ABSTRACT

Title: LOW BIRTH WEIGHT AND THE CRIMINAL
                                      CAREER

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This thesis examines the relationship between low birth weight and crime over the life course. Recent research has explored low birth weight as a proxy measure for neuropsychological deficits that affect antisocial and delinquent behavior, but it is limited in scope with regard to the dimensions of the criminal career (e.g., onset, frequency, and persistence). This study uses data from the classic study of 500 delinquents and 500 nondelinquents and subsequent follow-ups conducted by Sheldon and Eleanor Glueck to examine low birth weight and the criminal career. Derived from multiple sources, these data contain information on offending from unofficial and official records spanning childhood, adolescence, and early adulthood. For this sample, low birth weight is not related to the dimensions of the criminal career examined here, nor is low birth weight related to offending in early adulthood. Implications for future research and policy are offered.

LOW BIRTH WEIGHT AND THE CRIMINAL CAREER

By

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Chapter 1: Introduction

Developmental criminologists assert that there are distinct causes of onset, escalation, and desistance of crime and antisocial behavior. Additionally, they contend there are separate developmental trajectories for different types of criminal careers (Loeber and LeBlanc, 1990; Moffitt, 1993). A number of theorists locate the sources of biological and social risk factors for serious, chronic, and violent offending in early childhood, often before children begin school. Patterson and Yoeger (1993), for example, claim that poor parenting practices predict early onset and chronic offending behavior. Gottfredson and Hirschi (1990) also argue that ineffective parenting during early childhood leads to low self-control and an increased propensity for antisocial behavior over the life course. Fishbein (2001: 13) presents a diathesis-stress model in which biological factors present at birth "set the stage" for crime through the way in which individuals interact with the world and how they respond to stressful experiences and environments, such as weak family structure and harsh punishment from parents. Similarly, Moffitt (1993) proposes that neuropsychological deficits increase one's risk for serious, chronic antisocial behavior. These deficits interact with one's environment to amplify further the risk of antisocial, delinquent, and criminal behavior over the life course. Raine's (2002: 322) review of biosocial studies suggests that birth complications interact with negative home environments to predispose individuals to adult violence.

One biological risk factor researchers have recently turned their attention to is low birth weight. Because low birth weight increases an infant's risk for neuropsychological deficit, which manifests in cognitive and behavioral problems

(themselves risk factors for criminal behavior), some criminologists expect low birth weight to have a direct relationship with crime (Tibbetts and Piquero, 1999). Furthermore, as low birth weight infants are more likely to be born to parents who lack the financial and social resources to care for a difficult child, low birth weight's relationship with crime is expected to be mediated by family environment factors (McCormick, 1985; Spencer and Logan, 2002). Finally, family environment also moderates the effect of low birth weight; the relationship between low birth weight and crime is exacerbated by negative interactions within family environments (Fishbein, 2001; Moffitt, 1993; Piquero and Lawton, 2002; Tibbetts and Piquero, 1999; White, Bates, and Buyske, 2001).

To date, the body of research regarding low birth weight as a risk factor for crime is quite small and limited in a number of ways. Primarily, though the existing research has explored the effects of low birth weight as it relates to age of onset and patterns of offending, this research is limited in scope regarding other important dimensions of the criminal career, such as violent offending and frequency of offending. Furthermore, the findings for these dimensions are inconsistent (McGloin and Pratt, 2003; Piquero and Lawton, 2002; Tibbetts and Piquero, 1999; White, Bates, and Buyske, 2001). In addition, the criminological research employs low birth weight in the place of other indicators of neuropsychological indicators. However, low birth weight increases the risk of deficits related to crime but is not a deficit on its own, and the intervening effect of low birth weight through its relationship with these deficits is not addressed. Similarly, much of this research focuses on indicators of socioeconomic status and family structure but neglect the mediating and interaction

effects of family processes (e.g. maternal supervision, erratic or harsh discipline, parent-child attachment) on the relationship between low birth weight and crime. Finally, the age-range examined is confined to adolescence in some cases, limiting our understanding of the relationship between low birth weight and crime in adulthood (McGloin and Pratt, 2003; Tibbetts and Piquero, 1999). The present analyses address these limitations by providing a more comprehensive assessment of the relationship between low birth weight and patterns of offending.

The goal of this thesis is to examine systematically the relationship between low birth weight and offending over the life course. First, I review the research linking low birth weight to the neuropsychological factors that criminologists maintain increase the risk of crime. I also provide a careful review of the few studies that have attempted to link low birth weight to specific criminal career dimensions. Second, I contribute to the current body of research with a more comprehensive examination of the relationship between low birth weight and dimensions of the criminal career in a sample of boys from the classic study of juvenile delinquency conducted by Sheldon and Eleanor Glueck (1950; 1968). These criminal career dimensions include prevalence of official delinquency and incidence of unofficial delinquent behavior, age of onset of offending (official and unofficial), violent offending, and frequency of offending while free through adolescence. I also explore the interaction of low birth weight with family environment, including family structure and family processes. Finally, I examine the long-term effects of low birth weight on criminal behavior during an 18-year follow-up, from adolescence to age 32.

Chapter 2: Previous Research

The current criminological literature utilizes low birth weight as a proxy indicator of neuropsychological deficits. The link between neuropsychological deficits and antisocial or criminal behavior has been widely researched and is well established (for a comprehensive review of neuropsychology and delinquency see Moffitt, 1990). The result of poor neural development during the perinatal period, neuropsychological deficits influence cognitive ability, temperament, and behavior (Fishbein, 2001; Moffitt, 1990, 1993). Poor cognitive ability and temperament, as well as childhood behavior problems are themselves empirically established risk factors for antisocial behavior over the life course (Farrington, 1989; Moffitt, 1990, 1997; also see McGloin, Pratt, and Maahs, 2004; Moffitt et al. 2001; Lynam, Moffitt, and Stouthamer-Loeber, 1993; Werner and Smith, 1992). Neuropsychological deficits have also been linked to violent behavior in adulthood (Farrington, 1989; Raine, 2002; Raine et al., 1996).

The influences of cognitive ability, temperament, and childhood behavior on subsequent antisocial and delinquent behavior have been studied separately as well as together. However, developmental criminologists such as Moffitt (1997: 120) considers IQ scores to be "an omnibus index of neuropsychological status" (see also Lynam, Moffitt, and Stouthamer-Loeber, 1993). Furthermore, IQ scores are as strongly related to delinquency and antisocial behavior as race or class, and this relationship holds when IQ is measured prior to delinquency as well as when controlling for socioeconomic status, race, academic attainment, and child's motivation (Moffitt, 1997: 121; see also Farrington, 1989; McGloin, Pratt, and

Maahs, 2004; Werner and Smith, 1992). Behavioral and temperamental risk factors measured separately from IQ have also been implicated in antisocial and violent behavior over phases of the life span (Farrington, 1989; Werner and Smith, 1992).

The causes underlying this individual vulnerability are many and may occur during pregnancy and the perinatal period. Maternal substance use, poor prenatal nutrition, and delivery complications are just some of factors associated with neuropsychological deficiencies (Moffitt, 1993: 680). Low birth weight is also associated with neuropsychological deficits, and it is through its influence on these deficits that it is expected to influence crime, which is why recent researchers have utilzed birth weight as a proxy indicator of neuropsychological vulnerability. The primary task of this review is to describe the sources of low birth weight and its connection to neuropsychological deficits. I then detail the current state of research regarding the relationship between low birth weight and crime.

Low birth weight and its sources

The issue of preterm birth and low birth weight is a complex one. Historically, the presumed reason for low birth weight was preterm delivery, and from the 1920s to the 1960s these terms were used interchangeably (Wilcox, 2001: 1233). In fact, the 1935 American Academy of Pediatrics definition of a premature infant was one who weighed 2500 grams or less (Conley, Strully, and Bennett, 2003: 8). However, not all small babies are born preterm, and not all preterm babies are born small (Wilcox, 2001). Premature or preterm birth is one that occurs before 37 weeks of gestation (Kalverboer, 1988). Additionally, infants are classified as small for gestational age (SGA) or appropriate for gestational age (AGA) regardless of

gestation, based on standards of fetal growth set in the medical field (Escalona, 1982).

Those who are born both preterm and small for gestational age are the most

vulnerable to central nervous system insult, neuropsychological deficits, neonatal

death, and childhood morbidity (McCormick, 1985; Wilcox, 2001; Wolke, 1998).

Regardless of whether an infant is born preterm or full term, SGA or AGA, the

current low birth weight (LBW) standard is birth weight under 2500 grams

(approximately five pounds eight ounces), while normal birth weight (NBW) is

greater than that (McCormick, 1985; Wilcox, 2001). Low birth weight infants are

further subdivided into very low birth weight (VLBW) (under 1500 grams) and

extremely low birth weight (ELBW) (under 1000 grams) (Wolke, 1998). Most of the

research reviewed here involves LBW infants with little regard from the authors as to

whether they are preterm or small for gestational age, which appears to be common

within the birth weight literature as a whole. The literature reviewed here focuses on

comparisons of birth weights, either to "normal" birth weight infants (typically over

2500 grams) or to a range of birth weights, either continuously or as multiple groups,

in order to understand the continuum of neuropsychological issues faced by small or

premature infants.

A number of factors contribute to birth weight, including biological and

genetic factors, as well as maternal nutrition and other social influences. Parental,

placental, and fetal factors and a complex interaction between genetics and

environment all play a role in birth weight as a function of fetal growth. Having one

or both parents who were SGA themselves puts infants at increased risk for being low

birth weight (Johnston, Clark, and Savage, 2002). However, while SGA mothers are

more likely to have SGA children, it is difficult to sort out the genetic influences from social and environmental influences, and there may be an accumulation of social risk factors for low birth weight across generations (McCormick, 1985; Spencer and Logan, 2002). Low birth weight is more prevalent in disadvantaged populations, including low-income families and minority populations. A number of possible factors that cause low birth weight are also associated with disadvantaged environments, including poor nutrition and inadequate weight gain, smoking, recreational drug use and alcohol use, maternal age (at both ends of the spectrum), and maternal ill health (Conley, Strully, and Bennett, 2003; Newburn-Cook et al., 2002; Spencer and Logan, 2002; Stephenson and Symonds, 2002). A disadvantaged couple is at increased risk for having a low birth weight daughter, who in turn may grow up to be poor, smoke, or suffer from poor health, and give birth to her own child at an early age. That child, in turn, is also at risk for being born small for gestational age (Spencer and Logan, 2002: 6). Intergenerational patterns of poverty and poor health can create a cumulative risk for low birth weight, as the long term effects of low birth weight may hinder school achievement and ultimately socioeconomic success in adulthood, and poverty and low birth weight may interact further to hinder development (Conley, Strully and Bennett, 2003).

Low birth weight and its connection to neuropsychological deficits

Just as defining low birth weight and identifying its causes is complex, so is the relationship between low birth weight and neuropsychological development and deficits. Three domains of development are affected by neuropsychological deficits—cognitive ability, temperament, and behavior (Moffitt, 1993). Evidence of

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the relationship between birth weight and cognitive ability seems bountiful, even net of potential confounding factors (e.g., ethnicity, maternal education, maternal IQ, supportive home environment) (Boardman et al., 2002; Breslau et al., 1996). The relationship is also present within birth weight groups, including the normal range of birth weights. Infants weighing just less than five pounds eight ounces (2500 grams) typically have higher scores than VLBW (under 1500 grams). Infants born with a weight just above five pounds eight ounces have lower scores on cognitive tests than those born at a greater weight[1] (Boardman et al., 2002; Breslau et al., 1996; Jefferies, Power, and Hertzman, 2002; Matte et al., 2001; Shenkin, Starr and Deary, 2004; Wolke, 1998). Furthermore, some evidence indicates that the difference in cognitive ability persists over time (Hack et al., 2002; Hack et al., 2004; Jefferies, Power, and Hertzman, 2002).

The support for the relationship between low birth weight and temperament and low birth weight and behavior is thinner relative to that for cognitive ability (Wolke, 1998). With regard to temperament, most research to date has found no significant difference between preterm or full term infants (Honjo et al., 2001; Wolkes, 1998). Though Weiss, St. Jonn-Seed, and Wilson (2004) found a higher rate of difficult temperament than expected in a sample of LBW and premature infants, birth weight was not a good predictor of temperament and they attributed temperament to genetic influence and perinatal morbidity. Honjo and colleagues (2001) looked at both temperament and child-rearing stress reported by mothers of LBW and full term healthy infants in Japan. While they found no significant

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[1] There is evidence that the relationship between cognitive ability and birth weight is curvilinear, so that very large infants also experience cognitive deficits (Shenkin, Starr and Deary, 2004). However, the relationship between very large infants and cognitive ability is beyond the scope of this review.

difference in temperament or child-rearing stress by birth weight group, mothers of LBW infants attributed a larger portion of their child-rearing stress to the child's temperament and behavior characteristics, suggesting mothers of LBW children may be more focused on and sensitive to their child's behavior (Honjo et al., 2001). Mothers of LBW children may be more sensitive to their child's behavior because they share similar temperamental and behavioral characteristics, though Honjo et al. did not examine this issue.

On the other hand, LBW children, especially VLBW children, show signs of hyperactivity and difficulty concentrating by preschool age, but conduct disorder and oppositional behavior are less common and less attributable to LBW status (Wolke, 1998: 568; see also Elgen, Lundervold, and Sommerfelt, 2004; Elgen, Sommerfelt, and Markestad, 2002; Indredavik et al., 2004). Kelly et al. (2001) found that boys who were lighter at birth had higher ratings of hyperactivity and conduct problems, but birth weight was not a significant predictor of conduct problems when controlling for social factors (family structure and whether a smoker lived in the household). Low birth weight children are more likely to experience internalizing problems, such as depression and anxiety, rather than externalizing problems like aggression (Elgen, Sommerfelt, and Markestad, 2002; Hack et al., 2002; Hack et al., 2004; Indredavik et al., 2004; Tessier et al., 1997). There is also evidence that birth weight interacts with family environment and maternal stability to increase the probability of anxiety, as well as with mother-child relations to increase behavioral disturbances at school (Levy-Shiff et al., 1994). However, contrary to this evidence, Kelly et al. (2001)

found that low birth weight was unrelated to emotional problems, and Levy-Shiff et al. (1994) found a significant relationship between low birth weight and aggression.

Elgen, Sommerfelt, and Markestad (2002) found more LBW children than NBW children reported problems in attention, social problems, anxiety and depression in their sample of Norwegian children followed to age 11. Teachers reported more problems in social behavior, attention, and delinquent behavior for LBW children relative to NBW children. While there was no significant interaction between birth weight and parental factors, parental factors were associated with problem behavior in both LBW and NBW children. In their follow-up of VLBW children to age 20, Hack et al. (2002, see also Hack et al., 2004) found that, even when controlling for neurosensory impairment, VLBW young adults were less involved in risk taking behaviors, including delinquent behavior, and their parents reported more attention problems relative to NBW young adults. Cooke (2004) found that VLBW young adults (ages 19 to 22) drank less and used drugs less than NBW young adults did, though there was no difference in police contacts between the groups. However, Chilcoat and Breslau (2002) found a greater incidence of drug use in LBW (2001 to 2500 grams) boys relative to NBW (greater than 2500 grams) and VLBW (less than 2000 grams) boys at age 11. Though the studies by Hack and her colleagues (2002, 2004) and Chilcoat and Breslau (2002) are not directly comparable, together they suggest that LBW children at the heavier end of the LBW spectrum are at greater risk for of antisocial behavior.

Whether problem behaviors are related to deficits in cognitive functioning is unclear. There is some evidence that the smallest or most premature children are at

greatest risk for attention deficits, though other evidence indicates that the differences between VLBW children and other children diminish when accounting for differences in IQ (Wolke, 1998). Based on a review of the extant research, Aylward (2002: 238) asserts that premature birth and low birth weight influence behavior indirectly through cognitive and neuromotor functions. On the other hand, Elgen, Sommerfelt, and Markestad (2002) found no difference in average IQ among low birth weight children with and without problem behavior. Further, Chilcoat and Breslau (2002) found that IQ, attention deficit, and externalizing behavior problems increased the risk for early drug use but did not mediate the relationship between birth weight and drug use.

Low birth weight alone is not responsible for cognitive, temperamental, and behavioral outcomes. The role of the social environment has a powerful mediating and moderating effect on the relationship between low birth weight and developmental outcomes throughout childhood (Boardman et al., 2002; Bradley et al., 1994a, 1994b; McCormick, 1985; Werner and Smith, 1992). Conley, Strully and Bennett (2003) found that higher income moderates and counteracts the effects of low birth weight on academic achievement to age 19 and conclude that birth weight matters most for those of low socioeconomic status. Bradley et al. (1994a) found that smaller family size, responsivity of the parent, acceptance of the child, variety of experience and availability of learning materials related to ranges of acceptable functioning in cognitive and behavioral competence as well as health and growth status among LBW children living in poverty at age three. Additionally, environmental factors have a cumulative effect on developmental outcomes in that

the probability of acceptable development increases with the number of protective factors (Bradley et al., 1994b).

There is evidence that maternal behavior and mother-child interactions influence the behavior and development of low birth weight and premature children (Wolke, 1998). Tully et al. (2004) found that expressed emotional maternal warmth among mothers of five-year-old twins moderated the main effect of birth weight on mothers' and teachers' ratings of attention-deficit-hyperactivity disorder (ADHD) symptoms. A higher level of maternal warmth among LBW children was associated with fewer symptoms, while low levels of maternal warmth were associated with more symptoms. However, there was no moderating effect on IQ.

Wolke (1998) argues that social and environmental factors have a greater influence on the cognitive and behavioral development of larger LBW and preterm babies while biological factors may be more salient for the outcomes of VLBW and very premature infants as they may have received greater insult to their central nervous systems. Regardless of the amount of influence biological factors have relative to birth weight, it seems clear that low birth weight is related to neuropsychological deficits, especially cognitive ability, and especially in poor or disadvantaged environments. However, as indicated by the research reviewed here, the role social environment plays in development may act to diminish or exacerbate the effects of low birth weight over time.

The relationship between low birth weight and crime

Few studies have tested the relationship between low birth weight and criminal behavior. In their classic study of 500 delinquents and 500 nondelinquents

in Boston, the Gluecks (1950: 170) found no significant difference in the proportion of low birth weight (under six pounds)/premature subjects between delinquents and nondelinquents, though their analysis was a simple comparison of proportions. Using more sophisticated statistical analyses recent research has begun to explore the relationship between low birth weight and some dimensions of the criminal career (McGloin and Pratt, 2003; Piquero and Lawton, 2002; Tibbetts and Piquero, 1999; White, Bates and Buyske, 2001). However, as indicated by the following review, this research does not offer a complete nor a consistent depiction of the relationship between low birth weight and crime.

Tibbetts and Piquero's (1999) test of the deficit-environment interaction hypothesis of Moffitt's developmental taxonomy theory used low birth weight as a proxy indicator for neuropsychological deficits to predict early onset of offending. The sample from the Longitudinal Study of the Biosocial Factors Related to Crime and Delinquency in Pennsylvania (Denno, 1990), which included data from the Philadelphia Collaborative Perinatal Project (CPP), was made up of at-risk inner-city youth from four cohorts born to black mothers between 1959 and 1962. Tibbetts and Piquero drew a subsample of youth (207 of the original 987) who had at least one recorded offense by the age of 18 (144 boys and 63 girls). Age of onset was defined as age at first police contact (as recorded by the Philadelphia Police Department), either arrest or remedial disposition, and ranged from eight to 18; age 14 was chosen as the marker for early versus late onset. Seventy study members qualified as early onset, while 137 were late onset. Low birth weight was defined as below six pounds; 32 percent qualified as low birth weight. Two variables, measured when the child

was age seven, fell under the construct "disadvantaged environment:" weak family structure and socioeconomic status. The number of changes in the mother's marital status, with whom the child lives, and whether the husband or father of the child was present in the household comprised weak family structure. Socioeconomic status was a composite score of three indicators, including education of head of household, income of head of household, and occupation of head of household. The interaction terms of low birth weight and disadvantaged environment indicators were tested separately for each indicator in the same model.

Results showed a significant effect of low birth weight, low socioeconomic status, and both interactions between birth weight and the disadvantaged environment variables on early age of onset; weak family structure did not have a main effect (Tibbetts and Piquero, 1999). These findings are consistent with the research regarding low birth weight and neuropsychological deficits in that birth weight matters, but environment is also important. However, this analysis has a number of limitations. Primarily, potentially intervening factors were not included in the model, such as cognitive ability, childhood behavior and temperament, all of which are related to low birth weight and onset of offending. It is unclear why some measurement of cognitive ability was not included, as the researchers appear to have had access to the public school data that other researchers have used to provide measures of intelligence (see McGloin and Pratt, 2003). Given the consistent relationship between low birth weight and cognitive ability, for example, and between cognitive ability and crime, it may be that low birth weight influences early onset through its relationship with cognitive ability. In addition, their measures of family

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social environment do not include family process variables such as supervision or attachment, which might also moderate the effects of low birth weight. Furthermore, Tibbetts and Piquero's (1999) model attempts to predict the first officially recorded offense rather than unofficial delinquency. While this may present a more conservative estimate than the use of unofficial delinquency, it offers only a glimpse at the effect of low birth weight on offending over the life course. Finally, the sample is restricted to inner-city black youth, a population that is more likely to be born small as well as be arrested, limiting the generalizability to other populations.

McGloin and Pratt (2003) also use data from the Longitudinal Study of Biosocial Factors Related to Crime and Delinquency in Pennsylvania (Denno, 1990). They examine link between cognitive ability and delinquent behavior, specifically onset of offending, early onset of offending and persistent offending to age 18, as measured by police contact. In addition to a cognitive ability measure (the California Achievement Test, or CAT) the independent variables included low birth weight (as a proxy measure for neuropsychological deficit), concentrated disadvantage (based on head of household income and with whom the child lived), and sex. McGloin and Pratt's measure of low birth weight is the same one used by Tibbetts and Piquero (1999), though McGloin and Pratt offer more details relating to the construction of the variable. Measured at birth by hospital staff, birth weights ranged from three to 12 pounds and were recoded so that 1 indicated low birth weight, defined as less than six pounds, and 0 indicated normal birth weight (McGloin and Pratt, 2003: 259). Though this weight is actually about eight ounces greater than the current medical diagnostic limit, they justify this greater cutoff as being "embedded in the context of

the time of collection" (the 1950s), before medical advances improved the survival rate for low birth children. It is also the cutoff adopted by the World Health Organization (McGloin and Pratt, 2003: 259). Approximately 21 percent of their entire sample (delinquents and nondelinquents) qualified as low birth weight (2003: 261).

Though low birth weight was not the independent variable of interest in these analyses, McGloin and Pratt's (2003) findings with regard to this variable are interesting nonetheless. While low birth weight had no significant effect on whether one was ever delinquent or was a persistent offender (two or more official contacts), it did have a significant influence on early onset of offending (offended before age 14). This effect was independent of the influence of cognitive ability and net of the effect of concentrated disadvantage, sex, and the interactions between cognitive ability and concentrated disadvantage and between cognitive ability and sex. It was not significant when the interaction between cognitive ability and low birth weight was added to the model and the interaction was similarly insignificant. This supports the idea that low birth weight contributes to early onset of offending, but it cannot speak to long term patterns of crime. It does not seem surprising that low birth weight was unrelated to whether one ever offends before age 18 if one considers adolescent offending a normative behavior. Furthermore, persistent offending was defined as two or more offenses because of the "precipitous drop-off as the number of contacts increased" past one (McGloin and Pratt, 2003: 258). If neuropsychological deficit is related to the most chronic and serious offending, it may be that these offenders are institutionalized for lengths of time before their 18th birthday,

artificially underestimating their true rate of offending. Alternatively, it could be that low birth weight infants are no more likely to one day become persistent offenders than are normal birth weight infants.

Piquero and Lawton (2002) address the contribution of low birth weight, family adversity and neighborhood disadvantage to chronic offending in a sample derived from the Baltimore, Maryland, portion of the National Collaborative Perinatal Project (NCPP). The Baltimore NCPP is a health and developmental study that followed women and their children from birth (between 1959 and 1965) until age eight. Both mothers and children were followed up between 1992 and 1994, when the subjects were between 29 and 33 years old (n=1758). Data included measures regarding the birth and early childhood of the children and census tract information from the original study. Follow-up interviews provided data regarding peers and criminal behavior, including the prevalence and frequency of arrest. The upper five percent of the frequency of arrest distribution (seven or more arrests) were identified as life-course-persistent or chronic offenders. Independent variables included peer delinquency, family adversity, individual risk (low birth weight, less than 2500 grams or five pounds eight ounces), biosocial interaction (low birth weight x adverse family environment), and neighborhood disadvantage. Data collected about the mother at the time of the subjects' birth made up the index variable "family adversity." This included the age of the mother at the birth of the subject (1 if under age 18), whether she received public assistance (1 if yes), her educational attainment (1 if less than high school), and whether she was married (1 if not married). The neighborhood disadvantage scale factor was based on census tract data and included the following

variables: percent young adult dropout, percent black, percent female-headed household, females 16 and older with children but no husband and living in poverty, mean family income, percent households with public assistance incomes, percent persons living below the poverty line, percent families with public assistance income, adult unemployment rate, male unemployment rate, and persons aged 18 to 24 (Piquero and Lawton, 2002: 278).

Though unrelated to whether one would be arrested, low birth weight in interaction with family adversity had a significant effect on chronic offending, as did family adversity independent of low birth weight, sex, and peer delinquency (Piquero and Lawton, 2002). When the analysis was restricted to the lowest 25 percent and highest 25 percent of neighborhood disadvantage, sex, family adversity, and the interaction term were significant only in the most disadvantaged neighborhoods. Again, this result is consistent with the research regarding neuropsychological factors and low birth weight in that low birth weight children raised in the most disadvantaged situations are at greatest risk for negative outcomes. This also suggests that low birth weight relates to another dimension of the criminal career: persistent offending. However, as with the previous studies, the sample was predominantly African American, who have a higher rate of low birth weight as well as arrest, limiting the generalizability of these findings to other populations. Further, Piquero and Lawton did not account for the intervening influence of neuropsychological factors.

In their test of Moffitt's developmental taxonomy in adulthood, White, Bates, and Buyske (2001) utilize proxy measures of neuropsychological dysfunction—birth

risk (low birth weight and/or prematurity) and low achievement scores—to assess the impact of deficits on patterns of offending of boys in the Rutgers Health and Human Development Project. This longitudinal, prospective, sequential cohort design study identified three cohorts of adolescents at ages 12, 17, and 18 in 1979 and 1981, via a telephone survey. The study followed subjects through three subsequent waves of data collection until 1992 to 1994, when they were between 25 and 31. At each wave, the 698 males reported on the frequency of delinquent behavior and identified aggressive behaviors they had engaged in, including armed robbery, assault, fighting with a weapon, or fighting in a gang in the three previous years. Self-reports of delinquency and aggression were then scaled for each wave. From these data, White, Bates, and Buyske (2001: 604) identified four groups of offenders: adolescence-to-adulthood-life-course-persistent delinquents (seven percent of the sample); adolescent-limited delinquents (33 percent); escalating delinquents who increased their level of delinquency through adolescence and into adulthood (13 percent); and non-offenders (47 percent).

Following Moffitt's developmental taxonomy of offenders, White, Bates, and Buyske (2001) examined risk factors associated with neuropsychological deficits. The proxy measure "birth risk" was based on low birth weight and premature birth, each coded as dichotomous variables and summed to compose the birth risk score (so that 2 would indicate both low birth weight and premature birth). As with two of the previous studies, six pounds marked the upper bound of low birth weight (McGloin and Pratt, 2003; Tibbetts and Piquero, 1999). Additional proxy measures of neuropsychological functioning included assessments of verbal IQ and executive

function measured at Time 1 and 3. Personality measures taken at Time 1 included impulsivity and harm avoidance. Sensation seeking (disinhibition) was measured at Time 1 and 2. Finally, family adversity included family socioeconomic status at Time 1 (highest parental educational level and highest parental occupational level), family structure (single- or two-parent family), and youth's perception of parental hostility (White, Bates, and Buyske, 2001: 603).

When used to predict the different offending groups, White, Bates, and Buyske (2001) found that birth risk was not significantly different among the four groups, though the interaction of birth risk with family structure was able to distinguish between nondelinquents and delinquents, adolescent-limited from persistent delinquents, and escalating from persistent delinquents. White, Bates, and Buyske (2001: 607) conclude that the risk factors related to the onset and stability of self-reported offending from childhood to adolescence may not be related to persistence from adolescence to adulthood and that social and environmental factors beyond childhood may have a more important role in persistent offending. However, these findings may be limited, as the sample was predominantly middle-class and working-class, so it might have few of the aggressive and life-course-persistent offenders with neuropsychological deficits associated with lower socioeconomic status samples.

Summary

This review of the literature indicates that low birth weight is related to neuropsychological deficits, especially cognitive ability, and particularly in disadvantaged environments. Further, the criminological literature highlights the

relationship between low birth weight and some dimensions of the criminal career, as well as the possible interaction between family environment and low birth weight. This research indicates that the relationship may vary with the outcome of interest. However, researchers have not reached a consensus regarding the significance of the relationship between low birth weight and chronic offending, nor have they systematically examined the different dimensions of the criminal career. Furthermore, with one exception, these studies focus on a limited age-range, fail to account for family processes, or do not adequately control for other intervening variables (e.g. cognitive ability, temperament, and behavior).

Chapter 3: Methodology

Research Questions

The analyses presented here are intended to offer a more comprehensive

assessment of the relationship between low birth weight and dimensions of the

criminal career, including participation, age of onset, frequency of offending while

not incarcerated, and violent offending from childhood and adolescence to early and

later adulthood. The rich data from the Gluecks' (1950, 1968) classic longitudinal

study of delinquency and adult crime provides a unique opportunity for such a

thorough exploration. Improving upon past research, I am able to focus on family

process as well as family structure variables. These data also allow me to include

individual factors through which low birth weight might influence crime, such as

temperament, childhood behavior, and IQ. In addition, the Glueck data enables me to

examine the low birth weight – crime relationship over a 25-year period, from age

seven to 32. To that end, I address the following questions: Is there a relationship

between low birth weight and official or unofficial delinquency? Do those born at a

low birth weight embark on a criminal career that is different from those born at a

normal birth weight? More specifically, do the criminal careers of low birth weight

boys begin earlier, feature violent offending and higher rates of arrests, and persist

over the life course? Finally, does low birth weight interact with family environment

to increase the risk of offending over the life course?

Hypotheses

Using cross-tabular analysis, the Gluecks (1950: 170) found that there was no

difference between delinquents and nondelinquents in the proportion of subjects born

prematurely or underweight, suggesting that there is no relationship between low birth weight and official delinquency in this sample. I reexamine this issue using more sophisticated statistical techniques. Throughout my hypotheses, I expect a bivariate relationship between birth weight and crime. I also expect low birth weight to influence crime through low birth weight's relationship with individual factors. Finally, I expect that the low birth weight – crime relationship is mediated by family factors.

H_1: I expect to find that low birth weight influences official delinquency. Further, as not all antisocial behaviors come to the attention of police, I hypothesize that low birth weight boys are more likely to be unofficially delinquent than normal birth weight boys.

H_2: Low birth weight boys are more likely to begin offending (officially and unofficially) at a younger age than normal birth weight boys.

H_3: Among delinquents, low birth weight boys are arrested more often than normal birth weight boys are.

H_4: Low birth weight delinquent boys are more likely to have been arrested for violent crimes.

H_5: Low birth weight interacts with indicators of a criminogenic family environment (both structure and process factors) to increase the likelihood of a) being officially and unofficially delinquent, b) offending at a young age, c) being arrested more often than normal birth weight boys, and d) being arrested for violent crime.

H_6: Low birth weight delinquents are more likely than normal birth weight delinquents to continue offending into early adulthood (ages 17 to 25) and later adulthood (ages 25 to 32).

H_7: Low birth weight interacts with indicators of a criminogenic family environment during childhood and adolescence to increase the likelihood that criminal behavior will persist into adulthood.

Sample

These analyses utilize data collected by Sheldon and Eleanor Glueck (1950, 1968) for their classic study of 500 delinquents and 500 nondelinquents followed from 1940 to 1965. These data were recoded and analyzed by Sampson and Laub (1993) and are archived at the Murray Archives at Harvard University. The Gluecks followed a group of serious and persistent delinquent boys born in the city of Boston between 1924 and 1935. Data were collected over 25 years (1940 to 1965), beginning when the boys were, on average, age 14 and ending at age 32. The Gluecks also followed a control group of 500 nondelinquent boys who were matched to the delinquents on age, ethnicity, IQ, and low-income residence (Glueck and Glueck, 1950).

In order to ensure the delinquent and nondelinquent groups were distinct, delinquent boys were selected from two correctional schools in Massachusetts and nondelinquents were recruited from Boston public schools (Glueck and Glueck, 1950: 27). Nondelinquent status of the boys in the control group was confirmed by court record checks, inquiries to social agencies, and home and school investigations, including interviews with parents, teachers, and the boys themselves (Glueck and

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Glueck, 1950). A full description of this study can be found in Glueck and Glueck (1950) and Sampson and Laub (1993).

Data

Adopting an interdisciplinary approach, the Gluecks collected data on a variety of risk factors, including aspects of the boys' birth and infancy, parental deviance, economic status, family structure and relations, parental supervision and monitoring, and complete psychiatric profiles. Sources of data include interviews with the boys and their families (especially mothers), as well as interviews with the boys' teachers and neighbors, and criminal justice and social welfare officials (Glueck and Glueck, 1950; Laub and Sampson, 2003). Offense data were based on unofficial sources as well as officially recorded behavior from police, court, and correctional records to age 17 (Laub and Sampson, 2003: 77-78; see also Glueck and Glueck, 1950).

The three waves of data collection covered childhood and adolescence (ages seven to 17), early adulthood (17 to 25) and later adulthood (25 to 32). Follow-up investigations were conducted as the men reached their 25th and 31st birthdays (Glueck and Glueck, 1968). At the second follow-up period, 438 delinquents (88 percent of the original sample) and 442 nondelinquents (88 percent) were studied. Twenty-five delinquents and 11 nondelinquents were deceased by the end of the second follow-up period (Glueck and Glueck, 1950; Laub and Sampson, 2003). When adjusted for mortality, the follow-up success rate was 92 percent. The men were interviewed in person, as were their spouses, employers and others. Criminal and military records were also checked. There were no significant differences on 110

variables between those who were followed up and those who were not (Glueck and Glueck, 1968: 46).

Independent Variables

    Low birth weight. The primary independent variable, premature birth or low birth weight was derived from interviews with mothers (Glueck and Glueck, 1950: 170). The Gluecks recorded low birth weight as a dichotomous variable, scored 1 if the boy was born preterm or weighed less than six pounds and 0 if not. Low birth weight or premature birth boys make up approximately six percent of the delinquent sample and seven percent of the nondelinquent sample[2] (see Table 1). Although birth records might provide a more accurate measure of birth weight and preterm birth, evidence indicates that parents can recall their child's birth weight accurately up to 16 years after the child's birth (O'Sullivan, Pearce, and Parker, 2000). Therefore, the Gluecks' measure of low birth weight should be valid. The upper-limit of a low birth weight or premature birth diagnosis standard set by American Academy of Pediatrics is slightly lower than the Gluecks' threshold of six pounds (2500 grams or five pounds eight ounces) (McGloin and Pratt, 2003; Tibbetts and Piquero, 1999). However, contemporary criminological research has used six pounds as the boundary for low birth weight (McGloin and Pratt, 2003; Tibbetts and Piquero, 1999; White, Bates, and Buyske, 2001). Furthermore, there is evidence that the relationship between low birth weight and neurocognitive deficits is gradient, even into the

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[2] Although not directly comparable, the 1950 reported prevalence of low birth weight infants was 7.5 percent of live births and remained relatively unchanged through 1990 (Kiely, Yu, and Rowley, 1994). This rate is similar to the proportion of low birth weight boys in the Glueck sample (approximately 6.5 percent), but it measures live births and does not account for the elevated level of mortality among low birth weight children, and therefore does not reflect the prevalence of low birth weight infants who survive into childhood and adolescence. It is difficult to know the prevalence and survival rate of low birth weight and premature infants in the 1920s and 1930s because many women gave birth at home and these births were not recorded immediately.

normal birth weight range, and optimal birth weight in most populations is greater than six pounds (Breslau et al., 1996; Shenkin, Starr, and Deary, 2004).

Family environment. Family structure and family process variables measure the family environment thought to contribute to criminal behavior (see Table 1). Family structure influences delinquency directly and indirectly through its effect on family processes. For example, children who are members of a large family or live in a single-parent home might receive less supervision than other children receive (Sampson and Laub, 1993). Structural variables thought to contribute to a criminogenic environment include family disruption, family size, family poverty, residential mobility, parental instability, and parental deviance.

Family disruption is a dichotomous measure, where 1 indicates "the boy was reared in a home where one or both parents were absent because of divorce, separation, or death" (Sampson and Laub, 1993: 71). Sixty-one percent of delinquents came from a home in which one parent was absent, compared to 34 percent of nondelinquents.

Family size is the number of children in the boy's family, ranging from one to eight or more. Approximately 66 percent of delinquent boys and 52 percent of nondelinquent boys came from families with five or more children.

Family poverty is measured with a standardized scale (based on z-scores) and is "composed of the average weekly income of the family and a measure of the family's reliance on outside aid" (Sampson and Laub, 1993: 72). Outside aid "measures whether the family was living in comfortable circumstances (having enough savings to cover four months of financial stress), marginal circumstances

(little or no savings but only occasional dependence on outside aid), or financial dependent (continuous receipt of outside aid for support)" (Sampson and Laub, 1994: 527). A high score indicates the combination of low income and dependence on outside aid. The mean family poverty score for delinquents is .56, and -.56 for nondelinquents.

Residential mobility measures the number of times a family moved during the boy's childhood and ranges from none or once to 16 or more (Sampson and Laub, 1993: 72). Approximately 54 percent of delinquents moved eight or more times, compared to 18.6 percent of nondelinquents.

Parental instability and parental deviance are intended to capture the parents' temperament and disposition, which are thought to influence both family poverty and child rearing practices (Sampson and Laub, 1994: 529). "Parental instability reflects whether none (0), one (1), or both (2) of the boy's parents were diagnosed with 'severe mental disease or distortion' including 'marked emotional instability,' 'pronounced temperamental deviation,' or 'extreme impulsiveness'" (Sampson and Laub, 1994: 529, citing Glueck and Glueck, 1950: 102). Twenty-two percent of delinquents have two unstable parents, compared to five percent of nondelinquents

Parental deviance combines "the criminality and drinking habits of both parents to form a general indicator of deviance. *Criminality* was determined by official records of arrest or conviction (excluding minor auto violations and violation of license laws). *Alcoholism and/or drunkenness* refers to intoxication and includes frequent, regular, or chronic addiction to alcohol" (Sampson and Laub, 1993: 73,

emphasis is original). Parental deviance ranges from 0 to 4; parents of delinquents have an average deviance score of 1.97, compared to .93 for nondelinquents

Family process variables thought to contribute to a criminogenic environment include low parent-child attachment, erratic, harsh, and threatening parental discipline, and lack of mother's supervision (Sampson and Laub, 1993). Parent-child attachment is an ordinal scale that combines measures of the warmth of the emotional bond between the child and his mother and/or father (as displayed in close association with the parent and expressions of admiration), and whether the parents were loving and accepting of the child or rejecting in emotional attention (Sampson and Laub, 1994: 530; Glueck and Glueck, 1962). The scale ranges from 1 to 5, where 5 indicates a high level of parent-child attachment. The average level of parent-child attachment among delinquents is 3.12; nondelinquents have an average level of 4.33.

Erratic or harsh parental discipline is measured with a standardized scale (z-scores) that combines measures of the degree to which mothers and fathers used inconsistent punishment in conjunction with harsh, physical punishment and/or threatening behavior (Sampson and Laub, 1994: 529). A high score indicates a greater degree of erratic or harsh discipline. Delinquent boys have an average score of .89, compared to -.90 for nondelinquents.

Mother's supervision is an ordinal scale in which supervision was coded as unsuitable (1 if the boy is left on his own or in the care of an irresponsible child or adult), fair (2 if partial supervision), or suitable (3 if mother either kept close watch over activities or arranged for suitable care when unavailable) (Glueck and Glueck, 1950: 112; Sampson and Laub, 1993: 74). Sixty-four percent of delinquent boys

were subject to unsuitable supervision, compared to just 13 percent of nondelinquents. Parent-child attachment, mother's supervision and erratic or harsh discipline have construct validity in that they are significantly correlated with each other in the expected theoretical direction (see Table 2; for details see Sampson and Laub, 1993: 74).

In order to reduce the number of variables on the right hand side of each model, thereby decreasing model degrees of freedom, increasing statistical power, and simplifying analysis of interaction terms, I constructed index variables intended to capture two theoretical constructs: known family process risk and known family structure risk. For each of the above family environment variables, I determined the cut-off point for the 20 percent at greatest risk and created dichotomous variables in which 1 indicates high risk. For example, 20 percent of the sample experienced 11 or more residential moves, so I designated those with a score of 11 or higher in residential mobility as being at high risk for offending based on this variable. Similarly, those who scored in the bottom 20 percent of parental attachment (below a score of 3 in a range of 1 to 5) were also designated as high risk.[3] In order to obtain risk scores for each boy, missing data was counted as "unknown risk" and coded as zero. Each boy then received a known family process risk score and a known family structure risk score based on the summation of known risk factors for each construct.[4]

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[3] The top 20 percent of risk in the remaining variables was identified as follows: Erratic/harsh discipline$\geq$1.039; mother's supervision$\leq$1; family disruption=1; family size$\geq$8; family poverty$\geq$1.524; parental stability$\geq$1; parental deviance$\geq$3.

[4] Family structure and process variables were also reduced to a single dimension factor score using principle components analysis. Regression models on that factor score produced results nearly identical to those with the two risk scores (results not shown).

Both family environment risk scores are significantly correlated with their component variables (see Table 2).

Although data reduction of this type provides the benefits listed above, dichotomizing and summing variables into one score results in the loss of variability and detail measured by the original variables. However, though we cannot distinguish which family factor or combination of factors drives a relationship when using a composite score, these scores reflect the presence of multiple risk factors for one boy, thereby indicting those at greatest risk for crime based on family environment factors (Bradley et al., 1994a).

Individual factors. To account for a possible intervening relationship, I include in the models variables that relate to both crime and low birth weight, including total IQ, temper tantrums, and child difficulty. Low birth weight increases a boy's risk for these factors, which in turn increase the risk of crime. Total IQ is a continuous variable that measures intelligence as assessed by the Wechsler-Bellevue Test (Glueck and Glueck, 1950). The mean total IQ for delinquents is 91.7 and nearly 94 for nondelinquents.

Temper tantrums refer to the extent to which the child engaged in violent temper tantrums and was predisposed to aggressiveness and fighting. A score of 1 on this dichotomous measure indicates that tantrums were the "predominant mode of response to difficult, distressing situations" based on parent and teacher reports (Glueck and Glueck, 1950: 152; Sampson and Laub, 1993: 88).

Child difficulty is a dichotomous variable derived from parent reports of child behavior and indicates whether the boy was overly restless and irritable during the

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early developmental period (Sampson and Laub, 1993: 88). Measures capturing both the emotional reactivity of temper tantrums and the restless behavior of the difficult child are included here in order to tap temperament and behavior development. It is believed that these characteristics are related to low birth weight and neuropsychological deficit, as well as criminal behavior (Moffitt, 1993; Sampson and Laub, 1993). Temper tantrums and child difficulty each predict official delinquency and adult deviance and are correlated in the expected direction, suggesting adequate construct and predictive validity for the measures (Sampson and Laub, 1993: 89). Approximately 39 percent of delinquent boys had temper tantrums as children, and 59 percent were considered difficult, compared to seven percent and 30 percent of nondelinquents, respectively.

Dependent Variables

The dependent variables in Table 3 are based on official and unofficial delinquency and adult criminal behavior. Official criminal history data were collected from police, court, and correctional records to age 32 (Glueck and Glueck, 1950; Sampson and Laub, 1993). Agencies contacted included the Massachusetts Board of Probation, Massachusetts Department of Correction, and the Massachusetts Department of Public Safety, which held state and federal fingerprint records. In addition, criminal history data were obtained from police department and court records where the delinquents were living when followed up by the Gluecks (Glueck and Glueck, 1968: 48). Unofficial delinquent behavior is based on self, parent, and teacher reports. Though the Gluecks followed both delinquents and nondelinquents to age 32, only the delinquent sample will be included in analyses in which the

dependent variable is based on arrest. By definition, nondelinquent boys have no arrest data through adolescence. As nondelinquent boys have no official record during adolescence, data relating to their adult criminal behavior is irrelevant to research questions regarding persistent criminal behavior.

Delinquent status is a dichotomous variable where official delinquent status is coded as 1. Unofficial delinquency includes behavior (to an average age of 14) of both the delinquent and the control groups and is a composite measure of total unofficial delinquency from self, parent, and teacher reports collected at the Wave 1 interview. Self-reported behaviors ranged from smoking, drinking and running away to truancy, destructive mischief, stealing and arson, among others. Parent-reported behaviors included the same behaviors reported by the boys but also included reports of lying, stubbornness, vile language, pugnacity, and tantrums. Teacher-reported behaviors ranged from smoking, untruthfulness, and stubbornness to disobedience, cheating, bullying, and defiance (for a full list of items for all unofficial reports, see Sampson and Laub, 1993: 51). The three reports are highly correlated and the composite score created by Sampson and Laub (1993: 51) includes only those items that were measured consistently across reporters and excluded items related to incorrigibility or behaviors reported by only one reporter. Delinquents committed an average of 14 unofficial delinquent acts, while nondelinquents committed nearly three unofficial delinquent acts on average.

Age of onset variables include age at first arrest (delinquents only) as well as early onset of unofficial delinquency for the entire sample (delinquents and nondelinquents). Age at first arrest is a continuous variable capturing the age at the

boy was first arrest for any crime; the delinquents' mean age at first arrest for any crime is 11.92.

Early onset was constructed using self-reports and indicates the age of onset of unofficial behavior for both delinquent and nondelinquent boys. This is a dichotomous variable in which a 1 indicates the boy reported engaging in delinquency before age eight and a 0 indicates that delinquent behavior began after age eight or not at all. Analysis by Sampson and Laub (1993, 1997) found evidence of construct and predictive validity. Evidence of construct validity comes from the fact that early onset is significantly correlated with tantrums and child difficulty, all of which are measures of troublesome child behavior. Furthermore, early onset has predictive ability; 95 percent of those with early onset were arrested before reaching adulthood, compared to 45 percent of those who did not offend by age eight (Sampson and Laub, 1993: 88-89; 1994). Thirteen percent of delinquents began their misbehavior before age eight, compared to less than one percent of nondelinquents.

Offense categories of interest for these analyses include any crime and violent offenses (homicide, assault, rape, and robbery) committed by the delinquent boys through adolescence (ages seven to 17), early adulthood (17 to 25), and later adulthood (25 to 32) (Sampson and Laub, 1993).[5] Frequency of arrest for total crime is the number of arrests per year while not incarcerated. The average frequency of arrest through adolescence is .43 crimes per year, through early adulthood is 1.6 crimes, and through later adulthood is one crime.

Any violent arrest is a dichotomous variable indicating whether the individual was arrested for violence. Fifteen percent of delinquent boys were arrested for a

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[5] Data on other crime types were also collected, including property and drug or alcohol arrests.

violent crime though adolescence, 35 percent were arrested in early adulthood, and 18 percent were arrested in later adulthood.

Data Analysis

The hypotheses are analyzed using Ordinary Least Squares (OLS) regression and logistic regression models.[6] OLS models are appropriate when the dependent variable is a continuous measure, such as total unofficial delinquency, age at first arrest for any crime, and frequency of arrest. Logistic models, which are used when the outcome of interest is dichotomous, examine relationships between low birth weight and delinquent status, early onset of misbehavior, any arrest for a violent crime. Both OLS and logit models allow me to assess observable variables that may influence the relationship between low birth weight and criminal outcomes.

As suggested by previous research on low birth weight, hypotheses 1, 2, 3, 4 and 6 examine the effect of low birth weight on criminal career dimensions. I first examine the bivariate relationship between low birth weight and each crime outcome using measures of association (point-biserial correlation for continuous outcomes and Yule's Q for binary outcomes). I then assess each crime outcome with two regression models. Model 1 includes individual factors, IQ, temper tantrums, and whether the boy was a difficult child, in order to examine whether the low birth weight – crime relationship occurs through the influence of low birth weight on neuropsychological

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[6] As the Glueck sample is not a probability sample, traditionally hypothesis testing is inappropriate (see Sampson and Laub, 1993, p. 271). However, in keeping with the standards of the field, significance levels are used here as a guideline for identifying influential variables.

deficit indicators. If individual factors act mediate the relationship, the observed relationship between low birth weight and crime will be reduced or eliminated.[7]

Model 1:

Crime = $\alpha + \beta_1$ Low birth weight + β_2 Total IQ + β_3 Temper tantrums + β_4 Difficult Child + ε

Model 2 includes variables measuring family structure and family process to determine if these aspects of family environment mediate the relationship between low birth weight and offending. If structure and process variables mediate the effect of low birth weight on lifetime offending patterns, any observed relationship between low birth weight and offending will be reduced or eliminated in the full model.

Model 2:

Crime = $\alpha + \beta_1$ Low birth weight + β_2 Total IQ + β_3 Temper tantrums + β_4 Difficult child + β_5 Parent-child attachment + β_6 Erratic/harsh discipline + β_7 Mother's supervision + β_8 Family disruption + β_9 Family size + β_{10} Family poverty + β_{11} Residential mobility + β_{12} Parental instability + β_{13} Parental deviance + ε

Hypotheses 5 and 7 explore the interaction between low birth weight and family environment. Again, two models analyze this relationship. In the first model (see Model 3), each crime variable is regressed on low birth weight, individual factors, known family process risk, and the interaction between low birth weight and known family process risk. In the second model (see Model 4), known family structure risk replaces family process and its interaction with low birth weight.[8]

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[7] Alternatively, total IQ, temper tantrums, and difficult child may have a suppressor effect on the relationship between low birth weight and crime. Suppressor variables indicate intervening relationships by suppressing the variance that is irrelevant to the prediction of crime, thereby enhancing the effect of low birth weight on crime (Tabachnick and Fidell, 2001).

[8] Multicollinearity does not appear to be an issue in Models 1 and 2. However, the correlation matrix in Table 2 indicates that low birth weight is highly correlated with its family process and family

Model 3:

Crime = α + β_1 Low birth weight + β_2 Total IQ + β_3 Temper tantrums + β_4 Difficult child + β_5

Known family process risk + β_6 Low birth weight x Known family process risk+ ε

Model 4:

Crime = α + β_1 Low birth weight + β_2 Total IQ + β_3 Temper tantrums + β_4 Difficult child + β_5

Known family structure risk + β_6 Low birth weight x Known family structure risk+ ε

A significant relationship between the interaction term and the outcome would indicate that the influence of low birth weight is conditional on the level of known family risk. A positive relationship indicates low birth weight boys are more likely to offend when they have a higher family risk score. A negative relationship could indicate two things: low birth weight boys are less likely to offend when they are in a high-risk family environment, or low birth weight boys are more likely to offend when they are in a low-risk environment.

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structure interaction terms (r=.688 and r=.790, respectively; p<.01). Multicollinearity between the component parts of an interaction term inflates standard errors for the coefficients, reducing their predictive efficiency (Jaccard, Turrisi, and Wan, 1990). To address the issue of multicollinearity, low birth weight, known family process risk, and known family structure risk were centered on the mean by subtracting the mean of each variable from its value for each case. These centered variables were then used to create new interaction terms. Most of the results did not change (not shown). Results for models using the non-centered interaction terms are reported. Changes in models with centered interaction terms are reported in footnotes in the Results section.

Chapter 4: Results

The first hypothesis examines whether low birth weight influences official and unofficial delinquency. Table 4 displays the associations between low birth weight and each of the dependent variables. There is no significant bivariate relationship between birth weight and any of the criminal career dimensions under examination. Nevertheless, contrary to the Gluecks' findings, Table 5 indicates that low birth weight significantly influences whether a boy is officially delinquent when accounting for IQ, temperament, and behavior in the entire sample of boys, though the significance level (p=.052) just surpasses the conventional level of significance (p<.05; see Table 5, Model 1).[9] However, the relationship is opposite of what was expected; low birth weight boys are 46.1 percent less likely to have been officially delinquent than normal birth weight boys (OR=.539). Moreover, family environment mediates the relationship between birth weight and delinquent status (see Table 5, Model 2). The association between birth weight and delinquent status washes out when family process and family structure variables are included in the model.[10]

No relationship between birth weight and the number of unofficial offenses is apparent (see Table 6). Individual factors, family processes, and most family

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[9] Though low birth weight is significantly correlated with total IQ and not difficult child or temper tantrums (see Table 2), total IQ alone does not enhance the relationship between low birth weight and delinquent status. Instead, the inclusion of all three variables act improves the predictive ability of low birth weight in this model, indicating that they act as suppressor variables cumulatively (results not shown).

[10] To determine which aspect of family environment mediates this relationship, each of the family environment variables were entered into the model separately with low birth weight and the individual factors. The three family process variables, parent-child attachment, maternal supervision, and erratic and harsh punishment, and family size each reduced the relationship between low birth weight and crime. None of the other family variables have a mediating effect (results not shown).

Models regressing each dependent variable on the known family process risk and known family structure risk composite variables in the place of the separate variables in Model 2 were also analyzed. However, there was no substantive change in the results (results not shown).

structure variables are better predictors of unofficial delinquency than low birth weight.

Hypothesis 2 asserts that low birth weight boys begin offending at an early age. I found no such relationship either with onset of offending before age eight (for the entire sample) or age at first arrest (delinquent boys only) (see Tables 7 and 8).

The third hypothesis asserts that, compared to normal birth weight delinquent boys, low birth weight delinquent boys are arrested at a greater frequency than normal birth weight boys. Low birth weight has no influence on frequency of arrest while not incarcerated during childhood and adolescence (see Table 9). Similarly, the fourth hypothesis states that low birth weight delinquent boys are more likely to be arrested for violent crimes. Again, low birth weight is not related to arrest for a violent crime before age 17 (see Table 10). In fact, only temper tantrums had a significant relationship with arrest for violent crime. However, temper tantrums in part reflects violent behavior in childhood. Thus, it appears that the best predictor of violent behavior is previous violent behavior.

Hypothesis 5 asserts that low birth weight interacts with family environment to increase the number of unofficial delinquent acts and the probability of being officially delinquent. Moreover, I hypothesize that high-risk family environments will exacerbate the effect of low birth weight on age at first arrest, early onset, frequency of arrest and arrest for a violent crime through adolescence. The interaction between low birth weight and known family process risk does not significantly influence any of the outcomes (see Table 11).[11] However, low birth

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[11] I analyzed each family environment variable in interaction with low birth weight in separate models for each dependent variable (results not shown). While there were a few significant interactions, these

weight has a marginally significant and negative effect on delinquent status when the

interaction between low birth weight and family structure and individual factors are

held constant (p<.10, see Table 12 for delinquency status).[12] The odds of being

delinquent decrease approximately 75 percent when the boy is low birth weight

(OR=.249). When all other independent variables are set at the mean, the (otherwise)

average low birth weight boy has a 23 percent chance of being delinquent, compared

to a 54 percent chance for the average normal birth weight boy.

Low birth weight and its interaction with known family structure risk also

significantly relate to total unofficial delinquency (p<.05 and p<.10, respectively; see

Table 12, for total unofficial delinquency).[13] However, unlike the findings for the

previous models and dependent variables discussed, the interaction between low birth

weight and known family structure risk is significant and in the expected, positive

direction. Though the effect of low birth weight is negative (low birth weight boys

commit fewer crimes than do normal birth weight boys), family structure moderates

the effect of low birth weight, increasing the number of unofficial delinquent acts

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may have been due to chance, as the number of analyses was quite high (90 regressions). Furthermore, I am hesitant to accept the results of the individual family interactions in logit models. There is very little variation in low birth weight, and many of the significant findings were because all of the low birth weight cases met the condition of the interaction term.

The interaction models were run with a single dimension factor score (containing all family environment variables except family size) x low birth weight and family size x low birth weight. There was no change to the substantive results (results not shown). The interaction models also were run with a single composite risk score, known criminogenic risk. Low birth weight and the interaction term were not significant in these models (results not shown).

[12] When regressed on the centered interaction term, low birth weight x known family structure risk score, the influence of low birth weight on delinquent status reaches significance at the p<.05 level. The raw coefficient is -.875 (se=.408, OR=.416). There was no change in the interaction term (results not shown).

[13] When regressed on the centered interaction term, low birth weight x known family structure risk score, the influence of low birth weight on total unofficial delinquency is no longer significant (p=.275). There was no change in the interaction term (results not shown).

committed. For example, when the boy is low birth weight, an increase of one point in the known family structure risk score is associated with increase of 2.5 unofficial delinquent acts. Comparatively, the offending of normal birth weight boys increases by 1.6 acts with each additional family structure risk. Therefore, low birth weight increases unofficial delinquency only for those boys in structurally high-risk family environments. Nevertheless, the interaction between low birth weight and family structure does not influence any other measure of crime through adolescence (early onset, age of first arrest, frequency of offending or violent arrest).

The sixth hypothesis examines the relationship between low birth weight and frequency of offending and violent offending into early adulthood (17 to 25) and later adulthood (25 to 32) among the delinquent group. The seventh hypothesis looks at whether that relationship is moderated by family environment. No relationship between low birth weight or the interaction terms and frequency of arrest is evident at either period. Similarly, no relationship was found between low birth weight or the interaction terms and violent arrest for those periods.

Taken as a whole, out of 40 separate tests I expect that four models will result in a significant finding by chance at the less conventional alpha-level of .10; at an alpha-level of .05, two models will be significant. Therefore, the significant findings of low birth weight (two at $p<.10$ and one at $p<.05$) and for the interaction term ($p<.10$) may be due to chance alone. It appears that for this sample of boys low birth weight does not increase the likelihood of adolescent delinquent behavior across many of the criminal career dimensions examined here, nor does it influence offending into adulthood.

Chapter 5: Discussion and Conclusion

Discussion

A small pool of criminological research has found a positive relationship between low birth weight and chronic offending as well as early onset of offending. The analyses presented here are intended to contribute to this research by examining the effects of low birth weight on a broader set of criminal career dimensions, including measures of official and unofficial behavior, while accounting for the intervening effect of individual factors related to low birth weight and crime. I also examined family process and family structure factors that might mediate or moderate these relationships. Overall, I found no significant difference between low birth weight and normal birth weight boys across key dimensions of the criminal career, including age of onset, frequency of offending, violent offending, or offending into adulthood. I did find that low birth weight boys in structurally disadvantaged family environments appear to commit more unofficial delinquent acts than normal birth weight boys in the same environments. This finding is in agreement with both the low birth weight and criminological research that asserts that birth weight matters in the most disadvantaged environments. However, contrary to previous research, I also found that low birth weight boys in this sample are less likely to be officially delinquent. It needs to be stressed that both findings are marginally significant and may be due to chance.

There are a number of possible explanations for the dearth of non-significant findings for low birth weight in this sample from the Gluecks' classic study of delinquency. One problem might be the lack of sufficient variability in low birth weight. In the Gluecks' sample, only 29 (5.6 percent) delinquent boys and 34 (6.8 percent)

nondelinquent boys were low birth weight. Moreover, eight delinquent low birth weight boys either died or were not followed up at ages 25 and 32. Therefore, only 21 of the 438 delinquent boys (4.8 percent) followed to age 32 were low birth weight. Lack of variability increases the standard error and the risk of failing to reject a false null hypothesis in an OLS regression. In the logistic regression models presented here, the limited variability resulted in the low birth weight cases often having the same outcome.

The dichotomous nature of the low birth weight variable might also limit our ability to reveal a relationship between low birth weight and crime in this sample. Pediatric and developmental research indicates a range of low birth weight outcomes when measured as either a continuous or an ordinal variable rather than as a binary variable (Kelly et al., 2001). Additionally, six pounds might be too high a cut-off to serve accurately as a proxy indicator of neuropsychological deficit, as there may be a significant increase in problem outcomes for those who are much smaller than six pounds (Kelly et al., 2001). However, all of the previous criminological research used dichotomous measures of low birth weight, and three used six pounds as the boundary (McGloin and Pratt, 2003; Piquero and Lawton, 2002; Tibbetts and Piquero, 1999; White, Bates, and Buyske, 2001). As the previous research found a low birth weight – crime relationship in other samples, it is difficult to know whether these criticisms adequately explain my own lack of findings.

Another possible explanation is that a period effect may be at work. The survival rate of infants born prematurely or very much under weight in the 1920s and 1930s was dramatically different from the survival rate for such infants in the later decades in which other samples were born. A study of prematurity, low birth weight, and mental

deficiency published in 1934—toward the end of the years in which the Glueck boys were born—reported that about half of these children survived their first year (Rosanoff and Inman-Kane, 1934). This same study surmised that a random sampling of elementary school children might contain 2.5 percent low birth weight or premature children. Furthermore, improvements in the perinatal care of low birth weight infants have contributed to the overall decline in infant mortality rates since the 1950s and 1960s, even while the rate of premature or low birth weight births remained relatively steady at 7.5 percent in the later half of the 20th century. The Centers for Disease Control and Prevention report that as much as 90 percent of the decline in infant mortality rates among white infants and 100 percent of the decline among African American infants from 1960 to 1983 can be attributed to lower birth-weight-specific mortality (MacDorman, Iyasu, and Gardner, 1994). Advances in perinatal and pediatric medicine during this period increased the survival rate among those infants, especially the smallest infants, which decades earlier would have perished, though they often survive with developmental and behavioral problems (Aylward, 2002). These problems, criminologists suggest, are what connect low birth weight to antisocial behavior, including crime, later in life. Though the Glueck sample might overcome many other potential period effects (see Sampson and Laub, 1993: 253-255), it is possible that medical advances in the decades after the Glueck boys were born make these boys qualitatively different from cohorts born after 1960. That is, the fact that the low birth weight boys in this sample survived infancy may indicate that were at the heavier end of the low birth weight spectrum, and thus less likely to suffer from neuropsychological problems related to birth weight.

Sample differences beyond period effects might also explain the difference in findings between the present analyses and previous criminological research. Though ethnically diverse and economically disadvantaged, all of the Glueck boys were white. The samples used in previous studies that found a relationship between birth weight and crime were predominantly African American, from inner-city areas, and had large proportions of low birth weight subjects (ranging from 14 to 32 percent, compared to 6.2 percent of the Glueck sample) (McGloin and Pratt, 2003; Piquero and Lawton, 2002; Tibbetts and Piquero, 1999). The rate of low birth weight among African Americans is more than twice that of whites (Kallan, 1993). Furthermore, African Americans in economically disadvantaged environments are at greatest risk for low birth weight and low birth weight children in disadvantaged environments are at greatest risk for deficits (Boardman et al., 2002; Bradley et al., 1994a, 1994b; McCormick, 1985; Pearl, Braveman, and Abrams, 2001; Werner and Smith, 1992). The samples used in these studies are not only at higher risk for being born low birth weight; they are arrested at a disproportionately high rate relative to whites as well.

Finally, the Glueck boys are not a randomly selected group but a sample chosen to contrast serious, persistent delinquents with nondelinquent boys matched on several key characteristics. Perhaps a relationship between low birth weight and crime can be found in a general probability sample that includes youth that participate in relatively minor delinquency. That is, delinquency not serious enough to be punished with a reform school commitment.

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The goal of this thesis was to offer a comprehensive assessment of the relationship between low birth weight and dimensions of the criminal career. The lack of such a relationship in the Glueck sample should not be taken as evidence that no relationship exists. The relationship between low birth weight and correlates of crime like IQ and childhood behavior suggests that the investigation of low birth weight as a potential risk factor for crime in more contemporary samples might still be viable. Future research should strive to clarify the relationship between low birth weight and antisocial behavior both during childhood and adolescence as well as adulthood. Furthermore, it should consider the influence of early childhood family processes as well as environmental factors that are proximate to adult antisocial behavior in order to get at the complexity of this relationship. Moreover, some attempt should be made to increase the variability of low birth weight in samples utilized by such research, either by using a continuous or ordinal measure of birth weight. The relationship between low birth weight and many developmental outcomes appears to be a gradient one; this may also be the case for crime. Finally, greater effort should be made to investigate the role of low birth weight in a more racially diverse sample in order to improve generalizability.

Researchers should also use caution in how they conceive of the relationship between low birth weight and crime. If investigating neuropsychological deficits, then established measures of neuropsychological deficits should be used when available. If no such measure exists in the data, perhaps a different research question or data set would be more appropriate. If investigating low birth weight, then measures of neuropsychological deficits should be included in the models to account for intervening relationships.

Neuropsychological deficits may be present from birth. If we can identify low birth weight as a risk factor for antisocial behavior because of its association with these deficits, it provides a simple and inexpensive measure for identifying at-risk youth from the moment they are born. This is not to say that preterm or low birth weight infants should be marked as potential delinquents with their first breath. Low birth weight is far from deterministic for many outcomes, including cognitive ability, temperament, and behavioral problems that may be distinct from criminal behavior. However, low birth weight children in disadvantaged environments are at an increased risk for many developmental problems known to be related to crime. Prevention and intervention strategies can focus not only on the early identification of low birth weight children but also of pregnant women at risk for having a low birth weight child. Providing financial, educational and medical services to mothers and their children will improve children's life chances across domains, including educational attainment, employment, and social behavior, as well as divert them from delinquent pathways (Conley, Strully and Bennett, 2003).

Tables

Table 1. Mean, standard deviation, minimum and maximum, and sample size for low birth weight, individual factors and family environment variables

| | Delinquent status | | | | | |
| | Delinquent | | Nondelinquent | | | |
	Mean	Standard deviation	Mean	Standard deviation	Min - Max	N
Low birth weight/premature	.06	.23	.07	.25	0 – 1	1000
Individual factors						
Total IQ	91.66	13.01	93.98	11.89	53 – 130	1000
Temper tantrums	.39	.49	.07	.25	0 – 1	1000
Difficult child	.59	.49	.30	.46	0 – 1	985
Family process						
Parent-child attachment	3.12	1.16	4.33	.91	1 – 5	960
Erratic/harsh discipline*	.89	1.27	-.90	1.67	-3.24 – 3.14	856
Mother's supervision	1.43	.62	2.52	.72	1 – 3	989
Family structure						
Family disruption	.61	.49	.34	.47	0 – 1	1000
Family size	5.44	2.10	4.73	2.26	1 – 8	999
Family poverty*	.56	1.61	-.56	1.46	-3.64 – 3.45	998
Residential mobility	8.67	4.78	4.84	3.81	1 – 16	999
Parental instability	.88	.75	.36	.58	0 – 2	972
Parental deviance	1.97	1.27	.93	1.05	0 – 4	1000
Family environment						
Known family process risk	1.55	.88	.39	.65	0 – 3	1000
Known family structure risk	2.47	1.45	1.12	1.12	0 – 6	1000

*Standardized scale based on a z-score

Table 2. Measures of association between independent variables; Pearson's and point-biserial correlations, Yule's Q and gamma

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Low birth weight/ premature	1.00	-.067* [a]	.123 [b]	.208 [b]	.076 [c]	.011 [a]	.011 [c]	.005 [b]	-.096** [a]	.054 [a]	.037 [a]	.025 [c]	.043 [c]	.016 [a]	.014 [a]	.688** [a]	.790** [a]
2. Total IQ		1.00	-.058 [a]	-.086** [a]	.057* [c]	-.098**	.076* [c]	-.002 [a]	-.106**	-.081*	.008	-.035 [c]	-.016 [c]	-.063*	-.067*	-.073*	-.069*
3. Temper tantrums			1.00	.542** [b]	-.420** [c]	.281** [a]	-.466** [c]	.273** [b]	.047 [a]	.214** [a]	.215** [a]	.386** [c]	.305** [c]	.266** [a]	.240** [a]	.133** [a]	.096** [a]
4. Difficult child				1.00	-.273** [c]	.211** [a]	-.314** [c]	.249** [b]	-.060 [a]	.081* [a]	.165** [a]	.300** [c]	.183** [c]	.196** [a]	.164** [a]	.109* [a]	.108** [a]
5. Parent-child attachment					1.00	-.404** [c]	.594** [c]	-.643** [c]	-.025 [c]	-.319** [c]	-.426** [c]	-.420** [c]	-.495** [c]	-.830** [c]	-.565** [c]	-.403** [c]	-.098 [c]
6. Erratic/harsh discipline						1.00	-.512** [c]	.133** [a]	.228**	.348**	.280**	.339** [c]	.336** [c]	.627**	.384**	.160**	.107**
7. Mother's supervision							1.00	-.426** [c]	-.116** [c]	-.317** [c]	-.461** [c]	-.538** [c]	-.562** [c]	-.903** [c]	-.573** [c]	-.488** [c]	-.199 [c]
8. Family disruption								1.00	-.089** [a]	.206** [a]	.404** [a]	.419** [c]	.550** [c]	.324** [a]	.615** [a]	.067* [a]	.080* [a]
9. Family size									1.00	.255**	.048	.021 [c]	.076* [c]	.046	.260**	-.070*	-.064
10. Family poverty										1.00	.404**	.252** [c]	.334** [c]	.342**	.566**	.117*	.141**
11. Residential mobility											1.00	.387** [c]	.474** [c]	.461**	.693**	.110**	.116**
12. Parental instability												1.00	.441** [c]	.513** [c]	.738** [c]	.411** [c]	.231 [c]
13. Parental deviance													1.00	.564** [c]	.680** [c]	.397** [c]	.239* [c]
14. Known family process risk														1.00	.531**	.210**	.125**
15. Known family structure risk															1.00	.127**	.160**
16. LBW x Process																1.00	.840**
17. LBW x Structure																	1.00

* p< .05 (2-tailed) **p< .01 (2-tailed) [a] Point-biserial correlation [b] Yule's Q [c] Gamma

Table 3. Mean, standard deviation, minimum and maximum, and sample size for official and unofficial crime

	Delinquent		Nondelinquent*			
	Mean	Standard deviation	Mean	Standard deviation	Min – Max	N
Unofficial crime						
Unofficial delinquency	14.21	4.14	2.68	2.30	1 – 26	1000
Early onset	.13	.34	.007	.08	0 – 1	894
Official crime						
Delinquent status	1	0	0	0	0 – 1	1000
Age at first arrest, any crime	11.92	2.09	-	-	7 – 16	480
Frequency of arrest while free, total crime						
Ages 7-17	.43	.25	-	-	.06 – 1.85	478
Ages 17-25	1.60	2.78	-	-	0 – 30.42	444
Ages 25-32	1.03	2.45	-	-	0 – 29.20	420
Any violent arrest						
Ages 7-17	.15	.36	-	-	0 – 1	479
Ages 17-25	.34	.47	-	-	0 – 1	445
Ages 25-32	.18	.39	-	-	0 – 1	420

*Only unofficial data to age 17 are analyzed for the nondelinquent group.

Table 4. Measures of association between low birth weight and dependent variables, point-biserial correlations and Yule's Q

	Delinquent status	Unofficial delinquency	Early onset	Age at first arrest	Frequency of arrest while free, 7-17	Frequency of arrest while free, 17-25	Frequency of arrest while free, 25-32	Any violent arrest, 7-17	Any violent arrest, 17-25	Any violent arrest, 25-32
Low birth weight/ premature	-.085 [b]	.004 [a]	.240 [b]	-.041 [a]	-.020 [a]	-.033 [a]	-.056 [a]	-.053 [b]	-.219 [b]	-.368 [b]

[a] Point-biserial correlation [b] Yule's Q

Table 5. Logistic regression of delinquent status on individual factors and family environment, full sample

	Model 1		Model 2	
	B (SE)	OR	B (SE)	OR
Low birth weight	-.618[#] (.318)	.539	-.374 (.464)	.688
Individual factors				
Total IQ	-.011[#] (.006)	.989	-.001 (.009)	1.001
Temper tantrums	2.015** (.209)	7.497	1.357** (.274)	3.885
Difficult child	.988** (.145)	2.686	.988** (.222)	2.686
Family process				
Parent-child attachment			-.478** (.110)	.620
Erratic/harsh discipline			.354** (.078)	1.425
Mother's Supervision			-1.217** (.158)	.296
Family structure				
Family disruption			.308 (.251)	1.361
Family size			.190** (.055)	1.209
Family poverty			.098 (.077)	1.103
Residential mobility			.014 (.028)	1.014
Parental instability			.164 (.162)	1.178
Parental deviance			.003 (.105)	1.003
Constant	2.46* (.55)		2.048[#] (1.076)	
Model significance	LRχ^2 (4 *df*)= 214.35**		LRχ^2 (13*df*)= 528.19**	
Coefficient of determination	Pseudo R^2=.1570		Pseudo R^2=.4793	
Sample Size	N=985		N=795	

[#] p<.10 *p< .05 **p< .01

Table 6. OLS regression of total unofficial delinquency on individual factors and family environment, full sample

	Model 1 B (SE)	Model 2 B (SE)
Low birth weight	-0.813 (.819)	.035 (.708)
Individual factors		
Total IQ	-0.024 (.016)	.004 (.014)
Temper tantrums	4.920** (.479)	2.017** (.439)
Difficult child	2.697** (.404)	1.315** (.362)
Family process		
Parent-child attachment		-.795** (.185)
Erratic/harsh discipline		.539** (.124)
Mother's Supervision		-2.578** (.275)
Family structure		
Family disruption		.731[#] (.412)
Family size		.311** (.086)
Family poverty		.163 (.128)
Residential mobility		.096* (.047)
Parental instability		.290 (.270)
Parental deviance		.141 (.171)
Constant	8.392** (1.491)	12.360** (1.760)
Model significance	$F_{(4, 980\ df)} = 50.73^{**}$	$F_{(13, 781\ df)} = 62.68^{**}$
Coefficient of determination	Adjusted R^2=.1682	Adjusted R^2=.5024
Sample Size	N=985	N=795

[#] $p<.10$ *$p<.05$ **$p<.01$

Table 7. Logistic regression of early onset on individual factors and family environment, full sample

	Model 1		Model 2	
	B (SE)	OR	B (SE)	OR
Low birth weight	.413 (.513)	1.511	.678 (.582)	1.969
Individual factors				
Total IQ	-.012 (.011)	.988	-.008 (.013)	.992
Temper tantrums	1.150** (.287)	3.160	.409 (.356)	1.507
Difficult child	.579* (.295)	1.784	.402 (.361)	1.495
Family process				
Parent-child attachment			-.148 (.156)	.862
Erratic/harsh discipline			.369** (.137)	1.446
Mother's Supervision			-.627* (.319)	.534
Family structure				
Family disruption			-.375 (.379)	.687
Family size			.011 (.087)	1.011
Family poverty			-.159 (.120)	.853
Residential mobility			.063 (.041)	1.065
Parental instability			.156 (.231)	1.169
Parental deviance			.203 (.157)	1.226
Constant	-2.279* (1.03)		-2.007 (1.652)	
Model significance	LRχ^2 (4*df*) = 28.42**		LRχ^2 (13*df*) = 58.83**	
Coefficient of determination	Pseudo R^2= .0656		Pseudo R^2=.1773	
Sample Size	N=884		N=724	

[#] p<.10 *p< .05 **p< .01

Table 8. OLS regression of age at first arrest for any crime on individual factors and family environment, delinquents only

	Model 1 B (SE)	Model 2 B (SE)
Low birth weight	-.032 (.422)	-.099 (.484)
Individual factors		
Total IQ	.026** (.007)	.024** (.008)
Temper tantrums	-.657** (.196)	-.406[#] (.223)
Difficult child	.001 (.194)	-.128 (.221)
Family process		
Parent-child attachment		.006 (.101)
Erratic/harsh discipline		-.204* (.087)
Mother's Supervision		.244 (.189)
Family structure		
Family disruption		.145 (.251)
Family size		-.001 (.057)
Family poverty		-.073 (.074)
Residential mobility		.020 (.028)
Parental instability		-.166 (.146)
Parental deviance		-.131 (.098)
Constant	9.754** (.684)	9.891** (1.066)
Model significance	$F_{(4, 446\ df)} = 6.36$**	$F_{(4, 361\ df)} = 2.66$**
Coefficient of determination	Adjusted $R^2 = .0436$	Adjusted $R^2 = .0546$
Sample Size	N=471	N=375

[#] p<.10 *p< .05 **p< .01

Table 9. OLS regression of frequency of arrest while free (any crime) between 7 and 17 on individual factors and family environment, delinquents only

	Model 1 B (SE)	Model 2 B (SE)
Low birth weight	-.038 (.051)	.005 (.056)
Individual factors		
Total IQ	-.001 (.001)	-.001 (.001)
Temper tantrums	-.007 (.024)	-.019 (.026)
Difficult child	-.000 (.024)	.020 (.026)
Family process		
Parent-child attachment		-.005 (.012)
Erratic/harsh discipline		.005 (.010)
Mother's Supervision		-.004 (.022)
Family structure		
Family disruption		-.027 (.029)
Family size		.014* (.007)
Family poverty		.004 (.009)
Residential mobility		-.003 (.003)
Parental instability		.009 (.017)
Parental deviance		.042** (.011)
Constant	.491** (.083)	.369** (.124)
Model significance	F (4, 464 *df*)= .28	F (13, 360 *df*)= 2.06 *
Coefficient of determination	Adjusted R^2= -.0062	Adjusted R^2=.0357
Sample Size	N=469	N=374

[#] p<.10 *p< .05 **p< .01

Table 10. Logistic regression of violent arrest between ages 7 and 17 on individual factors and family environment, delinquents only

	Model 1		Model 2	
	B (SE)	OR	B (SE)	OR
Low birth weight	-.463 (.642)	.630	-.656 (.787)	.519
Individual factors				
Total IQ	-.005 (.010)	.995	-.007 (.012)	.993
Temper tantrums	1.055** (.270)	2.871	1.205** (.308)	3.338
Difficult child	-.160 (.272)	.853	-027 (.310)	.923
Family process				
Parent-child attachment			.112 (.143)	1.118
Erratic/harsh discipline			-.174 (.123)	.840
Mother's Supervision			-.123 (.277)	.884
Family structure				
Family disruption			-.515 (.355)	.597
Family size			-.040 (.078)	.961
Family poverty			-.020 (.101)	.980
Residential mobility			-.040 (.039)	.960
Parental instability			-.125 (.207)	.883
Parental deviance			.239[#] (.135)	1.261
Constant	-1.643[#] (.952)		-1.123 (1.493)	
Model significance	LRχ² (4*df*)= 16.23**		LRχ² (13*df*)= 25.46*	
Coefficient of determination	Pseudo R²= .0407		Pseudo R²= .0781	
Sample Size	N=470		N=374	

[#] p<.10 *p< .05 **p< .01

Table 11. Logistic and OLS regression of under-17 offending on low birth weight/family process interactions

Model 3: Family process	Delinquent status		Total unofficial delinquency	Early onset		Age of first arrest	Frequency of offending while free, 7-17	Any violent arrest, 7-17	
	B (SE)	OR	B (SE)	B (SE)	OR	B (SE)	B (SE)	B (SE)	OR
Low birth weight	-.782 (.666)	.457	-1.000 (.955)	-1.830 (1.818)	.160	.606 (1.004)	-.097 (.122)	-.975 (1.664)	.377
Total IQ	-.008 (.007)	992	-.013 (.013)	-.011 (.011)	.989	.026** (.007)	-.001 (.001)	-.005 (.010)	.995
Temper tantrums	1.830** (.242)	6.236	3.034** (.417)	.819** (.298)	2.267	-.629** (.195)	.009 (.024)	1.068** (.271)	2.910
Difficult child	.972** (.177)	2.644	1.760** (.345)	.381 (.304)	1.464	.009 (.194)	.001 (.024)	-.147 (.273)	.864
Known family process risk	1.648** (.117)	5.197	3.524** (.184)	.592** (.151)	1.808	-.226* (.111)	.015 (.013)	-.217 (.155)	.805
LBW*Family process	.104 (.545)	1.109	.319 (.645)	1.147 (.814)	3.148	-.311 (.502)	.030 (.061)	.313 (.785)	1.368
Constant	-1.440* (.682)		4.817** (1.273)	-2.874** (1.078)		10.095 (.701)**	.468** (.085)	-1.350 (.973)	
Model significance	$LR\chi^2$ (6*df*)= 531.08**		F(6,978*df*)= 112.83**	$LR\chi^2$ (6*df*)= 50.95**		F(6,464*df*)= 5.16**	F(6,462*df*)=.47	$LR\chi^2$ (6*df*)= 18.22**	
Coefficient of determination	Pseudo R^2= .3889		Adjusted R^2= .4054	Pseudo R^2= .1176		Adjusted R^2=.0504	Adjusted R^2= -.0068	Pseudo R^2= .0456	
Sample size	N= 985		N= 985	N= 884		N= 471	N= 469	N= 470	

[#] p<.10 *p< .05 **p< .01

Table 12. Logistic and OLS regression of under-17 offending on low birth weight/family structure interactions

Model 4: Family structure	Delinquent status		Total unofficial delinquency	Early onset		Age of first arrest	Frequency of offending while free, 7-17	Any violent arrest, 7-17	
	B (SE)	OR	B (SE)	B (SE)	OR	B (SE)	B (SE)	B (SE)	OR
Low birth weight	-1.389[#] (.786)	.249	-2.423* (1.230)	.417 (1.031)	1.517	-.403 (1.149)	.044 (.138)	-.685 (1.977)	.504
Total IQ	-.009 (.006)	.991	-.016 (.014)	-.011 (.010)	.989	.026** (.007)	-.001 (.001)	-.006 (.010)	.994
Temper tantrums	1.839** (.224)	6.290	3.643** (.451)	.966** (.296)	2.629	-.645 (.196)	-.011 (.024)	1.079** (.271)	2.941
Difficult child	.949** (.159)	2.583	2.123** (.374)	.504[#] (.299)	1.655	.005 (.194)	-.001 (.023)	-.139 (.273)	.870
Known family structure risk	.704** (.065)	2.023	1.637** (.129)	.252** (.096)	1.286	.074 (.066)	.023** (.008)	-.122 (.093)	.885
LBW*Family structure	.287 (.322)	1.332	.891[#] (.529)	-.009 (.364)	.991	.137 (.367)	-.031 (.044)	.094 (.628)	1.099
Constant	-1.110[#] (.617)		5.222** (1.395)	-2.723** (1.049)		9.947** (.706)	.431** (.085)	-1.332 (.984)	
Model significance	LRχ² (6*df*)= 378.84**		F(6,978*df*)= 69.89**	LRχ² (6*df*)= 35.54**		F(6,978*df*)= 4.45**	F(6,462*df*)= 1.58	LRχ² (6*df*)= 17.96**	
Coefficient of determination	Pseudo R²= .2774		Adjusted R²= .2958	Pseudo R²= .0820		Adjusted R²=.0422	R²= .0074	Pseudo R²= .0450	
Sample size	N= 985		N= 985	N= 884		N= 471	N= 469	N= 470	

[#] p<.10 *p< .05 **p< .01

Table 13. OLS regression of frequency of arrest while free (any crime) between ages 17 and 25 on individual factors and family environment, delinquents only

	Model 1 B (SE)	Model 2 B (SE)
Low birth weight	-.409 (.663)	-.001 (.698)
Individual factors		
Total IQ	-.007 (.010)	-.013 (.011)
Temper tantrums	.290 (.280)	.399 (.296)
Difficult child	.156 (.277)	.370 (.292)
Family process		
Parent-child attachment		-.208 (.136)
Erratic/harsh discipline		.011 (.116)
Mother's Supervision		-.210 (.249)
Family structure		
Family disruption		-.540 (.330)
Family size		.042 (.077)
Family poverty		.091 (.099)
Residential mobility		-.016 (.037)
Parental instability		-.327[#] (.196)
Parental deviance		.206[#] (.130)
Constant	2.061* (.990)	3.272* (1.411)
Model significance	$F_{(4, 430\ df)}$= .57	$F_{(3, 332\ df)}$= 1.34
Coefficient of determination	Adjusted R^2= -.0039	Adjusted R^2=.0126
Sample Size	N=435	N=346

[#] p<.10 *p< .05 **p< .01

Table 14. OLS regression of frequency of arrest while free (any crime) between ages 25 and 32 on individual factors and family environment, delinquents only

	Model 1 B (SE)	Model 2 B (SE)
Low birth weight	-.664 (.614)	-.342 (.715)
Individual factors		
Total IQ	.008 (.009)	.010 (.011)
Temper tantrums	.302 (.253)	.584* (.291)
Difficult child	.256 (.249)	.442 (.286)
Family process		
Parent-child attachment		-.170 (.136)
Erratic/harsh discipline		-.153 (.114)
Mother's Supervision		-.264 (.246)
Family structure		
Family disruption		.225 (.325)
Family size		.154* (.077)
Family poverty		-.102 (.097)
Residential mobility		-.016 (.036)
Parental instability		-.031 (.195)
Parental deviance		.032 (.129)
Constant	.027 (.887)	-.154 (1.395)
Model significance	$F_{(4, 406\ df)}= 1.20$	$F_{(13, 310\ df)}= 1.28$
Coefficient of determination	Adjusted R^2=.0020	Adjusted R^2=.0110
Sample Size	N=411	N=324

[#] p<.10 *p< .05 **p< .01

Table 15. Logistic regression of violent arrest between ages 17 and 25 on individual factors and family environment, delinquents only

	Model 1		Model 2	
	B (SE)	OR	B (SE)	OR
Low birth weight	-.325 (.506)	.723	-.212 (.576)	.809
Individual factors				
Total IQ	-.014[#] (.008)	.986	-.013 (.010)	.987
Temper tantrums	.441* (.210)	1.554	.706** (.248)	2.025
Difficult child	.008 (.210)	1.008	.015 (.247)	1.015
Family process				
Parent-child attachment			.168 (.116)	1.183
Erratic/harsh discipline			.017 (.097)	1.018
Mother's Supervision			-.551* (.223)	.576
Family structure				
Family disruption			-.043 (.282)	.953
Family size			.010 (.065)	1.010
Family poverty			.010 (.083)	1.010
Residential mobility			.007 (.031)	1.007
Parental instability			-.359* (.168)	.699
Parental deviance			-.074 (.110)	.929
Constant	.430 (.747)		.739 (1.196)	
Model significance	LRχ^2 (4*df*)= 7.84[#]		LRχ^2 (13*df*)= 20.53[#]	
Coefficient of determination	Pseudo R^2= .0140		Pseudo R^2= .0465	
Sample Size	N=436		N=347	

[#] p<.10 *p< .05 **p< .01

Table 16. Logistic regression of violent arrest between ages 25 and 32 on individual factors and family environment, delinquents only

	Model 1		Model 2	
	B (SE)	OR	B (SE)	OR
Low birth weight	-.528 (.769)	.590	-.047 (.797)	.954
Individual factors				
Total IQ	.014 (.010)	1.014	.011 (.012)	1.011
Temper tantrums	.209 (.261)	1.233	.329 (.302)	1.390
Difficult child	.160 (.263)	1.173	.119 (.303)	1.127
Family process				
Parent-child attachment			.035 (.145)	1.035
Erratic/harsh discipline			-.250* (.124)	.779
Mother's Supervision			-.336 (.274)	.715
Family structure				
Family disruption			-.116 (.342)	.890
Family size			.065 (.081)	1.068
Family poverty			-.020 (.102)	.980
Residential mobility			-.002 (.038)	.998
Parental instability			-.001 (.203)	.999
Parental deviance			-.003 (.136)	.997
Constant	-2.951** (.949)		-2.480 (1.490)	
Model significance	LRχ^2 (4*df*)= 3.80		LRχ^2 (13*df*)= 8.39	
Coefficient of determination	Pseudo R^2= .0097		Pseudo R^2= .0273	
Sample Size	N=411		N=324	

[#] p<.10 *p< .05 **p< .01

Table 17. Logistic and OLS regression of over-17 offending on low birth weight/family process interactions

Model 3: Family process	Frequency of offending while free, 17-25	Frequency of offending while free, 25-32	Any violent arrest, 17-25		Any violent arrest, 25-32	
	B (SE)	B (SE)	B (SE)	OR	B (SE)	OR
Low birth weight	-.808 (1.456)	-.487 (1.352)	-2.473 (1.588)	.084	.077 (1.455)	1.080
Total IQ	-.007 (.010)	.008 (.009)	-.013[#] (.008)	.987	.014 (.010)	1.014
Temper tantrums	.255 (.281)	.297 (.254)	.435* (.212)	1.545	.224 (.262)	1.251
Difficult child	.146 (.277)	.255 (.250)	.004 (.212)	1.004	.167 (.263)	1.182
Known family process risk	.226 (.159)	.084 (.143)	-.148 (.121)	.863	-.096 (.149)	.908
LBW x Family process	.179 (.712)	-.112 (.668)	1.114 (.703)	3.048	-.345 (.796)	.708
Constant	1.742[#] (1.014)	-.082 (.909)	.613 (.768)		-2.821** (.967)	
Model significance	$F_{(6, 428df)}$= .78	$F_{(6, 404df)}$= .85	$LR\chi^2$ $_{(6df)}$= 11.81[#]		$LR\chi^2$ $_{(6df)}$= 4.53	
Coefficient of determination	Adjusted R^2= -.0031	Adjusted R^2= -.0021	Pseudo R^2= .0211		Pseudo R^2= .0115	
Sample size	N= 435	N= 411	N= 436		N= 411	

[#] $p<.10$ *$p< .05$ **$p< .01$

Table 18. Logistic and OLS regression of over-17 offending on low birth weight/family structure interactions

Model 4: Family structure	Frequency of offending while free, 17-25 B (SE)	Frequency of offending while free, 25-32 B (SE)	Any violent arrest, 17-25 B (SE)	OR	Any violent arrest, 25-32 B (SE)	OR
Low birth weight	-.055 (1.718)	-.311 (1.515)	-2.409 (1.782)	.090	1.010 (1.708)	3.003
Total IQ	-.007 (.010)	.008 (.009)	-.014[#] (.008)	.986	.014 (.010)	1.014
Temper tantrums	.273 (.281)	.304 (.254)	.452* (.211)	1.571	.228 (.263)	1.256
Difficult child	.153 (.278)	.254 (.250)	.018 (.211)	1.019	.157 (.263)	1.170
Known family structure risk	.082 (.094)	-.000 (.085)	-.053 (.072)	.948	-.012 (.088)	.988
LBW x Family structure	-.136 (.570)	-.128 (.502)	.696 (.533)	2.006	-.674 (.724)	.510
Constant	1.869[#] (1.015)	.026 (.911)	.581 (.768)		-2.936** (.972)	
Model significance	F(6, 428df)=.51	F(6, 404df)= .81	LRχ^2 (6df)= 10.11		LRχ^2 (6df)= 4.84	
Coefficient of determination	Adjusted R^2= -.0068	Adjusted R^2= -.0028	Pseudo R^2= .0181		Pseudo R^2= .0123	
Sample size	N= 435	N= 411	N= 436		N= 411	

[#] p<.10 *p< .05 **p< .01

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