Issue Paper #12

PARTNERSHIP FOR AMERICA'S ECONOMIC SUCCESS

Long-Run Economic Effects of Early Childhood Programs on Adult Earnings

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Funding for this report was provided by the Partnership for America's Economic Success (PAES). The views expressed in this paper are those of the authors and do not necessarily reflect the views of the reviewers, PAES, the Pew Charitable Trusts (Pew), or the author's organizations. The results and conclusions presented are those of the authors.

The Partnership for America's Economic Success was created by a group of business leaders, economists, advocates, and a dozen funders in order to document the economic impacts to the nation of proven investments in children from before birth to age five. Funders include the Buffet Early Childhood Fund; Robert Dugger; George Gund Foundation; Horace Hagedorn Foundation; Paul Tudor Jones; Ohio Children's Foundation; Peppercorn Foundation; The Pew Charitable Trusts; PNC Financial Services Group, Inc.; Scholastic, Inc.; The Schott Foundation for Public Education; and Anonymous. The Partnership is managed by The Pew Charitable Trusts.

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Release Date: February 20, 2009

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Abstract

Researchers and policymakers alike want to better understand the long-run effects of investments in children's well-being. Yet, only a few studies have examined how participants in early childhood interventions fare as adults. These studies suggest that early investments may have sizable payoffs for children's later success. In the absence of long-run data on children's outcomes, how can we determine the long-run monetary value of improvements in young children's well-being?

In this report we describe a way to link improvements in aspects of children's early health, achievement, and behavior to improved labor market outcomes when they become adults. We apply the same method to link improvements in the parenting children receive with their success in the labor market as adults. Our results suggest that investments in early childhood that improve these aspects of development will likely have important payoffs. However, the magnitude of these payoffs is strongly dependent on the extent to which early program effects are maintained over time.

We draw both substantive and methodological conclusions from this research. Both are important to understanding and quantifying the potential of early interventions to improve later outcomes. Our key substantive finding is that early improvements in child health, academic achievement, and behavior as well as improved parenting can yield sizable economic benefits for adult earnings. Our key methodological contribution is the application of a two-step method for linking improvements in early outcomes to long-run economic gains.

Introduction

Researchers and policymakers alike want to better understand the long-run effects of investments in children's well-being. Yet, only a few studies have examined how participants in early childhood interventions fare as adults. These studies suggest that early investments may have sizable payoffs for children's later success. Such studies are valuable, but also rare and costly. With limited data researchers often rely on the magnitude of the program effect to discuss a program's success. Yet, typical characterizations of effect sizes as small, medium, or large provide little guidance about the magnitude of economic benefits likely to accrue from such effects (Duncan & Magnuson, 2007). In the absence of long-run data on children's outcomes, how can we determine the long-run monetary value of improvements in young children's well-being?

In this report we describe a way to link improvements in aspects of children's early health, achievement, and behavior to improved labor market outcomes when they become adults. We apply the same method to link improvements in the parenting children receive with their success in the labor market as adults. Our results suggest that investments in early childhood that improve these aspects of development will likely have important payoffs. However, the magnitude of these payoffs is strongly dependent on the extent to which early program effects are maintained over time.

Methods

The most direct way to estimate the effects of early interventions on later outcomes is to observe these effects directly, by randomly assigning children to a treatment group that receives the intervention or to a comparison group that does not receive the intervention. Following both groups of children years after the intervention has ended and comparing them on important outcomes provides an indication of whether the intervention had lasting influence. However, this takes considerable time and can be very costly. In addition, such long-term studies are often plagued by high and selective attrition, which makes it difficult to accurately estimate long-run program effects. Alternatively, we can determine the likely value of interventions by estimating the extent to which early academic skills, health, and behavior predict economically relevant outcomes such as educational attainment or labor market participation.

In this section, we provide a discussion of the methods by which we estimate the value of improvements in early childhood academic skills, health, behavior, and parenting for adult earnings. First, we discuss a conceptual model that illustrates how early childhood factors may be linked to adult earnings. For the most part, we relied on previous research to provide empirical evidence about the strength of such linkages, and therefore we discuss our criteria for identifying high-quality studies. In addition, we explain how our literature review led us to focus on a small number of specific pathways between early development and adult earnings; these are a subset of the many complex pathways in the conceptual model. Finally, we discuss our methods for estimating the present value of adult earnings at a child's birth and at age 5.

Early interventions typically target at least one important domain of development (e.g, health, academic skills, behavior), and in turn, there are multiple pathways by which early development may affect children's earnings as adults. Figure 1 provides a conceptual framework that illustrates the primary pathways we are concerned with in this work.[1] Adult wages are a function of workers' prior academic skills, behavior, and health, which in our model are represented by such domains in adolescence. This collection of adolescent outcomes has important antecedents during early childhood. Likewise, by shaping the context of development in early childhood or adolescence, parenting may have long-run influences on adult earnings. It is important to note, however, that these effects are likely to be indirect, and to operate through children's skills, behavior, and health. Although the strength of the associations between developmental domains in early childhood and adolescence will vary across outcomes being considered, this model suggests that intervening during early childhood to promote health, academic skills, and behavior may well have long-run effects on later success.

We reviewed previous research to assess the strength of the association between early development and parenting and later earnings. The quality of the research design is very important for this exercise, because studies that approximate causal estimates provide the best information about how changes in early outcomes will lead to changes in later outcomes. For this reason, we focused in our review on high-quality studies that used rigorous methods to handle issues of causal inference. In particular, we sought studies that attempted to reduce omitted

[1] There are, of course, many macroeconomic and contextual factors that affect one's earnings and success in the labor market, but these do not figure into our analysis.

variable biases, by using either sibling or family fixed effects or by including a comprehensive set of covariates.[2]

Within the domains of health, behavior, and parenting, we also faced the challenge of identifying particular indicators. For example, health could include general health status, disabilities, or low birth weight. Likewise, behavior might include aggression, social competence, or attention. Our choice of indicators within each domain was determined by the availability of high-quality studies which provided evidence of a consensus about the likely magnitude of the association between the indicator and later outcomes. Finally, we required that at least one rigorous study using a population-based sample from the United States had been conducted.[3]

We looked first for studies that directly estimated the effects of these early domains on later labor market outcomes. Such long-run studies are likely to provide the most complete understanding of the effects of early investments, as they incorporate all of the possible mechanisms by which these outcomes influence later outcomes. For example, improved health in early childhood may lead to better health as a young adult as well as improved achievement and behavior, all of which may in turn influence a worker's job prospects and wages. Predicting later labor market success as a function of early health results in an estimate that includes the benefits from all possible pathways.

In our review, we were able to find several high-quality studies that linked low birth weight, an indicator of early health, to later earnings. Unfortunately, however, we found that high-quality studies predicting adult labor market outcomes as a function of early achievement, behavior, or parenting are rare (and often specific to a particular population).[4] More common are high-quality studies that link early achievement, behavior, and parenting to later achievement, often in adolescence. These studies are useful because there is also high-quality evidence about the long-run payoffs to achievement in the labor market.

Thus, for the domains of early achievement, behavior, and parenting, we engaged in a two-step estimation process. First, we surveyed the literature to arrive at an estimate of the extent to which early achievement, behavior, and parenting predict achievement during adolescence, and second, we surveyed the literature to determine the extent to which achievement during adolescence predicts success in the labor market as measured by adult earnings, again focusing on high-

[2] A challenge in these studies is being able to adequately adjust for the differences in family background that might lead both to poor early childhood outcomes and lower achievement or earnings later in life. One strategy is to make use of comparison of siblings, and in some cases twins. This has the benefit of holding constant many, although not all, family characteristics shared by siblings with higher and lower birth weights. An alternative strategy is to measure and to include as covariates in the analyses many of the family background characteristics that might create such a spurious association.

[3] In several instances our review led us to use unpublished papers, which have not yet undergone peer review, and, in the case of parenting, to conduct our own analyses. The unpublished papers that we selected have been presented at professional meetings and are not the only sources we use for a particular estimate. In the case of our own analyses, we provide details of the analyses in Appendix 2 and note that these estimates are similar to those found in other studies.

[4] These studies are rare for the same reasons that long-run evaluations of early intervention programs are rare; such studies are time-consuming and impose high costs. For example, Krueger's (2003) estimate of the long-run economic benefits of reduced class size for third graders relies on simple correlations from a British cohort study. We chose not to use this approach for several reasons including the different educational and labor market setting, the lack of appropriate controls, and the timing of the assessments.

quality studies. Figure 2 provides an illustration of how we are assessing the influence of early childhood health (low birth weight), academic skills (reading and math), behavior (attention), and parenting (home environment) on adult earnings.

The drawback of the two-step approach is that, in contrast to directly assessing the effect of early outcomes on later labor market outcomes, the economic benefit of only one pathway of influence is estimated. That is, although early skills and achievement may affect success in the labor market through several mechanisms, only the influence they have via raising achievement is calculated. For example, if improving children's early behavior affects their labor market outcomes by increasing both their later academic skills and their interpersonal skills, only the benefits of increased academic skills will be estimated.[5] This is apparent in contrasting our conceptual model in Figure 1 with our analytic model in Figure 2. In Figure 1, associations are apparent between all the early childhood domains and the adolescent domains. In contrast, in Figure 2, the pathways between early academic skills, health, and behavior and the later adolescent behavior and health domains are not included. Likewise, the pathways between adolescent behavior and health and adult earnings are not estimated. Similarly, we only estimate the effects of parenting that operate through adolescent achievement.

Another important difference between our conceptual model (Figure 1) and our analytic model (Figure 2) is the specificity of the measures for physical health (low birth weight), behavior (attention), and parenting (home environment). As noted earlier, these measures are just one of many possible indicators for each domain. Our choice of these measures was determined by our review of the literature, in which we sought to identify measures within each domain that have been linked to adult earnings or adolescent achievement using high-quality research methods. Other indicators of children's health, behavior, and parenting were considered, but did not meet our inclusion criteria. This suggests that we have much more to learn about how children's early health and behavior affect later outcomes.

Translating results from empirical studies into specific dollar amounts required that we also estimate the value of lifetime earnings, our measure of labor market success, for an infant or a young child. Lifetime earnings reflect both the intensity of employment (hours, weeks, years) as well as one's productivity (wage rate). We estimate the value of earnings for individuals with a high school degree or some college (the average worker in the U.S.) in 2006 dollars.[6] It is important to recognize that the earnings profiles will differ across demographic groups, not only by educational status, but also by gender, race, and ethnicity. Our use of an average worker may obscure important differences in lifetime earnings, and thus the economic value of interventions that target particular populations may also differ accordingly.[7]

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[5] An alternative to the two-step method we employ would be to conduct a microsimulation. The necessary information about relevant associations between early and later domains needed to conduct such an analysis, however, is not available in the literature.

[6] All monetary values presented in the paper are estimated for 2006 dollars.

[7] We have chosen not to adjust lifetime earnings for mortality, but mortality also differs across demographic groups and could influence the value of lifetime earnings (e.g., higher rates of early mortality will decrease the value of lifetime earnings). It is also possible that if early interventions are implemented on a large scale leading to substantial improvements in children's skills, abilities and behaviors, then as a result the returns to such skills may decrease (as the supply of skills in the labor market increases).

For an earnings profile, there are two important parameters to consider in estimating the lifetime value: real wage growth and a real discount rate. Wage growth refers to increases in earnings due to improved productivity of the workforce. This approach is needed because we are using the earnings profile of workers in 2006, and historically per person wages have been increasing in the overall economy.[8] The discount rate refers to the annual rate of growth of an investment that is expected over time. To arrive at the value of infants' or 5-year-olds' lifetime earnings, estimated at birth or age 5 (respectively), we must make assumptions about each of these parameter. Consequently, we provide estimates based on a range of values for both wage growth and discount rates (see Appendix 1 for additional details)..

In the next section, we describe our estimates for four important early outcomes: low birth weight, academic skills, attention, and the quality of children's home environments. In each section we discuss the literature that we reviewed and posit estimates of the economic benefits of improvements in these domains.

Health: Low Birth Weight

Low birth weight is an important indicator of infant health and may have long-run implications for workers' economic well-being. A host of medical studies document lower levels of health and achievement among low birth weight children, particularly those born at very low birth weights (Reichman, 2005). A few studies have also directly estimated the effects of low birth weight on later earnings using rigorous methods, and the results are remarkably consistent in suggesting that higher birth weights are likely to lead to higher levels of educational attainment, academic achievement, and earnings. Based on the work of Johnson and Schoeni (2007) and Behrman and Rosenzweig (2004), we estimate that preventing low birth weight is likely to improve an individual's earnings by between 10 and 15% percent.[9]

Table 1 provides estimates of the expected economic value of preventing a low birth weight for an individual, if low birth weight is associated with a 10 percent reduction in lifetime earnings. That is, these estimates represent the difference in earnings for the average low birth weight child compared to the average normal birth weight child (non-low birth weight). The choice of wage growth rate and discount rate are important, with estimated benefits ranging from $27,834 to $137,438. Assuming what we consider to be middle-range parameters (1 percent growth in

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[8] Historically, during the 20th century annual wage growth was between 1-2% a year, but Krueger (2003) suggests that future wage growth is projected to be slightly less than 1% a year.

[9] These studies are selected because they both employ sibling fixed effects models, which as noted earlier hold constant many of family background characteristics that might be confounded with LBW. The Behrman and Rosenzweig (2004) sample is comprised of female monozygotic twin mothers born between 1936 and 1955 in Minnesota. Estimates from Behrman and Rosenzweig (2004), based on fetal growth rather than low birth weight, suggest that increasing low birth weight infants' fetal growth by 17 oz. (about one pound, close to the average difference in weight between being low birth weight and not being low birth weight) would increase earnings by 10%. The specificity of the sample used by Behrman and Rosenzweig, particularly the use of twins, provides some advantages but also limits the generalizability of the findings, and as a result we looked for additional studies using a more representative sample. Johnson and Schoeni (2007) use a sample of (non-twin) brothers between 1951 and 1975 from the Panel Study of Income Dynamics, a large national study. Johnson and Schoeni's (2007) sibling analysis finds that low birth weight reduces earnings by about 16% at age 35. Although each of these studies has limitations, the fact that estimates are similar despite differing measures, samples, and time frames boosts our confidence that these effects are meaningful, even if the precise magnitude of effects is uncertain.

wages and a 3 percent discount rate), the value of preventing a low birth weight birth is quite substantial, $60,261 (the figure highlighted in bold in the table). Table 2 provides similar estimates if low birth weight is associated with a larger (15 percent) reduction in lifetime earnings. Again, assumptions about the magnitude of wage growth and discount rates are important, with estimates ranging from $41,751 to $206,156. Here our middle-range estimate implies that preventing a low birth weight (LBW) birth would yield a benefit of $90,392.

Table 1 Estimated present value of preventing a LBW birth, assuming a 10% effect of LBW on lifetime earnings, estimated at birth

Wage growth:	0%	1%	2%
Discount rate			
2%	59,787	90,224	137,438
3%	40,464	**60,261**	90,589
4%	27,834	40,926	60,730

Table 2 Estimated present value of preventing a LBW birth, assuming a 15% effect of LBW on lifetime earnings, estimated at birth

Wage growth:	0%	1%	2%
Discount rate			
2%	89,680	135,335	206,156
3%	60,695	**90,392**	135,883
4%	41,751	61,389	91,095

These estimates tell us the value of preventing low birth weight for an individual based on its association with improved earnings. There is evidence to suggest that reducing low birth weight would also have other positive effects--for example, by reducing disability or the use of social welfare benefits--and thus our estimates are likely to understate the total economic benefits of preventing LBW.[10]

We might also want to understand the value of a program that prevents low birth weight for a population. In this case, we must also take into account how effective interventions may be at preventing low birth weight. Unfortunately, there are decidedly few programs that have been documented to successfully reduce low birth weight. A review of medical and psychoeducational interventions suggests that these do not significantly affect birth weight (Lu, Tache, Alexander, Kotelchuck, & Halfon, 2003). A more promising approach to preventing low birth weight is the Supplemental Nutrition Program for Women, Infants, and Children (WIC). Although there is some debate about these studies, the preponderance of the evidence suggests that WIC improves birth weight. [11] Bitler and Currie (2005) find that WIC reduces the probability that an infant is

[10] See Oreopoulos, Stabile, Walld, and Roos (2007) and Conley, Strully, and Bennett (2003) for evidence of the association between LBW and other relevant outcomes.
[11] See, for example, Joyce, Gibson, and Coleman (2005) and Ludwig and Miller (2005) for further discussion of WIC's effectiveness.

low birth weight by 29 percent, from a base rate of about 8.1%.[12] To arrive at estimates for the value of the WIC program, we would adjust the savings by this proportion. If we assume a 1 percent wage growth rate and 3 percent discount rate, then we would estimate the present value of the benefits of WIC in reducing low birth weight to be between $1,416 and $2,123. If the WIC program improves other early outcomes for children, which in turn translate into higher earnings, the long-run benefits of the program will be larger than those estimated here.

Achievement: Academic Skills

Early academic skills are the foundation of later learning. This has led researchers and policymakers alike to suggest that we can set children on the path for economic success by boosting their early academic skills (Duncan, Ludwig, & Magnuson, 2007; Heckman, 2006; Knudsen, Heckman, Cameron, & Shonkoff, 2006). Yet, in seeking to understand how early academic skills may lead to improved earnings in adulthood, an immediate challenge is the lack of studies that directly predict earnings as a function of early skills. The lack of such studies is due in large part to data limitations. Few studies that have assessed children's early academic skills have followed them long enough to collect data on their adult earnings or labor market experiences.[13] As a result, connecting early achievement to later labor market outcomes requires a two-step process: first, surveying studies that link early achievement to achievement during adolescence; and second, surveying studies that link achievement during adolescence to subsequent labor market outcomes. Thus, we arrive at estimates by considering how early achievement is linked to achievement during adolescence, and in turn, how adolescents' achievement is linked to adult earnings.

The widely documented decline over time of early intervention program impacts on achievement suggests that early skills are far from perfectly predictive of later skills (Aos, Lieb, Mayfield, Miller, & Pennucci, 2004; Shonkoff & Phillips, 2002).[14] Yet, just how predictive are early skills? In trying to answer this question, we face the challenge of assessing how predictive early skills are of later skills, and identifying how much of the association is likely to be causal. Learning requires that new academic skills build on prior skills, suggesting that children with higher levels of academic achievement will continue to outperform other children over time. However, we expect that only part of this correlation is due to the influence of early skills per se. Continuity in achievement levels is likely also due to the persistence of other advantages, such as socioeconomic status, that lead to higher levels of both early and later academic skills and which are unlikely to be changed by early child interventions.

How can studies estimate the causal effect of improvements in early academic skills on later skills? One approach is to measure many of the characteristics that might lead to higher levels of

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[12] This is the rate for Bitler and Currie's (2005) full sample which is not exactly the correct rate for our calculations, given that it based on both WIC users and non-users. Unfortunately, they don't provide mean LBW rates separately for WIC subgroups.

[13] A few long-term studies of high quality early education programs have followed children into their adult years and found that these programs increase later earnings (see Shonkoff & Phillips, 2000, for a review). The extent to which earning increases are due specifically to earlier improvements in academic skills rather than improvements in other developmental domains such as behavior or health is uncertain.

both early and later academic skills. This method was employed by Duncan and colleagues in a recent study that linked preschool-age achievement and behavior with later achievement (Duncan, Dowsett, Classens, Magnuson, Huston, Klebanov, et al., 2007). The study used several large datasets, most notably the children of the National Longitudinal Survey of Youth (NLSY), which administered the same Peabody Individual Achievement Test (PIAT) assessments between ages 5 and 14. This multivariate regression study had several admirable qualities that make it useful for our purposes. First, it included comprehensive measures of family background, including for example, family structure, income and parental education. It also included measures of children's problem behavior measured at the same time as their achievement (age 5 or 6), as well as their temperament and receptive vocabulary at ages 3 or 4. Such a set of controls should be helpful in trying to tease out the predictive power of achievement per se rather than related aspects of children's lives and behavior. Second, it was a nationally based large sample.

NLSY analyses of the effects of both reading and math skills at age 5 or 6 on subsequent reading and math skills at age 13 or 14 yielded rather modest associations. In these models, results suggest that a one standard deviation unit increase in reading at age 5 or 6 was associated with a 0.16 standard deviation unit increase in reading at ages 13 or 14. The similar estimate for math was 0.22.[15] Therefore, if an intervention program only targeted children's reading skills (or only targeted children's math skills) we might expect considerable decline of the impacts over time, with only around 20 percent of the initial benefits remaining (or put another way, 80 percent of the benefits fading out). However, if a program improved both reading and math skills by a standard deviation, then the total effects would amount to a much larger gain (0.38), with less decline over time (about 60 percent). We recognize that these effects are conservative not only because they adjust for potentially important confounds, including children's concurrent problem behavior, but also because they do not take measurement error into account which will attenuate associations.[16]

Next we turn to the economics literature to identify estimates of the association between achievement skills during adolescence and later earnings. Several studies have considered this question, and the results vary, but generally they point to estimates implying that a one standard deviation increase in academic skills (both reading and math skills) in adolescence will result in

[15] The effects of early reading on later math and of early math on later reading were slightly smaller. The other studies in Duncan et al.'s (2007) research did not follow children for as long. However, it is interesting to note that estimates across other studies for time points early in childhood were not much larger than these estimates, suggesting that these are reasonable associations. The slightly stronger predictive power of math was replicated across studies.

[16] The 0.38 estimate is the additive estimate of math and reading coefficients. It is worth noting that this estimate is quite close to the raw correlation between early and later reading (or math) skills, which is 0.42 (0.43). These correlations are fairly similar across racial or ethnic groups, with the exception that the correlation between early and later math skills seems to be somewhat lower for blacks than for the other groups (.29 for blacks; .45 for Hispanics and .42 for whites). The temporal reliability of the PIAT is adequate, but far from perfect--on average .89 for reading and .74 for math (Dunn & Markwardt, 1970). In addition, the NLSY estimates were not sensitive to the inclusion of family background controls or measures of children's temperament and receptive vocabulary at age 3 or 4. For comparative purposes it is worth noting that the partial correlation between achievement in first (age 7) and eighth grade (age 14) in the Perry Preschool treatment sample is slightly higher. For both the reading California Achievement Test (CAT) the raw correlation is .59 and for the math CAT the correlation is .47 (personal communication with James Heckman, 10/28/08). For the same sample, partial correlations that control for IQ at program entry, SES, father presence and maternal employment, are about .53 for reading CAT and .42 for math CAT.

a 10 percent to 20 percent increase in adult earnings (Cawley, Heckman, & Vytlacil, 2001; Krueger, 2003; Murnane, Willet, Duhaldeborde, & Tyler, 2000; Neal & Johnson, 1996).[17]

Combining these estimates with the present value of lifetime earnings, estimated at age 5, we are thus able to place a dollar value on improved early achievement. We again show a range of estimates, varying not only the wage growth and discount values, but also the predictive power of early skills to later skills, and of skills in adolescence to labor market earnings. Tables 3 and 4 show what would be expected from improving either math or reading skills during the preschool years, with 80 percent of the original standard deviation improvement fading out by early adolescence.[18] Estimates in Table 3 assume that a standard deviation increase in adolescent achievement improves later earnings by 10 percent, and Table 4 assumes the same increase improves earnings by 20 percent. Tables 5 and 6 provide estimates for what might be expected if an intervention program increased both early reading and math achievement, and thus only 60 percent of the achievement impacts faded by early adolescence. Finally, for comparative purposes we present in Tables 7 and 8 estimates of the economic benefits that might accrue if 80 percent of the improvements in academic achievement were maintained through adolescence (only 20 percent decline over time). Such high levels of persistence have not been found for early childhood interventions, yet it is possible that a sustained intervention might be more effective at preventing fade-out.[19]

As expected, the estimated economic value of gains in early achievement varies depending on the assumptions made. At the low end, if we assume programs raise only reading skills (or only math skills), 80 percent of those gains fade, and adolescent skills improve lifetime earnings by 10 percent; the middle-range present value of a program that raises early skills by one standard deviation is $13,294 (Table 3). If we assume adolescent skills instead raise lifetime earnings by 20 percent, our middle-range estimate increases to $26,587 (Table 4). Taking into account that programs might raise both reading and math skills raises the estimated value more substantially, to $26,587 or $53,175 (taking the middle-range estimates from Tables 5 and 6). Finally, assuming stronger persistence of early skill gains yields considerably higher estimated present values of $53,175 or $106,350 (taking the middle-range estimates from Tables 7 and 8).

[17] Estimates vary across ethnic, racial, and gender groups and appear to be closely linked to improvements in educational attainment; see Cawley, Heckman, & Vytlacil (2001) and Murnane et al. (2000) for a discussion. A recent study by Rose (2006), which controlled for 8th grade achievement, finds little return to increases in achievement during high school for males. In contrast, Rose's (2006) estimates of the same returns for females are of a similar magnitude as found in earlier research.

[18] This analysis assumes that increasing either early reading or math skills would have an average effect of 0.2 on both later reading and math skills.

[19] The numbers in Tables 4 and 5 are identical, even though the underlying assumptions are different, because the specific set of assumptions used in the two tables yield comparable results. The same is true for Tables 6 and 7.

Table 3 Estimated present value of a one standard deviation increase in early reading skills assuming a 10% effect of adolescent achievement on lifetime earnings (80% decline over time)

Wage growth:	0%	1%	2%
Discount rate			
2%	13,202	18,956	27,488
3%	9,382	**13,294**	19,023
4%	6,773	9,475	13,384

Table 4 Estimated present value of a one standard deviation increase in early reading skills assuming a 20% effect of adolescent achievement on lifetime earnings (80% decline over time)

Wage growth:	0%	1%	2%
Discount rate			
2%	26,404	37,912	54,975
3%	18,763	**26,587**	38,047
4%	13,546	18,950	26,769

Table 5 Estimated present value of a one standard deviation increase in early reading and math skills assuming a 10% effect of adolescent achievement on lifetime earnings (60% decline over time)

Wage growth:	0%	1%	2%
Discount rate			
2%	26,404	37,912	54,975
3%	18,763	**26,587**	38,047
4%	13,546	18,950	26,769

Table 6 Estimated present value of a one standard deviation increase in reading and math skills assuming a 20% effect of adolescent achievement on lifetime earnings (60% decline over time)

Wage growth:	0%	1%	2%
Discount rate			
2%	52,808	75,823	109,950
3%	37,527	**53,175**	76,094
4%	27,091	37,901	53,538

Table 7 Estimated present value of a one standard deviation increase in early reading and math skills assuming a 10% effect of adolescent achievement on lifetime earnings (20% decline over time)

Wage growth:	0%	1%	2%
Discount rate			
2%	52,808	75,823	109,950
3%	37,527	**53,175**	76,094
4%	27,091	37,901	53,538

Table 8 Estimated present value of a one standard deviation increase in early reading and math skills assuming a 20% effect of adolescent achievement on lifetime earnings (20% decline over time)

Wage growth:	0%	1%	2%
Discount rate			
2%	105,615	151,647	219,900
3%	75,053	**106,350**	152,188
4%	54,183	75,801	107,075

The estimates provided in Tables 3-8 suggest the benefits that are likely to accrue from a one standard deviation improvement in academic skills. In the field of early intervention such large improvements in achievement are unusual. Indeed, only the most high-quality and intensive programs have resulted in such large effects, and evaluations of large scale interventions typically result in considerably smaller estimates. For example, recent evaluations of Head Start and prekindergarten programs suggest effects between 0.20 and 0.40 on a range of academic skill measures (see, for example, Ludwig & Phillips, 2007; Wong, Cook, Barnett, & Jung, 2007). Based on the estimates in the tables, we would thus expect to reap proportionately smaller economic benefits from these programs.[20] For example, if a program increased both math and reading scores by 0.40 of a standard deviation, then the likely economic benefits would range from $10,634 (40 percent of $26587, Table 5) to $21,270 (40 percent of $53,175, Table 6).

However, it is important to recall that these estimates only count economic rewards that accrue due to the persistence of increased achievement through adolescence, and as such are almost certainly an underestimate of the full economic returns. If improvements in early academic skills also reduce other outcomes that have implications for achievement, for example, teen childbearing or incarceration, then our estimates will not capture these benefits. Similarly, if programs that raise early skill levels also yield improvements in child health or behavior, which in turn are linked to improved adult outcomes, our estimates will not capture those benefits.

Behavior: Attention Skills

An important dimension of early behavior is a child's ability to pay attention and focus on tasks at hand. Early deficits in attention skills have been shown to affect initial and later school achievement, as they interfere with a child's ability to learn in the classroom setting (for a review of this literature, see Currie & Stabile, 2006, and Fletcher & Wolfe, 2007). Long-run studies linking early deficits in attention skills with later labor market outcomes are lacking, so we apply a two-step method, first estimating the links between early attention skills and later achievement, and second estimating the link between later achievement and adult earnings.

It is methodologically challenging to estimate the causal effects of early attention skills on children's later achievement, and recent studies provide a range of estimates. We employed analyses conducted by Duncan and colleagues (2007), which used regression methods with a comprehensive set of controls across several large datasets. As described earlier the controls used include measures of family background that are unlikely to be affected by an early intervention

[20] The assumption of proportionality of early and later effects has not been empirically tested.

such as SES and family structure. The regressions also include measures of reading and math skills measured at the same time as parent-reported attention, which will isolate attention problems from concurrent achievement. This is an appropriate model, if an intervention targets attention behavior but does not also directly seek to improve children's achievement (subsequent improvements in achievement that result from improvement in attention are factored into this model).

Data from the NLSY data, a large national sample, suggest that increasing attention skills (measured by attention problems) by one standard deviation at school entry (age 5 or 6) would raise young adolescents' reading by 0.05 and math by 0.11 of a standard deviation.[21] However, analyses in Duncan and colleagues (2007) using data from the NICHD Study of Early Child Care and a similar regression model, which has a teacher-reported measure of attention problems, suggest stronger links between early attention skills and 5th grade achievement, of between 0.11 and 0.17.[22] Therefore, in our tables, we apply two estimates for the link between early attention problems and later achievement. Tables 9 and 10 present estimates in which a 0.05 effect of attention on later achievement is combined with the assumption that a one standard deviation increase in adolescent achievement would yield a 10 percent increase in adult earnings (Table 9) or a 20 percent increase in adult earnings (Table 10). Tables 11 and 12 present higher estimates, in which a 0.11 standard deviation increase in adolescent attention is combined with the assumption that a standard deviation increase in achievement produces 10 percent (Table 11) or 20 percent (Table 12) higher earnings. As was the case for achievement, these point estimates are conservative because they represent partial correlations and do not take into account measurement error which will attenuate estimates.

The results in Table 9 suggest that increasing attention skills by one standard deviation at age 5 is likely to yield $3,323 in benefits (taking our middle-range estimate). Assuming that later achievement is more strongly linked to later earnings, in Table 10, yields an estimated benefit of $6,647 (taking the middle-range figure). Assuming that early attention skills are more strongly linked to adolescent achievement yields estimated benefits of roughly $7,000 to $15,000, depending on the assumptions made about the links between adolescent achievement and later earnings (taking the middle-range estimates from Tables 11 and 12).

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[21] Other estimates for the children of the NLSY that take unobserved family factors into account, by comparing siblings, suggest somewhat smaller links, on the order of 0.04 and 0.05 (Currie & Stabile, 2007). However, recent work by Fletcher and Wolfe (2007), which also looks at the link between attention and achievement, suggests that sibling comparisons may not be an appropriate method because it may understate the effects of attention on achievement.

[22] The attention problem measure in the NLSY is a subscale of the parent reported Behavior Problems Index the measure in the NICHD SECCYD is a subscale of the teacher Child Behavior Check List (CBCL). The NICHD analyses only follow children through 5th grade, thus it is unclear whether the association between early attention and adolescent achievement would be as strong.

Table 9 Estimated present value of a one standard deviation increase in attention skills at age 5, assuming a 0.05 effect of early attention skills on adolescent achievement and a 10% effect of adolescent achievement on adult earnings

Wage growth:	0%	1%	2%
Discount rate:			
2%	3,300	4,739	6,872
3%	2,345	**3,323**	4,756
4%	1,693	2,369	3,346

Table 10 Estimated present value of a one standard deviation increase in attention skills at age 5, assuming a 0.05 effect of early attention skills on adolescent achievement and a 20% effect of adolescent achievement on adult earnings

Wage growth:	0%	1%	2%
Discount rate			
2%	6,601	9,478	13,744
3%	4,691	**6,647**	9,512
4%	3,386	4,738	6,692

Table 11 Estimated present value of a one standard deviation increase in attention skills at age 5, assuming a 0.11 effect of early attention skills on adolescent achievement and a 10% effect of adolescent achievement on adult earnings

Wage growth:	0%	1%	2%
Discount rate			
2%	7,261	10,426	15,118
3%	5,160	**7,312**	10,463
4%	3,725	5,211	7,361

Table 12 Estimated present value of a one standard deviation increase in attention skills at age 5, assuming a 0.11 effect of early attention skills on adolescent achievement and a 20% effect of adolescent achievement on adult earnings

Wage growth:	0%	1%	2%
Discount rate			
2%	14,522	20,851	30,236
3%	10,320	**14,623**	20,926
4%	7,450	10,423	14,723

Again, we note that the estimates presented in the tables provide an expected value for a standard deviation increase in early attention for an individual. The expected value of programs that seek to improve children's attention is likely to be smaller given that the average effect of programs on children's attention is also likely be smaller. Parenting training programs for families of children with high levels of attention problems are able to improve children's attention skills substantially; studies suggest that effect sizes are on the order of 0.60 to 0.80 (Jones, Daley, Hutchings, Bywater, & Eames, 2007; Sonuga-Barke, Daley, Thompson, Laver-Bradbury, & Weeks, 2001). Effect sizes of this magnitude would yield proportionately smaller improvements in earnings, with estimates ranging from approximately $1, 994 to $11,698 (assuming 1 percent wage growth rate, 3 percent discount rate, Tables 9 and 12). However, the expected benefits from programs for a more general population of children may be smaller. Of course, our estimates reflect only the benefit from improved attention that will operate through increases in achievement. If increases in attention skills lead to improvements in other aspects of child and adolescent development, the economic rewards to such programs are likely to be larger.

Parenting: Home Environment

Studies of child development consistently point to the important role played by the parenting children receive in early childhood. As is apparent from our conceptual and analytic models (Figures 1 and 2), parenting matters because it is likely to be an important context that shapes children's health, academic skills, and behavior.[23] Parenting is difficult and costly to measure, so studies often attempt to gauge the quality of parenting and early experiences in the home by using scales that rate the quality of the home environment. In particular, studies have used the Home Observation and Measurement of the Environment (HOME) scale, developed by Caldwell and Bradley (1984), to assess the cognitive stimulation and emotional support families provide. Studies have consistently found that higher quality early environments, as measured by the HOME scale, are associated with better school achievement, although studies of the links between early home environment and adult earnings are lacking. Therefore, we again apply a two-step method, first establishing the links between improvements in the early home environment and adolescent achievement, and second establishing the links between adolescent achievement and adult earnings.

Published estimates of the links between the early home environment and later achievement, although typically positive and significant, did not provide estimates of the associations between early home environments and later achievement needed for this work. We, therefore, carried out our own analyses, using data on the children of the NLSY and the Infant Health and Development Project.[24] Results from analyses with the NLSY suggest that a standard deviation increase in the quality of the home environment in early childhood as measured by the HOME scale at age 6 is associated with a 0.10 (reading) to 0.14 (math) increase in adolescent achievement. Results from the IHDP suggest a higher association, with estimates of 0.23 to 0.28.[25] We suspect that the difference in the magnitude of the estimates reflects the discrepancy in the quality of the home environment measures, as the IHDP measure is more comprehensive.[26] We provide estimates based on the midpoint of both sets of findings using 0.12 and 0.255 effects

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[23] The relationship is likely to be bidirectional, with children's health, achievement, and behavior also influencing parenting (Collins, Maccoby, Steinberg, Hetherington, & Bornstein, 2000).
[24] See Appendix 2 for details. Both samples and methods were based on those reported in Duncan et al. (2007).
[25] The magnitude of these effects is comparable to those reported by Aughinbaugh and Gittleman (2003), who find that a standard deviation improvement in the HOME score is associated with an increase of 0.10 to 0.15 on the PIAT-Reading and Math tests for school-age children and youth in the NLSY.
[26] Correcting for measurement error would increase the estimates from the NLSY. The NLSY HOME-SF is reported to have a reliability of .71 (Baker, Keck, Mott, & Quinlin, 1993), and correcting the attenuation that results from poor measurement would yield an association of 0.19 between the early HOME environment and reading and 0.27 between the early HOME environment and math (authors' calculations).

of the early home environment on later achievement. We further assume that a standard deviation increase in adolescent achievement improves adult earnings by 10 percent (Tables 13 and 15) or 20 percent (Tables 14 and 16).

The results indicate that improvements in early home environment can yield sizable benefits in adult earnings. Our middle-range estimate from Table 13 suggests benefits of $7,976, while our middle-range estimate from Table 16 suggests benefits of $33,899 (the mid-range values in Tables 14 and 15 lie between these two estimates). It is important to note that these represent only the benefits that accrue through the effects of early home environment on achievement, and in turn, through achievement's effects on earnings. If, as is likely, early home environment affects other aspects of children's development, the benefits are likely to be substantially larger than those shown here.

Table 13 Estimated present value of a standard deviation increase in the home environment, assuming a 0.12 effect of home environment on adolescent achievement and a 10% effect of adolescent achievement on adult earnings

Wage growth:	0%	1%	2%
Discount rate			
2%	7,921	11,374	16,493
3%	5,629	**7,976**	11,414
4%	4,064	5,685	8,031

Table 14 Estimated present value of a standard deviation increase in the home environment, assuming a 0.12 effect of home environment on adolescent achievement and a 20% effect of adolescent achievement on adult earnings

Wage growth:	0%	1%	2%
Discount rate			
2%	15,842	22,747	32,985
3%	11,258	**15,952**	22,828
4%	8,127	11,370	16,061

Table 15 Estimated present value of a standard deviation increase in the home environment, assuming a 0.255 effect of home environment on adolescent achievement and 10% effect of adolescent achievement on adult earnings

Wage growth:	0%	1%	2%
Discount rate			
2%	16,832	24,169	35,047
3%	11,962	**16,949**	24,255
4%	8,635	12,081	17,065

Table 16 Estimated present value of a standard deviation increase in the home environment, assuming a 0.255 effect of home environment on adolescent achievement and a 20% effect of adolescent achievement on adult earnings

Wage growth:	0%	1%	2%
Discount rate			
2%	33,665	48,337	70,093
3%	23,923	**33,899**	48,510
4%	17,271	24,162	34,130

These estimates suggest the benefits that are likely to accrue from a standard deviation increase in the quality of the home environment for an individual child. Programs to improve children's home environments do not typically result in such large effects, and thus the economic returns for a any particular program are likely to be smaller, presumably proportionately so. For example, the Early Head Start Home Visiting programs resulted in about 0.09 to 0.10 standard deviation improvements in the emotional and support for learning subscales of the HOME (Love, Kisker, Ross, Schochet, Brooks-Gunn, Paulsell, et al., 2002). Therefore, we would estimate the economic value of the Early Head Start program's effects on the HOME to be between $798 (10% of $7,976, Table 13) and $3,390 (10% of $33,899, Table 16). These amounts, however, do not include the value of other benefits arising from the Early Head Start program.

Conclusions

We draw both substantive and methodological conclusions from this research. Both are important to understanding and quantifying the potential of early interventions to improve later outcomes.

Our key substantive finding is that early improvements in child health, academic achievement, and behavior as well as improved parenting can yield sizable economic benefits for adult earnings. The magnitude of the effects depends on what we know, or assume, about how much early outcomes can be improved, how strongly those improvements connect to adolescent outcomes, and finally how tightly adolescent outcomes link to adult earnings. Our analysis indicates that there is much more to be learned about how early health, behavior, and achievement are linked to later outcomes. In part, this reflects the lack of large and representative longitudinal studies that have followed children from early childhood through adulthood, and the methodological difficulties in estimating causal associations. If we are to better understand the long-run effects of investments in early childhood, we need additional research that describes the extent to which experiences and skills in early childhood are linked to outcomes in adulthood.

Using a range of estimates grounded in the available literature, we find effects that range from modest to quite sizable. This is all the more striking when we recall that our estimates, for the most part, capture only a portion of the effects that early interventions are likely to have. Given data constraints, we have focused on effects that work through improvements in school achievement in adolescence and that result in gains in one adult outcome, earnings. We have neglected effects that work through other intermediate outcomes such as behavior and health, including peer effects, as well as effects on other adult outcomes. If we could measure the full range of effects, the economic payoffs would surely be much larger than those estimated here.

Our key methodological contribution is the development and application of a two-step method for linking improvements in early outcomes to long-run economic gains. To date, estimates of the long-run effects of early intervention programs have primarily relied on the relatively few studies that track program participants over time. Although such estimates have proved extremely useful, the downside of that approach is its reliance on a very small number of studies, and studies that often represent "hothouse" interventions delivered to very disadvantaged participants, often many decades ago. Our method allows us to use nationally representative data on more contemporary samples to piece together the likely effects of improvements in domains of early health and development on later outcomes, even when long-run follow-up data are lacking. As such, the method outlined here can be used flexibly to estimate a range of program impacts and to help analysts and policymakers think about the relative merits of addressing one type of early health or developmental problem rather than another.

We hasten to add, however, that our method has important limitations. As we have emphasized, we are for the most part estimating only a portion of likely impacts, and leaving others unstudied. It is possible that early interventions may affect more than one aspect of early development. For example, an early education program may improve children's attention and achievement. Our analysis does not estimate such joint effects. Whether such benefits are likely to be additive across outcomes, or whether synergies would lead to larger initial effects or less decline in effects over time, is uncertain. Moreover, our estimates are only as good as the data and studies on which they rely.

In some cases, measures of constructs are not as precise as we would like; in others, studies have not firmly established that the associations being modeled are causal. Moreover, error which creates considerable uncertainty exists at each step in the linking process, suggesting that the dollar values that we arrive at should be interpreted as a heuristic, with implicitly wide bounds.

Finally, our estimates are based on the earnings profile of an average worker with a high school degree or some college. This average masks considerable heterogeneity across demographic groups. If interventions are targeted to particular populations, the benefits are likely to differ. In spite of these limitations, however, we think our method holds promise as a way of illustrating what the benefits of early interventions are likely to be.

A useful next step would be to estimate the fuller set of economic benefits likely to accrue from early childhood investments. When a more complete understanding of such benefits is established, it would be helpful to compare those benefits with the costs of the most promising intervention programs. Such information would enable researchers and policymakers to identify the most cost-effective programs for young children.

References

Aos, S., Lieb, R., Mayfield, J., Miller, M., & Pennucci, A. (2004). *Benefits and costs of prevention and early intervention programs for youth* (Report). Olympia, Washington: Washington State Institute for Public Policy.

Aughinbaugh, A., & Gittleman, M. (2003). Does money matter? A comparison of the effect of income on child development in the United States and Great Britain. *Journal of Human Resources, 38*(2), 416–440.

Baker, P. C., Keck, C. K., Mott, F. L., & Quinlan, S. V. (1993). *NLSY child handbook* (Rev. Ed.). Columbus, OH: The Ohio State University, Center for Human Resources Research.

Behrman, J. R., & Rosenzweig, M. R. (2004). Returns to birthweight. *The Review of Economics and Statistics, 86*(2), 586–601.

Bitler, M. P., & Currie, J. (2005). Does WIC work? The effects of WIC on pregnancy and birth outcomes. *Journal of Policy Analysis and Management, 24*, 73–91.

Caldwell, B., & Bradley, R. (1984). Home observation for measurement of the environment. Little Rock: University of Arkansas at Little Rock.

Cawley, J., Heckman, J., & Vytlacil, E. (2001). Three observations on wages and measured cognitive ability. *Labour Economics, 8*, 419–442.

Collins, W. A., Maccoby, E. E., Steinberg, L., Hetherington, E. M., & Bornstein, M. H. (2000). Contemporary research on parenting. The case for nature and nurture. *American Psychologist*, *55*(2), 218–32.

Conley, D., Strully, K., & Bennett, N. G. (2003). A pound of flesh or just proxy? Using twin differences to estimate the effect of birthweight on life chances (Working Paper No. 9901). Cambridge, MA: National Bureau of Economic Research.

Currie, J., & Stabile, M. (2007). Child mental health and human capital accumulation: The case of ADHD. *Journal of Health Economics, 25*, 1094–1118.

Duncan, G., Dowsett, C., Classens, A., Magnuson, K., Huston, A., Klebanov, P., et al. (2007). School Readiness and Later Achievement. *Developmental Psychology*, 43, 1428-1446.

Duncan, G., & Magnuson, K. (2007). Penny wise and effect size foolish. *Child Development Perspectives*, 1, 46-51, Duncan, G., Ludwig, J., & Magnuson, K. (2007). Reducing poverty through preschool interventions. *Future of Children, 17*, 143–160.

Dunn, L. M., & Markwardt, F. C. Jr. (1970). *Peabody Individual Achievement Test manual*. Circle Pines, MN: American Guidance System.

Fletcher, J., & Wolfe, B. (2007). Child mental health and human capital accumulation: The case of ADHD revisited (Working Paper No. 13474). Cambridge, MA: National Bureau of Economic Research.

Heckman, J. (2006). Skill Formation and the Economics of Investing in Disadvantaged Children. *Science*, 312, 1900-1902.

Johnson, R. C., & Schoeni, R. (2007). *The influence of early life events on human capital, health status and labor market experiences over the life course.* Manuscript, University of California, Berkeley, Goldman School of Public Policy.

Jones, K., Daley, D., Hutchings, J., Bywater, T., & Eames, C. (2007). Efficacy of the Incredible Years Basic parenting training programme as an early intervention for children with conduct problems and ADHD. *Child: Care, Health, and Development, 33*, 749–756.

Joyce, T., Gibson, D., & Colman, S. (2005). The changing association between prenatal participation in WIC and birth outcomes in New York City**.** *Journal of Policy Analysis and Management, 24*, 661–685.

Knudsen, E., Heckman, J., Cameron, J. & Shonkoff, J. (2006). Economic, neurological, and behavioral perspectives on building America's future workforce. *Proceedings of the National Academy of Science*, 103, 10155-10162.

Krueger, A. (2003). Economic considerations and class size. *Economic Journal, 113*, 34–63.

Love, J. M., Kisker, E., Ross, C. M., Schochet, P.Z., Brooks-Gunn, J., Paulsell, D., et al. (2002). *Making a difference in the lives of infants and toddlers and their families: The impacts of Early Head Start*. Washington, DC: U.S. Department of Health and Human Services, Administration for Children and Families.

Lu, M., Tache, V., Alexander, G., Kotelchuck, M., & Halfon, N. (2003). Preventing low birth weight: Is prenatal care the answer? *Journal of Maternal-Fetal and Neonatal Medicine*, 13,362–380.

Ludwig, J., & Phillips, D. (2007). The benefits and costs of Head Start. *Social Policy Report, 21*, 1–18.

Ludwig, J., & Miller, M. (2005). Interpreting the WIC debate. *Journal of Policy Analysis and Management, 24*, 691–701.

McCarton, C. M., Brooks-Gunn, J., Wallace I.F., Bauer, C. R., Bennett, F. C., Bernbaum, J. C., et al. (1997). Results at age 8 years of early intervention for low-birth-weight premature infants. The Infant Health and Development Program. *Journal of the American Medical Association, 277*,126–132.

McCormick, M., Brooks-Gunn, J., & Buka, S., Goldman, J., Yu, J., Salganik, M., et al. (2006). Early Intervention in Low Birth Weight Premature Infants: Results at 18 Years of Age for the Infant Health and Development Program. *Pediatrics*, *117*, 771–780.

Murnane, R., Willett, J., Duehaldeborde, Y., & Tyler, J. (2000). How important are the cognitive skills of teenagers in predicting subsequent earnings. *Journal of Public Policy and Analysis*, 19, 547-568.

Neal, D., & Johnson, W. (1996). The role of pre-market factors in the black-white wage differences. *Journal of Political Economy, 104*, 869–895.

Oreopoulos, P., Stabile, M., Walld, R., & Roos, L. (2007). Short, medium, and long term consequences of poor infant health: An analysis using siblings and twins (Working Paper). Canada: University of Toronto, Center for Economics and Public Affairs.

Reichman, N. (2005). Low birth weight and school readiness. *The Future of Children, 15*, 91–115.

Rose, H. (2006). Do gains in test scores explain labor market outcomes? *Economics of Education Review*, 25, 430-446.

Shonkoff, J., & Phillips, D. (Eds.). (2000). *From neurons to neighborhoods: The science of early childhood development*. Washington, DC: National Academy Press.

Sonuga-Barke, E.J.S., Daley, D., Thompson, M., Laver-Bradbury, C., & Weeks, A. (2001). Parent-based therapies for attention-deficit/hyperactivity disorder: A randomized controlled trial with a community sample. *Journal of the American Academy of Child and Adolescent Psychiatry*, *40*, 402–408

Wong, V. C., Cook, T. D., Barnett, W. S., & Jung, K. **(**2007**).** An effectiveness-based evaluation of five state pre-kindergarten programs. *Journal of Policy Analysis and Management*, *27*, 122 – 154.

Appendix 1. Estimating present value for lifetime earnings

We estimated the present value for lifetime earnings using data from the 2006 March Current Population Survey (CPS). This was done using the age-earnings profile for workers ages 20 to 65 with a high school diploma or some college. This group was selected because it has the average level of education in the United States, but it is worth noting that it is not clear whether this is the appropriate education group to select. Interventions to promote birth weight, achievement, and attention often target disadvantaged children who may, in absence of the intervention, have low levels of education. If the program participants, on average, have less than a high school education or some college, then these values of lifetime earnings may be higher than typically expected, leading to higher estimated economic benefits for improving early skills. In the text we provide estimates for workers with high school degree or some college (based on Appendix Tables A1.1 and A1.2 below). We also provide below these estimates separately for each group (in Appendix Tables A1.3-A1.6).

To estimate the age earnings profile, observations with earnings less than 0 were coded to missing, and CPS-generated individual weights were applied. The earning estimates are based on workers and non-workers alike, therefore the estimates take into account the fact that some individuals do not participate in the labor market. The resulting age-earnings profile is provided in Table A1.7.

We provide estimates of the present value of lifetime earnings for the two ages--birth and age 5, the age at which most children enter formal schooling. We inflate reported earnings by 20 percent to estimate the value of fringe benefits and then calculate the present value of lifetime earnings (Table A1.7 does not include this fringe adjustment, all other tables do). We do not adjust for expected mortality, thus our estimates assume a worker lives to age 65. This assumption may be more or less appropriate, depending on the population served by a particular intervention. For each estimate, we show a range of values that vary depending on the assumptions made about wage growth rates and discount rates. We indicate in bold those estimates that we think represent a middle ground.

Table A1.1 Present value for lifetime earnings of individuals with a high school degree or some college, estimated at age 5

Wage growth:	0%	1%	2%
Discount rate			
2%	660,097	947,794	1,374,375
3%	469,084	**664,686**	951,175
4%	338,644	473,759	669,221

Note: Estimates include a 20% fringe benefit adjustment.

Table A1.2. Present value for lifetime earnings of individuals with a high school degree or some college, estimated at birth

Wage growth:	0%	1%	2%
Discount rate			
2%	597,870	902,235	1,374,375
3%	404,636	**602,611**	905,889
4%	278,340	409,258	607,301

Note: Estimates include a 20% fringe benefit adjustment.

Table A1.3 Present value for lifetime earnings of individuals with a high school degree, estimated at age 5

Wage growth:	0%	1%	2%
Discount rate			
2%	732,624	1,058,248	1,543,357
3%	517,493	**737,806**	1,062,084
4%	371,318	522,744	742,926

Note: Estimates include a 20% fringe benefit adjustment.

Table A1.4 Present value for lifetime earnings of individuals with a high school degree, estimated at birth

Wage growth:	0%	1%	2%
Discount rate			
2%	663,561	1,007,381	1,543,357
3%	446,394	**668,903**	1,011,518
4%	305,196	451,574	674,186

Note: Estimates include a 20% fringe benefit adjustment.

Table A1.5 Present value for lifetime earnings of individuals with some college, estimated at age 5

Wage growth:	0%	1%	2%
Discount rate			
2%	622,397	889,387	1,283,936
3%	444,491	**626,664**	892,520
4%	322,538	448,853	630,880

Note: Estimates include a 20% fringe benefit adjustment.

Table A1.6 Present value for lifetime earnings of individuals with some college, estimated at birth

Wage growth:	0%	1%	2%
Discount rate			
2%	563,725	846,637	1,283,936
3%	383,422	**568,140**	850,027
4%	265,102	387,744	572,507

Note: Estimates include a 20% fringe benefit adjustment.

Table A1.7 March 2006 CPS Age Earnings Profile for Individuals with High School Diploma or Some College

Age	Average Earnings
20	$ 9,066.73
21	$ 10,872.91
22	$ 11,695.56
23	$ 15,287.21
24	$ 15,707.72
25	$ 21,189.80
26	$ 19,745.32
27	$ 22,210.21
28	$ 23,218.24
29	$ 23,161.57
30	$ 25,090.40
31	$ 25,295.15
32	$ 25,107.08
33	$ 25,169.43
34	$ 26,645.55
35	$ 27,880.73
36	$ 29,260.74
37	$ 28,220.63
38	$ 29,287.99
39	$ 29,533.01
40	$ 30,672.86
41	$ 29,519.49
42	$ 30,382.78
43	$ 30,575.44
44	$ 32,071.18
45	$ 29,836.32
46	$ 30,225.69
47	$ 30,657.52
48	$ 32,305.78
49	$ 34,077.45
50	$ 30,703.53
51	$ 30,419.57

Appendix Table A1.7 Continued March 2006 CPS Age Earnings Profile for Individuals with High School Diploma or Some College

Age	Average Earnings
52	$ 29,512.88
53	$ 29,521.02
54	$ 28,546.58
55	$ 31,298.63
56	$ 26,306.31
57	$ 26,529.45
58	$ 25,737.97
59	$ 25,097.69
60	$ 22,834.49
61	$ 22,478.30
62	$ 20,762.68
63	$ 15,514.71
64	$ 13,619.18
65	$ 12,459.20

Source: Authors' calculation of the March 2006 CPS data. Estimates do not include 20% fringe benefit adjustment. 500 Observations with earnings of less than 0 were set to missing. N=60,863.

Appendix 2: Estimates of the effects of home environment on later achievement: Evidence from the NLSY and IHDP program

In order to estimate the effects of the quality of children's home environments on their later achievement, we conducted analyses with two datasets--the National Longitudinal Survey of Youth (NLSY) and the Infant Health and Development Project (IHDP). In each dataset the quality of children's early environments was measured and the children were followed through adolescence. Below we provide more detail on these analyses.

Infant Health and Development Program

IHDP draws from an eight-site medical subsample of 700 low birth weight, premature infants and their families. Longitudinal data from preschool until age18 are available (see McCarton et al., 1997, and McCormick et al., 2006, for additional details). In these analyses we use the subsample of about 200 children with higher birth weights (between 1,500 and 2,500 grams) who were assessed at age 18. Our primary independent variable of interest is the total HOME scale, a measure of the quality of the emotional caregiving and support for cognitive development that children experience measured at age 3. Our dependent variables are the Woodcock Johnson Tests of Achievement-Revised, which includes a Broad Reading and Broad Math subscale, measured at age 18. We use OLS regressions to estimate the association between the HOME scale and children's later achievement and include a set of covariates to reduce the potential for bias. The covariates include dummy variables for the programs sites, treatment status, mother's marital status and age at birth, as well as the children's race or ethnicity. Continuous measures of the mothers' educational attainment and verbal ability (measured by the Peabody Picture Vocabulary Test- PPVT), the infant's birth weight, an index of infant health, and the ratio of the family's income to needs averaged over the first three years of life are included. Effect sizes and t-statistics from the analyses are presented in Table A2.1. The results suggest that a one standard deviation increase in the HOME scale at age 3 would result in a 0.28 standard deviation increase in reading skills and a 0.23 standard deviation increase in math skills at age 18.

Table A2.1: Summary of effect sizes and t-statistics from regressions of achievement at age 18 on the HOME at age 3, IHDP

	WJ Reading	WJ Math
HOME Scale	.28(3.51)**	.23(3.06)**
Birth Weight (gms)	.04(0.70)	.12(2.20)*
Neonatal Health Index	-.05(0.80)	.01(0.13)
Female	.18(3.22)**	.12(2.16)*
Black	-.08(0.90)	-.16(1.85)
Hispanic	-.05(0.69)	-.14(1.98)*
Married	.01(0.13)	-.04(0.66)
Teen Mother	.06(1.00)	.05(0.77)
Maternal Education	.19(2.27)*	.29(3.69)**
Mother's PPVT	.21(2.60)*	-.00(0.05)
Average Income-to-needs	-.00(0.04)	.13(1.50)
Adjusted R-squared	0.43	0.46

Notes: *p-value<.05, ** p-value<.01. Program site and treatment status dummy variables are also included in the models as covariates.

National Longitudinal Survey of Youth

The Children of the National Longitudinal Survey of Youth study provides nationally representative longitudinal data collected from the Maternal and Child Supplement to the National Longitudinal Study of Youth (NLSY) 1979 Cohort (for additional details see Baker et al., 1993). Data have been collected on children beginning in 1986 through 2004. We have pooled children across cohorts to create a sample of about 1,750 children with available data on the quality of children's early home environment and achievement measured in early adolescence. In the analyses, the key dependent variable is the Peabody Individual Achievement Tests reading recognition and math subscales scores assessed at approximately age 13. The key independent variable is total score on the HOME Short Form measured at approximately age 6. We use OLS regression to estimate the association between the early HOME and adolescent test scores and include a set of controls to reduce the potential for omitted variable biases. The set of covariates include measures of the family income and household structure measured over the first five years of life, mothers' academic aptitude (Armed Forces Qualifying Test, AFQT), mothers' highest grade completed, and country of birth. Also included are indicators for the child's race, ethnicity and age. Effect sizes and t-statistics from the analyses are presented in Table A2.2. The results suggest that a one standard deviation increase in the HOME-SF scale at age 6 would result in a 0.10 standard deviation increase in reading skills and a 0.14 standard deviation increase in math skills at age 13.

Table A2.2: Summary of effect sizes and t-statistics from regressions of achievement at age 13 on the HOME-SF at age 6, NLSY

	PIAT Reading	PIAT Math
HOME-SF	0.10(5.02)**	0.14(5.28)**
Mother Highest Grade Completed	0.02(1.55)	0.02(1.72)
% Years in Poverty	-0.36(3.66)**	-0.19(1.67)
% Years Near Poverty	-0.23(3.04)**	-0.12(1.37)
% Years Middle Income	-0.25(3.04)**	-0.20(1.74)
% Years Urban Residence	-0.04(0.79)	0.04(0.75)
% Years Mother Never Married	0.02(0.32)	-0.00(0.05)
% Years Mother Divorced	0.16(2.02)*	0.18(1.88)
% Years Reside with Grandmother	0.03(0.48)	-0.06(0.64)
Average Number of Children in Household	-0.05(2.26)*	-0.03(1.10)
Black	-0.06(1.04)	-0.17(2.57)*
Hispanic	0.05(0.88)	-0.10(1.31)
Boy	-0.09(2.71)**	0.11(2.48)*
AFQT	0.64(6.73)**	1.05(7.46)**
Mother Age at Child's Birth	-0.01(1.04)	0.01(0.77)
Mother Born in US	-0.15(1.53)	-0.13(1.00)
R-squared	0.56	0.25

Notes: *p-value<.05, **p-value<.01. Models also contain controls for the cohort membership, child age, missing data dummy variables

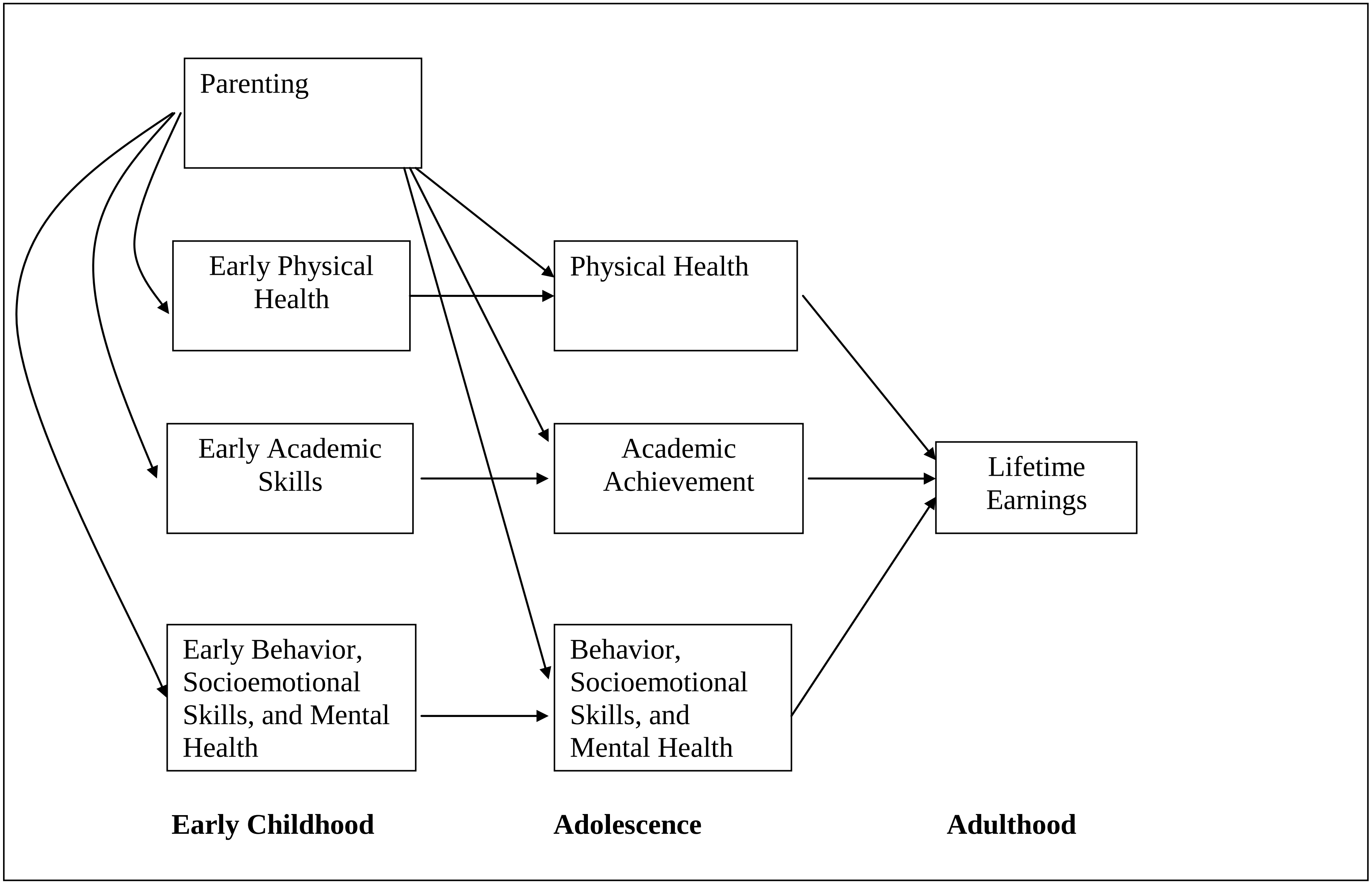

Figure 1: Conceptual Model of How Early Parenting, Physical Health, Academic Skills, and Behavior Influence Adult Lifetime Earnings

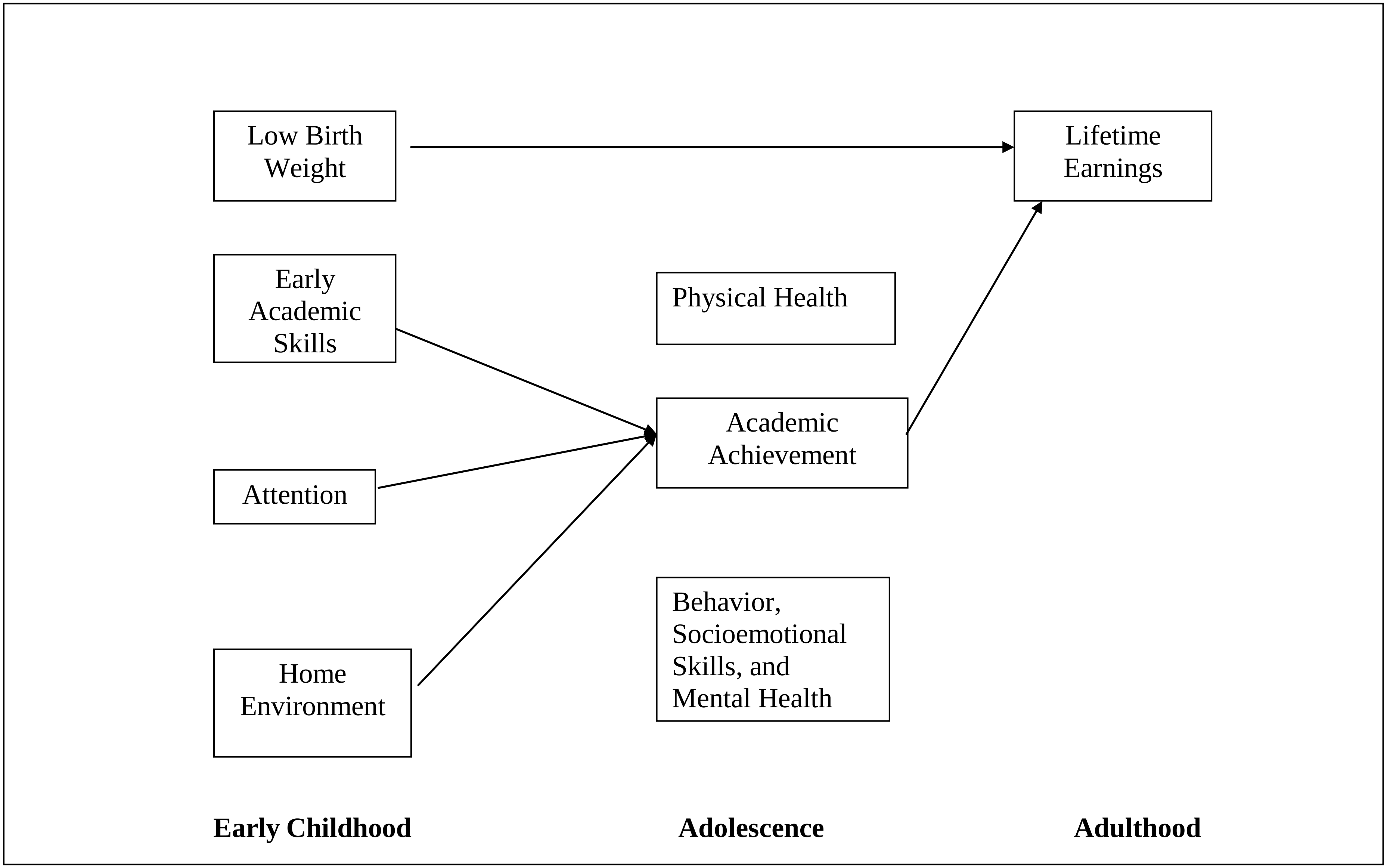

Figure 2: Model for Analysis of How Improvements in Low Birth Weight, Early Academic Skills, Attention, and Home Environments Affect Lifetime Earnings