Published in final edited form as:

Child Dev. 2011 ; 82(2): 555–582. doi:10.1111/j.1467-8624.2010.01562.x.

Paths of Effects from Preschool to Adult Well-Being: A Confirmatory Analysis of the Child-Parent Center Program

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Abstract

We investigated the contribution of five hypotheses to the estimated effects of preschool in the Child-Parent Centers on occupational prestige, felony arrest, and depressive symptoms in adulthood in the Chicago Longitudinal Study. An alternative-intervention, quasi-experimental design included over 1,400 low-income participants (93% of whom were black) who attended preschool for 1–2 years or the usual early educational intervention and were traced to age 24. LISREL analysis of five hypotheses (cognitive advantage, family support, school support, motivational advantage, and social adjustment) indicated that while each individually accounted for part of the estimated direct effect of preschool on adult well-being, the best-fitting model across outcomes included indicators of all five hypotheses. The full model completely accounted for the direct effect of preschool on occupational prestige and official felony arrest, and 79% on depression symptoms. Key mediators included cognitive skills at school entry, school quality in the elementary grades, juvenile arrest, and school completion. The identified processes may help establish, strengthen, and sustain effects in other programs and settings.

A large body of research over five decades shows that educational enrichment for children and families in the early years of life promotes well-being in many domains from school entry to adulthood (Camilli et al., 2010; Karoly, Kilburn, & Cannon, 2005; Reynolds & Temple, 2008). Long-term effects on delinquency and crime, educational attainment, and socioeconomic status are especially significant (Campbell et al., 2002; Consortium for Longitudinal Studies, 1983; Schweinhart et al., 1993, 2005; Reynolds et al., 2001, 2007). These findings are consistent with the length, intensity and ecological focus of intervention.

While there is now a critical mass of evidence in support of long-term effects, the causal mechanisms or pathways that account for these findings are not well understood. Comprehensive models have rarely been tested and differential effects across a range of outcomes and programs are unknown (Cuhna & Heckman, 2008; Reynolds, Ou, & Topitzes, 2004; Reynolds & Temple, 2008). Three phases of research on pathways of intervention effects are illustrative. In the earliest studies representing the first phase, the cognitive advantage hypothesis was found to be the initiator and primary mediator of long-term effects on school achievement, educational attainment, and economic well-being (Berrueta-Clement et al., 1984; Consortium for Longitudinal Studies, 1983). Cognitive advantage, as assessed by IQ test scores, was the sole mediator of long-term effects in the Carolina Abecedarian Project (Campbell et al., 1998). Other mediators were not directly assessed or taken into account.

The second phase of research added family and motivational factors to better document the complexity of influences (Barnett et al., 1998; Reynolds et al., 1996; Schweinhart et al.,

1993; Zigler, Taussig, & Black, 1992). For example, Seitz et al. (1983) found that cognitive advantage was partly a function of increased motivation in accounting for the impact of a Head Start program on school achievement. Barnett et al. (1998) found that the initial cognitive advantage in the Perry preschool led to later advantages through motivation and social adjustment ultimately accounting for effects on educational attainment. Generally, these studies demonstrated support for the cognitive advantage hypothesis but less support for other paths of influence.

In recognition of the complex array of factors during and after intervention that account for long-term effects, the third phase of research has emphasized comprehensive sets of child, family, and school-related mediators within an alternative-model framework. This led to the development of the 5-hypothesis model of intervention effects (5HM; Reynolds, 2000). Derived from the accumulated research on early intervention over four decades, the model posits that the effects are explained by indicators of five general paths of influence: cognitive advantage, motivational advantage, social adjustment, family support behavior, and school support behavior. A major tenet of this comprehensive approach is that contribution of any one hypothesis can be accurately assessed only in conjunction with the others. School quality, for example, has been found to account for links between preschool participation and later school performance (Currie & Thomas, 2000; Lee & Loeb, 1995) but has not been included in studies that assess other hypotheses. Within 5HM, investigation of alternative models also is essential to determine the combination of hypothesized paths that fit the data best. The model has been found to have adequate fit with observed data and explain substantial percentages of direct effects of intervention on adolescent outcomes (Ou, 2005; Reynolds, 2000; Reynolds et al., 1996, 2004).

Promoting Healthy Child Development

As documented in the confirmatory approach to assessing social interventions (Reynolds, 2005), knowledge about mechanisms and pathways advances child development and policy research in three ways. First, causal inferences are strengthened. Since the length of time between the end of the program and outcome assessment can be a decade or more, documenting the process of change is central for understanding the impacts of preventive interventions (Susser, 1973; O'Connell, Boat, & Warner, 2009). Even in well-controlled studies, there are many intervening events and experiences that challenge the capacity to infer causality. If the identified mechanisms lead to a coherent explanation of the main-effect relation, causal inference is enhanced (MacKinnon, 2008). Confidence that an intervention enhances well-being or reduces the prevalence of economically-consequential behaviors is critical in dissemination and policy decisions, especially when alternative uses of funds are possible. Increased levels of confidence about intervention effects can also help broaden support for intervention strategies that may be necessary before funding or program expansion occurs.

Second, clarification about mechanisms is important for program design and modification. Empirically supported paths can contribute to a variety of improvement efforts. For example, if family support behavior is identified as an important mechanism of effects, greater attention to parental involvement and the provision of family services would be one improvement strategy. This knowledge can also be used to design new programs or strengthen existing elements. In addition to family services, if socio-emotional factors or peer relations are sources of long-term effects, instructional activities could be better aligned to increase the likelihood of affecting these processes. A finding that developed abilities is a key source of effects would suggest a different alignment of activities such as language and literacy instruction. More generally, the identification of mechanisms can help establish key

principles of effectiveness in the design, modification, and validation of programs to promote health and well-being.

Finally, the identification of mechanisms can increase generalizability of findings. To the extent that findings across studies share a common mechanism, program replication and expansion in different contexts would be more likely to be successful. Knowledge of key processes that initiate and sustain effects may also be used to help ensure reproducibility. For example, postprogram school and family contexts may directly influence the strength of longer-term effects. This information can also explain why interventions did not yield consistent or enduring effects. Empirical support for an identified theory of change may also inform the development of other interventions or strategies. For example, an intervention that is found to reduce school dropout by enhancing school climate could also be broadened to prevent delinquency using the same mediator or “active ingredient.”

Paths of Preschool Impacts in the Chicago Longitudinal Study

Previous analyses of the 5HM in the Chicago Longitudinal Study (CLS, 2005) indicate it can account for the estimated direct effects of intervention (Ou, 2005; Reynolds, 2000; Reynolds et al., 2004). The CLS follows a panel of over 1,500 low-income minority children (93% African American) and investigates the effects of the Child-Parent Center (CPC) early educational intervention. Funded by Title I of the Elementary and Secondary Education Act and established in 1967 as the second oldest publicly funded preschool, the program provides comprehensive education and family-support services for children beginning at age 3. Small classes and intensive family services are run by certified classroom teachers. Three unique features of the study make it particularly appropriate for assessing mediation: (a) the intervention is a sustained large-scale program implemented in the Chicago public schools, (b) consistent evidence has accumulated that participation is associated with enduring effects on well-being, and (c) data collection has been comprehensive in assessing intervening experiences that may account for long-term impacts.

After finding support for the model at the age 15 follow up, Reynolds et al. (2004) investigated the contributions of the hypotheses to CPC effects on high school completion by age 20 and official juvenile arrest by age 18. Based on over 1,300 participants, model fit was tested for each hypothesis separately and together using LISREL maximum likelihood estimation. Like the earlier study, the full model was found to fit the data well with each hypothesis contributing. The full model accounted for 67% of the main effect of preschool on high school completion and 73% of the main effect on juvenile arrest. The primary mediators were kindergarten word analysis scores (cognitive advantage), attendance in high-quality magnet schools, the number of school moves (school support hypothesis), and parent involvement and lower rates of child maltreatment (family support hypothesis). Each of these hypotheses accounted for approximately one-quarter to one-third of the total indirect effects of preschool, though contributions varied by outcome. The school support hypothesis accounted for a larger share of the link to juvenile arrest. The motivational advantage (measured by school commitment), and the social adjustment hypotheses (classroom adjustment) were instrumental in establishing a good-fitting model but made relatively small contributions overall.

Previous CLS studies have three limitations that restrict inferences. First, the outcomes were measured by the end of adolescence before the transition to adulthood and other life-course changes in family, school, and work settings. The extent to which the 5HM can account for adult effects is critical for assessing the validity of the model.

Second, the studies did not investigate the processes for health and well-being more broadly. The focus was on the important but conventionally assessed outcomes of school completion and delinquency. Since the CPC program was a comprehensive child development intervention, the five hypotheses may account for a wider range of outcomes. The economic and policy significance of promoting health and well-being in young adulthood is high. The estimated costs of school dropout and unemployment (National Science & Technology Council, 1997), crime (Cohen, 1998), adult depression (Greenberg et al., 2003), and no health insurance (Hadley et al., 2008) exceed \$600 billion annually.

Finally, earlier reports may not have included the most representative measures of the social adjustment and motivational advantages hypotheses. Reynolds (2000) and Reynolds et al. (2004), for example, used only one measure for each hypothesis from third to sixth grades. This may have resulted in conservative estimates. More comprehensive and age-appropriate measures are needed such as earlier and later measures of both hypotheses.

Present Study

Using the 5HM, we investigated for the first time the processes of effects of CPC preschool on three indicators of adult well-being: occupational prestige, felony arrest, and depressive symptoms. Three questions are addressed:

- A. Considered separately, do each of the five hypotheses account for significant proportions of the observed main effects of CPC preschool on adult well-being?
- B. To what extent does the 5-hypothesis model account for the explanation of main effects and the process of change leading to well-being above and beyond single and dual (two) hypotheses?
- C. How well does the 5HM account for estimated effects of preschool on adult well-being?

In the age-24 follow-up study, Reynolds et al., (2007) assessed direct links between CPC preschool participation and general health and well-being for over 1,400 participants, which represented over 90% of the original sample. Relative to the comparison group that enrolled in the usual interventions in preschool or kindergarten, CPC preschool participants had higher rates of school completion, 4-year college attendance, and more years of completed education. They were less likely to be arrested for felonies, convicted, and incarcerated. Among other findings, program participation was also associated with lower rates of adulthood depressive symptoms and higher rates of health insurance coverage. Impacts on occupational prestige also have been documented (Reynolds et al., 2009).

Although these findings demonstrate the direct effects of intervention on general well-being, the mechanisms that account for them were not assessed. In the present study, we tested the extent to which the 5HM accounted for the effects. School completion and juvenile arrest, the focus of Reynolds et al. (2004), were penultimate to adult well-being.

A Confirmatory Model Linking Early Education to Adult Well-Being

Figure 1 shows the pathways through which early education was hypothesized to influence young adult well-being. Based on earlier syntheses of theory and research in early childhood intervention (Reynolds, 2000; Reynolds et al., 2004), the five hypotheses have been identified as key contributors to enduring and long-term effects. This framework is also central to the Confirmatory Evaluation approach to impact assessment (Reynolds, 1998). This approach is a theory-driven impact analysis that examines the pattern of empirical findings against the causal criteria of temporal sequence, size, gradient (dosage/response),

specificity, consistency, and coherence. A major tenet is that the plausibility of an estimated effect can be strengthened through systematic testing of hypothesized mechanisms.

The conceptual foundations of the model derive from ecological, resilience, and human capital theories. Ecological systems theory (Bronfenbrenner, 1989; Bronfenbrenner & Morris, 1998) specifies that well-being is influenced substantially by the social contexts, both proximal and distal, in which the child grows up and in interaction with experience. The enduring effects of intervention will depend, in part, on the quality and continuity of the postprogram learning environments. As part of the mesosystem, the home-school relation is of particular relevance. The family and school support hypotheses of the model reflect this importance. In resilience theory (Rutter & Rutter, 1993), well-being is conceptualized as individualized responses to risk and protective factors. The identification of protective mechanisms that lead individuals to overcome adversity and display functional competence is a primary focus. Applied to the model, the five hypotheses are protective mechanisms of behaviors that mediate links between early education and adult well-being. Finally, the human capital perspective (Becker, 1964; Heckman, 2000) emphasizes the development of cognitive and socio-emotional skills broadly defined as instrumental to well-being. This perspective is particularly relevant in young adulthood as occupational status and productive citizenship are emphasized over schooling outcomes. Educational attainment and juvenile arrest, for example, are well established as predictors of well-being and transmitters of the impact of earlier experiences. Given the age, length, intensity, and scope of enrichment, long-term effects are viewed as a complex interplay of child, family, and school experiences.

As shown in Figure 1, CPC preschool is hypothesized to directly affect cognitive skills at the beginning of kindergarten, as measured by composite scores on the Iowa Test of Basic Skills. This measure of cognitive advantage then predicts many indicators of the social adjustment, motivational advantage, family support, and school support hypothesis as well as later measures of cognitive advantage. These other intervening influences are expected to directly or indirectly affect educational attainment leading to well-being (see Reynolds et al., 2004). Measures of family support, social adjustment, school support, and motivation are consistent with the previous model, the accumulated research on intervention effects, and the predictors of well-being. For example, reduced child maltreatment is hypothesized as an outcome of CPC (Reynolds & Robertson, 2003) and a predictor of adult well-being, especially felony arrest (Topitzes, 2006; Widom, 2000). As a measure of the social adjustment hypothesis, delinquency would be expected to affect this process and directly link to measures of adult well-being.

The sequence of variables is based on the program theory, the time period of measurement, and previous research. The influences of cognitive advantage, social adjustment, and family support hypotheses generally precede motivational advantage and school support hypotheses. The early measure of cognitive skills was conceptualized as affecting both social adjustment and family support behaviors. For these latter two hypotheses, the direction of influence could not be clearly established during these ages. Although motivation and school support measures were sequenced later in the model, they were expected to predict additional measures of social adjustment (juvenile delinquency) and cognitive advantage (reading achievement). High school completion is the penultimate outcome in the model. Based on a large literature, it is a key predictor of well-being (Levin & Belfield, 2007; U. S. Census, 2002).

The model has five defining attributes that increase efficiency and interpretability.

1. Intervening experiences measured from ages 5 to 15 were emphasized. This attribute is consistent with the previous study at the end of adolescence. Thus, the

stability of findings over time can be assessed. Expansion of the model to include other measures after age 15 would have increased model complexity and introduced redundancy. For example, high school experiences were not directly assessed and would be expected to be manifested through elementary school quality, juvenile arrest, and school completion.

2. Transmission process is linear and recursive. Although nonlinear and nonrecursive models are testable, they are not central features of the program theory. Previous studies also indicate that such models do not fit as well or are as interpretable as linear, recursive models (Reynolds et al., 2004; Schweinhart et al., 1993). Further, these assumptions establish model overidentification and enable direct comparison of alternative models within a nested structure.
3. The age of measurement for the indicators of the five hypotheses was based on the program theory, previous research in this and other studies, and temporal order found in life course studies. Juvenile arrest, for example, would be expected to be influenced by maltreatment but predict high school completion rather than be a consequence of it.
4. Influenced by complex array of skills and experiences, school completion is a component of all five hypotheses, but primarily motivation, school quality, and social adjustment. Although cognitive advantage and family support behaviors also are determinants, their constructs do not directly reflect child school behavior. The former are developed abilities spanning general to specific test performance while the latter denotes parenting practices and attitudes.
5. The remaining measures of the five hypotheses are defined by one and only one hypothesis. Although it is possible that some indicators reflect additional hypotheses, they were defined based on previous studies. For example cognitive skills have motivational components, but the content of the assessment is developed abilities. School mobility could be an indicator of family support for those who changed schools because of a residential move, which was less frequent. Nevertheless, the effects of each variable account for the others. This may introduce conservative bias.

Although the model was estimated as an integrative system, we also estimated the contribution of each hypothesis separately and cumulatively. We emphasized the hypotheses that initiate the pathway of influence, that is are directly predicted by preschool. Of course, the hypotheses could work in tandem or as a chain-of-links. For example, preschool may affect occupational prestige through a combination of cognitive advantage, family, and school support factors, and these are investigated. The overall fit of the model is key to interpretability.

Finally, the estimated paths are correlational and predictive rather than causal. Our test of alternative models may strengthen causal inferences about the estimated effects of preschool and enhance the generalizability of findings. We expected the cognitive advantage, school support, and family support hypotheses to generally contribute most to the explanation of preschool effects, although the pattern of influences will vary by outcome.

Method

Sample and Design

The sample participates in the Chicago Longitudinal Study (CLS, 2005), an on-going investigation of the life course of 1,539 low-income minority children (93% Black) born in 1979 or 1980 who grew up in high-poverty neighborhoods. The original sample included the

entire cohort of 989 children who entered the CPCs in preschool and completed kindergarten in 1986 in 20 centers, and 550 children who participated in alternative kindergarten programs in the Chicago Public Schools without CPC preschool experience. The comparison group attended 5 randomly selected schools (from 27) participating in all-day kindergarten as part of a city-wide school intervention project. As a result of living in Title I eligible areas, all children participated in government-funded programs in preschool or kindergarten (Reynolds, 2000; Reynolds et al., 2007).

At an average age of 24 1/2 years, 89.2% (N = 1,372) of the original sample had valid data on educational attainment by August 2004 (see Table 1). Recovery rates for the preschool and comparison groups were 90.2% and 87.3%, respectively. Sample recovery rates were higher for criminal behavior (92%) and lower for health status (87%) and depressive symptoms (74%), which were based largely on the adult survey at age 22–24. The high rates of sample recovery are due to the use of many sources of administrative and survey data and to follow up tracking. About two thirds of the sample resided in Illinois between ages 20–24, with many others remaining in the Midwest. No evidence of selective attrition was detected, which is consistent with prior studies (e.g., Ou & Reynolds, 2006; Reynolds et al., 2002; Temple, Reynolds, & Miedel, 2000). For additional information, see CLS (2005) and Reynolds et al. (2007).

Chicago Child-Parent Center (CPC) Program

The CPC program is described fully in previous reports (Reynolds, 2000, 2005; Reynolds, Temple, Robertson, & Mann, 2002). We provide a summary of the main features. Located in or close to elementary schools, the CPC program provides educational and family-support services between the ages of 3 and 9 (preschool to second or third grade). At the time of the study sample's participation, the 24 centers each served 100 to 150 preschool children. The centers are located in the poorest neighborhoods. In 1989, the mean rate of family poverty was 41% for the CPC community areas compared to 17% for the nonCPC areas.

Within a structure of comprehensive services similar to Head Start, the intervention emphasizes the acquisition of basic skills in language arts and math through relatively structured but diverse learning experiences that include teacher-directed whole-class instruction, small-group and individualized activities, frequent field trips, and play. Literacy experiences involving word analysis, oral communication, and listening skills are central to the model (Chicago Board of Education, 1988; Sullivan, 1971). All teachers have bachelor's degrees with certification in early childhood.

Each center is directed by a head teacher and two coordinators. The parent-resource teacher coordinates the family-support component. The paraprofessional school-community representative provides outreach to families. Major elements of the intervention include: low child-to-staff ratios in preschool (17:2), kindergarten (25:2), and the primary grades (25:2); an intensive parent program that includes parenting education, volunteering in the classroom, attending school events and field trips, furthering educational attainment, and home visitation; and health and nutrition services, including screening and diagnostic services, speech therapy, meal services, and referrals by program nurses. Parents are expected to participate in the program up to a 1/2 day per week through a variety of supported activities.

The preschool program is 3 hours per day, 5 days a week during the school year, and usually includes a 6-week summer program. After full-day or part-day kindergarten, school-age services are provided under the direction of the curriculum parent-resource teacher. The school-age intervention is open to any child in the school, either in first and second grade in 14 sites or first through third grade in 6 sites. Rates of participation of eligible children were

high as the program was located in areas not served by other preschools, and nearly all families could not afford private care.

Group Comparability

Table 1 shows the characteristics of the educational attainment sample and group comparability for demographic factors at the time of program entry. Overall, the two groups experienced, on average, the same number of family socioeconomic risk factors growing up (e.g., low family income, single-parent family status, and neighborhood poverty). Examination of risk indicators and other background factors indicates that CPC participants at follow up were more likely to have parents who have completed high school and be female. Alternatively, the CPC group was more likely to live in higher poverty areas. Rates of child abuse and neglect, teenage parenthood, financial problems, and other family difficulties were similar between groups (The pattern of characteristics was similar for the other outcomes). Estimation of main effects will take into account the family risk indicators, gender, race/ethnicity, child maltreatment, and later program participation. We examined paths of influence using a reduced set of covariates.

Group differences in the outcomes provide valid estimates of program impact due to the nature of the comparison group and established findings over many years (see Reynolds & Temple; 1995; Reynolds et al., 2007, 2010). Children in the comparison group participated because they enrolled in randomly selected schools with full-day kindergarten programs, which exceeded the usual treatment. By comparing groups that received different intervention services, findings estimate the value added by CPC above and beyond alternative intervention. Only 60% of the preschool group attended all-day kindergarten and 15% of the comparison group had Head Start. Thus estimates of main and mediational effects are likely to be conservative. Moreover, previous studies show no evidence of selection or attrition bias (e.g., Arteaga et al., 2009; Reynolds et al., 2002, 2007; Temple & Reynolds, 2009).

Outcome Measures

The outcomes are conceptualized as indicators of the multidimensional concept of adult well-being. Similar to social competence, these measures are theoretically related to the ultimate goals of the CPC program, which is the enhancement of school success, social competence, economic self-sufficiency, and general health. These outcomes become stable in the third decade, and are most predictive of later economic and social well-being (Levin & Belfield, 2007; U. S. Census Bureau, 2002). Previous studies show a consistent pattern of effects (Reynolds et al., 2007, 2009).

Socioeconomic status—The primary measure was occupational prestige by age 24, which was assessed through adult survey responses between ages 22 and 24, and supplemented with state- or county-level administrative data from criminal, employment, and college records. Based on well-known ratings of socioeconomic position (Barratt, 2005; Davis et al., 1991), we coded participants' current and/or most recent two job descriptions on a 9-point scale with 1 denoting generally unskilled job classifications (e.g., laborers), 5 for moderate levels of job skill synonymous with postsecondary training (e.g., certified nursing assistant, bank teller), and 9 representing high levels of job skill and occupational prestige associated with advanced education and high earnings capacity (e.g., doctors, lawyers). In the analysis, we emphasized the dichotomously coded version of the scale (4 or higher versus all others), which given the age of sample participants, was expected to provide the most reliable and interpretable measure of skill level. Missing values on occupation (14%) were estimated based on educational attainment, income, and incarceration history. The mean occupational score was 2.8 with 27% of the sample having

scores of 4 or higher (semi-skilled jobs such as security guard and customer service representative or above). The sample size was 1,335. Although moderately correlated with and predicted by educational attainment (Levin & Belfield, 2007), occupational prestige is a strong contributor to economic self-sufficiency (U. S. Census, 2002; Wilson, 2009).

Criminal behavior—The primary measure of crime was felony arrests, indicating whether individuals had any such arrests from ages 18 to 24. Data came from administrative records from county, state and federal agencies and were supplemented with self-reports at ages 22 to 24. Most records were from Illinois and other midwestern states through December 9, 2004 (average age 24.8 years). For example, Illinois records were primarily from the State Department of Corrections and the Circuit Court of Cook County. We used a dichotomous variable to maximize interpretability and to maintain consistency with other outcomes. The most frequent arrests for felony charges were drug possession or manufacture, unlawful use of a weapon, robbery, battery, and burglary. The count variable of felony arrest was highly skewed and of less relevance because it is the presence or absence of arrests that is most plausibly affected by preschool and intervening hypotheses. See Reynolds et al. (2007) for additional measures.

Mental health—Depressive symptoms were assessed by the depression subscale of the Brief Symptom Inventory (Derogatis, 1975). Participants at ages 22–24 rated how often in the past month they feel the following symptoms, ranging from 0 (not at all) to 5 (almost every day): (a) depressed, (b) hopeless, (c) lonely, (d) life is not worth living, and (e) sad. A sixth item (“I feel anxious”) was dropped. It was not strongly correlated with the other items and worsened reliability. The shorter and modified five-item scale had a reliability of .84 and demonstrated the expected pattern of modest correlations with other measures of psychological well-being. Consistent with previous studies (Derogatis & Lynn, 2000; Shrout & Yager, 1989) and to reduce overidentification of cases, we used in the analysis a dichotomous variable indicating the frequent presence of one or more of the following symptoms: felt depressed, lonely, or sad almost every day, felt hopeless a few times a week or more, or felt life is not worth living two or more times a month. This coding reflects the differences among items in severity of symptoms. For example, feelings that “life is not worth living” is a qualitatively more severe symptom than hopelessness or sadness. Use of a cut-off score is recommended to increase accuracy and interpretability of relatively brief scales (Derogatis & Lynn, 2000). Studies also have confirmed that brief scales of five or more items have high levels of specificity and sensitivity (Shrout & Yager, 1989; Zimmerman & Mattia, 2001). Reliability was estimated at .90 in the structural model.

Measures of Program Participation and Covariates

Preschool participation—Children who participated in the CPC preschool component for one or two years beginning at age 3 were coded 1 and those in the comparison group were coded 0. About half of the children enrolled for 2 years of a half-day program. 60% CPC preschoolers attended full-day kindergarten. The entire comparison group enrolled in full-day kindergarten programs. Their preschool participation mirrored the community. Our preschool measure indexes the added value of a comprehensive program relative to typical early childhood services.

Covariates—Two covariates are included in the pathway models: gender and mother’s education by child’s age 4. Gender came from school records. Girls were coded 1 and boys 0. Mother’s education was measured from administrative records, birth records, and supplemented with parent reports as the years of schooling (6 to 17). For main effects, we added the following dichotomous variables: race/ethnicity, mother’s employment status, single-parent family status, eligibility for fully subsidized meals, participation in public aid

programs, receipt of child welfare services by age 3, teenage parenthood, participation in the CPC school-age program, and 4 or more children in the family (see Reynolds et al., 2007, 2010). A large number of covariates in LISREL reduces efficiency and worsens model fit.

Cognitive Advantage Hypothesis

Cognitive skills at kindergarten entry—As an indicator of developed abilities, we used scores on the basic composite of the Iowa Tests of Basic Skills (ITBS; Level 5; Hieronymus, Lindquist, & Hoover, 1982) measured in October of the kindergarten year (age 5). This is a composite scale measuring listening and word analysis skills, vocabulary, language, and mathematics concepts. Test norms were 1978. Internal consistency reliability is .94 (Hieronymus et al., 1982). ITBS developmental standard scores, which are an equal-interval scale, were analyzed.

ITBS reading scores at age 14—The reading comprehension subtest of the ITBS was 58 items and emphasized understanding of text passages (Level 14 or 13; Hieronymus & Hoover, 1990). The test was group-administered as part of a larger battery in April of 1994 of the eighth grade year. Retained students were in seventh grade. ITBS standard scores were used in the analyses, which are independent of test level. Test norms were from 1988. The reliability of the scale was .92 (Reynolds, 2000).

Grade retention or special education placement by age 15—This is a dichotomous variable indicating whether one experienced grade retention or special education placement from first grade through eighth grade (ages 7–15). Data were obtained from a grade-by-grade analysis of school system records.

Family Support Hypothesis

Parent involvement in school—As a measure of the family-school relationship, parent involvement in school is a key goal of the CPC program (Sullivan, 1971) and of preschool interventions generally. Parent involvement is measured by the average rating of teachers on the item “parent’s participation in school” over the ages of 7 to 9. This item was measured by a 5-point scale (1 = poor/not at all, 3 = average, 5 = excellent/much). Previous analysis have indicated it shows construct distinction with school performance and convergent and discriminant validity. Parent involvement also has been a frequently correlate and mediator of child outcomes in previous CLS reports (Reynolds, 2000; Reynolds et al., 2004) and in other studies (Fan & Chen, 2001). Notably, the influence of parent involvement is above and beyond the influence of cognitive skills, social adjustment, school commitment and other factors.

Child abuse and neglect—The second indicator of family support behavior was whether children experienced an indicated (substantiated) report of child maltreatment as determined by official records from the state Department of Child and Family Services or petitions to the juvenile court from ages 4 to 17 (1 = substantiated report, 0 = none). Juvenile court records were verified against computer records and without knowledge of youths’ program participation. Substantiated reports predict a wide range of life course outcomes (Mersky & Reynolds, 2007; Topitzes et al., 2009)

Social Adjustment Hypothesis

Social adjustment—Teacher ratings of children’s social adjustment were assessed by a 6-item scale measured over ages 7 to 9 (first to third grade). Developed for the CLS, the items were as follows: concentrates on work, follows directions, is self-confident, participates in group discussions, gets along well with others, and takes responsibility for actions.

Responses were coded from poor/not at all (1) to excellent/very much (5). We used the average of the available scores over the three-year period. Reliability (alphas > .90) and predictive validity of the scale are high (Ou & Reynolds, 2008). Teacher ratings are widely used indicators of social development in studies of intervention (Reynolds, 2000; Schweinhart et al., 1993) and life-course development (Entwisle, Alexander, & Olson, 1997).

Juvenile arrest—This indicates if individuals were ever arrested by age 18. The incidence of petitions to the Cook County Juvenile Court and two other Midwestern locations were collected. Data were collected through record searches at the juvenile court without knowledge of youths' program participation. Searches were repeated twice for 5% random samples, and verified against computer records. To be included in the sample, youth had to reside in Chicago at age 10 or older. These arrests occurred between ages 10 and 18 (1990–1998). They are formal petitions for criminal charges that go before a judge. Some petitions result in warnings or referrals to social service agencies.

Motivational Advantage Hypothesis

School commitment—This measure was a composite of 13 self-reported items about commitment to education. Assessed at age 9 and 10 as part of a survey about school and family experiences, items were rated on a 3-point scale with higher scores indicating greater commitment. Items at age 10 were: I try hard in school, School is important, My teacher thinks I will go far in school, When I get bad grades I try even harder, I give up when school work gets hard [reversed], My teacher expects me to do well in school, and I get bored in school [reversed] ($\alpha = .59$). Factor analyses supported unidimensionality. Because the items were slightly different between age 9 and 10, z-scores were calculated and averaged. Reliability was set at .90 in the structural model. Later measures yielded similar patterns of findings.

High school completion—As primarily a measure of motivation, school support, and social adjustment, this dichotomous variable indicates whether youths completed their secondary education with an official diploma or were awarded a General Education Development (GED) credential by September 2001 (mean age = 21.5 years). All others, including those who remained in high school, were coded as non-completers. The data were obtained from year-by-year administrative records in all schools youth attended and were supplemented by interviews with family members and tracking records. The Chicago public schools provided most of the administrative data on completion. Data on postsecondary education, which also was used to confirm high school completion status, came primarily from the Illinois Shared Enrollment and Graduation Information Consortium (2007) and the City Colleges of Chicago. About a third of high school completers were GED recipients. Reliability was set at .95 in the structural model.

School Support Hypothesis

School quality—This was measured through a dichotomous variable indicating whether study participants over grades 4–8 (ages 10–14) attended either (a) selective citywide magnet schools or (b) those in which 40% or more of the student body was at/above national norms in ITBS reading and math. Data came from the State of Illinois Report Card from the fifth grade year (1990–1991). Scores were highly consistent across the measured grades. Magnet schools have selective enrollment policies that require good school performance and high expectations for success. A large amount of evidence indicates that attendance in schools with relatively high percentages of proficient achievers positively affects school climate, expectations for performance, peer norms, and prosocial behavior (Wang, Haertel, & Walberg, 1993). These links have been corroborated in the CLS study. For example,

enrollment in higher quality schools is moderately associated with student ratings of school climate and teacher ratings of classroom quality (Ou & Reynolds, 2008). School quality is also a key element in educational productivity (Walberg, 1984). This measure is also consistent with previous models in the CLS (Ou, 2005; Reynolds et al., 2004) and in other projects (Currie & Thomas, 2000). In CLS studies, school quality has been found to be an important outcome of early intervention, and predicts educational attainment and juvenile delinquency (Reynolds, 2000; Reynolds et al., 2007). Its influence in the model is above and beyond most other mediators including early cognitive skills and social adjustment.

School mobility—This individual-level measure was the number of times youth changed schools between the ages of 10 to 14 (grade 4 to 8). Obtained from a grade-by-grade analysis of school records, school mobility is a key negative indicator of the continuity in learning environments (Bronfenbrenner, 1989) that has been frequently associated with lower school performance and with higher levels of school dropout and behavioral problems (Rumberger, 2003; Temple & Reynolds, 1999). Mobility often disrupts the stability in learning environments important for well-being and has an influence above and beyond family background and pre-mobility achievement.

Missing values—Except for the outcomes, missing data were imputed in LISREL using multiple imputation through the expectation-maximization (EM) algorithm (Schafer, 1997). The variables used for imputations were gender, family risk index score, full day kindergarten participation, preschool participation, and kindergarten school sites. There was strong evidence that data were missing at random, after accounting for background variables. Of the 13 model variables, 7 were imputed: maternal education (3.1% of cases), parent involvement (7.6%), school mobility (8.1%), reading achievement (9.2%), classroom adjustment (17.3%), school commitment (18.1%), and cognitive skills (28%).

Data Analysis

We used the structural equation modeling (SEM) program LISREL (Joreskog & Sorbom, 1996a) to investigate the 5HM. Following the confirmatory approach (Reynolds, 1998), we first investigated the main effects of program participation for well-being. We reported adjusted rates from probit regression analysis in STATA (Stata Press Staff, 2007) transformed to marginal effects. The 5HM in Figure 1 was testing via maximum likelihood (ML) using the same procedure as Reynolds et al. (2004). The standardized regression coefficients describe the direct and indirect effects. The main focus of the analyses was the indirect (or mediated) effects of measures of program participation and the intervening variables that contribute to these effects. We used single indicators to represent latent variables, and included estimates of measurement errors to increase the accuracy of estimates.

Estimates were based on the polychoric correlation matrix from PRELIS (Joreskog & Sorbom, 1996a, 1996b) using pairwise-present cases. Significance tests were based on the maximum sample sizes for each outcome. We used a test statistic of 2.50 to denote statistical significance (p value of about .01). The sample sizes used in the analyses were 1,134 for depressive symptoms, 1,335 for occupational prestige, and 1,418 for felony arrest. Because outcome variables were dichotomous, it is possible that significance tests are imprecise to a small degree. Joreskog and Sorbom (1996a) indicated that except in cases of high skewness, ML yields consistent estimates.

Two indicators of model fit were used: the root mean square error of approximation (RMSEA) and adjusted goodness of fit index (AGFI). According to Byrne (1998), values of the root mean square error of approximation (RMSEA) below 0.05 indicate a good fit, and

values as high as .08 represent reasonable errors of approximation in the population. AGFI values above .90 indicate good fit. Besides the ML model, we also reported two other indicators of model fit. The total indirect effect of preschool on each outcome through intervening variables was indexed as a percentage of the total indirect effect explained by the indicators of 5HM. Finally, to describe the direct contribution of the hypotheses to the main effects of preschool we included the percentage of the main effect explained by the hypotheses separately and together. This is referred to as the difference-in-difference approach (MacKinnon, 2008).

Two sets of models were tested for each outcome. The first set included each hypothesis separately, without the joint effects of other hypotheses. The fit of each of the five hypotheses was compared against the main-effect model positing no mediation (all paths to intervening factors set to 0; see Appendix A). The second set was the cumulative model in which the joint contribution of the hypotheses was included following the sequence in Figure 1. The baseline model was the traditional cognitive advantage model with other mediating paths set to 0. We expected that (a) each of the five hypotheses contribute to improved model fit over the direct-effects model, (b) dual hypotheses would further improve model fit over the individual hypotheses, and (c) the full 5HM will provide the best fit compared to less comprehensive models, including the cognitive advantage plus family support hypothesis

Results

Consistent with the confirmatory approach, we first present findings on direct link between CPC preschool and the three main measures of adult well-being. This is followed by a description of correlations among program, mediators, and outcomes. The primary results section summarizes the contributions of the 5HM to adult impacts.

Main Effects of CPC Preschool on Adult Well-Being

Table 2 shows that after adjusting for the influence of background factors, CPC preschool was associated with significantly greater well-being. In addition to prevalence rates and mean differences, effect sizes in standard deviations (*d*) are reported. For occupational prestige, 28.2% of the preschool group had a job skill level of 4 or higher (e.g., semi-skilled occupation or above) compared to 21.5% for the comparison group. This is a 31% increase in job skill level over the comparison group (*d* = .22 SD, based on probit transformation). Findings were similar using the continuous measure of occupational prestige. Notably, study participants had generally low levels of occupational status. This is due in part to the original economic disadvantage of the sample.

Preschool participants had a significantly lower rate of felony arrest (9.9% vs 14.5%, *p* = .02), which is a 32% reduction over the comparison group (*d* = .23 SD). This finding is consistent with other measures of involvement in the criminal justice system such as incarceration, conviction, and felony conviction (see Table 2). No differences were found in arrest for any charge (felony or otherwise). Preschool participants also had significantly lower rates of juvenile arrest (Reynolds et al., 2002). See Reynolds et al. (2007) for additional estimates.

For the third outcome, depressive symptoms, preschool participants reported a significantly lower rate of one or more symptoms in the past month as assessed between ages 22–24 (12.8% vs. 17.4%, *p* = .057). Although this difference borders the 5% level, there are several reasons to interpret this as meaningful. First, this difference was consistent with the attrition-corrected estimate from propensity scores (12.8% vs. 17.7%, *p* = .040; see Reynolds & Ou, 2009). Second, the estimated effect is sizable in percentage terms—a 26% reduction over the

comparison group. The d statistic of .20 SD is similar to the other outcomes and is interpretable as within the range of practical significance (Lipsey & Wilson, 2001). Third, as a measure of psychological well-being, measurement error is likely to be higher than for other indicators, which would introduce a conservative bias. Finally, the economic impacts of depression are high, estimated annually at \$83 billion in treatment burden and lost productivity (Greenberg et al., 2003).

Although not the focus of the analysis, preschool participants had significantly higher rates high school completion at age 21 (79.5% vs. 71.4%, $p = .002$), which is a penultimate outcome in Figure 1. This difference has endured up to age 25 as well as for other indicators of educational attainment. Preschool participants also had significantly higher rates of health insurance coverage and lower rates of substance misuse (see Table 2). Based on d , these were in the range of practical significance. See Reynolds and Ou (2009) for estimates of alternative models.

Links among Preschool Participation, Mediators, and Outcomes

Given the evidence that preschool was associated with the adult well-being, we examined the correlations among measures. They have a conservative bias because of range restriction of the dichotomous variables. Table 3 shows that preschool was positively correlated with the mediators, including the ITBS cognitive composite, parent involvement, classroom adjustment, school commitment, attendance in high-quality schools, and school completion. It was negatively correlated with abuse or neglect report, school mobility, remedial education, and juvenile arrest. With few exceptions, the hypothesized mediators were significantly correlated, in the expected direction, with adult well-being. This is an important precondition of examining long-term mediation.

Summary of Model Fit

We hypothesized on the basis of previous syntheses and findings that the inclusion of all indicators of the 5HM would provide the best model fit in accounting for the relation between preschool and adult well-being. As shown in Table 4, the findings of the model fitting corroborate the contributions of all five hypotheses. A comparative analysis of the nested models shows the superior fit of 5HM (Model 9) over less comprehensive models for each of the outcomes, including the traditional cognitive advantage (Model 2) and the cognitive advantage and family support (Model 4) hypotheses. This was also the case for the cognitive advantage, social adjustment, and motivational advantage hypotheses (Model 6). The fit statistics for the cumulative models in Table 4 are based on the time sequence of the paths from Figure 1. Although each of the mediators contributed to improved model fit above and beyond the baseline model, only when the full set was included did the models fit the data well.

In the rest of the results section, we (a) describe the findings for best-fitting Model 9 by outcome, (b) identify the main paths of influence and their percentage contributions to the indirect effects of preschool, and (c) detail the percentage contributions of the hypotheses to the main effects of preschool using the difference-in-difference approach. See Appendix A for the fit statistics of the baseline model with no mediators and single-mediator paths.

Mediators of the Effects of Preschool on Felony Arrest

As shown in Table 4, only the most comprehensive model (Model 9) had fit statistics in the acceptable range (RMSEA in the .08 range). The best-fitting model included indicators of all five hypotheses and high school completion ($\chi^2 = 201$ (26), RMSEA = .068, AGFI = .92). This model, with high school completion added, was an improvement over Model 8. It

accounted for 79% of the variance in felony arrest. Figure 2 displays the major standardized coefficients.

The paths leading from preschool to felony arrest were diverse. As shown in Figure 2, two intervening factors directly mediated the main effect of preschool. One was a family support indicator—abuse/neglect report, and the other was school support indicator—number of school moves. Preschool participation was associated with lower incidence of child abuse and neglect ($b = -.13$), which in turn linked to felony arrest ($b = .12$). Preschool participation was associated with fewer school moves ($b = -.13$), which in turn linked to felony arrest in the expected direction ($b = .09$). The thicker paths in Figure 2 show the direct mediation of abuse/neglect and mobility without contributions from other mediators.

The cognitive advantage hypothesis contributed to the effects circuitously. Preschool participation was associated with an immediate cognitive advantage ($b = .36$) that led to a higher rate of attendance in high-quality schools ($b = .24$), higher ITBS reading scores ($b = .07$), higher classroom adjustment ($b = .38$), a lower rate of grade retention or special education placement ($b = -.15$), a lower incidence of child abuse and neglect ($b = -.16$), and to a higher level of parent involvement in school ($b = .19$). Cognitive advantage also contributed to arrest through other mediators except for school commitment. The major predictors of felony arrest were ITBS reading ($b = -.13$), high school completion ($b = -.37$), juvenile arrest ($b = .22$), and abuse and neglect ($b = .12$).

Empirical verification of the family and school support hypotheses in contributing to felony arrest is a new and significant finding. The social adjustment and motivational advantage hypotheses also made notable contributions to processes leading to arrest, although it was through school completion that classroom adjustment was most influential.

Mediators of the Effects of Preschool on Depressive Symptoms

As with felony arrest, the two most comprehensive models fit the data best (Models 8 and 9). This pattern indicated that all five sets of hypotheses contribute to the link between preschool and depressive symptoms. Relative to the others, the full model fit the data best ($\chi^2 = 164.86$ (26), RMSEA = .068, AGFI = .914). The model variables explained 22% of the variance in symptoms. Figure 2 shows the significant standardized coefficients of Model 9.

The major direct path from preschool to depressive symptoms was via school support. As shown in Figure 2, preschool participation was associated with fewer school moves ($b = -.13$), and number of school moves was associated with higher rates of symptoms ($b = .09$). The thicker paths show the direct mediation through mobility. Complex paths included cognitive advantage, family support, social adjustment, and motivational advantage indicators.

In a pattern similar to felony arrest, the cognitive advantage hypothesis contributed to reduced depressive symptoms in conjunction with other mediators. The program impact on cognitive skills ($b = .36$) carried over to parent involvement ($b = .19$), greater attendance in high-quality schools ($b = .24$), and lower likelihood of retention or special education placement ($b = -.16$). The major predictors of symptoms were high school completion ($b = -.22$), classroom adjustment ($b = -.15$), number of school moves ($b = .09$), school commitment ($b = .09$), and juvenile arrest ($b = .27$).

Both the family support and school support hypotheses made major contributions. Preschool participants were less likely to experience child abuse and neglect ($b = -.12$) and had higher parent involvement in school ($b = .15$), both of which linked to school support indicators as

well as juvenile arrest leading to symptoms. School mobility directly predicted symptoms whereas school quality impacted symptoms through high school completion.

The social adjustment and motivational advantage hypotheses contributed primarily through high school completion and juvenile arrest. In addition, both classroom adjustment and school commitment directly predicted symptoms and were important links for other processes. For example, school commitment served as a “bridge” between cognitive advantage and classroom adjustment to later symptoms. Classroom adjustment also was influential through remedial education and school completion.

Mediators of the Effects of Preschool on Occupational Prestige

The full model fit the data best (Model 9, $\chi^2 = 195.80$ (26), RMSEA = .069, AGFI = .914), and accounted for 53 percent of the variance in occupational prestige. As shown in Figure 2, no single hypotheses accounted for the relation to well-being. The three predictors of prestige spanned three hypotheses, with high school completion being the strongest ($b = .47$), followed by juvenile arrest ($b = -.24$), and reading achievement ($b = .14$). The family support hypothesis contributed through links with juvenile arrest. The school support hypothesis, including school quality and mobility linked to prestige primarily through high school completion.

Similar to other outcomes, the cognitive advantage hypothesis contributed to the preschool effect in a variety of ways, including through school quality, reading achievement, classroom adjustment and remedial education, and the family support indicators of parent involvement and child abuse and neglect. Only school commitment did not contribute to the transmission of cognitive advantage.

The social adjustment and motivation hypotheses also contributed substantially to occupational prestige through other intervening factors. It was through attendance in high-quality schools, parents' involvement in school or incidence of child abuse and neglect that preschool influenced juvenile arrest, which then affected occupational prestige. Juvenile arrest and school completion, however, were dominant in the final transmission of effects.

Indirect Effects of Preschool Participation on Well-Being

Table 5 summarizes the major contributing pathways to the long-term effects of CPC preschool as a proportion of the total standardized indirect effect. This is the second indicator of the model's explanatory power. Estimates are from LISREL and take account of measurement error and correlated errors. The total indirect effect is the sum of all paths of influence from preschool leading to outcomes as shown in Figure 2. For example, the standardized total indirect effect of preschool on felony arrest was $-.147$. The path through abuse/neglect ($bs = -.13 \times .12$ or $-.0156$) was 10.6% of the total indirect effect ($-.0156/-.147$). We categorized the indirect effects by mediator, with the primary emphasis on the mediators that initiated the indirect effect—were directly and significantly associated with preschool. The paths in Table 5 sum to less than 100% because some insignificant paths were excluded.

Contributions of 5HM to well-being—The pattern of contributions of each hypothesis to the total indirect effect was similar across outcomes. The cognitive advantage hypothesis contributed the most to the indirect effects, followed by school support, and family support. Cognitive advantage accounted for 26% to 40% of the indirect effects of preschool on well-being, with depressive symptoms being largest and occupational prestige the lowest. With equivalent influence as cognitive advantage, school support accounted for 20% to 29% of

the indirect effect of preschool. The greatest contribution was to depressive symptoms. Family support accounted for 10% to 24% of the indirect effects.

Primarily due to their later placement in the model, social adjustment and motivation advantage made smaller contributions to indirect effects. For example, juvenile arrest had only direct effects on the outcomes and contributed through complex paths involving mediators measured at younger ages. As measures of motivational advantage, high school completion directly predicted the outcomes. School commitment negatively predicted depressive symptoms

Specific paths of influence—As further shown in Table 5, the most influential paths accounting for the impact of preschool varied by outcome. For felony arrest, child abuse/neglect (10.6% of the total indirect effect), attendance in high quality elementary schools and high school completion (8.2%), school mobility (8.0%), child abuse/neglect and juvenile arrest (5.1%), and cognitive skills at school entry and abuse/neglect (4.7%) were the main contributors.

For depressive symptoms, cognitive skills at school entry and classroom adjustment (22% of total), school mobility (12.2%), abuse/neglect and juvenile arrest (8.8%), attendance in high quality elementary schools and high school completion (7.4%), and parent involvement and juvenile arrest (4.2%) were most influential.

Finally, attendance in high quality schools and high school completion (9.6% of total), abuse/neglect and juvenile arrest (5.1%), cognitive skills, attendance in high quality schools, and high school completion (4.6%), cognitive skills, classroom adjustment, and high school completion (4.2%), and mobility and high school completion (3.9%) contributed the most to the link between preschool and occupational prestige.

Direct Mediation of Preschool Effects on Adult Well-Being

We also assessed the direct mediation of the preschool link to adult well-being as a percentage reduction in the size of the main effect (difference-in-difference). This is the third indicator of the explanatory power of 5HM. In contrast to the LISREL model fitting approach based on Figure 1, the direct mediation approach estimates the difference between the main effect without the mediators included (b) and the main effect with the mediators included (b^*) as a percentage of the main effect without mediators ($b - b^*/b$). The program coefficients were standardized values estimated in LISREL. This percentage reduction approach does not include indirect effects, however. Findings indicate (see Appendix C) that substantial proportions of the main effect of preschool were explained by the five hypotheses. Across the outcomes, the full model (Model 13, Appendix C) contributed most to the explanation of the main effects. The direct effect for both felony arrest and occupational prestige were completely accounted for by the 5HM. The full model accounted for 79% of the main effect on depressive symptoms.

Alternative Models

To examine robustness of findings, a number of alternative models were tested. The continuous measure of occupational prestige and count of the number of felony arrests yielded a similar pattern of coefficients and model fit as the dichotomously-coded variables. Secondary outcome measures (incarceration, college attendance) also were found to have similar patterns of influence. Finally, alternative indicators for some hypotheses were found to weaken model fit, introduce redundancy, or not increase meditational power. For example, as a secondary measure of motivational advantage, youth expectations to attend college did not improve fit in any of the models tested. Alternatively, removal of reading

achievement as an intermediate indicator of cognitive advantage significantly weakened model fit and explanatory power. The inclusion of alternative covariates, such as the family risk index, yielded similar patterns of results. See Reynolds and Ou (2009) for analyses of health insurance and other models.

Summary Paths

Figure 3 summarizes key direct and indirect paths of influence in the full 5HM. The displayed paths made the strongest and most significant contributions to the transmission process. With few exceptions, the pattern of influences was similar across outcomes. CPC preschool led to better young adult well-being through three phases of transmission. First, the initial impacts of preschool were on cognitive skills and family support behaviors which then contributed to positive school support experiences, although preschool directly affected school quality and mobility above and beyond other cognitive and family influences. These initial impacts provided the foundation for long-term effects. In the second phase classroom adjustment, school support, and family supported experiences transmitted the initial impacts of intervention to the penultimate outcomes of juvenile arrest and high school completion. School support, family support, and classroom adjustment also directly predicted adult well-being independent of adolescent behaviors. In third phase, juvenile arrest and high school completion were the strongest predictors of well-being and thereby represent the end point in a chain-of-links that transmit the impacts of preschool to well-being. Most of the influences of the earlier mediators were dependent on juvenile arrest and school completion in affecting later well-being.

Discussion

We investigated pathways through which CPC preschool participation impacts three measures of health and well-being by age 24. Significantly extending on previous findings through adolescence (Reynolds, 2000; Reynolds et al., 2004), we found that the best-fitting model included indicators of all five hypotheses. The 5HM fit better than the commonly tested models of cognitive advantage alone, cognitive advantage and family support, and cognitive advantage, social adjustment, and motivational advantage hypotheses. The cognitive advantage, family support, and school support hypotheses contributed most by initiating the cumulative advantages leading to well-being. The five sets of mediators completely accounted for estimated direct effects of preschool on occupational prestige, and most of the impact on depressive symptoms. High school completion and juvenile delinquency were key transmitters of impacts.

Unique Contributions

The study makes three major contributions to understanding long-term effects of early childhood intervention. First, the study expands support for the five-hypothesis model to young adult outcomes. As the only study that has investigated a comprehensive set of mediators on adult health and well-being, the findings establish for the first time key sources of intervention effects. Most previous studies have tested one or two major hypotheses and have not systematically tested alternative models across a wide range of mediators. The cognitive advantage hypothesis alone or combined with family support has been the most commonly investigated (Schweinhart et al., 1993; Reynolds, 2000).

While our findings are consistent with the earlier study through adolescence (Reynolds et al., 2004), the present study advances knowledge in several respects. First, the model accounted for effects of intervention on health and well-being rather than education. This broader life course framework provides a better assessment of continuity during adult transitions. In addition, the model represented the hypotheses more completely. Indicators of

social adjustment and motivation were assessed earlier and during adolescence. Furthermore, and due in part to more thorough measurement, findings revealed stronger contributions of motivation and social adjustment to the transmission of effects, although they did not initiate the long-term effects.

By implementing the methodology of confirmatory evaluation, 5HM fit the data well compared to many alternatives and accounted for most or all of the direct effects of preschool. In order of total contribution, the cognitive advantage, school support, and family support hypotheses were the primary sources of the indirect effects on adult well-being. Social adjustment and motivation hypotheses were critical, however, in establishing good-fitting models via juvenile arrest and high school completion. These findings, which are consistent with the ecological and human capital perspectives, increase confidence that our tested mediators account for the adult effects of intervention. The contribution of each hypothesis was established only after the influence of other hypotheses was estimated, which is a significant advantage over most previous studies. Findings that the best fitting models included indicators of all five hypotheses suggest that each should be examined in studies of mediation and the transmission of effects. The framework for investigating these and other relations is part of the confirmatory approach.

The second contribution is that the study clarifies the initiators of the impact of preschool that lead to later well-being. Initiating influences are those outcomes that are directly impacted by intervention and that affect other intervening outcomes culminating in better well-being. The literature on human capital emphasizes cognitive-academic skills and socio-emotional development (noncognitive skills) that determine later well-being (Cunha & Heckman, 2008; Heckman, 2000) while ecological models incorporate family and school factors that contribute independently or in interaction with individual attributes (Bronfenbrenner & Morris, 1998; Rutter & Rutter, 1993). Our findings provide support for both perspectives but revealed that cognitive, family, and school factors were most influential.

We found evidence for five initiators of the effect of preschool. The first was cognitive skills at kindergarten entry, which directly affected six other intervening factors including classroom adjustment, family processes, school quality and later achievement. The family support measures of parent involvement in school and child maltreatment also were initiators of preschool effects and directly predicted measures of school support or social adjustment. The two remaining initiators of the long-term effects of preschool were school quality and school mobility, which after being predicted by preschool participation, directly predicted later achievement, high school completion and juvenile arrest. Consistent with previous studies (Campbell et al., 2001; Consortium for Longitudinal Studies, 1983; Reynolds, 2000; Schweinhart et al., 1993), these findings reveal the importance of cognitive skills, and family and school support factors as initiators of long-term effects. These can be targets of intervention in their own right.

While social adjustment and motivation hypotheses were not found to initiate the effects of preschool on adult well-being, they contributed indirectly through being part of a chain-of-links. For example, preschool affected classroom adjustment through cognitive skills at age 5 and then classroom adjustment directly influenced later school achievement and school completion culminating greater well-being. The strong predictive role of juvenile arrest and school completion support the contributions of motivation and social behavior in transmitting the effects of earlier experiences to adult well-being. This pattern of stronger indirect rather than direct effects of social and motivational influences is consistent with previous studies (Barnett et al., 1998; Consortium for Longitudinal Studies, 1983; Reynolds et al., 1996, 2004; Schweinhart et al., 1993). It is less consistent with but complementary of

research showing the impact of noncognitive skills to human capital (Cunha & Heckman, 2008; Heckman & Krueger, 2003).

The third major contribution of the study to understanding early intervention effects is that because we tested impacts associated with an on-going sustained and large-scale preschool program, our findings are more generalizable to contemporary programs than most previous studies. Most studies are research demonstrations that differ in significant ways from contemporary programs (Karoly et al., 2005; Reynolds & Temple, 2008). The CPC program has many features in common with state and federally-funded preschools, and being administered by public schools, can be widely disseminated. Teacher qualifications, class sizes and ratios, and scope of services are generally consistent with contemporary practice. Moreover, the large sample size also increases confidence in the stability of estimates and the likely reproducibility across contexts. A complete cohort of CPC graduates were followed to adulthood with high sample recovery and compared to a large sample of children who participated in the usual early childhood intervention. This contrast also is ecologically valid since it is now typical that comparison groups in state- or federally-funded programs enroll in other intervention services. Finally, a defining feature of this study was the systematic testing of alternative hypotheses of how the longer-term effects of intervention emerge. The pattern of findings corroborates key elements of the program theory thereby strengthening inferences about program impact. The extent to which these identified processes would be replicated in other contexts and programs deserves further investigation.

Differences in Pathways by Outcome

Although each hypothesis contributed to the explanation of effects or to overall model fit, the pattern of findings differed by outcome and generally paralleled known determinants. Based on the summary of paths in Table 5, the cognitive advantage, school support, and family support hypotheses were generally equal in influencing adult crime. These links are consistent with life course determinants of criminal behavior including child maltreatment (Topitzes, 2006; Widom, 2000), cognitive skills (Loeber & Farrington, 1998; Topitzes, 2006), and school experiences (Reynolds et al. 2004). For occupational prestige, cognitive advantage and school support accounted for larger proportions of the indirect effects of preschool with family support, primarily through child maltreatment, accounting for lower proportions of indirect effects. This is consistent with much previous research showing the strong role of school success and positive school experiences in economic well-being (Levin & Belfield, 2007; U. S. Census, 2002).

The pattern of contributions for depressive symptoms differed from the other outcomes in that cognitive advantage made greater proportional contributions than school and family support factors. The social adjustment hypothesis, via early classroom adjustment, and the motivational advantage hypothesis, via school commitment, also meaningfully contributed. The cognitive, perceptual, and social interactional precursors of depression are well established in cognitive in developmental science (Jacobs, Reinecke, Gollan, & Kane, 2008). In further support of the contribution of social adjustment, classroom social adjustment directly mediated the effect of preschool on depressive symptoms, as well as felony arrest and occupational prestige, above and beyond the cognitive and motivational model (see Appendix C). The distinctive pattern of predictors and processes for depressive symptoms suggests a more diverse set of mediators of preschool effects than the other outcomes. This is also consistent with the finding that the main effect on depression was not explained as well as for criminal behavior and occupational status.

High school completion had a key role in model validation and appears to be essential in the transmission process to adult well-being. Indeed, the influence of school remedial services,

classroom adjustment, school mobility, and school quality on adult well-being was dependent at least in part on school completion. The importance of school completion is especially apparent in urban contexts like Chicago given the role of schools in helping to compensate for economic disadvantage in promoting competence and economic independence (Ou & Reynolds, 2008; Entwisle et al., 1997; Levin & Belfield, 2007; Wilson, 2009). Moreover, school completion has motivational as well as social and school support components that strengthen its links to adaptive behavior in adulthood. The perceived value of and commitment to completing high school extends to health and well-being more generally.

Without high school completion, none of the models fit the data well. This was especially apparent for occupational prestige and felony arrest, as these models went from relatively poor fitting to good fitting as a consequence of educational attainment. School completion contributed less to depressive symptoms. This pattern is generally consistent with the life-course literature that attainment has closer connections with occupational status and criminal history than with health and mental health (Loeber & Farrington, 1998; U. S. Census, 2002). The major role of juvenile arrest in predicting educational attainment and adult arrest also is well documented (Loeber & Farrington, 1998; van der Geest et al. 2009) and would be expected to extend to other indicators of well-being. As demonstrated in our study, social adjustment was a direct predictor of well-being and helped transmit the impact of preschool.

Limitations

We note three limitations that restrict inferences. Like all SEM studies, the pattern of findings is correlational and should be interpreted within the framework of the 5HM. The assignment to program and control groups also was quasi-experimental and strong causal inferences are more challenging. Rather, our findings demonstrate that the hypothesized mediators contribute substantially to the explanation of the link between preschool and adult well-being. Although our findings should be viewed within this context, four findings strengthen confidence. First, the model was comprehensive and thereby minimized omitted variables bias present in most meditational studies. Measurement errors were taken into account. Second, the model fit the data well by multiple criteria and substantial proportions of the direct effects of intervention were explained. Third, the findings were robust across analyses that included reduced and expanded sets of mediators, alternative outcomes, and different model specifications (Reynolds & Ou, 2009).

A second limitation is that some hypotheses were not measured as completely as possible. The primary measure of motivation was school commitment by age 10. Later measures, alternative measures such as educational expectations and perceived competence, or multiple-indicator approaches may have increased the total contributions. Nevertheless, the addition of educational expectations did not increase percentage contributions. Finally, measures of school support hypothesis may have been underrepresented. School climate and instructional practices may be influential in the transmission of effects. In support of model variables, we used measures that were strongly connected to the theory of the CPC program and that had empirical support as potential mediators. To be consequential, additional variables have to contribute above and beyond the influence of other variables.

The third limitation is that some assumptions may have been overly restrictive. To simplify estimation, the model was estimated as a linear recursive system. To the extent that the relations among hypotheses are nonreciprocal or nonlinear, the model may have misspecifications. For example, relations among cognitive, social, and motivational development are more complex than represented in the model. The assumption of the model, based on the accumulated intervention theories, was that cognitive skills are more predictive of social and motivational outcomes than the reverse. Moreover, because we estimated 5HM

for the total sample, it is possible that processes vary by child and family attributes. Ou and Reynolds (in press), for example, found that while the 5HM of educational attainment held for both males and females, specific hypotheses varied in impact. Subgroup analyses, while consistent with the ecological model, were beyond the scope of the current study. The confirmatory nature of the study however, strengthens interpretability and is likely to increase the stability of estimates over less developed models.

Raising Healthy Children: Implications for Policy and Practice

The major implications of the study reflect the three contributions of the pathways approach to translational and policy research discussed in the introduction: (a) strengthen confidence for policy decisions, (b) inform program improvement, and (c) increase generalizability of findings. First, given the consistency and strength of model fit, confidence that preschool programs like the CPCs promote youth and adult well-being is substantially increased. The theory of the CPC program, which was empirically corroborated, is that early enrichment of language and literacy through center-based education within a family supportive environment strengthens school success leading to greater well-being. One implication is that increasing access to preschool and other early intervention programs deserves higher priority. Although states have substantially increased investments in preschool programs, nationally only 24% of 4-year-olds attend state-funded programs (Barnett et al., 2009). Moreover, only 38 states have state-financed programs. The amount of evidence on the positive and enduring effects of high-quality preschool programs is large. There is not only a critical mass of evidence from long-term cost-benefit analyses (Karoly et al., 2005), but increasing evidence that large-scale programs can improve school readiness and transition to elementary school.

Moreover, compared to the evidence on interventions for older children, evidence on the effects of preschool intervention is strong. Extensive longitudinal studies of other social programs are rare and those that have been conducted have not investigated processes of impact as thoroughly as early intervention (O'Connell et al., 2009; Reynolds & Temple, 2008). Findings of this study show the benefits of high-quality programs and provide a framework for documenting and understanding long-term effects and cost-effectiveness for other programs. Study findings, for example, strengthen confidence in the economic benefits of CPC demonstrated at age 21 (Reynolds et al., 2002) and age 26 (Reynolds et al., 2010). A major share of the benefits ranging from \$7–12 per dollar invested derive from school success, educational attainment, and crime prevention of which mechanisms have been corroborated.

Second, study findings provide support for strengthening programs and sustaining their effects. Given the importance of entering kindergarten with good literacy skills, improving the quality of preschool programs and increasing their length and intensity would be expected to strengthen the paths leading to well-being. As a public-school program, for example, teachers in the CPCs have bachelor's degrees with certificates in early childhood. Participation begins at age 3, and kindergarten is on site. The philosophy of the education component is to learn basic skills. These features are key to demonstrated benefits. Likewise, greater opportunities for parent involvement in early interventions also would be expected to strengthen the contribution of the family support hypothesis. Unlike most other programs, each CPC has a staffed resource room for coordinating activities in and outside the centers. The provision of comprehensive services is more likely to broaden paths of influence necessary for sustained effects.

Strengthening the quality of elementary schools is likely to promote the transmission of long-term effects, especially for children at risk. Structural changes may include reduced class size (Finn et al., 2001; Aos et al. 2007), preschool to third grade programs that provide

comprehensive instructional and family support services (Takanishi & Kauerz, 2008; Reynolds & Temple, 1998), and whole-school reforms such as Schools of the 21st Century (Zigler & Styfco, 1993) and the School Development Program (Comer et al. 1999). Interventions to promote social emotional learning and school commitment (Durlak, 1997; O'Connell et al., 2009) may also help strengthen learning gains as would services to reduce the detrimental effects of mobility (Rumberger, 2003; Titus, 2007), child maltreatment (Topitzes, 2006; Widom, 2000), and grade retention (Reynolds & Temple, 2006), which are key mediators of preschool.

Finally, study findings provide further support for the generalizability of the identified processes from preschool to well-being. In the CLS, key elements of the model have been found to be consistent between adolescence and adulthood and for different outcomes. For example, the cognitive advantage, family support, and school support hypotheses account for the main effects of intervention for achievement, delinquency, remedial education, consumer skills (Reynolds, 2000), educational attainment (Ou, 2005; Reynolds et al. 2004), and adult well-being as assessed in the present study. These hypotheses also are corroborated in accounting for the effects of extended intervention over ages 3 to 9 (Reynolds, 2000) as well as child maltreatment (Topitzes et al., 2009). Further support for key processes has been demonstrated in the Abecedarian Project and the Perry Preschool Program (Reynolds et al., in press).

Moreover, other interventions that impact these processes would be expected to contribute to enhanced well-being. These could be independent or complementary of preschool. For example, interventions that prevent child maltreatment may have longer-term effects on health and well-being through impacting juvenile delinquency, school achievement, and need for remedial education. Similarly, programs and strategies to increase early classroom adjustment, parental involvement, and school achievement as well as reduce involvement in the juvenile justice system would be likely to be effective through elements of the five hypothesis model. Combined with other studies (Campbell et al, 2001; Consortium for Longitudinal Studies, 1983; Schweinhart et al., 1993), the cognitive advantage hypothesis is a consistent explanation of long-term effects. More generally, early cognitive and scholastic advantages lead to social and motivational gains that culminate in enhanced well-being. The generalizability of this and related processes will be critical in establishing the reproducibility of effects in other programs and contexts.

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Figure 1.
Conceptual framework of the Five Hypothesis Model of Intervention Effects

Figure 2a.

Figure 2b.

Figure 2c.

Figure 2.

Figure 2a. LISREL mediation model for any felony arrest by age 24, coefficients are standardized and adjusted for measurement errors.

Note. Covariates included gender and mother's education.

Figure 2b. LISREL mediation model for depressive symptom by age 24, coefficients are standardized and adjusted for measurement errors.

Note. Covariates included gender and mother's education.

Figure 2c. LISREL mediation model for occupational prestige by age 24, coefficients are standardized and adjusted for measurement errors.

Note. Covariates included gender and mother's education.

Figure 3.

Summarized paths

Note. Covariates included gender and mother's education.

Table 1

Characteristics and Equivalence of CPC Preschool and Comparison Groups

Characteristics	Educational Attainment Sample (N=1,372)	CPC Preschool Group	No- Preschool Group	P- value	Original Sample P-value (N=1,539)
Percent black	93.3	93.4	93.1	.910	.677
Percent female	51.8	53.9	48.3	.054	.109
Percent eligible for free lunch by child's age 3	82.9	83.2	82.4	.759	.384
Percent mother did not completed HS by child's age 3	53.4	50.5	58.7	.005	.001
Percent single parent by child's age 3	75.8	76.2	74.9	.639	.613
Percent 4 or more children in household by child's age 3	17.6	16.4	19.7	.151	.281
Percent mother was teen (<18) at child's birth	17.1	16.4	18.2	.403	.309
Percent mother unemployed by child's age 3	62.9	64.7	59.6	.083	.123
Percent TANF/AFDC participation by child's age 3	61.9	62.6	60.4	.440	.609
Percent 60% or more poverty in school attendance area	75.9	77.6	72.9	.055	.069
Percent any child welfare case histories by child's age 3	3.8	3.1	5.3	.068	.040
Percent missing any sociodemographic factors	13.3	12.3	15.2	.135	.037
Number of Family risk index	4.51	4.51	4.51	.995	.802
Percent family financial problems at child's ages 0–5	52.9	53.4	52.0	.676	.413
Percent home environment problems at child's ages 0–5	8.6	9.7	6.4	.073	.073

Table 2

Main Effects of CPC Preschool Participation on Selected Adult Outcomes By Age 24

Outcomes Measures	N	CPC Preschool	No CPC Preschool	Diff.	p- value	Effect Size <i>d</i> Index
Educational Attainment by Age 24						
Highest grade completed	1367	11.98	11.68	0.30	.002	0.183
High school completion, %	1372	79.47	71.37	8.10	.002	0.263
Attended 4 year college, %	1372	13.57	10.43	3.14	.133	0.157
Occupational Prestige/Skill (1–9)						
Occupational prestige (1–9)	1335	2.79	2.55	0.24	.008	0.157
Occupational prestige > 3, %	1335	28.17	21.48	6.69	.017	0.216
Adult Crime by Age 24						
Felony arrest, %	1418	9.90	14.47	–4.57	.020	0.225
Conviction, %	1418	15.29	19.66	–4.37	.063	0.172
Incarceration or jail, %	1413	14.79	19.80	–5.01	.033	0.200
Incarceration, %	1413	6.18	9.91	–3.73	.015	0.250
Health						
Indicated depressive symptoms, %	1134	12.82	17.41	–4.59	.057	0.200
Substance use since 16, %	1137	25.81	28.31	–2.50	.417	0.075
Substance misuse since 16, %	1473	14.31	18.80	–4.49	.044	0.180
Health Insurance						
Insurance coverage (public or private), %	1303	71.89	60.95	10.94	.000	0.300
Private insurance coverage, %	1303	40.30	33.93	6.37	.042	0.169

Note:

1. Adjusted for gender, race/ethnicity, school-age intervention, single parent status by child's age 3, mother was less than 18 years old at child's birth, mother not completed high school by child's age 3, have 4 or more children by age 3, AFDC/TANF by age 3, mother not employed by child's age 3, free lunch eligibility by age 3, number of missing from the individual indicators, and child welfare history by age 3.
2. High school completion was tested for attrition, using maximum likelihood version of Heckman selection correction. Adjusted for covariates and attrition, the adjusted means for preschool group and comparison group are 79.47 and 70.82, respectively. The marginal effect of preschool is 8.65 ($p = 0.01$), $RHO = -0.06$, $chi2 = 0.08$, $prob > chi2 = 0.78$.

Table 3

Correlations among Program, Mediators, and Outcomes

Intervening variables	Age of assessment	Hypothesis	CPC preschool	Any felony arrest	Depressive symptom	Occupational prestige
ITBS cognitive composite	5	CA	.276**	-.102**	-.103**	.165**
Parent participation in school	8-12	FS	.180**	-.190**	-.133**	.225**
Abuse or neglect report	4-17	FS	-.088**	.126**	.044	-.097**
Classroom adjustment	7-9	SA	.133**	-.236**	-.183**	.305**
School commitment	9-10	MA	.092**	-.188**	-.071*	.197**
Attend high-quality school	10-14	SS	.141**	-.111**	-.049	.139**
School mobility	10-14	SS	-.161**	.205**	.125**	-.140**
Retention or special education	6-15	CA	-.120**	.190**	.075*	-.195**
ITBS reading score	14	CA	.150**	-.267**	-.154**	.314**
Juvenile arrest	By 18	SA	-.101**	.456**	.168**	-.237**
High school completion	By 21	MA, SS, SA	.130**	-.354**	-.183**	.355**

Note. Values are Pearson zero-order correlations using pairwise-present cases.

**

p < .05

p < .01

Table 4

LISREL Goodness of Fit Statistics for Cumulative Mediator Models

Model	DF	DF change	X ²	X ² Change	RMSEA	Std. RMR	AGFI
Felony Arrest							
1. Family support	69	--	4671.86	--	.253	.201	.351
2. Cognitive advantage	67	--	4578.06	--	.253	.198	.343
3. Cognitive + motivation	58	9	2705.82	1872.24	.190	.136	.544
4. Cognitive + family	53	14	2059.52	2518.54	.169	.102	.618
5. Cognitive + social adjustment	54	13	1225.48	3352.58	.127	.085	.762
6. 5 + motivation	47	7	1159.58	65.9	.130	.081	.747
7. 6 + family	35	12	757.63	401.95	.118	.053	.783
8. 7 + school	27	8	453.36	304.27	.103	.037	.827
9. 8 + high school completion (final model)	26	1	201.00	252.36	.068	.033	.917
Depressive Symptom							
1. Family support	69	--	3286.91	--	.242	.196	.387
2. Cognitive advantage	67	--	3125.81	--	.235	.192	.401
3. Cognitive + motivation	58	9	1646.19	1479.62	.159	.127	.652
4. Cognitive + family	53	14	1292.11	1833.70	.147	.096	.694
5. Cognitive + social adjustment	54	13	709.26	2416.55	.106	.076	.823
6. 5 + motivation	47	7	659.65	49.61	.108	.073	.815
7. 6 + family	35	12	396.88	262.77	.092	.047	.857
8. 7 + school	27	8	193.08	203.8	.072	.033	.906
9. 8 + high school completion (final model)	26	1	164.86	28.22	.068	.032	.914
Occupational Prestige							
1. Family support	69	--	4212.13	--	.252	.207	.354
2. Cognitive advantage	67	--	3961.31	--	.244	.202	.374
3. Cognitive + motivation	58	9	2200.14	1761.17	.174	.135	.603
4. Cognitive + family	53	14	1762.19	2199.12	.160	.104	.648
5. Cognitive + social adjustment	54	13	975.12	2986.19	.115	.081	.797
6. 5 + motivation	47	7	914.73	60.39	.118	.078	.786
7. 6 + family	35	12	608.19	306.54	.107	.052	.815
8. 7 + school	27	8	371.87	236.32	.095	.037	.850

Model	DF	DF change	X ²	X ² Change	RMSEA	Std. RMR	AGFI
9. 8 + high school completion (final model)	26	1	195.80	176.07	.069	.032	.914

Note.

1. Covariates (gender and maternal education) and their paths to mediators were included in direct effects model.
2. Model 2 (cognitive advantage) was the reference model for models 3 to 5. Model 5 was the reference model for Model 6. Model 6 was the reference model for Model 7. Model 7 was the reference model for Model 8. Model 8 was the reference model for Model 9. The DF and X² Change were the changes between that model and its reference model.

Table 5

Percentage Contributions of Hypotheses/Mediators to Standardized Total Indirect Effects of CPC Preschool Participation

Key Pathways	Felony arrest	Depressive symptoms	Occupational prestige
CPC preschool participation	-.147 (-10.23)	-.096 (-5.70)	.158 (9.014)
Percentage due to:			
Family Support	24.1	18.4	10.4
Parent involve. & mobility	.9	1.4	--
Parent involve. & juvenile arrest	2.3	4.2	2.3
Parent involve, mobility & high school completion	.4	.3	.5
Parent involve, mobility & juvenile arrest	.1	--	--
Abuse/neglect	10.6	--	--
Abuse/neglect & mobility	1.3	1.8	--
Abuse/neglect & high-quality school	--	--	--
Abuse/neglect & juvenile arrest	5.1	8.8	5.1
Abuse/neglect, high-quality school & reading age 14	.4	--	.4
Abuse/neglect, high-quality school & high school completion	.9	.8	1.1
Abuse/neglect, high-quality school & juvenile arrest	.4	.7	.4
Abuse/neglect, mobility & high school completion	.5	.4	.6
Abuse/neglect, mobility & juvenile arrest	1.2	--	--
School Support	27.2	28.7	20.2
High-quality school attendance	--	--	--
High-quality school & high school completion	8.2	7.4	9.6
High-quality school & juvenile arrest	3.2	6.1	3.3
High-quality school & reading age 14	3.3	--	3.4
School mobility	8.0	12.2	--
Mobility & high school completion	3.3	3.0	3.9
Mobility & juvenile arrest	1.2	--	--
Cognitive Advantage	28.9	39.6	26.0
Cognitive composite & reading age 14	2.2	--	2.2
Cognitive composite & abuse/neglect	4.7	--	--
Cognitive composite & classroom adjustment	--	21.9	--
Cognitive composite & high-quality school	--	--	--
Cognitive composite, adjustment & high school completion	3.4	3.2	4.2
Cognitive composite, adjustment & reading age 14	3.5	--	3.6
Cognitive composite, retention/special edu & reading age 14	2.2	--	2.1
Cognitive composite, retention/special edu & high school completion	3.0	2.9	3.8
Cognitive composite, high-quality school & reading age 14	1.6	--	1.6
Cognitive composite, high-quality school & high school completion	3.9	3.6	4.6
Cognitive composite, high-quality school & juvenile arrest	1.6	2.9	1.6
Cognitive composite, abuse & high-quality school	--	--	--
Cognitive composite, abuse & mobility	.6	.9	--

Key Pathways	Felony arrest	Depressive symptoms	Occupational prestige
Cognitive composite, abuse & juvenile arrest	2.2	4.2	2.3
Motivational Advantage	--	--	.3
Social Adjustment	--	2.2	.8
Total Percentage Explained	80.2	88.9	57.7

Note. Values are derived from the LISREL best-fitting model (Model 9, Table 4) and Figure 2. Nonsignificant paths from CPC preschool to mediators were not included in percentage values (e.g., motivation and social adjustment). Values in parentheses are t-values.

Appendix A

LISREL Goodness of Fit Statistics for Single Mediator Models

Model	DF	DF change	X ²	X ² Change	RMSEA	Std. RMR	AGFI
Felony Arrest							
1. Main effect (No mediation)	73	--	5004.25	--	.265	.205	.329
2. Cognitive advantage	67	6	4578.06	426.19	.253	.198	.343
3. Family support	69	4	4671.86	332.39	.253	.201	.351
4. Social adjustment	69	4	4375.64	628.61	.246	.200	.374
5. Motivation	71	2	4932.53	71.72	.261	.204	.333
6. School support	69	4	4635.58	368.67	.253	.201	.350
Depressive Symptoms							
1. Main effect (No mediation)	73	--	3381.34	--	.243	.199	.393
2. Cognitive advantage	67	6	3125.81	255.53	.235	.192	.401
3. Family support	69	4	3286.91	94.43	.242	.196	.387
4. Social adjustment	69	4	3183.86	197.48	.239	.195	.396
5. Motivation	71	2	3362.00	19.34	.243	.199	.388
6. School support	69	4	3218.14	163.2	.239	.196	.396
Occupational Prestige							
1. Main effect (No mediation)	73	--	4405.95	--	.261	.211	.342
2. Cognitive advantage	67	6	3961.31	444.64	.244	.202	.374
3. Family support	69	4	4212.13	193.82	.252	.207	.354
4. Social adjustment	69	4	3927.42	478.53	.243	.204	.384
5. Motivation	71	2	4320.37	85.58	.255	.210	.351
6. School support	69	4	4171.78	234.17	.253	.207	.352

Note. Covariates (gender and maternal education) and their paths to mediators were included in direct effects model.

Appendix B

Correlation Matrix for Observed Variables in the Structural Model for Felony Arrest (N=1,418) and Depressive Symptoms (N=1,134)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. CPC preschool	1.00	.053	.109	.363	-.179	.192	.171	-.203	.327	.118	.232	-.197	-.178	.208	-.120
2. Females	.053	1.00	.015	.059	.054	.188	.259	-.065	.123	.148	.109	-.270	-.486	.205	-.057
3. Maternal education	.109	.015	1.00	.203	-.125	.166	.137	-.071	.259	.094	.214	-.171	-.081	.139	-.090
4. ITBS cognitive composite	.363	.059	.203	.94	-.201	.423	.387	-.159	.376	.225	.261	-.388	-.096	.169	-.158
5. Abuse/Neglect	-.179	.054	-.125	-.201	.90	-.196	-.164	.220	-.256	-.150	-.280	.238	.303	-.302	.107
6. ITBS reading age 14	.192	.188	.166	.423	-.196	.95	.612	-.206	.343	.370	.379	-.632	-.323	.428	-.236
7. Social adjustment	.171	.259	.137	.387	-.164	.612	.95	-.175	.159	.413	.531	-.613	-.297	.393	-.279
8. School mobility	-.203	-.065	-.071	-.159	.220	-.206	-.175	.95	-.248	-.157	-.220	.228	.216	-.290	.183
9. School quality	.327	.123	.259	.376	-.256	.343	.159	-.248	.95	.158	.240	-.132	-.298	.363	-.131
10. School commitment	.118	.148	.094	.225	-.150	.370	.413	-.157	.158	.90	.258	-.387	-.208	.301	-.105
11. Parental involvement	.232	.109	.214	.261	-.280	.379	.531	-.220	.240	.258	.90	-.394	-.286	.331	-.209
12. Retention/spec education	-.197	-.270	-.171	-.388	.238	-.632	-.613	.228	-.132	-.387	-.394	.90	.302	-.422	.144
13. Juvenile delinquency	-.178	-.486	-.081	-.096	.303	-.323	-.297	.216	-.298	-.208	-.286	.302	.95	-.542	.319
14. High school completion	.208	.205	.139	.169	-.302	.428	.393	-.290	.363	.301	.331	-.422	-.542	.90	-.336
15. Felony arrest/depressive symptoms	-.162	-.674	-.091	-.150	.263	-.386	-.378	.281	-.315	-.260	-.284	.332	.700	-.599	--

Note. The up diagonal matrix is correlation for depressive symptom, and the down diagonal matrix is correlation for felony arrest. Correlations were estimated as polyserial/polychoric by PRELIS 2.5 with pairwise-present cases. The reliabilities (1-measurement error) are entered in the diagonal of the correlation matrix. Measurement errors in the observed variables were estimated from either published reliabilities or CLS reliabilities. The reliabilities were 0.95 and 0.90 for felony arrest and depressive symptom, respectively. The correction among outcomes were .385 for felony arrest and depressive symptom, -.366 for depressive symptom and occupational prestige, and -.668 for felony arrest and occupational prestige. Occupational prestige had the following correlations with explanatory variables (table order 1 to 14): .138, .250, -.232, .422, .406, -.194, .279, .274, .298, -.352, -.526, and .610.

Appendix C

Percentage Contributions of Mediators to Standardized Direct (Main) Effects of Preschool

Sequential models	Felony arrest	Depressive symptoms	Occupational prestige
1. Main effect (no mediation)	-.119 ***	-.109 ***	.112 ***
2. Cognitive advantage	-.087 ***	-.060	.034
	29.4%	45.0%	69.6%
3. Family support	-.042 *	-.060 *	.031
	64.7%	45.0%	72.3%
4. Social adjustment	-.029	-.026	0.0
	75.6%	76.2%	100%
5. Motivation	-.102 ***	-.100 ***	.086 ***
	14.3%	8.3%	23.2%
6. School support	-.026	-.062 *	.027
	78.2%	43.1%	75.9%
7. Cognitive + family	-.038 *	-.031	0.0
	68.1%	71.6%	100%
8. Cognitive + adjustment	-.019	-.012	0.0
	84.0%	89.0%	100%
9. Cognitive + motivation	-.080 ***	-.055	.027
	32.8%	49.5%	75.9%
10. Cognitive + adjustment + motivation	-.019	-.013	0.0
	84.0%	88.1%	100%
11. Cognitive + adjustment + motivation + family	-.011	-.015	0.0
	90.8%	86.2%	100%
12. 11 + school	0.0	-.031	0.0
	100%	71.6%	100%
13. 12 + high school completion (final model)	0.0	-.023	0.0
	100%	78.9%	100%

Note. Values are standardized coefficients of direct preschool impact and percentage contribution of mediators to this impact (main effect) based on difference-in-differences (%reduction = $b - b^*/b$; b^* = program coefficient). The coefficients were estimated in LISREL and account for measurement error and correlated errors in measurement and across equations.

 $p < .001$,
**
 $p < .01$
*
 $p < .05$.