Increasing Our Understanding of the Health-Income Gradient♦

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Abstract

There have been numerous attempts to both document the income-health gradient and to understand the nature of the tie. In this paper we review and summarize existing studies and then use a unique school based panel data set to attempt to further our understanding of the relationship. The school based nature of the data allow us to add community SES to the model and the long duration (5 observations, 9 years) allow us to add to the understanding of the pattern of the tie and to test for a variety of measures of income. Increasing understanding of the income-health gradient has clear policy implications in terms of effective targeting of interventions to decrease the gradient and hence decrease health disparities among children.

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Increasing Our Understanding of the Health-Income Gradient

The observation that there is a relationship between income and health has a long history but research on the nature of the relationship and its causes has exploded in recent years. Part of the interest may be tied to trying to understand the increasing inequality in income and wealth found in many developed countries; but part of it is likely tied to the large disparities in health that seem to exist and perhaps increase even in the face of more and more effective health care. These disparities seem closely tied to disparities in income and more generally socio-economic status (SES). The relationship has been difficult to study because the causal pattern is far from clear: does poor health lead to low incomes? Does low income contribute to poor health? Are there other factors that simultaneously cause both poor health and poverty? And there are clearly derivative questions for policy such as how to design policies to reduce disparities in health.

Recent efforts to understand the so-called income gradient have focused on two strategies: study children for whom the likely path is from family income to health and use natural experiments. We will follow the first strategy and focus on children but we note here that the study of natural experiments has provided consistent evidence that an increase in income, or in some cases an increase in community resources, is tied to improvements in health[1]. These studies include unexpected changes in pensions for elderly black and Coloured in South Africa (Case, 2004), an experimental program providing conditional cash transfers in Mexico (the Progresa or Opportunidades program (see Ferdinand, Gertler and Neufield, 2008)), and the introduction of casinos by American Indian tribes once legalization was established in 1988 (see Costello, 2003 and Wolfe, et al 2011).

Children are studied because, for most children in developed countries, family income does not depend on their own health. This partially eliminates one possible causal path. However,

[1] A possible exception is work by Ruhm on the influence of unemployment on health; but the test in that research is not only on income but changes in the allocation of time and in stress.

there is some evidence that children's health can affect family income through effects on (usually maternal) labor supply (see Gould 2004).

That there is a consistent difference in children's health by income can be seen in Table 1 for the United States. This difference is documented in terms of a higher probability of low birth weight, chronic conditions, mental problems, activity limitations and general health. And as indicated by activity limitations, the disparity appears to increase as children age. The disparities by income also exist for adults and across countries. In Appendix 1 we show regression adjusted differences for adults in the U.S. and Australia.

What might lie behind this gradient? Is it deprivation or poverty that leads those with extremely low incomes to suffer from poor health? That is, is the poor health of those living in poverty or near poverty due to inadequate nutrition, lack of access to and utilization of quality health care, is it exposure to a variety of physical hazards or is it high stress levels associated with extreme poverty? If so, then we expect to see a much flatter gradient in countries with more generous support systems either in terms of income and/or access to health care.

Is it instead that ever more income continues to lead to better health, as those with more income can buy more nutritious food, live in a safer environment, belong to health clubs, obtain high quality medical care? That is, does more income continuously allow one to have better health? And if so, is there a declining marginal gain in health from increasing income at high levels of income? This last question is particularly relevant for transfer programs and, if true, suggests that among two communities with equal average income, the one with more equality in income will have better average health than a community with more inequality in income.

In the rest of the paper we focus on children in order to better understand the gradient. We first review the existing literature beginning with the Case, Lubotsky, and Paxson paper of 2002 before turning to our own work.

BASIC MODEL

Underlying the research on the income gradient that focuses on children is a standard model based on work by Grossman (1972 and 2000).

The model begins with a family utility maximization problem

$$U_t = U(H_t, X_t, C_t, L_t^l; \eta_t^u, \varepsilon_t^u) \tag{1}$$

where U_t is utility of the family at time t, H_t is the health of a child, X_t is a set of goods that affects child health (e.g., food, toys and housing), C_t represents other commodities consumed by the household, (L_t^l) is leisure time, and η_t^u and ε_t^u are exogenous observable and unobservable factors, respectively, that influence U_t.

Following the accumulation of health stock as in Grossman, the production of child health can be represented as:

$$H_t = H(X_t, L_t^h; \eta_t^h, \varepsilon_t^h) \tag{2}$$

where L_t^h *is the amount of time used in the production of child* health, η_t^h *and* ε_t^h *are respectively exogenous observable and unobservable* variables influencing H_t. *(Note:* H_{t-1} is sometimes included in these models as well but the original Grossman model used initial health stock, which might best be captured by stock at birth and is sometimes empirically captured as birth weight.)

The budget constraint of the household or family can be represented as

$$Y_t = w_t L_t^L = P_t^X X_t + P_t^C C_t \tag{3}$$

where Y_t *is family income,* L_t^L *is the time spent to earn wage income,* w_t , P_t^X *and* P_t^C *are respectively the wage rate, and prices of* X_t *and* C_t.

The household's time constraint can be thought of as

$$L = L_t^l + L_t^L + L_t^h \tag{4}$$

where *L* is the total fixed amount of time available (e.g., 24 hours per day).

A household maximizes its intertemporal utility with a discount rate *a*, subject to the budget and time constraints plus the condition of positive initial stock of child health ($H_0 > 0$, frequently conceived of as birth weight).

Taking first derivatives of the Lagrangian function with respect to child health, and taking its lag repeatedly until the initial condition is met, the Marshallian demand function for child health is:

$$H_t^* = H(H_0, \omega_k; \eta_t^h, \eta_t^u, \varepsilon_t^h, \varepsilon_t^u) \tag{5}$$

where $\omega = \{H, X, C, L^L, L^l, L^H\}$ *and k=1, 2, . . ., t−1.*

According to (5) the optimal level of child health is determined by allocation of parental time between income generated through work, household chores and leisure, the consumption of child health-related goods and other goods and services

The empirical specification is then something like the following:

$$H_{it} = \alpha Y + \beta Z_{it} + \mu_{it} \tag{6}$$

where H_{it} is the stock of health of child i in period t, , Y represents average income of the family, where there is a question of whether current or permanent income is preferred, Z_{it} is a set of exogenous variables that affect child health and μ_{it} represents unobservable determinants of H. Again H_{it-1}, the stock of health of child i in period t−1, is sometimes included to reduce unobserved influences on child health. The error term of this demand equation, μ_{it} has two components: a child specific component that does not vary over time and a time varying component which is assumed to be exogenous and uncorrelated over time.

Once this model is specified there remain several core issues: (1) even with children, family income may be endogenous (in the case of a child with severe disability, parents may alter

their work behavior and hence income) (2) How to measure health? The most commonly used measure is general health in which an individual or responsible adult responds whether their children's health is excellent, very good, good, fair or poor (3) How to best measure income? The possibilities include current or annual, permanent, neighborhood, or for some purposes, whether the family is poor or near poor.

The first paper to explore the question of the time path of the income gradient among children is Case, Lubotsky and Paxson (2002) (CLP). Using primarily cross sectional data from the National Health Interview Survey [NHIS] for years 1986 to 1995 for children 0–17 they explore the time path using four age categories (0–3; 4–8; 9–12 and 13–17). Using the general health measure and ordered probit regression they find clear evidence of an income—health gradient at all ages and a steepening gradient with age. They explore this pattern as well using a panel data set (Panel Study of Income Dynamics or PSID) and find the same pattern. And using the panel data they explore an alternative set of income measures which all find the same steepening influence of income as children age.

This paper set off a chain of other studies—some use data from other countries, which have universal health insurance, while others use alternative data sets for the U.S. Many of these are included in Table 2 below, which documents the question asked, the data set used, methods, findings and a summary-sentence on implications. For example, Currie and Stabile (2003) use data from Canada to ask if the same steepening pattern exists for children under universal coverage. In addition to replicating the CLP study they also attempt to understand if the "cause" for this pattern is that low income children are less able to recover from a health shock than higher income children or that low income children are subject to more health shocks. Health shocks are defined by a set of chronic conditions. Their results suggest that, at least in Canada, low income children recover as well as higher income children from a health shock but have more of them.

In Table 3 we compare results across studies and countries. We bring together the coefficients from ordered probit runs using log income. Each of these studies uses the same five response general health outcome variable, excellent = 1 to poor = 5.[2] The right hand side control variables generally include child's sex, race/ethnicity, mother's age, mother's education and parent's marital status. In each case we see a substantial increase in the coefficient going from the youngest age group, 0–3 to the next age group, 4–8. However moving to the third age group, 9–12, the results are more mixed with half of the studies showing no steepening between the second and third group. Finally moving to the oldest group, 13+, suggests an increase or steepening, with the study of the U.K. as the only exception (the fifth study of Australian children only has the two youngest ages included.) Thus all five of the included studies provides evidence of a general steepening of the income gradient as children age with strong evidence for young children but more mixed evidence for the 9–12 year olds. All of these studies are either done with cross sectional data or short panels (2 observations per child). This limits their ability to study whether it is current income or permanent income that appears more closely tied to a child's health.[3] The one study that uses the PSID has two observations on child health but does not make use of the fuller data on family income. Murasko (2008) does explore a few dimensions of income including hot deck imputations for missing income, the use of income from one year rather than a 2 year average and the use of wage income in place of family income. He finds that the two year average income (and family income vs. wage income) shows a stronger tie to child health. But his use of year two income, measured subsequent to the initial observation of child health casts some doubt

[2]In some cases these categories have been collapsed to two or three categories. Numerous studies have explored the reliability of self or parent reported general health. The focus is on their ability to predict future morbidity and mortality. Maarten Lindeboom and Eddy van Doorslaer 2004 in *Journal of Health Economics* 23(6): 1083–1099 reported on using data on Canadian adults and found homogenous reporting of health status for language, income and education. Marja Jylha 2009 in *Social Science & Medicine* 69(3): 307–316 states this more strongly: "In population studies, self-rated health is probably the most feasible, most inclusive and most informative measure of health status. In a given cultural environment, it is a powerful predictor of future health and use of health services."

[3]Permanent income is generally defined in these short panels as the average income over two years and is then used to explore the health income gradient for all measures of health regardless of timing.

on the reliability of his comparison of permanent versus current income. The approach used in both Khanama et al and Murasko is to use the earliest or prior health status to capture the influence of income on children prior to the age under study. Thus they suggest that including prior health (by an indicator of poor/fair health for example) captures the influence of income on health up until the most recent period of time. Under this perspective, estimates of the tie between income and health in the current period capture only the marginal influence of income on health. This approach reduces the coefficient on income but still retains the overall pattern of results.

The addition of parent's health in the Khanama et al estimates reduces the statistical significance of income as a determinant of a child's health, though the steepening pattern as a child ages remains. The authors suggest that this is a way in which income influences health; that is, a parent's poorer health is tied to lower incomes so that by including this channel the direct influence of income is reduced.

Thus the existing literature confirms that children's health is tied to income with some steepening as child age, particularly in earlier childhood, and, that universal health care is not sufficient to significantly reduce, let alone eliminate this income gradient. What then can we add?

Each of the studies we outline above has one or more of the following limitations: (1) use of cross-sectional data or short panel data (2) reliance on noisy income measures and (3) inability to control for health endowments (e.g. birth weight). In addition previous studies have been unable to control for environmental confounding influences, such as neighborhood SES and crime, which can affect both family income and child health status. In this study we are able to overcome these limitations by using the Early Childhood Longitudinal Study-Kindergarten Cohort data, which follows children over 9 years between Kindergarten entry and 8th grade and includes five observations of health and family income per child. The ECLS-K also uses a school-based sampling scheme, which allows the use of average income of the school; it also includes measures of the child's health endowment (birth weight). The multiple observations per child allow us to construct a variety of long term (permanent) income measures. In particular, unlike

previous studies, we are not forced to use income from future observations (averaging over the short panel) in the construction of permanent income. We turn to our research below.

DATA

In the research reported below we use the Early Childhood Longitudinal Study-Kindergarten Cohort data [ECLS-K]. These data were collected beginning in 1998–99 and trace children from kindergarten through grade 8. The correspondence between grade and child's age is: Kindergarten 6.28 (.88); 1st grade 7.24 (.87), 3rd grade 9.25 (.87), 5th grade 11.87 (0.80) and 8th grade, 14.45 (.49) thus the sample goes from about age 6 to age 15. There are 6431 observations. Table 4 shows basic descriptive information of our sample at kindergarten and 8th grade. Across all five observations, the proportion of children in the sample with health that is less than or equal to good health varies from .15 to .20 over the five observations with a standard deviation [S.D] of .36–.40. Current income in 10,000s varies from $5.1 to $7.0 with a S.D. that varies from 4.6 to 5.2. Permanent income (in 10,000s) varies from $5.1 to $ 6.1 with a S.D of 4.4 to 5.1. These rather narrow and consistently sized S.D. suggest that any pattern that emerges should not be due to changing S.D. in income or health.

RESULTS

Employing the model shown above, we first replicate the CLP model using the ECLS-K data which are panel data over 9 years. These full results are shown in Appendix Table 2. The equations we estimate are:

$$H_{it} = \alpha + \beta_1 \log(Y_{it}) + \beta_2 X_{it} + \varepsilon_{it}$$

where the health measure is the five response general health in which 1 = poor and 5 = excellent health in the specified grade. In addition to current log income (which is based on 26 categories with a top category of greater than $200,000) the additional control variables are male, age in

years, dummy variables for race (Black, Hispanic and Other race with White, non-Hispanic as the omitted category), Mother's age, mother's marital status, mother's education, and a dummy variable indicating missing parent information[4].

Two sets of estimates are presented: the first showing the simple bivariate ordered probit result using current income and the second including the standard set of control variables indicated above. Both show the expected tie between more income and better health from K to 5th grade but a flat or decreasing tie by the 8th grade[5]. These results then are consistent with the literature reviewed above and suggest that the use of grades in place of age maintains the income-health gradient.

To explicitly review the comparability of using grade based data for ages, we compare our results using grades to the Khanama et al study based on Australian data which also used grade levels. Appendix Table 1 presents these results. Both show a tie between health and income that steepens between kindergarten and 1st grade. Not surprisingly the estimated tie is greater for the U.S. than for Australia (.123 versus .092 for K) but of surprise is the greater increase or steepening in Australia compared to the U.S.[6] The table does provide evidence of the consistency of using grades for age in studies of the income-health gradient of children.

Next we explore the income health gradient making use of the unique features of the ECLS-K. We also modify the specification slightly to include birth weight, a measure of initial

[4] Consistent with most of the literature we use family income without adjusting for family size. Below we test the importance of this by adjusting family income using the equivalence scale suggested by the National Academy Committee's recommendations for measuring poverty.

[5] Pooling the data, we can test whether the coefficient on income is statistically different across data waves in comparison to the effect in Kindergarten. We find that the effect, relative to baseline, becomes statistically distinguishable in the 5th grade and 8th grade waves in models that control for demographic variables. The 5th grade and 3rd grade effects are different at $p<0.12$ level.

[6] Note that since the Australian study reported self rated health using 5=excellent to 1= poor we report results in this form in this table.

health that we believe belongs in the model[7]. The full specifications can be found in Appendix Table 2 .

Permanent income: The first issue we explored above is a comparison of current income with permanent income. Our first definition of permanent income is one that uses only those measures of income observed up to the present at each grade level; by grade 8, all five measures of income are included. We expect that permanent income is a more accurate measure of income and hence might expect a "better" fit. To do so, we run the same basic ordered probit but substitute our measure of permanent income for current income. Figure 1 indicates that the gradient is steeper with the use of permanent income and shows a pattern of continual steepening, with a far greater slope between 5th and 8th grade with a difference that reaches .07 or nearly 30 percent higher by 8th grade. The influence of income appears to be more than 100 percent greater by grade 8 compared to kindergarten. All of the coefficients on income are statistically significant at the one percent level.[8]

With our data we are also able to compare our definition of permanent income with several alternatives, including that used in other studies; that is we compare permanent income which only uses income already observed at the time the health data is gathered with a definition that uses all, first a two year rolling average and then a three year rolling average from grade K to grade 8 and tie that measure to health at each grade (see Table 5). The use of these measures of permanent income suggests a greater tie between income and health at early grades than our other measures but a flatter overall tie. The permanent income measure that uses all years of observed income is the flattest of these estimates of the gradient with a much greater coefficient at kindergarten and then a gradually increasing set of coefficients except for a slightly smaller

[7] The pattern of results is very close across the two specifications. Of note are the slightly larger coefficients on log income when birth weight is included and the slight decrease in the coefficient for 8th grade compared to 5th grade when birth weight is included. The differences are so small that there does not seem to be significant bias in the income coefficient when birth weight or initial health is not included in other models.

[8] By definition the gradient begins at the identical spot for kindergarten.

coefficient for 5th grade compared to 3rd grade. Again, the coefficient for 8th grade is the largest of the set (and by definition equal to that in our "preferred estimate.") Compared to the coefficients on current income and our preferred measure of permanent income, the pre-post measure does not seem to accurately represent the income health gradient in the earlier years, when the measure is most likely to be an error of the families' income at those points in time. Overall our interpretation of this three way comparison is that the pre-post measure of permanent income overstates the initial extent of the income gradient and understates the steepening. Nevertheless we believe that these results suggest that the finding of a strong income health gradient is not sensitive to the measure of family income used, although the exact pattern of the steepening of the gradient as a child ages is sensitive to the measure of income employed.

In a final test of the sensitivity of the gradient to the definition of income, we use both a 3 year and then a 2 year rolling average which only includes income up to the grade level observed. For both of these specifications, the gradient is continually increasing but the gradient is flatter than our preferred use of all measures of income up to the grade observed.

Does the use of an equivalence scale modify the results? In most economic analysis, the use of income adjusted for family size is preferred. In this way, rather than assuming that the full family income is available for all family members, an adjustment is made so that larger families have less income available for each household member than the same total family income for a smaller unit. The problem however, is which equivalent scale to use. The federal poverty line has one scale while the World Bank and other research organizations use quite different scales. Below we report on results using two different equivalence scales: the first a simple one that uses the square root of family size (Smeeding et al 1993) and the other a three parameter scale that was recommended by a volume from The National Academy on measuring poverty[9].

[9] More specifically this scale has the following form: $(1 + \alpha*(A -1) + \kappa K)^{\theta}$ where A are adults, K are children, an additional adult increases needs by α percent of the needs of a single individual, a child increases needs in the family by κ percent of the needs of a single individual, and the scale elasticity is constant and is equal to θ. We use .7 for κ and θ.

Table 6 shows our results comparing our measure of permanent income with these two alternative equivalence scales. The results are quite similar using the two different scales. Compared to the unadjusted estimates the adjusted versions suggest a somewhat flatter gradient although in all cases the gradient is increasing over the 9 year period. And once again, all coefficients on income are statistically significant at the 1 percent level.

A unique aspect of the ECLS-K data is the school based design. This allows us to take into account the average SES of the neighborhood in which these children live. That is, we view each school as being similar to a relatively homogeneous community in terms of SES. We base this perspective on the neighborhood feeder pattern of a large majority of schools in the U.S.[10] To test the influence of neighborhood income on the health gradient, we aggregate the individual level income measures to the school level (leaving out the focal individual). Table 7 presents these results. We do this first using the mean and then the median of school income defined as noted above. Next we examine whether there appears to be an additional influence of average school income on the health of students; in this case we have both family permanent income and school income (mean and median in separate estimates). The results including only school average income suggest positive influence of school income on health with weaker effects for 8th grade. This could be due to the larger school and less precise measure of income in 8th grade or that neighborhood income matters less for adolescents. For both measures of school income, the largest coefficient is for 1st grade. Thus these results suggest a positive tie between neighborhood or school income and health but not an increasing gradient over time. The estimates with both family income and school average income suggest that school income is an additional factor influencing health of young children (kindergarten and 1st grade). That is, in kindergarten and first grade, attending school with wealthier classmates seems to be tied to reporting better health and that this does not differ according to own family income. The influence of family permanent

[10]For example Jorge Martinez-Vazquez, Mark Rider and Mary Beth Walker 1997 found in their study of the heterogeneity of geographic areas by race that the number of school districts tend to increase when racial heterogeneity of a state population increases.

income is little changed with the addition of school average income, especially when mean school income is included.[11]

Thus we conclude that, almost regardless of the measure of family income used (variations of permanent income, adjustment for family size and inclusion of neighborhood income),we find evidence of a strong income gradient of health that increases as children get older (are in older grades.) We also explored one additional specification that is based on a recent paper that uses a birth cohort dataset from the U.K, where Propper et al. (2007) found that controlling for maternal mental health eliminates the income-health gradient. In Appendix Table 3 we examine this issue in our US dataset by controlling for a measure of maternal depression[12]. The main results suggest a minimal reduction in the income-health link in our sample, suggesting that the observed children's income gradient in the U.S. is not the result of mother's mental health and raising some question of what the underlying phenomena is in the UK that might explain these very different results.

To get a sense of the likely influence we calculated marginal effects for the ordered probit specifications for two specifications; the first are those reported in Table 5. These results are presented in Table 8 Panel A for our preferred model using the log of permanent income. The marginal effect of increasing income is found to predict a 5.7 percentage point increase in the likelihood of reporting excellent health in Kindergarten, which increases to a 12.1 percent increase by 8th grade. In all these calculations, the income variables are statistically significant at the 1% level and these marginal effects are calculated at the mean of all variables in the model. In Panel B we present the marginal effect of increasing income when we use all years of family income as our measure of income in all regressions beginning at Kindergarten and continuing

[11] We also estimated specifications using a school fixed effects model over children in all schools in the sample. The school fixed effects results suggest a general pattern of an increasing income gradient but with a decreasing slope between grades 5 and 8. Results are available from the authors.

[12] Since the maternal depression questions are only asked in every other wave of the ECLS-K data, we use either the current or previous wave depression measure. The question available in the survey is "How often during the past week have you felt depressed?". The answers included "never", "some of the time", "a moderate amount of time", or "most of the time".

through 8th grade. Our previous results discussed above and shown in figure 2 suggested that these results show the flattest income gradients of all of our estimates with a stronger influence of income at younger grades than was the case for most of our measures of income. The marginals confirm this pattern. Here we see that the influence of a 10% increase in the log of family income is estimated to be nearly one percent at kindergarten and gradually increasing to 1.21 percent by 8th grade. These results then confirm a strong influence of family income on health along with an increasing gradient but suggest both a stronger influence at younger grades (ages) and a less steep gradient that when we employ other measures of income.

Which pattern is likely to more accurately represent the tie between family income and child health? Economists tend to favor permanent income captured over a long period with a view that families can predict their income and behave according to the long term income constraint. On the other hand, nine years is a relatively long period of time, families may well predict with uncertainty and so the permanent income measure that uses current income and all prior incomes (which are obviously known to the family) may better capture the true income constraint. We leave it to readers to decide for themselves if they prefer one measure over the other.

Even with these differences which capture the "extreme" of our results we find both a strong positive link between family income and child health and an increasing gradient of health.

CONCLUSION

After reviewing many aspects of the existing literature we find robust evidence of a strong and generally steepening income gradient of health regardless of the exact measure of family income that is included in the analysis. A primary contribution of this paper is our ability to explore so many measures of income. We are able to do this since we study the same children over a long period of time –a panel over nine years with five observations per child. Thus we are able to address the question of the form of the steepening of the gradient with age using more satisfactory data. Second, since we have such a long period of time over which we observe each

child, we construct a variety of measures of long term or permanent income over time. Third, we add to the current exploration that focuses only on family income, by including community SES as captured by the SES of the children who attend the same school as the "observation" child. That is, by using school average income, we include a measure for otherwise unobserved community heterogeneity and implicitly include a test for the extent to which the child's family income matters, once we take community income into account. Finally, by including a measure of the child's health status at birth, birth weight, a measure consistent with the concept of early health endowment in the Grossman model of the production of health, we capture some unobserved characteristics of the child which allows us to better identify the tie between the family's permanent income and child health in our empirical estimates.

Our results using panel data of children from age 6 to 15 provides quite clear evidence of a tie between family income and child health that steepens at least from ages 6 to about 12. Our results suggest that the pattern is robust to the inclusion of a measure of initial health as captured by birth weight as well as to a measure of maternal mental health. We provide evidence that the use of permanent income, including only income measured prior to the period when a child's health is measured, shows a strong increasing income gradient of health, and we provide evidence that, at least for kindergarteners and first graders, community (school) income may itself influence a child's health. The fact that family income is robust to the inclusion of school income suggests there is little bias in excluding neighborhood income in other studies, at least for the U.S.

To bring these comparisons together we add a figure that captures these differences in Figure 2 below. Here we show five estimates for each grade, all of which include birth weight as a control variable: one that uses current income and then two similar sets using two different measures of permanent income (one using all years and one using only prior and current years). Our fourth estimates are for equivalent size adjusted income using the 3 parameter adjustment. Finally we include a set with school mean income included in the estimates using permanent

income based on prior and current year only. The robustness of the main findings is quite striking and is a core contribution of the paper.

Of course there are caveats in using the ECLS-K data. Chief among these is that not all children are present at each wave. In the analysis presented above we chose to present the results using the maximum sample possible at each grade. But this opens up the possibility that temporary attrition may influence the results. To partly answer this, we conducted an analysis using a balanced sample. These results, presented in Appendix Table 4 suggests that while there are some differences in using the balanced sample, the overall pattern remains and so again the evidence on the income gradient appears robust to numerous modifications.

What might these results suggest for public policy? One, they provide evidence of the importance of the income distribution, especially low income, for health of the next generation. Two, and tied to this, they suggest a pattern by which intergenerational mobility might be limited. Three, these results enforce the importance of increasing the income of low income families in determining future productivity or finding other ways to compensate for the family's low income if these children are to successfully compete in the labor market based on their human capital..

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Tables

Table 1: Health of Poor vs. Nonpoor Children; NHIS Data, Children 2-17 US 2001–05

Health Measure	Poor	Nonpoor
Low birth weight	0.112	0.078
Ever told had asthma	.159	.131
Ever mental problems	.119	.079
Ever told ADHD	.071	.060
Activity limitations	.114	.070
ages 2-3	.061	.037
ages 4-8	.097	.062
ages 9-12	.139	.067
Days missed Illness/injury 12 mos	4.471	3.531
Any chronic condition	.324	.265
N	7,363	36,858

Source: Currie and Lin 2007.

Table 2: Table of Studies of Children

Table of Studies of Children							
Paper	Case, A., Lubotsky,D., and Paxson, C., 2002	Currie, J. and Stabile, M., 2003	Condliffe, S. and Link, C. R., 2008	Currie, A., Shields, M.A., and Price, W., 2007	Currie, J., Decker, S., and Lin, W., 2008	Murasko, J. 2008	R Khanama, HS Nghiemb and L Connelly 2009
Motivation	Focus on children; sources of the gradient	Canada;Focus on recovery and quantity of shocks	US; Focus on recovery and quantity of shocks	England; Compare with US	Focus on public health insurance expansions	health; cumulative vs. current income; panel	Australia; panel; explain gradient
Data	Maternal reported general health status of children (0-17)		US MEPS and PSID, 1996-2002	HSE (2-15)	US NHIS 1986-2005	US MEPS 1996-2005	LSAC 2 Cohorts
Method	Ordered probit regression	Ordered probit regression and linear probability regression	Ordered probit regression and linear probability regression	Ordered probit regression and linear probability regression	Index of generosity of the state's public health insurance programs as IV for individual Medicaid/SCHIP eligibility and conduct 2SLS	ordered probit	binary and ordered Probit models
Findings	Children's health is positively related to family income at every age, and the slope of the gradient increases for older children	Despite the universal health coverage, there exists an income gradient of children's health that steepens during childhood. The gradient is likely due to higher rate of health shocks among low-income children.	In U.S., children in low income families are more likely than children in high income families to still suffer from chronic conditions present 5 years ago. Income gradient becomes steeper with age, partly because low income children are less able to recover from health shocks.	Although family income has a positive relationship with general health status, strength of the relationship is smaller than in US. Gradient does not increase with children's age. No evidence of a significant income differential in probability of a child having a chronic health condition	More generous insurance coverage at early childhood is associated with better health at older ages (ages 9-17). In addition, the relationship between family income and children's health has weakened for older children after the year the SCHIP initiated	Replicate Case (2002) pattern though somewhat weaker. Increased persistence of health status among older children; stronger contemporaneous influence of income on adolescents	Similar findings as US studies in that children from higher income families have better health but gradient flatter. No evidence of more health shocks or failure to respond to shocks by income. Some suggestion that health of mother part of explanation of the gradient
Implications	low family income on children's health tend to accumulate during childhood. Thus, children from lower income families may suffer from both lower SES and poorer health when they transition into adulthood	Policies that focus only on reducing gaps in access to medical care may not be sufficient to reduce disparities in health.	Public policies that increase access to medical care for low income children could be useful in reducing the income gradient of children's health.	Family income may not be a major determinant of children's health in England. NHS may influence. Challenged by Case, Lee and Paxson that findings reflect miscoding of chronic condiitons.	Assuring access to health care in early childhood may prevent the income gradient of children's health from becoming steeper over time.	Since influence of SES cumulative, interventions at an earlier age may be most effective	National health service can reduce gradient but not come close to eliminating it.

Table 3: A Comparison of Results from Studies of Four Countries of the Tie between Family Income and Child Health
Parent's reports of child general health, 1=excellent, 5=poor. Ordered probits

		Age of Child			
Study	Country	0–3	4–8	9–12	13+
CLP	USA	-0.183	-0.244	-0.268	-0.323
		[0.008]	[0.008]	[0.009]	[0.008]
CS	Canada	-0.151	-0.216	-0.252	-0.272
		[0.026]	[0.019]	[0.024]	[0.040]
CLP07	UK	-0.143	-0.212	-0.203	-0.194
		[0.036]	[0.026]	[0.030]	[0.034]
KNC	AU	-0.05	-0.131		
		[0.024]	[0.024]		
M	USA	-0.079	-0.134	-0.132	-0.195
		[0.023]	[0.018]	[0.022]	[0.036]

Notes: CLP = Case. Lubotsky and Paxson 2002 using NHIS; CS = Currie and Stabile, 2003 using NLSCY.
CLP07=Case, Lee and Paxson 2007 using HSE and KNC= Khanam, Ngheim and Connelly 2009 using LSAC.
M=Murasko 2008 using MEPS. Control variables include age dummies, sex, race, parent education, ln family size with some additions that vary by study.

Table 4: Descriptive Characteristics of ECLS-K Sample

	Kindergarten			8th Grade		
Variable	Obs	Mean	Std.	Obs	Mean	Std.
Poor Health	7,431	0.17	0.37	6,953	0.15	0.36
Child Health Status (5=excellent, 1=poor)	7,431	4.33	0.83	6,953	4.33	0.81
Child Health Status = Excellent	7,431	0.53		6,953	0.51	
Child Health Status = Very Good	7,431	0.30		6,953	0.34	
Child Health Status = Good	7,431	0.14		6,953	0.12	
Child Health Status = Fair	7,431	0.03		6,953	0.03	
Child Health Status = Poor	7,431	0.00		6,953	0.00	
Log Income	7,405	10.51	0.96	6,953	10.84	0.85
Current Income (10000s)	7,431	5.17	5.15	6,953	6.98	5.18
Permanent Income (current and previous wave) (10000s)	7,431	5.17	5.15	6,953	6.09	4.46
School average income (10000s)	7,032	5.71	3.31	6,369	6.02	2.66
Parent Health (1=excellent, 5=poor)	7,411	2.26	0.79	6,933	2.26	0.79
Mom Depressed (1=never, 4=most of the time)	7,395	1.34	0.50	6,928	1.35	0.51
Birth weight (lbs)	7,291	7.38	1.32			
Male	7,431	0.52	0.50	6,953	0.51	0.50
Age	7,426	6.23	0.38	6,948	14.45	0.49
Black	7,431	0.17	0.37	6,953	0.16	0.36
Hispanic	7,431	0.17	0.38	6,953	0.18	0.38
Other Race	7,431	0.04	0.20	6,953	0.04	0.20
Mom Education	7,431	13.48	2.45	6,953	13.50	2.46
Mom Age (wave 1)	7,431	33.56	6.49	6,953	33.82	6.28
Married	7,431	0.71	0.45	6,953	0.70	0.46

Table 5

Table comparing alternative measures of permanent income

Grade	K	1	3	5	8
Set uses only current and prior family incomes					
Log (Perm Income)	0.142***	0.165***	0.204***	0.238***	0.305***
	(0.037)	(0.046)	(0.047)	(0.046)	(0.055)
Log (3 Year Income)	0.142***	0.165***	0.204***	0.226***	0.261***
	(0.037)	(0.046)	(0.047)	(0.043)	(0.049)
Log (2 Year Income)	0.142***	0.165***	0.205***	0.210***	0.262***
	(0.037)	(0.046)	(0.048)	(0.041)	(0.048)
Set uses all years of income					
Log (All Years Income)	0.248***	0.264***	0.280***	0.261***	0.305***
	(0.050)	(0.054)	(0.053)	(0.047)	(0.055)
Log (2 Year Rolling)	0.184***	0.165***	0.205***	0.210***	0.262***
	(0.044)	(0.046)	(0.048)	(0.041)	(0.048)
Log (3 Year Rolling)	0.184***	0.183***	0.204***	0.226***	0.261***
	(0.045)	(0.048)	(0.047)	(0.043)	(0.049)

Notes: each coefficient is from a separate regression.

Table 6

Table Comparing Income and alternative equivalent scales

Grade	K	1	3	5	8
Log (Perm Income)	0.142***	0.165***	0.204***	0.238***	0.305***
	(0.037)	(0.046)	(0.047)	(0.046)	(0.055)
Log (Perm Income with Equiv Scale)	0.150***	0.155***	0.205***	0.211***	0.229***
2-parameter	(0.037)	(0.043)	(0.044)	(0.043)	(0.049)
Log (Perm Income with Equiv Scale)	0.150***	0.153***	0.208***	0.212***	0.242***
3-parameter	(0.037)	(0.043)	(0.044)	(0.043)	(0.050)

Notes: each coefficient is from a separate regression.

Table 7

Table Adding School Average Income to Model with and without family income

Grade	K	1	3	5	8
Log (Perm Income)	0.142***	0.165***	0.204***	0.238***	0.305***
	(0.037)	(0.046)	(0.047)	(0.046)	(0.055)
Log (School Mean)	0.161***	0.265***	0.157***	0.135**	0.102*
	(0.060)	(0.059)	(0.061)	(0.054)	(0.056)
Log (School Median)	0.191***	0.197***	0.149***	0.147***	0.092*
	(0.057)	(0.052)	(0.054)	(0.045)	(0.053)
Estimates with both family and school income included					
Log (Perm Income)	0.124***	0.117***	0.233***	0.259***	0.325***
	(0.039)	(0.044)	(0.054)	(0.051)	(0.058)
Log (School Mean)	0.108*	0.215***	0.059	0.058	0.048
	(0.062)	(0.061)	(0.065)	(0.056)	(0.058)
Log (Perm Income)	0.112***	0.124**	0.246***	0.208***	0.306***
	(0.038)	(0.053)	(0.058)	(0.051)	(0.060)
Log (School Median)	0.134**	0.130**	0.010	0.054	-0.005
	(0.060)	(0.054)	(0.062)	(0.050)	(0.058)

Notes: each coefficient is from a separate regression in the top rows. Sets of two coefficients from separate regressions in the bottom rows.

Table 8
Marginal Effects of Permanent Income on Child Health:
Panel A: Results using Current and Prior Values of Income.

	Coefficient	Mfx Poor Health	Mfx Fair Health	Mfx Good Health	Mfx Very Good Health	Mfx Excellent Health	Sample
Kindergarten	0.142***	-0.001*	-0.008***	-0.025***	-0.023***	0.057***	7265
	(0.037)	(0.000)	(0.002)	(0.007)	(0.006)	(0.015)	
1st Grade	0.165***	-0.001**	-0.007***	-0.026***	-0.031***	0.065***	7001
	(0.046)	(0.001)	(0.002)	(0.007)	(0.009)	(0.018)	
3rd Grade	0.204***	-0.001*	-0.010***	-0.036***	-0.033***	0.081***	6800
	(0.047)	(0.000)	(0.003)	(0.009)	(0.008)	(0.019)	
5th Grade	0.238***	-0.001**	-0.011***	-0.049***	-0.034***	0.095***	7032
	(0.046)	(0.001)	(0.002)	(0.010)	(0.007)	(0.018)	
8th Grade	0.305***	-0.001	-0.014***	-0.049***	-0.057***	0.121***	6533
	(0.055)	(0.001)	(0.003)	(0.010)	(0.010)	(0.022)	

Panel B: Results using all Values of Income

	Coefficient	Mfx Poor Health	Mfx Fair Health	Mfx Good Health	Mfx Very Good Health	Mfx Excellent Health	Sample
Kindergarten	0.246***	-0.001**	-0.013***	-0.044***	-0.039***	0.098***	7265
	(0.050)	(0.001)	(0.003)	(0.009)	(0.008)	(0.020)	
1st Grade	0.264***	-0.002**	-0.012***	-0.042***	-0.049***	0.104***	7001
	(0.054)	(0.001)	(0.003)	(0.009)	(0.011)	(0.022)	
3rd Grade	0.280***	-0.001	-0.014***	-0.050***	-0.046***	0.111***	6800
	(0.053)	(0.001)	(0.003)	(0.010)	(0.009)	(0.021)	
5th Grade	0.261***	-0.002**	-0.012***	-0.053***	-0.037***	0.104***	7032
	(0.047)	(0.001)	(0.002)	(0.010)	(0.007)	(0.019)	
8th Grade	0.305***	-0.001	-0.014***	-0.049***	-0.057***	0.121***	6533
	(0.055)	(0.001)	(0.003)	(0.010)	(0.010)	(0.022)	

Figures

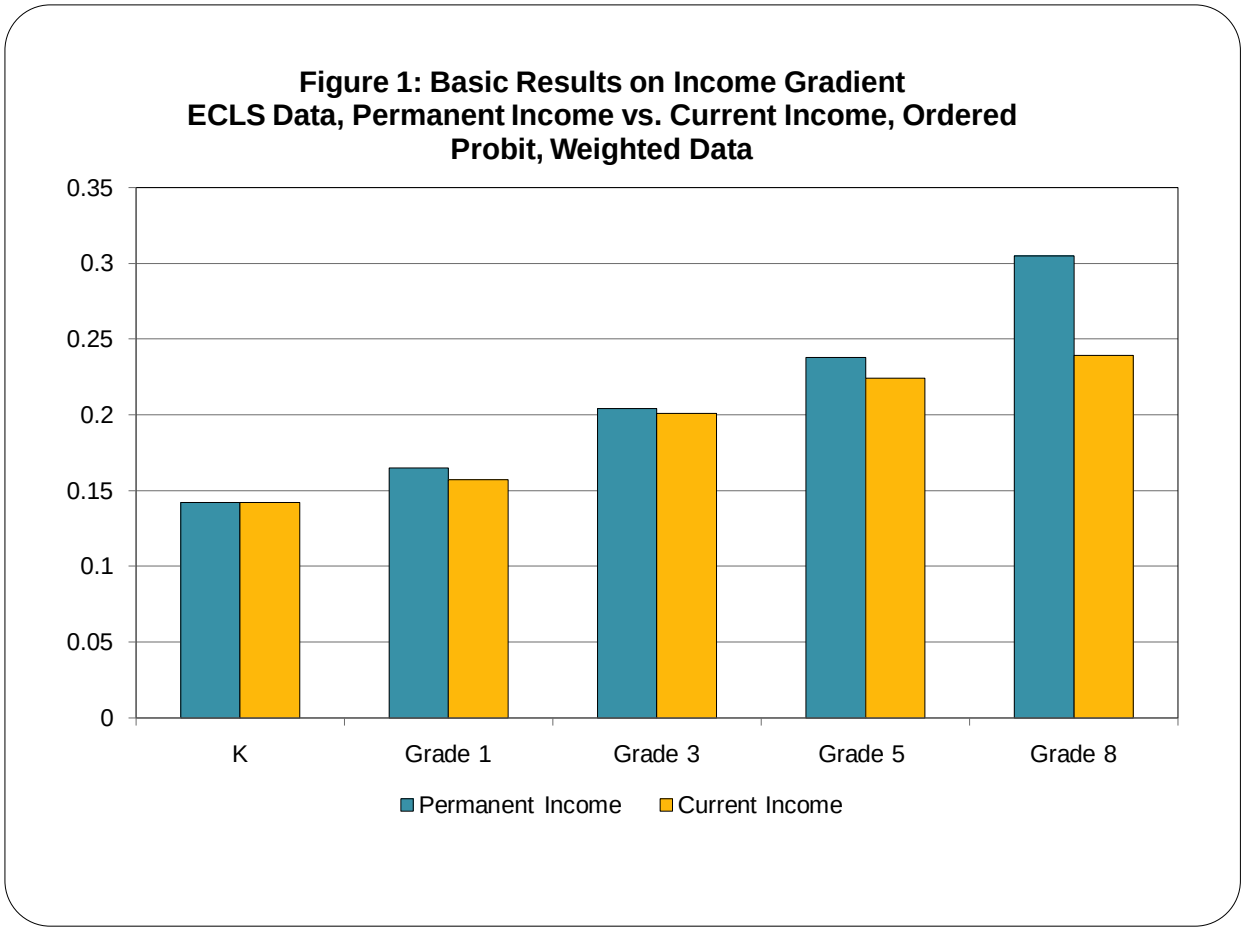
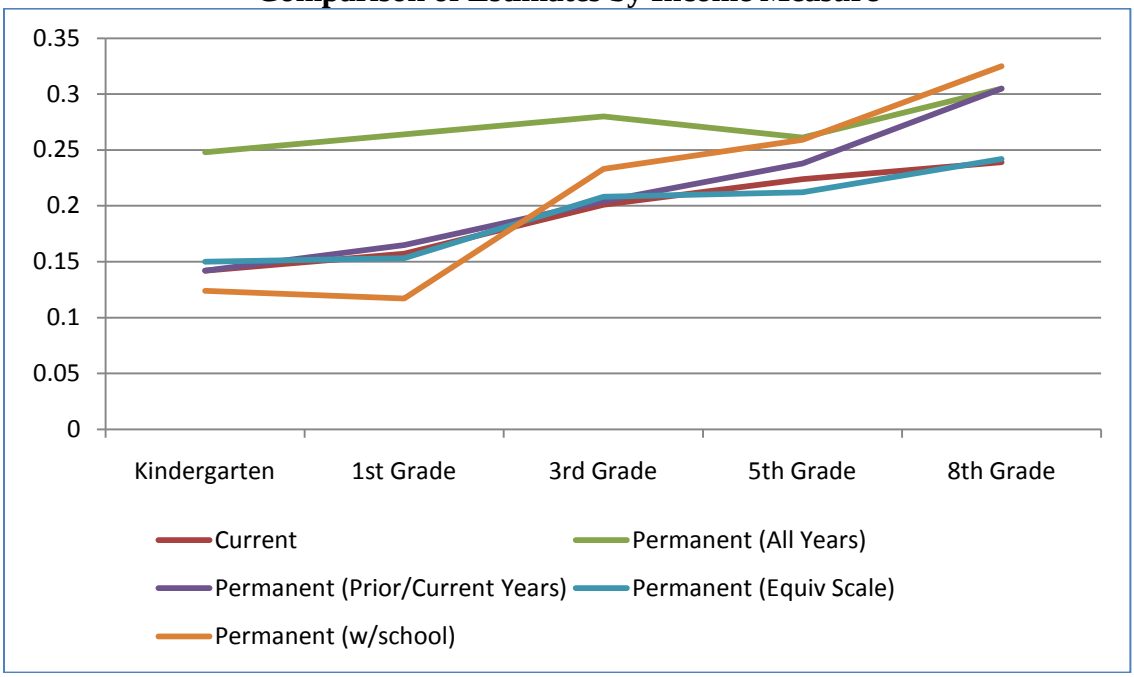


Figure 1: Basic Results on Income Gradient
ECLS Data, Permanent Income vs. Current Income, Ordered Probit, Weighted Data
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
K
Grade 1
Grade 3
Grade 5
Grade 8
Permanent Income
Current Income

Figure 2
Comparison of Estimates by Income Measure



Notes: All estimates include birth weight

Appendix Tables

Comparison of ECLSK to Australian Study Kindergarten as 1st observation

Appendix Table 1: Steepening of the Health-Income Gradient with Child Age US and Australia, K-Cohort, Panel Data, Ordered Probits

	Grade				
Study	K	1st	3rd	5th	8th
Australia	-0.092	-0.151			
Khanam et al. 2009	[0.031]	[0.034]			
USA	-0.123	-0.160	-0.206	-.252	-.252
Fletcher Wolfe 2010	[0.035]	[0.040]	[0.040]	[0.035]	[0.041]

Notes: Dependent variable is ordered general health. Australia – LSAC data. Includes age and wave, sex, race, log HH size, presence and age biological parents, parent's education and employment. USA: ECLS-K data. Includes age and wave, sex, race, presence and age of mother, marital status of parents, parent's education and dummy if income missing.

Appendix Table 2: Full Results for Association between Current Income and Child Health

Outcome	SRHS	SRHS	SRHS	SRHS	SRHS
Grade	K	1	3	5	8
Log (Current Income)	0.142***	0.157***	0.201***	0.224***	0.239***
	(0.037)	(0.045)	(0.044)	(0.038)	(0.045)
Male	-0.113**	0.011	-0.000	-0.073	-0.086
	(0.049)	(0.055)	(0.057)	(0.046)	(0.054)
Age	-0.119	-0.055	-0.101	-0.083	-0.141**
	(0.076)	(0.077)	(0.073)	(0.096)	(0.061)
Black	-0.041	-0.204**	-0.121	-0.241**	-0.247***
	(0.100)	(0.102)	(0.096)	(0.097)	(0.088)
Hispanic	-0.082	-0.174***	-0.057	-0.203***	-0.231***
	(0.060)	(0.063)	(0.065)	(0.061)	(0.067)
Other Race	-0.088	-0.092	0.155	-0.143	0.018
	(0.107)	(0.135)	(0.113)	(0.108)	(0.128)
Birth Weight	0.022	0.014	0.028	0.018	0.005
	(0.019)	(0.022)	(0.022)	(0.019)	(0.019)
Maternal Education	0.054***	0.040***	0.058***	0.051***	0.044***
	(0.012)	(0.015)	(0.014)	(0.013)	(0.014)
Paternal Education	0.016	0.026*	0.005	0.022*	0.000
	(0.012)	(0.014)	(0.015)	(0.012)	(0.012)
Maternal Age	0.004	-0.007*	-0.002	-0.001	-0.004
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)
Parents Married	0.218**	0.186**	-0.122	-0.106	-0.077
	(0.087)	(0.086)	(0.088)	(0.069)	(0.067)
Missing Parent Information	0.242**	0.218**	0.063	-0.025	0.156**
	(0.095)	(0.093)	(0.098)	(0.079)	(0.077)
Observations	7265	6559	6247	7032	6533

Appendix Table 3
The Effects of Income on Childhood Health: Controls for Maternal Depression

Outcome	SRHS	SRHS	SRHS	SRHS	SRHS	SRHS	SRHS	SRHS	SRHS	SRHS
Grade	K	K	1	1	3	3	5	5	8	8
Log (Perm Income)	0.142***	0.129***	0.165***	0.155***	0.204***	0.200***	0.238***	0.221***	0.305***	0.295***
	(0.037)	(0.037)	(0.046)	(0.047)	(0.047)	(0.049)	(0.046)	(0.050)	(0.055)	(0.056)
Mom Depression		-0.116***		-0.159***		-0.115***		-0.117***		-0.125***
		(0.036)		(0.041)		(0.039)		(0.036)		(0.045)
Male	-0.113**	-0.114**	-0.000	0.019	0.006	0.015	-0.072	-0.081*	-0.082	-0.098*
	(0.049)	(0.051)	(0.053)	(0.053)	(0.053)	(0.053)	(0.046)	(0.047)	(0.054)	(0.054)
Age	-0.119	-0.128*	-0.070	-0.088	-0.137*	-0.122*	-0.077	-0.097	-0.135**	-0.128**
	(0.076)	(0.077)	(0.073)	(0.075)	(0.074)	(0.074)	(0.098)	(0.103)	(0.062)	(0.063)
Black	-0.041	-0.079	-0.202**	-0.221**	-0.212**	-0.211**	-0.230**	-0.207*	-0.212**	-0.237***
	(0.100)	(0.105)	(0.097)	(0.101)	(0.099)	(0.106)	(0.098)	(0.108)	(0.091)	(0.091)
Hispanic	-0.082	-0.091	-0.214***	-0.204***	-0.090	-0.073	-0.192***	-0.167***	-0.212***	-0.212***
	(0.060)	(0.062)	(0.061)	(0.062)	(0.063)	(0.064)	(0.061)	(0.064)	(0.067)	(0.068)
Other Race	-0.088	-0.073	-0.119	-0.110	0.097	0.095	-0.150	-0.118	0.025	0.028
	(0.107)	(0.114)	(0.135)	(0.141)	(0.108)	(0.110)	(0.111)	(0.117)	(0.136)	(0.143)
Birth Weight	0.022	0.025	0.018	0.015	0.030	0.028	0.016	0.015	0.004	0.004
	(0.019)	(0.020)	(0.021)	(0.022)	(0.020)	(0.021)	(0.019)	(0.020)	(0.019)	(0.019)
Maternal Education	0.054***	0.054***	0.043***	0.037**	0.056***	0.057***	0.050***	0.047***	0.038***	0.036***
	(0.012)	(0.013)	(0.014)	(0.014)	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)	(0.014)
Paternal Education	0.016	0.017	0.017	0.021	0.004	0.001	0.022*	0.022*	-0.006	-0.005
	(0.012)	(0.012)	(0.015)	(0.015)	(0.014)	(0.014)	(0.012)	(0.012)	(0.013)	(0.013)
Maternal Age	0.004	0.005	-0.007**	-0.006	-0.002	-0.002	-0.002	0.002	-0.005	-0.005
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
Parents Married	0.218**	0.169*	0.164**	0.157*	-0.080	-0.119	-0.058	-0.074	-0.044	-0.074
	(0.087)	(0.093)	(0.083)	(0.085)	(0.081)	(0.084)	(0.067)	(0.070)	(0.066)	(0.066)
Observations	7265	7033	7001	6814	6800	6671	7032	6525	6533	6458

Appendix Table 4: Results for Balanced and Unbalanced Samples

Outcome	SRHS	SRHS	SRHS	SRHS	SRHS	SRHS	SRHS	SRHS	SRHS	SRHS
Grade	K	K	1	1	3	3	5	5	8	8
	Unbalanced	Balanced	Unbalanced	Balanced	Unbalanced	Balanced	Unbalanced	Balanced	Unbalanced	Balanced
Log (Perm Income)	0.142***	0.130***	0.165***	0.177***	0.204***	0.218***	0.238***	0.252***	0.305***	0.283***
	(0.037)	(0.044)	(0.046)	(0.055)	(0.047)	(0.055)	(0.046)	(0.054)	(0.055)	(0.058)
Male	-0.113**	-0.130**	-0.000	-0.036	0.006	0.011	-0.072	-0.083	-0.082	-0.079
	(0.049)	(0.055)	(0.053)	(0.059)	(0.053)	(0.059)	(0.046)	(0.051)	(0.054)	(0.057)
Age	-0.119	-0.149*	-0.070	-0.066	-0.137*	-0.097	-0.077	-0.105	-0.135**	-0.136**
	(0.076)	(0.085)	(0.073)	(0.081)	(0.074)	(0.082)	(0.098)	(0.116)	(0.062)	(0.066)
Black	-0.041	0.008	-0.202**	-0.183	-0.212**	-0.242**	-0.230**	-0.204*	-0.212**	-0.173*
	(0.100)	(0.121)	(0.097)	(0.119)	(0.099)	(0.114)	(0.098)	(0.114)	(0.091)	(0.098)
Hispanic	-0.082	-0.090	-0.214***	-0.265***	-0.090	-0.091	-0.192***	-0.174**	-0.212***	-0.204***
	(0.060)	(0.072)	(0.061)	(0.069)	(0.063)	(0.069)	(0.061)	(0.068)	(0.067)	(0.074)
Other Race	-0.088	-0.086	-0.119	-0.149	0.097	0.124	-0.150	-0.086	0.025	-0.001
	(0.107)	(0.127)	(0.135)	(0.155)	(0.108)	(0.126)	(0.111)	(0.122)	(0.136)	(0.147)
Birth Weight	0.022	0.010	0.018	0.009	0.030	0.032	0.016	0.004	0.004	-0.003
	(0.019)	(0.022)	(0.021)	(0.023)	(0.020)	(0.022)	(0.019)	(0.022)	(0.019)	(0.020)
Maternal Education	0.054***	0.043***	0.043***	0.041***	0.056***	0.057***	0.050***	0.052***	0.038***	0.045***
	(0.012)	(0.014)	(0.014)	(0.015)	(0.013)	(0.014)	(0.013)	(0.014)	(0.014)	(0.014)
Paternal Education	0.016	0.024*	0.017	0.010	0.004	0.000	0.022*	0.019	-0.006	-0.009
	(0.012)	(0.014)	(0.015)	(0.016)	(0.014)	(0.015)	(0.012)	(0.013)	(0.013)	(0.013)
Maternal Age	0.004	0.007	-0.007**	-0.006	-0.002	-0.001	-0.002	0.000	-0.005	-0.005
	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.004)
Parents Married	0.218**	0.309***	0.164**	0.263***	-0.080	-0.110	-0.058	-0.019	-0.044	-0.082
	(0.087)	(0.099)	(0.083)	(0.095)	(0.081)	(0.092)	(0.067)	(0.078)	(0.066)	(0.072)
Observations	7265	5926	7001	5926	6800	5926	7032	5926	6533	5926
Test of Equality		0.511		0.597		0.545		0.562		0.375

Notes: Additional Control: Missing Parental Information