent. This is roughly in line with Searight *et al.* (2001) who report that approximately 6 to 16 percent of boys and 2 to 9 percent of girls meet the diagnostic criteria for conduct disorder. The fraction of our sample that saw professional help is much smaller, approximately 3 percent.

The number of twins with a within-family difference on one of the three measures of conduct disorder is much larger in the sample of all twins than in the sample of identical twins (columns 2 and 4). This illustrates

Table I. Table of means for sample of children with all conduct disorder measures non-missing

	All twin pairs		Identical twins	
	Mean	Twin differences	Mean	Twin differences
Conduct disorder measures				
Conduct disorder score (1–21)	1.880	3596	1.674	1394
APA Definition	0.131	956	0.112	330
Professional help	0.027	264	0.024	92
Positive human capital				
Grade repetition	0.157	792	0.167	250
Marks high school (1–3)	2.3	2186	2.3	748
High school graduation	0.792	1102	0.790	197
Negative human capital				
3+ Attacking others	0.192	658	0.191	252
Arrested since 18 years old	0.074	290	0.069	102
Jail	0.019	70	0.018	22
Covariates				
Education mother	10.3		10.3	
Education father	10.5		10.5	
Age in 1996	29.9		29.9	
Gender (male = 1)	0.442		0.409	
Birth weight (grams)	2540		2430	
<i>N</i>	5322		2250	

The column 'Twin differences' shows the number of individuals with a within-twin pair difference on a specific variable. APA, American Psychiatric Association.

that genetic factors, that are exactly the same within pairs of identical twins, are important for the development of conduct disorder. The average (standard deviation) of the within twin differences for the conduct disorder score is 1.9 (2.5) for the sample of all twins and 1.7 (2.3) for the sample of identical twins. The intra-class correlation for the conduct disorder score is 0.63 for identical twins and 0.30 for fraternal twins. The smaller amount of variation in the sample of identical twins makes the estimates more vulnerable for measurement error (Griliches, 1979) and may limit the opportunities for finding significant effects of conduct disorder on human capital. It should also be noted that the number of pairs used in the estimation may be smaller because of missing values on human capital outcomes.

Nearly 39% of all twins reported negatively on all 21 statements of conduct disorder, and nearly 73% have a conduct disorder score of less than three.¹ This distribution is remarkably similar to the distribution of conduct disorder (antisocial/aggression) for Canada reported in Currie and Stabile (2009). As expected, the conduct disorder score for twins who reported 'yes' on the APA Definition or those who sought professional help are much higher; on average, more than 5 (4) points higher for the second (third) definition of conduct disorder. Behaviors most frequently reported are wagged school, staying out late, shop-lifting, misbehaved at school, and stole from home and family.

A first exploration of the relationship between conduct disorder and human capital is shown in Figure 1. The figure shows the association between the conduct disorder score and our measures of positive and negative human capital.²

The association between conduct disorder and human capital seems remarkably consistent for all measures of human capital. An increase of conduct disorder is associated with a decrease in positive human capital and an increase in negative human capital. For instance, higher levels of conduct disorder are associated with lower marks in high school and a lower probability of graduating from high school. In addition, higher levels of conduct disorder are associated with higher probabilities of attacking others, being arrested since the age of 18, or

¹These descriptives can be obtained from the authors on request.

²The associations are constructed by locally weighted least squares (LOWESS).

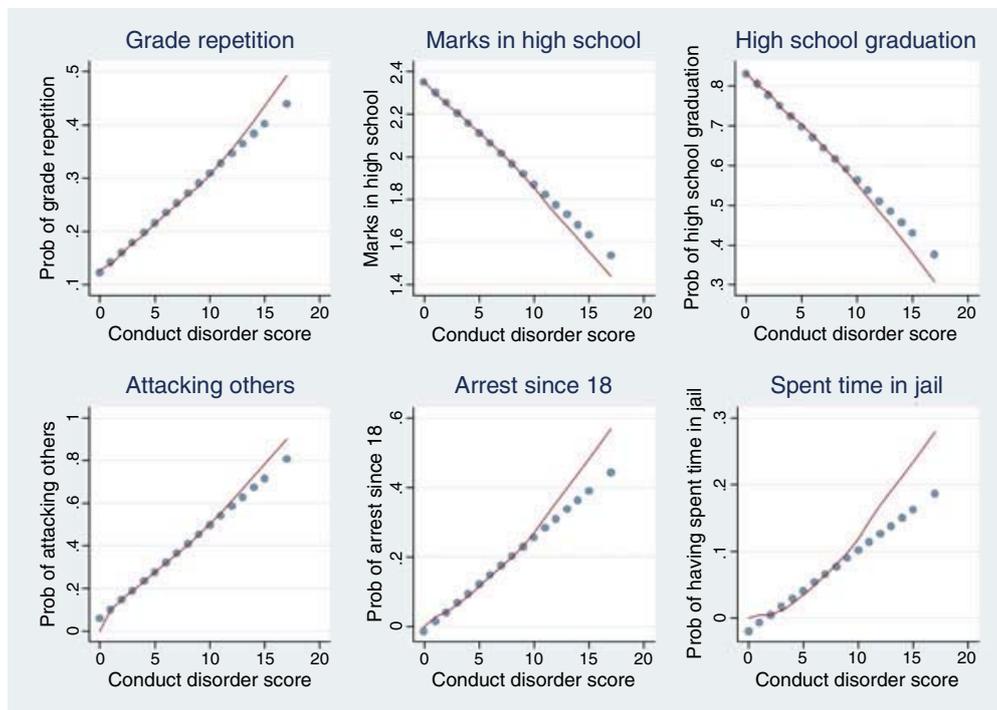


Figure 1. The associations between conduct disorder scores and human capital

having been incarcerated. In line with previous studies for the USA and Canada (Currie and Stabile, 2006, 2009), we find that the association between conduct disorder and human capital seems quite linear. Even low scores of conduct disorder are associated with lower human capital accumulation.

3. METHODOLOGY

We follow the same approach as in previous papers on the effects of childhood mental health problems on human capital accumulation. First, we estimate OLS models of the relationship between conduct disorder and positive and negative human capital outcomes. As these estimates might be biased by unobserved factors we proceed with estimating within-twin fixed effects models:

$$HC_{ij} = \alpha + \beta CD_{ij} + \gamma X_{ij} + f_j + \varepsilon_{ij}, \quad (1)$$

where HC_{ij} is a measure of positive/negative human capital; CD_{ij} is one of our three measures of conduct disorder; X_{ij} is a vector of covariates, consisting of age, gender, birth weight, and mothers' and fathers' education; f_j captures unobserved family effects common to all twins within the same family, and ε_{ij} is a random error term. Index i corresponds to the twin number; index j corresponds to the twin family id. In this model, the family fixed effects are removed by differencing within pairs of twins. Since our data contain information on the age of onset of the conduct disorder behavior according to the APA Definition, we also use OLS and within-twin fixed effects models to estimate the effect of the age at which conduct disorder behaviors occur on human capital accumulation. We constructed three indicator dummies by slicing up the age-of-onset range into three parts with approximately the same proportion of individuals: 3–12, 13–14 and 15–18 years. Hence, twins coded as zero on the APA Definition have a value of zero on these three dummies. Twins with age of onset of 17 years have a value of 1 on the dummy for the age range 15–18 years. For investigating the effect of age of onset of conduct disorder, we estimated the following fixed effects model:

$$HC_{ij} = \alpha + \beta CD_{ij}^{\leq 12} + \delta CD_{ij}^{13-14} + \lambda CD_{ij}^{15-18} + \gamma X_{ij} + f_j + \varepsilon_{ij} \quad (2)$$

It should be noted that the identification of the parameters in this equation mostly relies on within-twin pair comparisons of twins with conduct disorder and twins who do not report conduct disorder. As such, the estimates capture both effects due to conduct disorder and the timing of conduct disorder. Controlling for conduct disorder would enable identifying both effects. However, in our approach, this means that we need pairs of twins who both report positive on conduct disorder, but who differ in the timing of conduct disorder. Unfortunately, this is too demanding for the data at hand. In addition to Equation 2, we also estimated a specification which included years of conduct disorder (18 years—age onset) and years of conduct disorder squared.

There are several concerns with estimates based on within-family models. First, the estimates might be biased due to within-family heterogeneity. Most previous papers on mental health problems of children estimate within-family models using the data of siblings. However, siblings may differ in genetic endowments. In addition, the socio-economic conditions facing siblings and the parental inputs received by siblings may differ if family circumstances change over time. As we use data on (identical) twins, it seems less likely that our estimates will be biased by within-family heterogeneity. The family circumstances for twins will probably be more equal than for siblings who differ in age. More importantly, identical twins share exactly the same genes whereas siblings on average only share half of their genetic endowments. By estimating fixed effects models for a separate sample of identical twins, we control for all differences in genetic endowments. In addition, we test the robustness of the estimates by excluding pairs of twins with very large differences in educational attainment. Large differences in education might indicate that these twins are quantitatively different from the rest of the sample and introduce heterogeneity which will confound the effects we are looking for. Potential sources of within-family heterogeneity are coexisting conditions such as mood disorders (depression), anxiety, ADHD, or substance use disorders. For instance, Currie and Stabile (2009) found that conduct disorder is co-morbid with depression and ADHD. These coexisting conditions might induce omitted variable bias. We address this issue by including controls for a large set of self-reported physical and mental health conditions before the age of 14. These conditions were measured in the first survey (see Appendix A1). In addition, we control for self-reported depression measured in the second survey. Unfortunately, our data do not include measures of ADHD.

A second concern in within-family models is the measurement error. The within-family estimator exacerbates measurement error, which is likely to bias the estimates towards zero (Griliches, 1979). Unfortunately, our data do not provide a second independent measure of conduct disorder which can be used as an instrumental variable and might solve the problem of measurement error (Ashenfelter and Krueger, 1994). However, by using three measures of conduct disorder we aim to circumvent the measurement error problem. In addition, we investigated recall bias by regressing the APA Definition of conduct disorder on age (or age and age squared) controlling for gender, parents' education and birth weight. However, all estimates of the age coefficients are statistically insignificant. We also found no evidence for recall bias with respect to the age of onset of conduct disorder.

4. MAIN ESTIMATION RESULTS

We examine the effect of conduct disorder problems on different human capital outcomes using the three measures of conduct disorder. Table II reports the estimated effects of conduct disorder on six types of human capital using linear regression (probability) models. The first three columns show the estimated effects of conduct disorder on positive human capital, the last three columns show the estimated effects on negative human capital. The top panel shows the results using the conduct disorder score, the middle panel shows the results for the APA Definition of conduct disorder and the bottom panel shows the results using the professional help definition. In each panel, we first report OLS estimates, next we report fixed effects estimates for the sample of all twins and finally, we report fixed effects estimates for the sample of identical twins.³ All regressions include

³OLS estimates for the sample of identical twins are very similar to the OLS estimates for the total sample of twins. These results can be obtained from the authors on request.

Table II. Estimates of the effect of conduct disorder on positive and negative human capital

	Grade repetition	Marks high school	High school graduation	Attacking others	Arrested since 18 years old	Jail
Conduct disorder score						
OLS	0.017 (0.003)*** [0.116]	-0.049 (0.004)*** [-0.207]	-0.026 (0.003)*** [-0.157]	0.041 (0.004)*** [0.266]	0.026 (0.003)*** [0.253]	0.014 (0.003)*** [0.253]
<i>N</i>	5286	5270	5288	2180	2178	2176
Fixed effects, All twins	0.009 (0.003)*** [0.059]	-0.038 (0.005)*** [-0.159]	-0.013 (0.003)*** [-0.081]	0.037 (0.006)*** [0.241]	0.019 (0.004)*** [0.182]	0.011 (0.002)*** [0.193]
<i>N</i>	5286	5270	5288	2180	2178	2176
Fixed effects, Identical twins	0.011 (0.005)** [0.077]	-0.017 (0.009)** [-0.072]	-0.010 (0.006) [-0.059]	0.029 (0.011)*** [0.189]	0.011 (0.007) [0.103]	0.007 (0.003)** [0.134]
<i>N</i>	2238	2238	2236	888	888	886
APA Definition						
OLS	0.096 (0.019)*** [0.089]	-0.267 (0.026)*** [-0.155]	-0.136 (0.019)*** [-0.113]	0.179 (0.022)*** [0.196]	0.124 (0.017)*** [0.201]	0.048 (0.011)*** [0.147]
<i>N</i>	5224	5210	5226	2140	2138	2136
Fixed effects, All twins	0.057 (0.018)*** [0.053]	-0.180 (0.031)*** [-0.105]	-0.054 (0.020)*** [-0.045]	0.146 (0.029)*** [0.159]	0.076 (0.019)*** [0.122]	0.020 (0.010)** [0.060]
<i>N</i>	5224	5210	5226	2140	2138	2136
Fixed effects, Identical twins	0.091 (0.026)*** [0.085]	-0.025 (0.045) [-0.014]	-0.036 (0.032) [-0.030]	0.162 (0.044)*** [0.177]	0.067 (0.028)** [0.108]	0.022 (0.013)* [0.067]
<i>N</i>	2220	2220	2218	876	876	874
Professional help						
OLS	0.201 (0.039)*** [0.090]	-0.308 (0.049)*** [-0.086]	-0.218 (0.040)*** [-0.087]	0.153 (0.045)*** [0.084]	0.125 (0.038)*** [0.103]	0.137 (0.035)*** [0.211]
<i>N</i>	5370	5354	5372	2246	2244	2242
Fixed effects, All twins	0.105 (0.033)*** 0.047	-0.157 (0.059)*** -0.044	-0.126 (0.038)*** -0.050	0.022 (0.054) 0.012	0.061 (0.036)* 0.050	0.101 (0.017)*** 0.154
<i>N</i>	5370	5354	5372	2246	2244	2242
Fixed effects, Identical twins	0.109 (0.048)** 0.049	-0.088 (0.085) -0.025	-0.130 (0.061)** -0.052	0.001 (0.085) 0.000	0.157 (0.054)*** 0.128	0.081 (0.025)*** 0.125
<i>N</i>	2274	2274	2272	916	916	914

Each cell contains the estimate of a regression of a human capital measure on conduct disorder. All models control for birth weight, age, age squared, gender and parents' education. Standard errors in brackets, standardized coefficient in square brackets. APA, American Psychiatric Association; OLS, ordinary least squares.

***Significant at 1% level; **significant at 5% level; *significant at 10% level.

birth weight, age, age squared, gender, and parents' education as controls. Some of these variables drop out from the fixed effects specifications. Each cell shows the results of a separate estimation.

The estimates in Table II suggest that conduct disorder has a negative effect on human capital accumulation and a positive effect on violent and criminal behavior. The largest effects are found when using the OLS estimation. As expected, the size of the estimates reduces when twin fixed effects are taken into account. For the full sample of twins, all estimates, except for one, remain statistically significant. The standard errors increase when we restrict the sample to identical twins only. However, even for the sample of identical twins, where the variation in conduct disorder is much smaller than in the full sample of twins (see Table I), nearly all estimates of the effect of conduct disorder on violent and criminal behavior are statistically significant.

Most remarkable and compelling are the effects of conduct disorder on negative human capital. The estimates of the effects on the probability of being arrested since the age of 18 years and on the probability of

spending time in jail seem quite large and robust. In addition, the estimates of the effects of conduct disorder on the probability of physically attacking others are very large for the first two measures of conduct disorder.

The estimates of the effects on positive human capital also indicate detrimental effects of conduct disorder. We find negative and significant estimates of conduct disorder on high school graduation in the OLS and fixed effects regressions using the full sample of twins. However, the effects for the first two definitions of conduct disorder become statistically insignificant for the sample of identical twins only. This corroborates the previous findings by Le *et al.* (2005), who investigated the effects of the conduct disorder score on high school graduation and on years of education (the quantity dimension of human capital accumulation). For the third definition of conduct disorder, we find that conduct disorder decreases the probability of high school graduation by 13% points using the sample of identical twins only. It is likely that this third measure of conduct disorder identifies individuals with severe behavior problems, which hinder their development. The difference in findings with Le *et al.* (2005) might be explained by the focus of the third measure of conduct disorder on this specific group. The indicators 'grade repetition' and 'marks in high school' provide insight in the time needed for attaining a certain level and the performance in high school. The estimates on grade retention suggest that one additional point on the conduct disorder score increases the probability of grade retention by 1.1% point (0.9% point for the sample of all twins). This estimate is remarkably close to the within-sibling estimate of 0.8% point both for the USA and Canada reported by Currie and Stabile (2009). Conduct disorder as classified by the APA Definition increases the probability of grade retention by 9% points and with the third definition of conduct disorder, the estimated effect is 11% points. We also find a statistically significant effect of the conduct disorder score on marks in high school.

A cautionary note is in order for the results for the three indicators of positive human capital, because we do not have information on the exact timing of the dependent variables. It is not clear whether the conduct disorder behavior, measured before the age of 18, predated or followed these outcomes. We address the issue of reverse causality in the section on the robustness checks (Section 5.1).

To check for differences between men and women, we re-estimated the main models with an interaction term of conduct disorder and gender. In line with Le *et al.* (2005), we find that the effect of conduct disorder on high school graduation is stronger for women than for men. However, for the third definition of conduct disorder we find that the effect of conduct disorder on "grade repetition" and on "jail" is stronger for men than for women.

In general, we find the largest effects of conduct disorder for the third measure. The size of the estimates for the first and the second measure seems roughly comparable if we consider that twins with conduct disorder according to the APA Definition score approximately 5 points higher on the conduct disorder score. In addition, we constructed a variable similar to the APA Definition based on the conduct disorder score only. This variable equaled 1 if the individual had a conduct disorder score of at least 3, and equaled zero if the individual had a lower conduct disorder score. Hence, the 12-month restriction has been dropped. We compared the estimation results of the effect of this new variable with the estimation results of the effect of the APA Definition of conduct disorder. We find that the size of the estimates is somewhat smaller when using this new variable. In particular, the size of the coefficient estimates increases and becomes similar to the results with the APA Definition when we recode individuals with conduct disorder scores of 3 (or 3 and 4) from one to zero.

4.1. Non-linearity

We also investigated whether the effects are non-linear by estimating the effects of dummies for having a conduct disorder score of more than 5 or at least 10.⁴ This corresponds to the 90th and 99th percentile. It should be noted that focusing on these top percentiles reduces the variation in conduct disorder that can be used, especially in the sample of identical twins. For most outcomes the estimates suggest that the effects of conduct disorder are quite linear. For instance, for the sample of all twins, the within estimates using the dummy for at least

⁴The estimation results on non linearity and the four subscales of conduct disorder can be obtained from the authors on request.

10 conduct disorder behaviors (above the 98th percentile) seem quite comparable with most estimates in Table II. Hence, there is no clear evidence for non-linear effects of conduct disorder.

4.2. Effects of four subscales of conduct disorder

The APA criteria suggest that conduct disorder has four underlying components: aggression to people and animals, destruction of property, deceitfulness or theft and serious violations of rules. We investigated the effects of these components by decomposing the conduct disorder score into these four groups of the APA criteria. The estimation results suggest that 'serious violations of rules' is the most important component of conduct disorder for the accumulation of positive human capital. This is not very surprising as this subscale includes items like 'misbehaved', 'wagged school', and 'suspended/expelled'. For the other subscales the estimates do not show a clear pattern. The estimates of the effect on negative human capital suggest that all subscales are important. The size of the effects of 'aggression to people and animals' and 'destruction of property' on 'attacking others' is remarkable. 'Destruction of property', 'deceitfulness/theft', and 'violation of rules' seem the most important factors for the probability of arrest or jail.

4.3. The effect of the timing of conduct disorder behaviors

Several recent studies suggest that the timing of intervention programs is important for disadvantaged children. For instance, Carneiro and Heckman (2003) show that socio-economic differences in cognitive and non-cognitive abilities appear early in life and widen over the life cycle of the child. Currie and Stabile (2009) find that early mental health problems have large significant effects on cognitive test scores, even controlling for later mental health problems. Loeber (1982) suggests that the earlier a child began displaying antisocial behavior, the more likely he or she is to persist in such behavior. Farmer (1995), on the other hand, does not support the hypothesis that earlier onset is associated with more deleterious outcomes. She finds that later onset, rather than earlier, is associated with earlier school leaving and lower level qualifications.

We estimated the effect of the timing of conduct disorder on human capital by including three dummies for the age-of-onset ranges: 3–12, 13–14, and 15–18 years old (see Equation 2). The estimates in Table III suggest that the timing of conduct disorder behaviors matters for human capital accumulation, especially for negative human capital. An earlier occurrence of conduct disorder seems more detrimental. The largest estimates of the effect of conduct disorder on 'attacking others' are obtained for the two youngest age ranges. In addition, an early age of onset (before age of 12) has a strong effect on the probability of incarceration, whereas a later age of onset has no effect on this outcome. The timing of conduct disorder on positive human capital seems less important. The youngest age range seems most important for high school graduation, but the estimates for identical twins are statistically insignificant. We also estimated models in which we included the years of conduct disorder before the age of 18 and the square of this age. These estimates confirm that the effect of conduct disorder on human capital is more deleterious if these behaviors occur earlier but the impact of the timing differs between outcomes (see Table A2 in Appendix).

We also investigated whether there is a relationship between the socio-economic background of the twins and the effect of the timing of conduct disorder on human capital. As wealthier families have more resources to mitigate conduct disorder problems, we might expect smaller effects for twins from these families. We separated our sample in families with a father who completed high school and families with a father who did not complete high school. However, estimates, which include an interaction between socio-economic background and the timing of conduct disorder behaviors show little effect of socio-economic background. We only find that conduct disorder has a larger effect on the probability of physically attacking others in families in which the father did not complete high school than in other families. Currie and Stabile (2009) also found little evidence that parental income mitigates negative effects of mental health problems of children.

The findings in this section are based on self-reports. We are not aware of evidence regarding the accuracy of self-reported data on the timing of conduct disorder. Therefore, a cautionary note on measurement error is in order.

Table III. The effect of the timing of conduct disorder on positive and negative human capital

APA Definition	Grade repetition	Marks high school	High school graduation	Attacking others	Arrested since 18	Jail
OLS						
Age of onset						
≤12 years	0.052 (0.034)	-0.255 (0.057)***	-0.180 (0.037)***	0.246 (0.043)***	0.133 (0.036)***	0.084 (0.029)***
13–14 year	0.161 (0.033)***	-0.329 (0.048)***	-0.211 (0.033)***	0.176 (0.038)***	0.130 (0.030)***	0.032 (0.016)**
15–17 year	0.073 (0.025)***	-0.233 (0.033)***	-0.065 (0.025)***	0.150 (0.031)***	0.118 (0.024)***	0.040 (0.014)***
<i>N</i>	5224	5208	5224	2138	2136	2134
Fixed effects, All twins						
≤12 years	0.049 (0.033)	-0.154 (0.059)***	-0.052 (0.038)	0.231 (0.052)***	0.054 (0.035)	0.044 (0.017)***
13–14 year	0.084 (0.028)***	-0.206 (0.050)***	-0.121 (0.033)***	0.179 (0.047)***	0.097 (0.031)***	0.004 (0.015)
15–17 year	0.043 (0.024)*	-0.173 (0.043)***	-0.012 (0.028)	0.095 (0.038)**	0.074 (0.025)***	0.017 (0.012)
<i>N</i>	5224	5208	5224	2138	2136	2134
Fixed effects, Identical twins						
≤12 year	0.069 (0.050)	-0.114 (0.087)	-0.031 (0.062)	0.225 (0.083)***	0.067 (0.053)	0.100 (0.024)***
13–14 year	0.087 (0.042)**	0.003 (0.073)	-0.081 (0.052)	0.295 (0.074)***	0.079 (0.047)*	-0.008 (0.021)
15–17 year	0.103 (0.034)***	-0.005 (0.059)	-0.013 (0.042)	0.074 (0.055)	0.061 (0.035)*	0.005 (0.016)
<i>N</i>	2220	2220	2218	876	876	874

Estimates of a separate regression of human capital measures on three dummies for the age of onset of conduct disorder, using the same controls as in Table II. Standard errors are in brackets. APA, American Psychiatric Association; OLS, ordinary least squares.

***Significant at 1% level; **significant at 5% level; *significant at 10% level.

5. ROBUSTNESS CHECKS

5.1. Reverse causality

A caveat, with respect to the findings on positive human capital in Table II, is that we do not observe the exact timing of the dependent variables. Therefore, we cannot be sure whether the conduct disorder behaviors predated or followed these outcomes. However, with respect to the APA Definition of conduct disorder, respondents were asked: ‘Did these behaviors cause problems for you at school?’ This question enables us to address the issue of reverse causality, because it seems likely that for respondents who answered ‘yes’ to this question, the causation runs from conduct disorder to human capital accumulation. We therefore re-estimated the models for positive human capital after excluding twins with conduct disorder according to the APA Definition who answered ‘no’ on this question. Hence, we excluded twins for which the causation of the effects is not clear. The results are shown in Table IV.

We observe that the pattern of findings in Table IV is similar to the findings in Table II, although the size of most estimates is larger. Hence, our findings are robust for excluding respondents for which the causation of the effects is not clear.

5.2. Missing values because of the routing of the questionnaire

In Section 2.2 we noted that because of the routing of the questionnaire, twins with a conduct disorder score of zero did not answer questions on negative human capital. These missing values may bias the estimates downward as it seems likely that twins with no childhood conduct disorder behavior will, on average, accumulate more positive and less negative human capital than twins with problem behaviors early in life. We checked

Table IV. The effect of conduct disorder (APA Definition) on positive human capital after excluding twins who state that their conduct disorder behaviors did not cause problems at school

APA Definition	Grade repetition	Marks high school	High school graduation
OLS	0.156 (0.035)***	-0.375 (0.048)***	-0.207 (0.036)***
<i>N</i>	4402	4388	4406
Fixed effects, All twins	0.102 (0.030)***	-0.276 (0.054)***	-0.092 (0.035)***
<i>N</i>	4402	4388	4406
Fixed effects, Identical twins	0.098 (0.043)**	-0.139 (0.079) ¹	-0.071 (0.055)
<i>N</i>	1928	1928	1928

APA, American Psychiatric Association; OLS, ordinary least squares; FE, fixed effects.

***Significant at 1% level; **significant at 5% level; *significant at 10% level.

the sensitivity of the results by imputing the sample mean of the specific outcome for twins with missing values and a conduct disorder score of zero. Table V shows the estimation results for the APA Definition of conduct disorder.

After the imputation of these missing values, all estimates become statistically significant. We also observe that the size of most estimates increases. This suggests that because of the routing of the questionnaire, we underestimate the deleterious effects of conduct disorder on negative human capital. Hence, the size of the estimates in the previous section (Section 4) may be considered as a lower bound of the true effects of conduct disorder on these outcomes.

5.3. Excluding pairs of twins with large differences in educational attainment

As a third robustness check, we excluded pairs of twins with large differences in educational attainment (more than 5.5 years difference within pairs). Large differences in education might indicate that these twins are quantitatively different from the rest of the sample and introduce heterogeneity, which will confound the effects we are looking for. We find that the estimates hardly change after the exclusions of these pairs of twins.

5.4. Comorbidities

Many children with a conduct disorder may have coexisting conditions such as mood disorders (depression), anxiety, ADHD, or substance use disorders. These conditions might bias our estimates. To our knowledge, only Currie and Stabile (2009) have addressed the issue of comorbidity so far. They found that the incidence of

Table V. Estimates of the effect of conduct disorder (APA Definition) on positive and negative human capital after imputation of missing values because of the routing of the questionnaire

APA Definition	Attacking others	Arrested since 18 years old	Jail
OLS	0.176 (0.019)***	0.115 (0.015)***	0.043 (0.010)***
<i>N</i>	5184	5180	5178
Fixed effects, All twins	0.158 (0.019)***	0.084 (0.012)***	0.025 (0.006)***
<i>N</i>	5184	5180	5178
Fixed effects, Identical twins	0.166 (0.030)***	0.060 (0.018)***	0.021 (0.008)**
<i>N</i>	2200	2198	2196

Estimates from regressions of negative human capital on the APA Definition of conduct disorder. Missing values for human capital are imputed with mean values. APA, American Psychiatric Association; OLS, ordinary least squares.

***Significant at 1% level; **significant at 5% level; *significant at 10% level.

hyperactivity, depression and conduct disorder are correlated across individuals. In order to account for this, Currie and Stabile (2009) include all mental health scores plus the total combined score in their estimation model. This yields estimation results which are consistent with the results from models that only include one mental health problem, although the estimates are less precise. Their results of the effect of conduct disorder on human capital accumulation in the USA sample become statistically insignificant after including all other mental health scores.

To address the issue of comorbidity, we included controls for a large set of self-reported physical and mental health conditions before the age of 14 measured in the first survey (see Appendix A1). Respondents were asked whether they had had any of the following before they were 14 years old: migraine/sick headaches; depression; asthma; alcohol problems; sudden, involuntary movements (tics); sudden, involuntary noises or utterances (vocal tics); involuntary utterance of swear words; autism; stuttering or stammering; diabetes; epilepsy or suspected epilepsy; seizure, convulsion; treatment for schizophrenia; treatment for manic–depression; cleft lip; melanoma; and moles that were removed. Unfortunately, our data do not include measures of hyperactivity. We included dummies for these 17 conditions in the models that use the APA Definition of conduct disorder. The estimation sample becomes smaller because of missing values on these dummies. A comparison of these estimates with estimates of the main model using this smaller sample shows that the estimated effect of conduct disorder on positive and negative human capital hardly change after the inclusion of these 17 dummies.⁵ In addition, we are able to use measures of depression from the second survey (see Appendix A1). In particular, respondents were asked: ‘Has there ever been two weeks or more when you were depressed or down most of the day, nearly every day?’: ‘Has there ever been two weeks or more when you were a lot less interested in most things or unable to enjoy the things you used to enjoy, most of the day nearly every day?’ Moreover, the age of onset was asked. From these variables we constructed a dummy variable for depression before the age of 18. Table VI shows the estimation results of the models that include conduct disorder and an indicator of depression before the age of 18 years.

Controlling for depression before the age of 18 does not change the results. The estimated effects of conduct disorder in Table VI are slightly smaller but very similar to the previous results in Table II. Depression during childhood also seems important for both positive and negative human capital, which confirms findings by Currie and Stabile (2009). Remarkably, for the indicators of positive human capital, the largest effects of depression are found within pairs of identical twins. These findings suggest that the estimates of the effect of conduct disorder on human capital are robust for including measures of coexisting physical or mental health conditions. However, some caution is needed because there might be many coexisting conditions which are typically difficult to observe. In addition, we do not have measures of hyperactivity, which has been found to be comorbid with conduct disorder.

6. CONCLUSIONS

In this paper, we examine the relationship between conduct disorder problems before the age of 18 and human capital accumulation. The estimates suggest that conduct disorder before the age of 18 has a strong effect on violent and criminal behavior after the age of 18. In addition, we find that conduct disorder has a negative effect on positive human capital. For instance, depending on the measure being used, we find that conduct disorder reduces high school graduation with 4 to 13% points and increases the probability of being arrested with 7 to 11% points. Our data has also provided the opportunity to investigate whether the timing of conduct disorder matters. In general, we find that earlier occurrence of conduct disorder is more deleterious. Various robustness checks suggest that these estimates may be lower bounds of the true effect of conduct disorder on human capital accumulation. For instance, because of the routing of our survey, twins with a conduct disorder score of zero

⁵Results can be obtained from the authors on request.

Table VI. Estimates of the effect of conduct disorder (APA Definition) on positive and negative human capital after including an indicator of depression before the age of 18

APA Definition	Grade repetition	Marks high school	High school	Attacking others	Arrested since 18 years old	Jail
OLS						
Conduct disorder	0.095 (0.019)***	-0.266 (0.026)***	-0.135 (0.019)***	0.176 (0.022)***	0.122 (0.017)***	0.045 (0.010)***
Depression	0.023 (0.018)	-0.016 (0.032)	-0.017 (0.019)	0.050 (0.028)*	0.046 (0.021)**	0.044 (0.015)***
<i>N</i>	5224	5210	5226	2140	2138	2136
Fixed effects, All twins						
Conduct disorder	0.055 (0.018)***	-0.179 (0.031)***	-0.052 (0.020)**	0.143 (0.029)***	0.073 (0.020)***	0.018 (0.009)*
Depression	0.029 (0.019)	-0.021 (0.034)	-0.040 (0.022)*	0.052 (0.039)	0.049 (0.026)*	0.047 (0.013)***
<i>N</i>	5224	5210	5226	2140	2138	2136
Fixed effects, Identical twins						
Conduct disorder	0.087 (0.026)***	-0.019 (0.045)	-0.030 (0.032)	0.155 (0.044)***	0.068 (0.028)**	0.021 (0.013)
Depression	0.062 (0.027)**	-0.093 (0.048)*	-0.100 (0.034)***	0.133 (0.063)**	-0.022 (0.040)	0.013 (0.019)
<i>N</i>	2220	2220	2218	876	876	874

Estimates from regressions of human capital on the APA Definition of conduct disorder. APA, American Psychiatric Association; OLS, ordinary least squares

***Significant at 1% level; **significant at 5% level; *significant at 10% level.

did not answer most questions on negative human capital. The size of the estimates increases if we impute the sample means of negative human capital outcomes for these twins.

Previous research (Currie and Stabile, 2009) indicates that conduct disorder before the age of 18 can have large deleterious longer-term effects on positive and negative human capital. Our findings, which are based on a much richer set of indicators of conduct disorder and on data of twins instead of data of siblings, corroborate these results. The magnitude of their estimates on grade repetition is very similar to our findings, and their results for young adult delinquency are in the same range as our estimates on attacking others and probability of being arrested.⁶

Le *et al.* (2005), who used the same Australian data set, also investigated the effect of the conduct disorder score on the quantity of human capital accumulation (high school graduation and years of education). For the sample of identical twins, they find that the estimated effect is not statistically significant. We find basically the same effect for this measure. However, by investigating a broader set of indicators of human capital and by using three measures of conduct disorder instead of one, we find evidence for detrimental effects of conduct disorder, even in the sample of identical twins. These findings lead us to conclude that conduct disorder decreases investment in positive human capital and increases negative human capital.

An important issue that is still unresolved in the literature relates to the source of the variation in conduct disorder, in particular, the variation within pairs of twins. The literature is not clear about the origin of conduct disorder variation within pairs of twins and mentions a range of factors related to prenatal and birth conditions and the environment for child rearing (Loeber *et al.* 1998). It is difficult to assess to which extent these variables might also vary within pairs of twins and, accordingly, generate variation in conduct disorder within pairs of twins. With respect to the nurture–nature debate, the data at hand might give some insight. We find that approximately two-thirds of the variation in conduct disorder is captured by fixed effects. For the outcome variables,

⁶Currie and Stabile (2009) estimates using a 16-point scale range between 0.010 and 0.034, whereas our estimates using a 21-point scale for identical twins range from 0.011 to 0.029.

we find that fixed factors capture more than 50% of the variation in positive human capital and between 10 to 30% of the variation in negative human capital.⁷ The variation captured by fixed effects is informative on the maximum share that can be attributed to nature. The remaining part is apparently still 'up for grab' after childhood. This suggests that, especially with respect to negative human capital, there is a scope for environmental factors or intervention programs to improve outcomes.

The empirical findings in this paper lead us to conclude that early behavior problems have detrimental longer-term effects on human capital, especially on violent and criminal behavior later in life.

APPENDIX A

A1. Data collection and external validity

In 1980–1982, a sample of 4,262 twin pairs, born between 1964 and 1971, were registered with the Australian Twin Register (ATR) as children by their parents in response to media appeals and systematic appeals through the school system. In 1989–1992, when the twins were 18–25 years old, the first survey by mailed questionnaire was conducted, called Alcohol Cohort 2. The response rate of this questionnaire survey was 63%. In 1996–2000, the second survey was launched, called TWIN89. Telephone interviews were completed with 6,267 individuals, 2,805 men (889 complete and 1,027 incomplete pairs) and 3,462 women (1,215 complete and 1,032 incomplete pairs), who were 30 years old on average (range from 24 to 39) at the time of the interview. The individual response rate for this telephone interview was 86%. The interview was based upon a modified version of the SSAGA (Semi-structured Assessment of the Genetics of Alcoholism). Modifications were made to the SSAGA to incorporate DSM-IV criteria (APA, 1994), as well as to adapt it for telephone use. Interviews were administered by trained lay interviewers who were blind to the psychiatric status of the co-twin. Interviews were supervised by a qualified clinical psychologist with 4 years of experience who reviewed all interview protocols. In addition, all interviews were tape-recorded and random interview tapes were reviewed for quality control.

Le *et al.* (2005) compared this twin sample with data of Australian individuals from the *Youth in Transition* surveys and concluded that the patterns, in relation to school leaving decisions, are broadly similar to those obtained from samples representative of the general population. Slutske *et al.* (1997) noted that twins seem representative of the general population with respect to conduct disorder. They also compared the rates of conduct disorder in the so-called older cohort of Australian twins (we used the younger cohort) with the self-reported rate of conduct disorder for the general USA population measured in the National Comorbidity Study.⁸ They concluded that the Australian sample did not consistently differ with rates estimated for the general USA population.

Another issue is that severe cases of conduct disorder might be under-sampled or have a higher probability of attrition. We compared the rates of conduct disorder among twins concordant for participation in the second survey with the rates of conduct disorder among twins whose co-twin did not participate in the second survey. If twins with conduct disorder were systematically under-sampled, higher rates of conduct disorder would be expected among twins whose co-twin did not participate in the survey (assuming that conduct disorder status is correlated in twin pairs). We found however no difference between the two groups of twins in our sample. Slutske *et al.* (1997) and Heath *et al.* (1998) also found no evidence for cooperation bias or attrition bias in the so-called older cohort of Australian twins.

⁷The intra-class correlations for identical twins are 0.49 for high school graduation, 0.51 for marks in high school, 0.60 for grade repetition, 0.10 for attacking others, 0.18 for arrest, and 0.29 for jail.

⁸We do not include the data of the older cohort in this paper because questions on negative human capital have not been asked.

A2. The measurement of conduct disorder

Table A1 shows the criteria for the diagnosis of conduct disorder as defined by the American Psychiatric Association (APA).

Table A1. DSM-IV diagnostic criteria for conduct disorder

A	<p>Repetitive and persistent pattern of behavior in which the basic rights of others or major age-appropriate societal norms or rules are violated, as manifested by the presence of three (or more) of the following criteria in the past 12 months, with at least one criterion present in the past 6 months:</p> <p>Aggression to people and animals</p> <ol style="list-style-type: none"> 1. Often bullies, threatens, or intimidates others 2. Often initiates physical fights 3. Has used a weapon that can cause serious physical harm to others (e.g., a bat, brick, broken bottle, knife, gun) 4. Has been physically cruel to people 5. Has been physically cruel to animals 6. Has stolen while confronting a victim (e.g., mugging, purse snatching, extortion, armed robbery) 7. Has forced someone into sexual activity <p>Destruction of property</p> <ol style="list-style-type: none"> 1. Has deliberately engaged in fire setting with the intention of causing serious damage 2. Has deliberately destroyed other's property (other than by fire setting) <p>Deceitfulness or theft</p> <ol style="list-style-type: none"> 1. Has broken into someone else's house, building, or car 2. Often lies to obtain goods or favours to avoid obligations (i.e., "cons" others) 3. Has stolen items of nontrivial value without confronting a victim (e.g., shoplifting, but without breaking and entering; forgery) <p>Serious violations of rules</p> <ol style="list-style-type: none"> 1. Often stays out at night despite parental prohibitions, beginning before age 13 years 2. Has run away from home overnight at least twice while living in parental or parental surrogate home (or once without returning for a lengthy period) 3. Is often truant from school, beginning before age 13 years.
B	The disturbance in behaviour causes clinically significant impairment in social, academic, or occupational functioning.
C	<p>If the individual is age 18 years or older, criteria are not met for antisocial personality disorder.</p> <p>Specify severity:</p> <p>Mild: few if any conduct problems in excess of those required to make the diagnosis and conduct problems cause only minor harms to others.</p> <p>Moderate: number of conduct problems and effect on others intermediate between "mild" and "severe."</p> <p>Severe: many conduct problems in excess of those required to make the diagnosis or conduct problems cause considerable harm to others.</p>

Source: American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 4th ed. Washington, DC: American Psychiatric Association, 1994:98–99.

Self-reported information on 21 statements that reflect behavioral problems before the age of 18 has been collected in the second survey when the twins were on average 30 years old. We created our first measure of conduct disorder by summing occurrences of these 21 statements.⁹ Our second measure of conduct disorder is based on the question 'Did you do at least 3 of these things within the same 12-month period?' Twins who responded 'yes' were coded as 1, twins who responded no or twins with a conduct disorder score of 0, 1 or 2 were coded as 0. As this measure perfectly matches the APA definition of conduct disorder we will use it as our main measure in the analysis. We call this measure the 'APA Definition'. Our survey also asked 'How old were you the first time you did at least 3 of these things within the same 12-month period?' We use this information to investigate the effect of the timing of conduct disorder. Our third measure of conduct disorder is based on the question 'Did you ever see a doctor, psychologist, social worker or any other professional like that because of these behaviors?' Twins who responded 'yes' were coded as 1, twins who responded 'no' or twins who were coded as 0 on the APA Definition were coded as 0 on this third measure. We define this measure as 'Professional help'. Seeking professional help may signal that conduct disorders hinder normal

⁹We use the same 19 statements as in Le *et al.* (2005) and also included 'misbehaved' and 'suspended/expelled'.

development and human capital accumulation. Obviously, this measure is endogenous as people choose or are advised to seek professional help.

The second measure of conduct disorder, which is directly based on the APA Definition, might be a better indicator than the conduct disorder score because of the additional restriction on the time range for the occurrence of the conduct disorders. Small variations on the conduct disorder score (the first definition) might not reflect real differences in conduct disorder if the conduct disorder behaviors occur with relatively large time lags. The psychiatric handbook (APA, 1994) emphasizes that at least three such behaviors should occur within the same 12-month period to make the diagnosis of conduct disorder. The advantage of the third measure is that seeking professional help is a clear signal that the behavior of the child is considered problematic, making it likely that this indicator really measures a difference in conduct disorder.

Table A2. The effect of the timing of conduct disorder on human capital

APA Definition	Grade repetition	Marks high school	High school graduation	Attacking others	Arrested since 18 years	Jail
OLS						
Years of CD	0.040 (0.009)***	-0.110 (0.013)***	-0.058 (0.009)***	0.061 (0.011)***	0.042 (0.009)***	0.012 (0.007)*
Years of CD squared	-0.003 (0.001)***	0.009 (0.002)***	0.004 (0.001)***	-0.004 (0.002)**	-0.003 (0.001)	-0.000 (0.001)
<i>N</i>	5222	5208	5224	2138	2136	2134
Fixed effects, All twins						
Years of CD	0.024 (0.009)***	-0.083 (0.016)***	-0.036 (0.010)***	0.060 (0.014)***	0.035 (0.009)***	0.011 (0.005)**
Years of CD squared	-0.002 (0.001)*	0.008 (0.002)***	0.004 (0.001)**	-0.005 (0.002)**	-0.003 (0.001)***	-0.001 (0.001)**
<i>N</i>	5222	5208	5224	2138	2136	2134
Fixed effects Identical twins						
Years of CD	0.044 (0.013)***	-0.000 (0.024)	-0.033 (0.017)*	0.056 (0.023)**	0.032 (0.014)**	0.004 (0.007)
Years of CD squared	-0.004 (0.002)**	-0.001 (0.003)	0.005 (0.002)*	-0.003 (0.003)	-0.003 (0.002)*	0.000 (0.001)
<i>N</i>	2220	2220	2218	876	876	874

Estimates of separate regression of a human capital measures on years of conduct disorder and years of conduct disorder squared using the same controls as in Table III. CD, conduct disorder.

*Significant at 1%; **significant at 5%; ***significant at 10%.

REFERENCES

- American Psychiatric Association. 1994. *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)* (4th ed.). American Psychiatric Association: Washington, DC.
- Ashenfelter O, Krueger AB. 1994. Estimates of the economic return to schooling from a new sample of twins. *The American Economic Review* **84**(5): 1157–1173.
- Australian Centre for Community Child Health. 2006. Royal Children's Hospital Melbourne. Research Centre of the Murdoch Childrens Research Institute, Media Information.
- Black S, Devereux PJ, Salvanes K. 2007. From the cradle to the labor market? The Effect of birth weight on adult outcomes. *Quarterly Journal of Economics* **122**(1): 409–439.
- Carneiro P, Heckman JJ. 2003. Human capital policy. In *Inequality in America: What Role for Human Capital Policies?* J. J. Heckman, A. B. Krueger, and B. M. Friedman. (eds.), MIT Press: Cambridge, MA; 77–239.
- Currie J, Stabile M. 2006. Child Mental Health and Human Capital Accumulation: The Case of ADHD. *Journal of Health Economics* **25**(6): 1094–1118.
- Currie J, Stabile M. 2009. Mental Health in Childhood and Human Capital. *The Problems of Disadvantaged Youth: An Economic Perspective*. University of Chicago Press.
- Farmer EMZ. 1995. Extremity of Externalizing Behaviour and Young Adult Outcomes. *Journal of Child Psychology* **36**(4): 617–632.

- Farrington D. 1973. Self-reports of deviant behavior: Predictive and stable? *The Journal of Criminal Law and Criminology* **64**(1): 99–110.
- Fletcher J, Wolfe BL. 2007. *Long-term consequences of childhood ADHD on criminal activities*. University of Wisconsin-Madison.
- Fletcher J, Wolfe BL. 2008. Child mental health and human capital accumulation: the case of ADHD revisited. *Journal of Health Economics* **27**: 794–800.
- Griliches Z. 1979. Sibling models and data in economics: beginnings of a survey. *Journal of Political Economy* **87**(5): S37–S64.
- Hardt R, Hardt S. 1997. On determining the quality of the delinquency self-report method. *Journal of Research in Crime and Delinquency* **July**: 247–257.
- Heath AC, Madden PAF, Martin NG. 1998. Assessing the effects of cooperation bias and attrition in behavioural genetic research using data-weighting. *Behavior Genetics* **28**(6): 415–427.
- Horney J, Marshall I. 1992. An experimental comparison of two self-report methods for measuring lambda. *Journal of Research in Crime and Delinquency* **29**(1): 102–121.
- Huizinga D, Elliott DS. 1986. Reassessing the reliability and validity of self-report delinquency measures. *Journal of Quantitative Criminology* **2**: 293–327.
- Le AT, Miller PW, Heath AC, Martin N. 2005. Early childhood behaviours, schooling, and labour market outcomes: estimates from a sample of twins. *Economics of Education Review* **24**: 1–17.
- Loeber R. 1982. The Stability of Antisocial and Delinquent Child Behaviour: A Review. *Child Development* **53**: 1431–1446.
- Loeber R, Farrington DP, Stouthamer-Loeber M, Van Kammen WB. 1998. *Antisocial behavior and mental health problems: Explanatory factors in childhood and adolescence*. Lawrence Erlbaum Associates: Mahwah, NJ.
- Maddux J, Desmond D. 1975. Reliability and validity of information from chronic heroin users. *Journal of Psychiatric Research* **12**(2): 87–95.
- Mieczkowski T. 1990. The accuracy of self-reported drug use: An evaluation and analysis of new data. In *Drugs, Crime and the Criminal Justice System*, Weisheit R (ed.), Anderson: Cincinnati; 275–302.
- Searight HR, Rottnek F, Abby SL. 2001. Conduct disorder: diagnoses and treatment in primary care. *American Family Physician* **63**(8): 1579–1588.
- Slutske WS, Heath AC, Dinwiddie SH, Madden PAF, Bucholz KK, Dunne MP, Statham DJ, Martin NG. 1997. Modelling genetic and environmental influences in the etiology of conduct disorder: a study of 2,682 adult twin pairs. *Journal of Abnormal Psychology* **106**(2): 266–279.
- Thornberry TP, Krohn MD. 2000. The self-report method for measuring delinquency and crime. *Criminal Justice* **4**: 33–83.
- Weiss R, Najavits L, Greenfield S, Soto J, Shaw S, Wyner D. 1998. Validity of substance use self-reports in dually diagnosed outpatients. *The American Journal of Psychiatry* **155**: 127–128.