Child Development, September/October 2004, Volume 75, Number 5, Pages 1299–1328

Paths of Effects of Early Childhood Intervention on Educational Attainment and Delinquency: A Confirmatory Analysis of the Chicago Child-Parent Centers

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This study investigated the contributions of 5 mechanisms to the effects of preschool participation in the Child-Parent Centers for 1,404 low-income children in the Chicago Longitudinal Study. Based on a matched-group design, preschool participation was associated with significantly higher rates of educational attainment and lower rates of juvenile arrest. LISREL analysis revealed that the primary mediators of effects for both outcomes were attendance in high-quality elementary schools and lower mobility (school support hypothesis), literacy skills in kindergarten and avoidance of grade retention (cognitive advantage hypothesis), and parent involvement in school and avoidance of child maltreatment (family support hypothesis). The model accounted for 58% and 79% of the preschool links with school completion and juvenile arrest, respectively. The maintenance early intervention effects are influenced by many alterable factors.

In the past decade, research on early interventions has expanded from a reliance on main effects to understanding the mechanisms of change. The foundation of this emerging focus is the accumulated evidence that participation in a variety of preschool programs not only enhances children's school readiness and early school performance (Karoly et al., 1998; Ramey & Ramey, 1998; White, 1985) but is associated, many years later, with reduced incidence of remedial education (Barnett, 1995; Karoly et al., 1998; Shonkoff & Phillips, 2000), delinquent behavior (Garces, Thomas, & Currie, 2002; Reynolds, Temple, Robertson, & Mann, 2001; Schweinhart, Barnes, & Weikart, 1993), and higher levels of educational attainment (Campbell, Ramey, Pungello, Sparling, & Miller-Johnson, 2002; Consortium for Longitudinal Studies, 1983; Reynolds et al., 2001; Schweinhart et al., 1993).

Evidence about the mechanisms or pathways through which the effects of intervention come about advances knowledge in three important ways. First, the identification of pathways of change brought about by intervention increases the generalizability of findings. A mechanism or mediator identified in an individual study (e.g., cognitive performance) may explain the link between program participation and outcomes in other settings and programs, and may contribute independently to broader measures of adjustment.

Second, examination of pathways of effects aid program design and improvement by identifying program elements (e.g., intensity) or environmental conditions (e.g., school quality) that can be modified to improve children's success. These factors then can be manipulated to help maintain or enhance the effects of intervention.

Third, research on pathways of intervention effectiveness strengthens causal inference. Based on the theory of the program, an identified mediator can provide an explanation of the origin and transmission of effects. This knowledge often increases confidence that the estimated effects are due to participation and not to co-occurring factors. Because the main attraction of preschool programs is their capacity to prevent the development of problem behavior and promote well-being years into the

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We are grateful for funding support provided by the National Institute of Child Health and Human Development (Grant R01HD034294), the Office of Educational Research and Improvement in the U.S. Department of Education (Grant R305T990477), and the Institute for Research on Poverty at the University of Wisconsin-Madison. We thank the Juvenile Justice Division in the Circuit Court of Cook County, the City Colleges of Chicago, the Illinois Department of Child and Family Services, and the Chapin Hall Center for Children at the University of Chicago for assistance in data collection. We also thank the Departments of Early Childhood Programs and Research, Assessment, and Analysis in the Chicago public schools for cooperation and collaboration in data collection and technical assistance. Earlier versions of this paper were presented at the 2001 annual meeting of Society for Prevention Research and the 1999 biennial meeting of the Society for Research in Child Development.

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future, causal explanation is critically important for early childhood interventions. Reynolds (1998) described systematic tests of plausible mechanisms as confirmatory program evaluation (CPE). The coherence of the program–outcome relation is strengthened if the mechanisms associated with effectiveness are theoretically linked to the program (Bunge, 1997; Rosenbaum, 1995). In this study, we investigated for the first time alternative hypotheses of the pathways of long-term effects of preschool participation on educational attainment and juvenile delinquency for youth in the Chicago Longitudinal Study (CLS).

Hypotheses of Effects of Early Childhood Intervention

Research over four decades has identified many explanations of the effects of participation in early childhood intervention. Five hypotheses have been predominant (Reynolds, 2000). The most common is the cognitive advantage hypothesis. It indicates that the long-term effects of intervention are initiated by improvements in children's developed abilities, as typically measured by standardized tests of cognitive ability, language and literacy skills, and school readiness. The cognitive and language stimulation experienced in center-based early education is expected to initiate a positive cycle of performance beginning at school entry and culminate in long-term effects on child well-being. Support for the cognitive advantage hypothesis as a primary mechanism of intervention effects is extensive (Campbell & Ramey, 1995; Consortium for Longitudinal Studies, 1983; Lazar, Darlington, Murray, & Snipper, 1982; Reynolds, Mavrogenes, Bezruczko, & Hagemann, 1996; Schweinhart et al., 1993; Schweinhart & Weikart, 1980; Shonkoff & Phillips, 2000). The evidence for the cognitive and scholastic advantages resulting from high-quality educational enrichment is broadly applicable to model and large-scale programs (Barnett, 1995; Karoly et al., 1998) and more recently has been confirmed with growth curve modeling (Burchinal, Campbell, Bryant, Wasik, & Ramey, 1997; Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2001) and structural equation modeling (SEM; Barnett, Young, & Schweinhart, 1998; Reynolds, 2000; Reynolds et al., 1996).

A second explanation for the effects of early childhood intervention on child outcomes is the family support hypothesis. This hypothesis indicates that longer term effects of intervention will occur to the extent that participation enhances parenting practices, attitudes and expectations, and involvement in children's education. Because most public programs, from Head Start to state-financed preschools, emphasize parent involvement and provide family services, changes in family functioning and socialization may directly affect child outcomes (Bronfenbrenner, 1975; Seitz, 1990). Although evidence corroborating the family support hypothesis is less consistent than that for the cognitive advantage hypothesis, several studies indicate that intensive family support services for parents with infants and young children, including frequent home visits and other social support services, are associated with children's later adjustment (Andrews, Lally, Mangione, Honig, & Wittner, 1982; Lally, Mangione, Honig, & Wittner, 1988; Olds et al., 1997; Seitz, Rosenbaum, & Apfel, 1985). These findings also extend to center-based early childhood education. Based on parent and teacher reports of school involvement, Reynolds et al. (1996) found that family support behavior mediated the effects of participation in the Child-Parent Centers (CPCs) on school achievement at age 12. Barnett et al. (1998) found that although teacher ratings of parent involvement did not mediate the effects of participation in the High/Scope Perry Preschool Program, they did contribute indirectly to children's educational attainment by promoting school achievement. The family support hypothesis may be a stronger contributor to children's outcomes for programs that combine child education and family services (Wasik, Ramey, Bryant, & Sparling, 1990). The best evidence for this conclusion is that nearly all early interventions that have been shown to reduce delinquency provide child education and family support services (Yoshikawa, 1995; Zigler, Taussig, & Black, 1992).

A third and more recent explanation for the long-term effects of early intervention is the school support hypothesis. Here, the effects of program participation would be expected to persist as a function of children attending schools of sufficient quality and support to maintain preschool learning gains. In secondary analysis of the National Educational Longitudinal Study, Lee and Loeb (1995) and Currie and Thomas (2000) found that Head Start graduates are more likely than other students to attend elementary schools of lower quality even after accounting for differences in socioeconomic status. Currie and Thomas, for example, found that the persistence of effects of Head Start on school achievement among Black children was a positive function of the achievement levels of the elementary schools they attended. Findings for children attending the CPCs, a program similar to Head Start, also indicated that the postprogram school environment influences the transmission of effects. School mobility can disrupt the link between preschool participation and later success (Reynolds, 1992; Temple &

Reynolds, 1999). On a more positive note, children's preschool achievement gains were maintained as a function of their participation in the school-age component of the program. School quality, measured by aggregate achievement, also mediated the effects of intervention on school performance at age 14 even after the contribution of other hypotheses was taken into account (Reynolds, 2000).

Two other hypotheses, motivational advantage and social adjustment, also have been identified as pathways through which the effects of early intervention are transmitted. The evidence remains sparse, however. In the motivational advantage hypothesis, the long-term effects of program participation are initially due to changes in children's task persistence, self-efficacy, perceived competence, or other self-system attributes rather than in cognitive achievement per se. Indeed, motivational development was an original goal of the Head Start program (Zigler & Berman, 1983; Zigler & Muenchow, 1992). This hypothesis derives, in part, from Zigler, Abelson, Trickett, and Seitz's (1982) finding that changes in intelligence test scores among low-income children may have a substantial motivational component. Recent studies have provided only limited support for the motivational advantage hypothesis as a major pathway of intervention effects, as preschool participation affects motivation indirectly through enhancing cognitive skills (Barnett et al., 1998; Consortium for Longitudinal Studies, 1983; Reynolds, 2000).

Finally, in the social adjustment hypothesis, increased social skills is the major reason participation in early intervention leads to long-term effects. Rather than directly changing children's cognitive status or motivation, participation may enhance children's internalization of social rules, self-regulation skills, and capacity to get along well with others (Heckman, 2000). Similar to findings on the motivational advantage hypothesis, empirical support is limited. In studies of the Perry Preschool Program (Barnett et al., 1998; Schweinhart et al, 1993) and the CPCs (Reynolds, 2000; Reynolds, Chang, & Temple, 1998), program participation affected social adjustment indirectly through improved cognitive status. Yet teacher ratings of social adjustment were a significant predictor of several measures of later behavior, including delinquency and special education placement.

As much as research has explored these hypotheses, comprehensive investigations are rare. The major limitation of previous studies is the lack of attention to alternative hypotheses of intervention effects. Most individual studies tested only one of the five hypotheses reviewed here, and thus findings are subject to model misspecification that could alter support for a particular hypothesis. Tests of two or more hypotheses were made only in a few studies (Barnett et al., 1998; Consortium for Longitudinal Studies, 1983; Reynolds, 2000; Reynolds et al., 1996). Alternative models using several hypotheses are needed before a more complete understanding of the mechanisms of effects is achieved. The five hypotheses are interrelated and the relations among them may be complex.

Another limitation of research is that few studies have investigated pathways that explain two of the most important long-term effects of early childhood intervention: educational attainment and delinquency. Arguably, few other social competencies have greater consequence for youth, and their connection to early childhood intervention is conceptually clear and empirically grounded (Guralnick, 1997; Karoly et al., 1998; Zigler & Berman, 1983). Higher levels of educational attainment predict socioeconomic success. Avoidance of delinquency and crime not only brightens an individual's economic prospects but can save the public billions of dollars in treatment and incarceration. The annual cost to society of school dropout and delinquency is estimated at $350 billion (Cohen, 1998; National Science and Technology Council, 1997). Yet the personal experiences and environmental conditions that mediate or explain these linkages are not well understood.

Finally, the pathways or mechanisms of the effects of participation in large-scale, public programs are unclear. We are aware of no previous studies that have investigated this issue for educational attainment and delinquency, although at least two studies have investigated mechanisms of effects on school achievement through age 15 (Reynolds, 2000; Reynolds et al., 1996). The extent to which pathways of program influences are similar among achievement, attainment, and social behavior has been underinvestigated. Previous studies were of model programs and emphasized the cognitive advantage hypothesis (Consortium for Longitudinal Studies, 1983; Schweinhart et al., 1993). Given the large investments being made in public programs (U.S. General Accounting Office, 1999), greater attention to how the long-term effects come about is needed to inform program improvement and expansion efforts.

Paths of Effects in the CLS

Using data from the CLS of the CPC program, we investigated five hypotheses of the long-term effects of preschool program participation on educational attainment at age 20 and juvenile delinquency by age

18. These hypotheses are associated with cognitive advantage, family support, social adjustment, motivational advantage, and school support for children's learning and development. We investigated whether the five hypotheses separately and together explain the effects of preschool participation on these later outcomes.

The CLS is well designed to investigate pathways of program effectiveness. For one, program participation is associated with long-term effects (see Reynolds, 1992, 1995, for findings on short-term effects). Reynolds et al. (2001) found that relative to a matched comparison group enrolled in alternative early childhood programs, preschool participation in the Title I Chicago CPCs was associated with significantly higher rates of school completion by age 20, with significantly lower rates of juvenile arrests and multiple juvenile arrests by age 18, and with significantly lower rates of grade retention and special education placement. Although participation in the school-age program and in the extended intervention for 4 to 6 years was associated with significantly lower rates of school remedial services, these levels of participation were for the most part not associated with higher rates of school completion and lower rates of juvenile arrest. These findings are a starting point for the present study. We investigated the pathways through which the effects of preschool participation led to higher rates of school completion and lower rates of delinquency. The mediators of school-age and extended program participation were not investigated because neither was associated with these long-term outcomes.

Moreover, as an ongoing 17-year investigation of the school and social adjustment of 1,539 children, large amounts of data have been collected on family, school, and personal experiences from multiple sources. These data and the large sample provide a powerful test of alternative hypotheses of program effects. Earlier CLS studies have investigated the hypotheses in whole or in part (Reynolds et al., 1998; Reynolds et al., 1996) but not for educational attainment or official delinquency. In the only test of all five hypotheses on competence outcomes in adolescence, Reynolds (2000) found that the cognitive advantage, family support, and school support hypotheses contributed most to the explanation of preschool effects. The cognitive advantage hypothesis, measured by standardized tests of school readiness in kindergarten, best explained effects on school achievement and need for remedial education, whereas the school support hypothesis, measured by mobility and school-level achievement, contributed most to delinquent behavior. The family support hypothesis, measured by indicators of parent involvement in school, also significantly contributed to the effects of participation on school achievement and need for remedial education.

The present study expanded on these studies significantly by testing the hypotheses of program effects for the long-term outcomes of educational attainment and juvenile delinquency. We are aware of no previous studies of large-scale public programs that have investigated the mediators of effects on these long-term program outcomes. No studies of any early intervention have investigated a comprehensive set of hypotheses of long-term effects. Previous reports in the CLS were limited to school performance and achievement by middle adolescence. Thus, the extent to which the five hypotheses of intervention effects contribute to educational attainment and delinquency—outcomes that can greatly affect adult well-being—are unknown.

Finally, as an established school-based program, the federally financed CPC program shares many features with contemporary government-funded early childhood programs. Findings are thus more likely to be generalizable to existing programs than many previous studies. Like Head Start and state programs, the CPC program provides comprehensive services, emphasizes school readiness, encourages parental involvement, and is administered through existing educational and social organizations.

We address three major questions: a) Do each of the five hypotheses of intervention effects mediate the link between preschool participation and educational attainment by age 20 and delinquency by age 18? b) How well does the full model intervention effects fit the observed data? c) When considered together, which hypotheses best explain the relation between preschool participation and educational attainment and delinquency?

A Confirmatory Model of Intervention Effects

Figure 1 shows the constructs and pathways through which early childhood intervention was hypothesized to affect educational attainment and delinquency. The five hypotheses are derived from a synthesis of previous research described in the Introduction (see also Reynolds, 2000). Investigation of the pathways of program effectiveness is a major element of CPE (Reynolds, 1998). CPE is a theory-driven approach for investigating the effects of social programs. It is an impact assessment that examines the pattern of empirical findings against several causal criteria, among them, size, gradient (dosage/

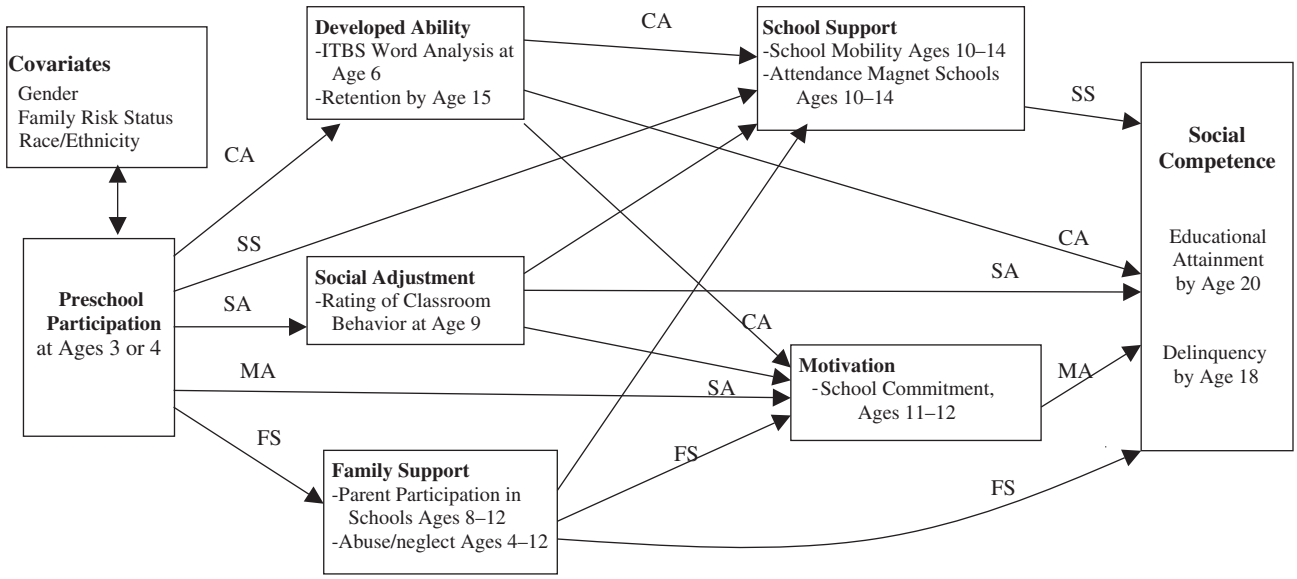


Figure 1. Conceptual framework of mediation model. ITBS = Iowa Test of Basic Skills; MA = motivational advantage hypothesis; CA = cognitive advantage hypothesis; SA = social adjustment hypothesis; FS = family support hypothesis; SS = school support hypothesis.

response), specificity, consistency, and coherence. Special emphasis is given to testing mechanisms and pathways that are associated with effectiveness. A major tenet of CPE is that the plausibility of an estimated program effect can be strengthened through systematic testing of hypothesized mechanisms. The major questions addressed in CPE are: Do intervention groups differ on the outcome variables? Do the estimated program effects differ by child, family, and program characteristics, and by outcome domain? What are the mechanisms that explain group differences and are they consistent with the program theory? The second question is not addressed specifically in this study (see Reynolds, 2000; Reynolds et al., 2001).

The conceptual underpinnings of the model are ecological systems theory and resilience theory. Ecological systems theory (Bronfenbrenner, 1989; Bronfenbrenner & Morris, 1998) specifies that well-being is affected substantially by the social contexts, both proximal and distal, in which children are embedded. The magnitude of program effects would be expected to increase or be sustained as a function of the quality of relationships among individual, family, and institutional systems. From this perspective, the persistence of effects of participation in early childhood intervention will depend on the quality and continuity of the postprogram learning environment, primarily within the family and school. In resilience theory (Masten & Garmezy, 1985; Rutter, 1987), well-being is conceptualized as individualized responses to risk and protective factors. A primary focus of resilience theory is the identification of protective mechanisms or pathways that lead individuals to overcome adversity and exhibit successful adjustment. Applied to intervention research, protective mechanisms are conceptualized as intervening behaviors and experiences that mediate the effects of program participation on program outcomes. Thus, they are the active ingredients that promote long-term beneficial effects. The five sets of pathways in Figure 1 represent these ingredients.

Three covariates—race, gender, and family risk status—are included in the model. These covariates are associated with all factors in the model. In other words, all covariates have paths to program participation, mediators, and developmental outcomes. However, to simplify the figure, those paths are not shown except for the path to program participation.

In the model, CPC preschool participation is hypothesized to affect directly cognitive development in kindergarten, measured by word analysis scores on the Iowa Test of Basic Skills (ITBS). This measure of the cognitive advantage hypothesis predicts teacher ratings of children's social adjustment at age 9 and two measures of family support behavior: parent involvement in school and incidence of child abuse and neglect. These intervening measures represent the social adjustment and family support hypotheses and are expected to affect directly later educational attainment and delinquency. Parent involvement in children's education, for example, is a frequent correlate of school success (Fan & Chen, 2001; Miedel & Reynolds, 1999). Child maltreatment

is a predictor of delinquency and school failure (Daro & McCurdy, 1994; Widom, 2000). Both family measures can be affected by intervention. These early intervening factors may also influence measures of school support and motivation, which in turn affect the outcome measures in the model. The measures of the school support hypothesis were school quality (magnet school attendance) and children' school mobility. Both have been used in previous studies (Reynolds, 2000; Reynolds et al., 1996) and are expected to affect directly educational and social development (Gamoran, 1996; Temple & Reynolds, 1999). The measure for the motivational advantage hypothesis was children's school commitment. Incidence of grade retention is a secondary measure of the cognitive advantage hypothesis given its close connection with low school achievement (McCoy & Reynolds, 1999; Shepard & Smith, 1989). Reduced incidence of grade retention is a consistent finding of studies of preschool impact (Barnett, 1995; Karoly et al., 1998; Reynolds, 2000) and is expected to mediate the long-term effects of CPC preschool participation. Based on our previous findings, we expected the cognitive advantage, school support, and family support hypotheses to contribute most to the explanation of preschool impact. The contributions of the social adjustment and motivational advantage hypotheses were expected to be smaller.

The sequence of variables is based on program theory, period of measurement, and previous research. Because the cognitive advantage and family support hypotheses are foundational to program theory, they precede the other mediators. Motivation is difficult to measure reliably in the early years of school and would be expected to be more influential for educational attainment and delinquency at the end of middle childhood, and this is when it is measured. Indicators of school support would also be expected to have their maximum impact later in elementary school.

When the direction of influence between the indicators could not be clearly established, a block recursive specification was used. This was done for the school support and motivational advantage hypotheses and for social adjustment and family support. To strengthen causal inference in the longitudinal model, the time of measurement of the mediators followed program participation and, as much as possible, preceded the two major outcomes. Notably, although each of the hypotheses may be independently associated with child outcomes, they also must be significantly and independently associated with program participation to be valid mediators of the link between program participation and long-term outcomes. A distinctive feature of our comprehensive model is that a particular hypothesis can be corroborated only if it makes a significant contribution to an outcome above and beyond the influence of other hypotheses. The path coefficients associated with the family support hypothesis, for example, reflect influences above and beyond the cognitive advantage and social adjustment hypotheses.

Although the model was estimated as an integrative system as displayed in Figure 1, 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 program participation. Of course, the hypotheses could work in combination. For example, program participation may affect educational attainment through early cognitive development and family support behavior or through a combination of cognitive, family support, and school support factors. These and other combinations are investigated. The overall fit of the model is key to the interpretability of results. Finally, the estimated paths are correlational and predictive rather than causal. Our test of alternative models may strengthen causal inference and increase confidence in the validity of the estimated effects of preschool participation on educational attainment and delinquency.

Method

Sample and Design

The study sample participates in the CLS (1999; Reynolds, Temple, & Ou, 2003), an ongoing investigation of the behavioral development of 1,539 low-income minority children (93% Black, 7% Hispanic) 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 (60% all-day) in 1986 in 20 centers, and 550 children who participated in alternative government-funded kindergarten programs in the Chicago Public Schools without CPC preschool experience. Fourteen percent of the same-age comparison group participated in Head Start preschool. The comparison group attended 5 randomly selected schools and 2 others participating in all-day kindergarten programs as part of a school intervention project. As a result of living in neighborhoods eligible for Title I, all study children participated in government-funded programs in preschool or kindergarten. If promoted continuously, children graduated from high school in 1998.

As shown in Table 1, we used two different sample sizes in model estimation. The educational attainment sample included 1,286 youth (83.6% of the original sample) for whom educational status was determined by September 2000 (*M* age = 20.3). This represented 85% of the original CPC group and 81% of the comparison group. The delinquency-status sample included 1,404 youth (91.5%) for whom data on official juvenile arrest was determined by age 18. Sample recoveries for the preschool and comparison groups were, respectively, 92.3% and 90%. The samples were representative of the original kindergarten sample.

Group differences in educational attainment and delinquency provide valid estimates of program impact for several reasons. First, children in the comparison group participated because they enrolled in randomly selected schools implementing full-day kindergarten programs, which was more than the usual treatment at the time. By comparing groups that received different intervention services, findings in this report estimate the value added by the CPC program above and beyond participation in an alternative intervention that itself provided educational enrichment and family support services (Reynolds, 2000; Reynolds et al., 2001). Indeed, only 60% of the preschool group attended all-day kindergarten. Thus, estimates of both the main effects and mediational effects are likely to be conservative.

Second, most children in the preschool and school-age comparison groups did not enroll in the program because they did not live in the attendance area of the CPCs. Thus, home residency rather than parent interest determined their participation. Third, we also included an extensive set of covariates in the model to account for measured differences between groups. Estimates of program effects were unaffected by alternative model specifications, including those with a variety of family demographics and site variables, as well as propensity score approaches (see the Results section for further details). Finally, previous studies in this project support the equivalence of the program groups and show no evidence of selection bias assessed by covariance analyses, simultaneous equation models, and latent-variable structural modeling (Reynolds, 2000; Reynolds & Temple, 1995, 1998; Reynolds et al., 2002; Temple, Reynolds, & Miedel, 2000).

A major contributor to these findings is that program staff makes significant efforts to enroll children most in need of intervention through extensive outreach activities and door-to-door canvassing. Indeed, more than 80% of all eligible children in the neighborhoods enrolled in the CPC program, suggesting high levels of program coverage that is well representative of the neighborhoods. This also was because the centers, from the beginning, were located outside of Head Start attendance areas and because eligible families could not afford the available out-of-home child care.

Table 2 shows the comparability of the preschool intervention and comparison groups for many demographic factors at the time of program entry or soon afterward. Overall, the two groups experienced, on average, the same number of family socioeconomic risk factors growing up (e.g., low family

Table 1
Child Characteristics of the Original and Study Samples in the Chicago Longitudinal Study

Characteristic	Original sample (*N* = 1,539)	Educational attainment sample (*N* = 1,286)	Delinquency sample (*N* = 1,404)
Percent girls	50.0	51.0	50.1
Percent Black	92.9	93.6	93.2
Percent parents not completed high school at child's age 8	56.1	51.7	53.3
Percent single parent by age 8	70.1	66.6	67.7
Percent parent unemployment by age 8	69.4	66.6	67.3
Percent ever reported receiving free lunch by age 8	78.5	77.7	77.8
Percent four or more children by age 8	34.3	35.2	36.0
Percent income level is 60%+poverty for school area	76.1	75.3	76.1
Percent missing two or more from parent education, single-parent status, parent unemployment, free lunch report, or number of children by age 8	29.1	21.6	23.7
Family risk index (0–6)	2.9	3.1	3.1
ITBS word analysis in kindergarten	63.8	63.7	63.6

Note. ITBS = Iowa Test of Basic Skills.

Table 2
Characteristics of Preschool Group and Comparison Group

Characteristic	CPC preschool group	No-preschool group	*p* value	Original sample *p* value ($N = 1{,}539$)
Educational attainment ($N = 1{,}286$)				
Percent girls	53.0	46.0	.02	.12
Percent Black	94.1	92.6	.31	.95
Percent parent not completed high school at child's age 8[a]	49.4	56.2	.02	.001
Percent single parent by age 8[a]	65.9	68.1	.46	.08
Percent parent was teen at child's birth	23.2	19.2	.16	.25
Percent parent unemployment by age 8[a]	67.8	64.5	.24	.38
Percent ever reported receiving free lunch by age 8[a]	78.7	75.7	.23	.27
Percent four or more children by age 8[a]	31.4	42.3	.00	.001
Percent child abuse/neglect report by age 4	1.0	0.7	.61	.58
Percent income level is 60%+poverty for school area[a]	77.1	71.9	.04	.04
Percent missing two or more from parent education, single-parent status, parent unemployment, free lunch report, or number of children by age 8	20.3	24.0	.14	.02
Family risk index (0–6)	3.1	3.0	.48	.18
Delinquency ($N = 1{,}404$)				
Percent girls	52.0	46.0	.04	–
Percent Black	93.5	92.7	.56	–
Percent parent not completed high school at child's age 8[a]	50.6	58.2	.007	–
Percent single parent by age 8[a]	66.3	70.2	.15	–
Percent parent was teen at child's birth	22.8	19.2	.19	–
Percent parent unemployment by age 8[a]	68.4	65.3	.26	–
Percent ever reported receiving free lunch by age 8[a]	78.6	76.3	.35	–
Percent four or more children by age 8[a]	32.6	42.4	.00	
Percent child abuse/neglect report by age 4	1.2	0.6	.28	–
Percent income level is 60%+poverty for school area[a]	77.5	73.1	.09	–
Percent missing two or more from parent education, single-parent status, parent unemployment, free lunch report, or number of children by age 8	22.2	26.4	.09	–
Family risk index (0–6)	3.1	3.0	.64	–

Note. CPC = Child-Parent Center. Sample sizes for groups are as following: educational attainment, CPC preschool ($n = 841$) and no-preschool group ($n = 445$); delinquency, CPC preschool ($n = 991$) and no-preschool group ($n = 493$).
[a]Individual indicators of family risk index.

income, single-parent family status, neighborhood poverty). The family risk index is a summary of the co-occurrence of risk factors negatively associated with child development outcomes (Bendersky & Lewis, 1994; Rutter, 1987). Examination of risk indicators and other background factors indicates that CPC participants were more likely to have parents who have completed high school and to reside in families with less than four siblings. Alternatively, the CPC group was more likely to live in higher poverty neighborhoods and slightly more likely to have a parent who is not employed and was a teen at child's birth. Rates of child abuse and neglect and teenage parenthood were similar between groups. Previous studies also support the equivalence of program and comparison groups and the absence of selection bias (Ou, 2003; Reynolds & Temple, 1995, 1998). Estimation of effects took into account the family risk index, gender, race/ethnicity, intervention sites, and later program participation. We also examined effects and paths of influence using the individual risk indicators as covariates. Notably, the comprehensiveness of the model in Figure 1 minimizes specification error.

CPC Program

Because the CPC program is described fully in previous reports (Reynolds, 1994, 2000; Reynolds & Temple, 1998; Sullivan, 1971), we provide only a summary of the main features. Located in or proximate to public elementary schools, the CPC program

provides educational and family support services to children from ages 3 to 9 (preschool to second or third grade, c). 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 activities; frequent field trips; and play. Literacy experiences involving phonemic awareness, word analysis, oral communication, and listening skills are highlighted as described in the instructional activity guide (Chicago Board of Education, 1988). The CPC program began in 1967 through funding from Title I of the Elementary and Secondary Education Act. After Head Start, it is the nation's oldest federally funded preschool program.

At the time of the sample's participation, each of the 24 centers served approximately 100 to 150 three- to five-year-olds (one center closed in 1987). The centers are located in the poorest neighborhoods in Chicago. The mean rate of family poverty in 1989 for the community areas serving the CPCs was 41%, compared with 17% for other areas of the city. Each center is directed by a head teacher and two coordinators. The parent-resource teacher coordinates the family support component. The school-community representative provides outreach to families and seeks to enroll children most in need. Community rates of enrollment exceed 80%. The low-income status of the families precluded enrollment in non-public care or education programs.

The preschool program runs 3 hr per day 5 days per week during the 9-month school year and usually includes a 6-week summer program. After full-day or part-day kindergarten, continuing services are provided in the affiliated schools under the direction of the curriculum parent-resource teacher. Participation in 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. In this study, it is used as a covariate.

Major elements of the program are as follows:

1. a structured set of educational activities emphasizing reading and math skills, complemented with other instructional materials such as Language Lotto, Alpha Time, and Peabody Language Development Kits;
2. low child-to-staff ratios in preschool (17 to 2) and kindergarten (25 to 2);
3. an intensive parent program that includes participating in parent room activities, volunteering in the classroom, attending school

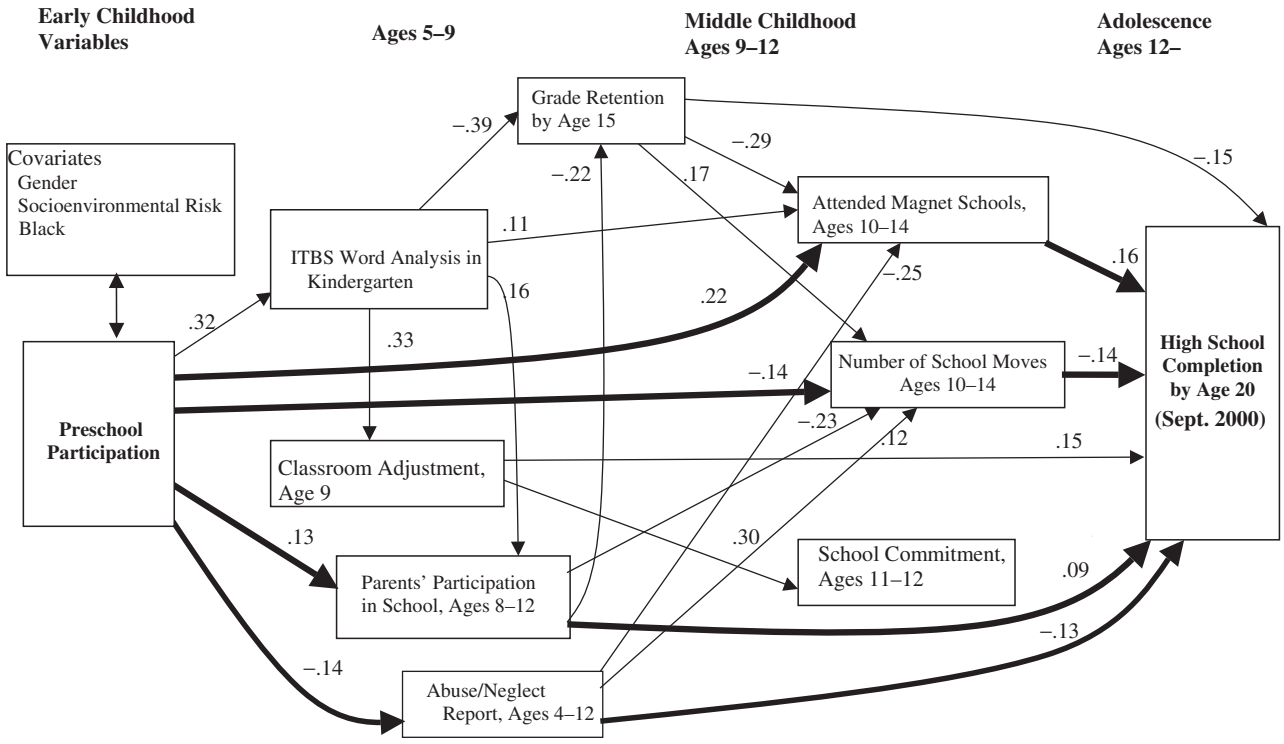


Figure 2. LISREL mediation model for high school completion, coefficients standardized and adjusted for measurement errors. $R^2 = .32$; root mean square error of approximation = 0.054; adjusted goodness-of-fit index = 0.95. All covariates have paths to program participation, mediators, and developmental outcomes. To simplify the figure, those paths are not shown except for the path to program participation.

events and field trips, and completing high school;
4. outreach activities including resource mobilization, home visitation, and enrollment of children;
5. regular staff development activities for teachers, all of whom have bachelor's degrees, are certified in early childhood education, and, as public school employees, are relatively well paid;
6. health and nutrition services including health screening, speech therapy, and nursing and meal services;
7. comprehensive school-age services including reduced class sizes (25 from 35+ children), teacher aides for each class, parent program activities, extra instructional materials, and individualized activities to promote reading and math achievement.

Measures of Program Participation and Covariates

Preschool participation. Children who participated in the CPC preschool component for 1 or 2 years beginning at age 3 were coded 1 and those in the comparison group were coded 0. Nearly half of the children enrolled for 2 years of a half-day program. All children who participated in CPC preschool also enrolled in kindergarten. The comparison group enrolled in all-day kindergarten programs in schools serving large proportions of low-income children. Their preschool participation mirrored that of the community; 14% enrolled in Head Start. Our preschool measure indexes the added value of an intensive preschool program over the usual intervention for low-income children.

School-age participation. Participation in the CPC school-age program was used as a covariate in estimating the impact of preschool participation on educational attainment and delinquency. Although school-age participation does contribute to some school competence outcomes, especially in combination with preschool participation, it is not associated with educational attainment and delinquency (Reynolds et al., 2001).

Gender. Girls were coded 1 and boys were coded 0.

Race/ethnicity. Black children were coded 1 and Hispanic children were coded 0.

Family risk status. The index provides a summary of the co-occurrence, or pile-up, of socioeconomic risk factors that are frequently associated with child and family functioning (Bendersky & Lewis, 1994; Rutter, 1987). The risk indicators were selected based on their well-known associations with child and family well-being (Bendersky & Lewis, 1994). It was the sum of six dichotomously coded risk factors measured from family surveys or school records from preschool to age 8 as follows: (a) parent did not complete high school, (b) eligible for a fully subsidized lunch defined as a family income at or below 130% of the federal poverty line, (c) residence in a school neighborhood in which 60% or more of children are in low-income families, (d) residence in a single-parent family, (e) parent not employed full- or part-time, and (f) four or more children in family. About 10% of cases with missing data were imputed in LISREL using the recommended EM algorithm (Schafer, 1997). Alternative approaches to estimating missing data led to equivalent results. The distribution of missing data was unrelated to program participation.

Program sites. Dichotomous variables for each of the 20 program sites were used as covariates for estimating the main effects of preschool participation on the outcome measures. These variables measured the local history and other possible unmeasured factors associated with enrollment at each site.

Cognitive Advantage Hypothesis

Word analysis skills. As an indicator of developed abilities, we used scores on the word analysis subtest of the ITBS at the end of kindergarten (age 6). This emergent literacy measure consists of 35 pictorial items assessing letter–sound correspondence and word attack skills. It is group administered and untimed. The internal consistency reliability coefficient is .87 (Hieronymus, Lindquist, & Hoover, 1980). Literacy is a major focus of the CPC preschool program and other early interventions. Previous studies have confirmed the measure's predictive validity (Reynolds 1989, 1991; Reynolds & Bezruczko, 1993). For example, word analysis scores are moderately correlated with reading comprehension in third and sixth grades (rs = .47 and .44) and with math achievement at the same ages (rs = .47 and .46).

Grade retention. Grade retention was measured as a dichotomous variable and was defined as any incidence of grade repetition from kindergarten through eighth grade (ages 6–15). Those promoted continuously were coded 0. Data were obtained from a grade-by-grade analysis of school system records. We defined retention as a measure of cognitive advantage. Grade retention is a fundamental indicator of scholastic competence and identifies children who do not meet basic school requirements. Although criteria for retention can vary by school, children are retained in grade primarily because of low school achievement in reading and math. As a major outcome of partici-

pation in early childhood intervention, grade retention is expected to mediate long-term effects directly and indirectly through its relation to early cognitive skills (McCoy & Reynolds, 1999).

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 (Zigler & Muenchow, 1992). Following Reynolds (2000), we operationalized parent involvement as the frequency of teacher and parent ratings of average or better on the item ''parent's participation in school'' over the ages of 8 to 12. Teacher ratings were obtained from yearly surveys of children's academic progress. The items were recoded to dichotomous variables from their 5-point scale (1 = poor/not at all, 3 = average, 5 = excellent/much). Parent ratings were based on a similar item measured from a survey questionnaire administered at an average age of 10. The dichotomous ratings of average or better were summed to form a scale from 0 to 6. We used teacher and parent ratings to minimize possible reporter bias. Responses were coded dichotomously to improve reliability of reports and to reduce ''halo'' effects. Principal components analyses have supported the measure's unidimensionality. Parent involvement also has been a frequently correlate and mediator of child outcomes in previous reports in our study (Reynolds, 2000; Reynolds et al., 1996) and in others (Fan & Chen, 2001).

Child abuse and neglect. The second indicator of family support behavior was whether children experienced a substantiated report of child abuse or neglect as determined by petitions to the juvenile court from ages 4 to 12 (1 = substantiated report, 0 = none). This age range was selected to fit between the measurement of preschool and the major outcomes. Data were collected through record searches at the county juvenile court without knowledge of youth's program participation. Searches were repeated twice for 5% random samples and verified against computer records.

Social Adjustment Hypothesis

Teacher ratings of children's classroom adjustment was measured at age 9 through a 6-item scale including the following: concentrates on work, follows directions, is self-confident, participates in group discussions, gets along well with others, and takes responsibility for actions. Items were coded from 1 (*poor/not at all*) to 5 (*excellent/very much*). The reliability of the scale exceeded .90. Missing scores were due to teacher nonresponse, and they were nonsystematic in the study sample. Teacher ratings of school adjustment are widely used indicators of social development and are significant predictors of school and social success (Entwisle, Alexander, Cadigan, & Pallas, 1987; Reynolds, 1989, 1991).

Motivational Advantage Hypothesis

This measure was a composite of 16 self-reported items about commitment to education. Assessed at ages 11 or 12 as part of a survey about school and family experiences, commitment items were rated on a scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*) and then summed. Among the items were: ''I try hard in school,'' ''I like school,'' ''School is important,'' ''I am smart,'' ''I get in trouble in school [reverse coded],'' ''When in school I'd rather be someplace [reverse coded],'' ''I give up when schoolwork gets hard [reverse coded],'' ''I get good grades in school,'' ''I do my homework,'' and ''I do better in school than my classmates'' (α at age 11 = .74; α at age 12 = .78). Principal components analysis indicated that the items represent a single underlying dimension regardless of the age of measurement. Children with missing scores at ages 11 or 12 were imputed with a nearly identical measure of school commitment at age 15 (9th or 10th grade). Only 14% of children had these imputed scores. An average of ages 11 and 12 measures was used if both were available. As expected, this measure was significantly associated with children's perceived competence and educational expectations (rs $>$.35), and is positively and independently associated with school achievement (Reynolds, 2000; Reynolds et al., 1996). Youth self-perceptions about education and schooling are consistent predictors of later well-being (Connell, Halpern-Felsher, Clifford, Crichlow, & Usinger, 1995; Consortium for Longitudinal Studies, 1983; Hauser & Featherman, 1977).

School Support Hypothesis

Magnet school attendance. As a measure of school quality, 1 or more years of attendance in magnet elementary schools from ages 10 to 14 was a major indicator of school support after preschool intervention. Magnet schools are selective elementary schools that provide specialized programs across the curriculum. Because a higher proportion of students in these schools exceed national norms in reading and math achievement, enrollment would be expected

to help maintain the effects of preschool intervention (Anderson, Walberg, & Weinstein, 1998; Hickey & Reynolds, 2002). The social climate in these schools also places a high value on achievement and prosocial behavior (Gamoran, 1996). We used a dichotomous measure of enrollment because of the lack of variation in years of enrollment.

School mobility. This individual-level measure was the number of times youth changed schools between the ages of 10 and 14. Obtained from a grade-by-grade analysis of school records, school mobility is a key negative indicator of the continuity in learning environments that has been frequently associated with lower school performance and higher levels of school dropout and behavioral problems (Mehana, 1997; Temple & Reynolds, 1999). Mobility often disrupts the stability in learning environments important for healthy development.

Outcome Measures

High school completion by age 20. This dichotomously coded variable indicated whether youth completed their secondary education with an official high school diploma or were awarded a GED certificate by September 2000 (M age = 20.3). All other youth, including those who remained in high school, were coded as noncompleters. The data were obtained from administrative records in all schools youth attended and were supplemented by interviews with family members. An age 21 measure from March 2001 was analyzed to determine the robustness of main effects. We also investigated the ordinal variable, highest grade completed.

Official juvenile arrest by age 18. The incidence of petitions to the Cook County Juvenile Court and two other locations were analyzed. These arrests occurred between ages 10 and 18 (from 1990 to 1998). They are formal petitions for youth who are arrested on criminal charges and go before a judge. Some petitions result in warnings or referrals to social service agencies. Data were collected through record searches at the juvenile court without knowledge of youth's program participation. Searches were repeated twice for 5% random samples and verified against computer records. To be included in the analysis, youth had to reside in Chicago at age 10 or older. We also investigated the number of arrests and multiple arrests.

Data Analysis

We used the SEM program LISREL (Jöreskog & Sörbom, 1996a) to investigate the contributions of the five hypotheses. Following the CPE approach, we first investigated the main effects of program participation for the two major outcome measures. We reported unadjusted and adjusted rates of school completion and juvenile arrest. The adjusted rates were based on probit regression analysis in Stata (Stata Press Staff, 2003) and included the covariates. Because probit coefficients are not directly interpretable, they were transformed in Stata to represent marginal effects synonomous with ordinary regression analysis (Greene, 1995). That is, the percentage-point change in the outcome associated with program participation.

The mediators that account for the estimated main effects were then tested through SEM. SEM is particularly appropriate for theory-driven tests of mediation. In this approach, a set of equations, one for each intervening and outcome variable, was estimated simultaneously by maximum likelihood as shown in Figure 1. The resulting structural coefficients (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 in variables to increase the accuracy of results (see Appendix A). The models for educational attainment and delinquency were estimated separately. A mediator must be independently associated with both program participation and the outcome to contribute to long-term effects. Moreover, the main effect between program participation and outcome will be substantially reduced after the mediator is added to the model that includes the program measure and covariates.

Estimates were based on the polychoric correlation matrix from PRELIS (Jöreskog & Sörbom, 1996a) using pairwise-present cases (see Jöreskog & Sörbom, 1996a, for information regarding PRELIS and polychoric correlation). Because they take into account range restriction and the lack of interval scaling, polychoric correlations provide more accurate estimates of association for variables measured on dichotomous or ordinal scales than other correlations such as Pearson and Spearman. Given the relatively small amount of missing data, the sample sizes ranged from 1,286 to 1,404. Significance tests were based on the maximum sample sizes. We used a test statistic of 2.50 to denote statistical significance (probability level of about .01). As expected, the dependency of observations between sites was low for long-term outcomes considered here. Estimation was

from maximum likelihood. We also attempted to estimate the model using weighted least squares, the recommended approach for polychoric correlations (with an asymptotic covariance matrix) in which the assumption of multivariate normality is relaxed (Jöreskog & Sörbom, 1996b). These models failed to converge, a common situation with complex models. Studies have indicated, however, that coefficients from maximum likelihood estimation of polychoric correlations are consistent with those from weighted least squares, especially if model variables do not deviate far from normalilty (Jöreskog & Sörbom, 1996a, 1996b). The model variables in our study did not deviate far from normality. In maximum likelihood, most typically, the standard errors of estimates are slightly underestimated and the chi-square fit is overestimated. Thus, we interpreted significance tests cautiously, especially for the model of juvenile arrest. Our model fit statistics are likely to be conservative.

Because both major outcome variables were dichotomous, it is possible that significance tests are imprecise to a small degree. High school completion approximated a normal distribution because nearly half of the sample was above and below the mean. Although juvenile arrest is a rare event, the 20% rate of arrest in our sample is close to the level recommended for reasonably robust standard errors (Stevens, 1990). To test robustness to distributional assumptions, we also estimated models for highest grade completed in school and the number of arrests. Nevertheless, we interpreted the significance tests for juvenile arrest cautiously and emphasized the magnitude of the coefficients. 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 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. We also reported the total indirect effect of preschool participation on each outcome through each intervening variable and the percentage of the total indirect effect explained by the indicators of the hypotheses.

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). That is, the unlikely hypothesis that the direct effect of program participation to program outcome is unmediated. The second set was the cumulative model in which the joint contribution of the hypotheses was included following the sequence expected by theory, prior research, and the time of measurement. Although direct paths were estimated between preschool participation and each mediator and between each mediator and outcome variable, the sequence of pathways began with cognitive advantage, followed by family support and social adjustment, and then school support and motivational advantage. The baseline model had mediational paths set to 0. We did not investigate the relation between delinquency and educational attainment. The model also included gender, race, and family risk status as covariates in estimating the direct and indirect effects of preschool intervention because previous research showed that they were correlated with preschool participation and both outcomes (Reynolds, 2000; Reynolds et al., 2001).

Results

Following the approach of CPE, we first present findings on the association between preschool participation and the two main outcome measures. This is followed by correlational analyses of the mediators. The primary Results section is estimation of the contribution of the five hypotheses of intervention effects.

Main Effects of Preschool Participation on High School Completion and Delinquency

As shown in Table 3, preschool participation was associated with significantly higher rates of high school completion by age 20 and with significantly lower rates of juvenile arrest by age 18. No differences were found between 1 and 2 years of participation. This pattern of findings was the same for both unadjusted and adjusted rates. Controlling for the influence of gender, race/ethnicity, family risk status, school-age intervention, and program sites, 55.9% of CPC participants completed high school by age 20 compared with 46.7% for the comparison group. This is a difference of 9.2 percentage points, a 20% increase over the comparison group. This finding is similar to that of an earlier measure reported by Reynolds et al. (2001) in which preschool participants experienced a 10.2 percentage point higher rate of school completion than did the comparison group. In further support of the robustness of findings, preschool participation was significantly associated with a higher rate of high school completion by age 21 (61.8% vs. 51.3%, respectively) and with a greater number of years of completed education at

Table 3
Main Effects of Program on Educational Attainment and Delinquency Outcomes

Outcome	*N*	CPC preschool	No CPC preschool	Diff.	*p* value
High school completion					
Age 20 (September 2000), %, unadjusted	1,286	55.5	47.0	8.5	.003
Age 20 (September 2000), %, adjusted	1,286	55.9	46.7	9.2	.028
Age 21 (March 2001), %, unadjusted	1,314	62.0	48.7	13.3	.000
Age 21 (March 2001), %, adjusted	1,314	61.8	51.3	10.5	.010
Age 21 (September 2001), %, unadjusted	1,315	63.5	50.1	13.4	.000
Age 21 (September 2001), %, adjusted	1,315	63.3	53.0	10.3	.011
Highest grade completed					
Age 20 (September 2000), unadjusted	1,265	11.09	10.75	0.34	.002
Age 20 (September 2000), adjusted	1,265	11.10	10.72	0.38	.012
Age 21 (March 2001), unadjusted	1,295	11.30	10.82	0.48	.000
Age 21 (March 2001), adjusted	1,295	11.27	10.88	0.39	.007
Age 21 (September 2001), unadjusted	1,296	11.30	10.82	0.48	.000
Age 21 (September 2001), adjusted	1,296	11.27	10.88	0.39	.007
Juvenile arrest by age 18					
Any, %, unadjusted	1,404	17.1	25.0	−7.9	.000
Any, %, adjusted	1,404	13.1	22.0	−8.9	.002
Any violent offense, %, unadjusted	1,404	9.4	14.6	−5.2	.004
Any violent offense, %, adjusted	1,404	6.9	14.1	−7.2	.001
Total number, unadjusted	1,404	0.49	0.71	−0.22	.020
Total number, adjusted	1,404	0.44	0.76	−0.32	.012

Note. CPC = Child-Parent Center. Adjusted for differences in gender, risk index, race/ethnicity, school-age participation, and program sites. With the exception of highest grade completion, all effects were estimated by probit regression or negative binomial regression (total number of arrest).

age 21 (11.27 vs. 10.88, respectively) and age 20 (11.1 vs. 10.7, respectively). These higher levels of educational attainment have practical significance. The estimated group difference translates into a net economic benefit in 1998 dollars of $28,000 per participant in expected lifetime earnings and government tax revenues alone (Reynolds, Temple, Robertson, & Mann, 2002).

For juvenile arrest, the adjusted rate of petitions to the juvenile court was 13.1% for the preschool group and 22.0% for the comparison group. This difference of 8.9 percentage points is a 40% reduction over the comparison group. This finding was consistent with other measures of juvenile delinquency including incidence of arrest for violent offenses and the number of arrests (see Table 3). The rate of juvenile arrest for violent offenses, for example, was 6.9% for the preschool group and 14.1% for the comparison group (a rate reduction of 51%). Given the high costs of crime to society, this link between preschool participation and delinquency prevention is practically significant. A one-third reduction in the rate of juvenile arrest translates into a net economic benefit in 1998 dollars of $21,000 per participant in savings in the criminal justice system and averted tangible and intangible crime victim costs (Reynolds et al., 2002).

The main effects were also estimated using individual risk indicators (single-parent status, parent education, and free lunch eligibility) as covariates. The pattern of findings was similar to those using the family risk index. Controlling for the influence of gender, race/ethnicity, individual risk indicators, school-age intervention, and program sites, 55.3% of CPC participants completed high school by age 20 compared with 47.3% for the comparison group ($p < .05$). For juvenile arrest, the adjusted rate of petitions to the juvenile court was 11.0% for the preschool group and 22.3% for the comparison group ($p < .01$). See Appendix B for additional estimates.

Links Among Preschool Participation, Mediators, and Outcomes

Given the evidence that program participation is associated with long-term educational and social benefits, we also investigated the pattern of correlations of the hypothesized mediators with program participation and the two outcomes (no adjustments). As shown in Table 4, preschool participants had significantly more positive ratings or higher scores than the comparison group for nearly all mediators. Preschool participants scored 6 standard

score points higher than the comparison group on ITBS word analysis at the end of kindergarten. This translates to a 5-month advantage in performance. They also had higher ratings of parent participation in school and higher ratings of classroom adjustment. Program participants were more likely to attend magnet elementary schools and were less likely to be retained in grade and to change schools. Links with child abuse and neglect and school commitment were only borderline significant. All of the hypothesized mediators were significantly associated, in the expected direction, with later high school completion and juvenile arrest (see Appendix A for correlations among all model variables). We note that these estimated correlations are conservative given the range restriction of the dichotomous outcomes.

In summary, the hypothesized mediators were significantly associated with preschool participation and the two major outcomes, two important preconditions for explaining the long-term effects of preschool participation.

Mediators of the Effects of Preschool on High School Completion

We estimated two sets of models in LISREL to determine the extent to which the hypothesized mediators explained the links between program participation and each outcome. The top half of Table 5 shows the fit statistics of the model with the mediators entered one at a time. Model 1 is the baseline model with only the main effect estimated. The lower half of Table 5 shows the fit statistics with the mediators entered cumulatively based on the time sequence displayed in Figure 1. Although each of the mediators contributed to improved model fit above and beyond the direct effects model with no mediating paths, the overall model fit was poor for the single-mediator models. Only when the mediators were included as a set did the models begin to fit the data well, that is, explain the link between preschool participation and high school completion.

As shown in Table 5, only the two most comprehensive models (Models 14 and 15) had fit statistics in the acceptable range (RMSEA in the .05 range). The best fitting model included indicators of all five hypotheses and eight mediators, $\chi^2 = 56.67$ (12), RMSEA = .054, AGFI = .95. This model, with youth's school commitment added, was a significant improvement over Model 14. It accounted for 35% of the variance in high school completion. Figure 2 displays the significant, standardized coefficients of Model 15.

The paths leading from preschool participation to high school completion were diverse and none was dominant. As shown by the thick arrows in Figure 2, four intervening factors directly mediated the main effect of preschool participation. Two of these were family support indicators. Preschool participation was associated with higher parent involvement ($b = .13$) in school and lower incidence of child abuse and neglect ($b = -.14$), which in turn linked to high school completion in the expected direction (bs = .09 and $-.13$, respectively). The two school support mediators also were direct mediators. Preschool participants were more likely to attend magnet schools ($b = .22$), and magnet school attendance was associated with greater school completion ($b = .16$). The estimated effect of preschool on high school completion also was explained by reduced school

Table 4
Associations Among Program, Mediators, and Outcomes

Intervening variable	Hypothesis	CPC preschool group	No-preschool group	*P* value	Correlation with high school completion	Correlation with delinquency arrest
ITBS word analysis (age 6)	CA	65.96	59.31	.000	.173*	−.102*
Parent participation in school (ages 8–12)	FS	1.80	1.42	.000	.228*	−.146*
Abuse or neglect report (ages 4–12)	FS	0.05	0.07	.064	−.092*	.063*
Classroom adjustment (age 9)	SA	19.25	18.23	.003	.277*	−.132*
School commitment (ages 11–12)	MA	52.05	50.66	.000	.082*	−.083*
Magnet school attendance (ages 10–14)	SS	0.14	0.04	.000	.154*	−.106*
School mobility (ages 10–14)	SS	0.81	1.16	.000	−.223*	.133*
Retention (ages 6–15)	CA	0.23	0.36	.000	−.246*	.140*

Note. $N = 1{,}286$, except for scores of classroom adjust ($N = 1{,}050$) and school commitment ($N = 1{,}144$).
CPC = Child-Parent Center; ITBS = Iowa Test of Basic Skills; CA = cognitive advantage hypothesis; FS = family support hypothesis; SA = social adjustment hypothesis; MA = motivational advantage hypothesis; SS = school support hypothesis.
*Groups have significantly different means.

Table 5
LISREL Goodness-of-Fit Statistics for Cumulative-Mediator Models for High School Completion

Model	*df*	*df* change	χ^2	χ^2 change	RMSEA	Std. RMR	AGFI
			Single-mediator models				
1. Main effect	68		2660.00		.21	.19	.57
2. Cognitive advantage	57	11	1980.95	679.05	.18	.17	.65
3. Family support	57	11	2355.83	304.17	.21	.18	.57
4. Classroom adjustment	63	5	2412.36	247.64	.20	.19	.59
5. Motivation	63	5	2588.78	71.22	.21	.19	.55
6. School support	57	11	2063.49	596.51	.19	.18	.61
			Cumulative-mediator models				
7. Direct effects (full)	28		646.87		.12	.10	.80
8. Plus word analysis	26	2	461.52	185.35	.11	.07	.83
9. Plus parent involvement	24	2	360.16	101.36	.10	.05	.86
10. Plus abuse and neglect	22	2	291.57	68.59	.09	.04	.87
11. Plus classroom adjustment	20	2	250.10	41.47	.09	.04	.87
12. Plus retention	18	2	202.71	47.39	.086	.03	.89
13. Plus mobility	16	2	158.60	44.11	.080	.03	.90
14. Plus magnet school	14	2	65.81	92.79	.054	.02	.95
15. Plus motivation (full)	12	2	57.67	8.14	.054	.02	.95

Note. RMSEA = root mean square error of approximation; RMR = root mean residual; AGFI = adjusted goodness-of-fit index. Covariates (gender, risk index, and race/ethnicity) and their paths to mediators were included in direct effects model.

mobility during middle childhood (*b*s = −.14 and −.14, respectively).

The cognitive advantage hypothesis contributed to the preschool effect more circuitously but its impact was widespread. Program participation was associated with an immediate boost in word analysis skills ($b = .32$) that led to a higher rate of attendance in magnet schools ($b = .11$), a lower rate of grade retention ($b = -.39$), and a higher level of parent involvement in school ($b = .16$). The effect on school commitment was through classroom adjustment. All of these mediators were significant predictors of high school completion, including school commitment. Thus, preschool participation affects later school completion in several ways, not the least of which is the immediate cognitive boost so consistently identified in previous studies. The family support and school support hypotheses also made major contributions as preschool participants were more likely to have involved parents, attend higher quality schools, and avoid school mobility. Indeed, empirical verification of the school support hypothesis in contributing to high school completion is a new and significant finding.

The social adjustment and motivational advantage hypotheses made notable contributions to processes leading to school completion. As shown in Figure 2, classroom adjustment directly predicted high school completion. It also predicted youth school commitment: It was through school commitment that classroom adjustment influenced juvenile arrest.

Mediators of the Effects of Preschool on Juvenile Arrest

As with high school completion, the cumulative models of preschool mediation shown in Table 6 fit the data much better than do the single-mediator models. Like those for high school completion, the two most comprehensive models fit the data best (Models 14 and 15). This pattern indicates that all five sets of hypotheses contribute to the explanation of the link between preschool participation and juvenile arrest. Relative to the others, the full model fit the data best, $\chi^2 = 51.37$ (12), RMSEA = .048, AGFI = .96. The model variables explained 35% of the variance in juvenile arrest. Figure 3 shows the significant standardized coefficients of the full model.

Two of the major paths leading from preschool participation involved the school support and family support hypotheses. Preschool participants were more likely to attend magnet schools ($b = .24$), which in turn reduced the likelihood of juvenile arrest ($b = -.19$). Although lower in magnitude of influence, the path from program participation to parent involvement in school ($b = .12$) and then to juvenile arrest ($b = -.07$) also was notable. Complex paths involved the indicators of cognitive advantage, social adjustment, and motivational advantage hypotheses.

Table 6
LISREL Goodness-of-Fit Statistics for Cumulative-Mediator Models for Juvenile Arrest

Model	*df*	*df* change	χ^2	χ^2 change	RMSEA	Std. RMR	AGFI
			Single-mediator models				
1. Main effect	68		2618.83		.20	.18	.61
2. Cognitive advantage	57	5	2044.15	574.68	.17	.17	.66
3. Family support	57	11	2347.79	271.04	.20	.17	.60
4. Classroom adjustment	63	5	2457.98	160.85	.19	.18	.61
5. Motivation	63	5	2534.91	83.92	.20	.18	.59
6. School support	57	18	2075.27	543.56	.18	.17	.64
			Cumulative-mediator models				
7. Direct effects (full)	28		482.59		.10	.08	.85
8. Plus word analysis	26	2	342.23	140.36	.09	.05	.89
9. Plus parent involvement	24	2	295.96	46.27	.09	.05	.89
10. Plus abuse and neglect	22	2	241.25	54.71	.08	.04	.90
11. Plus classroom adjustment	20	2	239.83	1.42	.08	.04	.89
12. Plus retention	18	2	236.03	3.84	.09	.03	.88
13. Plus mobility	16	2	207.71	28.32	.09	.03	.89
14. Plus magnet school	14	2	82.49	125.22	.06	.02	.94
15. Plus motivation (full)	12	2	51.37	31.12	.05	.02	.96

Note. RMSEA = root mean square error of approximation; RMR = root mean residual; AGFI = adjusted goodness-of-fit index. Covariates (gender, risk index, and race/ethnicity) and their paths to mediators were included in direct effects model.

In a pattern similar to high school completion, the cognitive advantage hypothesis contributed to reduced juvenile arrest in conjunction with other mediators. The program impact on word analysis skills in kindergarten ($b = .31$) carried over to parent involvement in school ($b = .17$), greater attendance in magnet schools ($b = .11$), and lower likelihood of retention ($b = -.39$) paired with magnet school attendance ($b = -.26$). The major predictors of juvenile arrest were magnet school attendance ($b = -.19$), school commitment ($b = -.14$), and parent involvement in school ($b = -.07$).

The motivational advantage hypothesis mediated the impact of preschool participation on juvenile arrest (respective paths for commitment were $b = .06$, not shown, and $b = -.14$), one of the first empirical demonstrations of support for motivational advantage. School commitment also served as a bridge between cognitive advantage, classroom adjustment, and family support experiences to later delinquency. This is best illustrated in Figure 3 by the influence of classroom adjustment on school commitment ($b = .29$), which in turn reduced the likelihood of delinquency ($b = -.14$).

Indirect Effects of Preschool Participation on Outcomes

Table 7 summarizes the major contributing pathways to the long-term effects of CPC participation as a proportion of the total standardized indirect effect. Proportion of the total indirect effect is estimated in LISREL. The total indirect effect is the sum of all paths of influence leading to the outcomes. It denotes the extent to which the influence of CPC participation is mediated by the intervening variables. We categorized the indirect effects by mediator, with the primary emphasis on the mediators that initiated the indirect effect—they were directly and significantly associated with program participation (see Table 7 for the percentage contributions of all contributing paths). The paths in Table 7 sum to less than 100% because some insignificant paths were excluded. (Contact the first author for additional information about the total effects—that is, sum of direct and indirect coefficients—for all model variables regardless of the significance of individual paths.) For alternative perspectives, see Sobel (1982) and the National Institute of Child Health and Human Development (NICHD) Early Childhood Research Network (2002).

The cognitive advantage hypothesis contributed the most to explaining of the link between CPC preschool participation and high school completion. It accounted for 31.5% of the total indirect effect of preschool participation. The contributing paths were complex, with about half due to cognitive factors alone (word analysis skills and grade retention) and half partially contributed by family support, school support, and motivational advantage hypotheses.

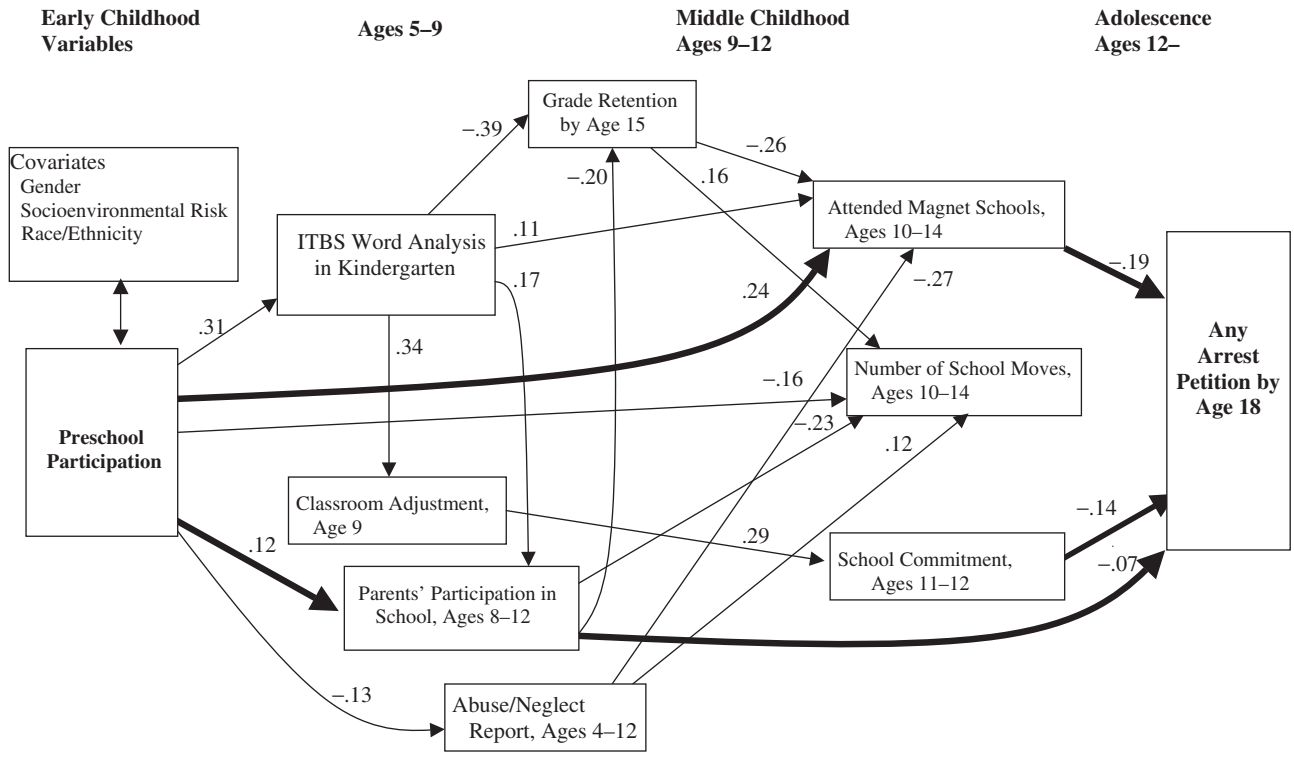


Figure 3. LISREL mediation model for any arrest petition by age 18, coefficients standardized and adjusted for measurement errors. $R^2 = .35$; root mean square error of approximation = 0.048; adjusted goodness-of-fit index = 0.96. All covariates have paths to program participation, mediators, and developmental outcomes. To simplify the figure, those paths are not shown except for the path to program participation.

The school support hypothesis accounted for 29.7% of the total indirect effect. Because the school support indicators were penultimate measures in the model, they could not initiate complex paths. The family support hypothesis accounted for 25.8% of the total indirect effect, with child abuse and neglect contributing the highest percentage. The motivational advantage hypothesis accounted for 1.7% of the total indirect effect (not significant).

For juvenile arrest, the school support hypothesis made a large contribution to the indirect effects. It accounted for 50.2% of the total indirect effect of preschool participation. Most of this percentage was due to increased magnet school attendance. The cognitive advantage hypothesis accounted for 18.6% of the total indirect effect. The primary contributors were word analysis skills in conjunction with magnet school attendance as well as parent involvement (family support) and grade retention. The family support hypothesis explained 22% of the indirect effect. Many paths contributed. Parent involvement in school accounted for nearly half of the total. Complex paths involving parent involvement in school and motivation, and child abuse and neglect and magnet school attendance also were influential. Motivation, as measured by school commitment, explained 7.6% of the indirect effect on juvenile arrest.

Support for Mediation of Preschool Impact

Table 8 shows the extent of mediation as the proportional reduction in the size of the main effect after the complete set of mediators were included, as reported in Figures 2 and 3. The program coefficients are standardized values estimated in LISREL. Full mediation of the preschool effect would result in a substantial reduction in the size of the coefficient, at least to the level of nonsignificance, and would approach 100%. In support of full mediation, the main effect of program participation on high school completion was reduced by 58.1% after the set of mediators was added to the model. About two fifths of the main (direct) effect was unexplained by the mediators, and the program coefficient was reduced to the level of nonsignificance (from $b = .124$ to $b = .052$). Several of the intervention hypotheses contributed to this finding (see Table 7).

For juvenile arrest, the set of mediators in the cumulative model also reduced the main effect of

Table 7
Total Indirect Effects of Program Mediators on Outcomes

Key pathway	Age 20 high school completion	Age 18 juvenile arrest
Preschool participation	.18[a]	−.11[a]
Percentage due to:		
Family support	25.8	22.0
Parent involvement in school	6.5	7.6
Parent involvement and motivation		
Parent involvement and mobility	2.2	
Parent involvement and retention	2.4	
Parent involvement and magnet school		
Abuse/neglect	10.1	8.3[b]
Abuse/neglect and motivation	.3	
Abuse/neglect and mobility	1.2	
Abuse/neglect and magnet school	3.1	6.1
School support	29.7	50.2
Attendance in magnet school	19.6	41.5
School mobility	10.9	8.7[b]
Cognitive advantage	31.5	18.6
Word analysis		
Word analysis and parent involvement	2.6	3.4
Word analysis and adjustment	8.8	
Word analysis and magnet school	3.1	5.9
Word analysis and retention	10.4	
Word analysis, adjustment, and motivation	1.9	3.9
Word analysis, retention, and magnet school	3.2	5.4
Word analysis, retention, and mobility	1.5	
Motivation advantage	1.7[b]	7.6[b]
Social adjustment	.8[b]	.00
Total	90.3	98.4

[a]The total indirect effects of preschool participation on high school completion and juvenile arrest are significant at .01 level.
[b]The paths were not significant.

program participation to nonsignificance (from $b = -.144$ to $b = -.031$). Also, 78.5% of the estimated program effect was accounted for by the mediators; 21.5% was unexplained. A substantial portion of the mediation was associated with magnet school attendance (see Table 7). Overall, this pattern of findings provides substantial corroboration of the explanatory power of the mediators in accounting for the long-term effects of preschool participation.

Robustness to Alternative Model Specifications

We tested several alternative models to determine the stability of the coefficients and the overall pattern

Table 8
Contribution of Mediators to Preschool Effects

	Educational outcome: High school completion	Delinquency outcome: Age 18 juvenile arrest
Direct program effects with mediators in model	.052 (1.91)	−.031 (−1.26)
Direct program effects without mediators in model	.124 (4.54)	−.144 (−6.06)
Percent of direct program effects mediated	58.1	78.5
Percent of direct program effects unmediated	41.9	21.5

Note. The *t* statistics are in parentheses. The coefficients were estimated by LISREL.

of findings. The results of these analyses indicate that our findings are robust to a wide variety of alternative models as follows.

Alternative covariates. We investigated whether models using individual risk indicators rather than the risk index altered the findings. We used the four risk indicators that were most associated with program participation and child outcomes as indicated in previous research. These were parent education, family income as measured by eligibility for the subsidized lunch program, single-parent family status, and four or more children in the family. As shown in Appendix C, findings were consistent with the original model as the percentage contributions of the cognitive advantage, family support, and school support hypotheses were nearly identical for both high school completion and juvenile arrest. Path coefficients also were similar (e.g., $b = .33$, revised, vs. .32, original, for program to word analyses) but model fit was worse in the alternative specification for high school completion (RMSEA = .065, AGFI = .916) and juvenile arrest (RMSEA = .060, AGFI = .927). Models based on more or fewer risk indicators yielded similar results, with the former having the poorest model fit. The inclusion of other covariates, such as participation in the CPC school-age intervention, also did not contribute to the model or alter the interpretation of the results. Indeed, the fit of the model was significantly worse with this variable added.

Additional mediators. To redress the possible underspecification of school achievement, we added an age 14 measure of reading achievement to the models. The addition of this well-known predictor of high school completion did not improve the overall model fit or the pattern of contributions among the mediators. Achievement did predict high school completion, however. A similar result occurred when reading achievement was added to the juvenile arrest model. An alternative measure of motivation, youth educational expectations, also yielded a similar pattern of findings for both outcomes as well as slightly greater direct effects. The consistency of findings across different model specifications is mostly attributable to the inclusion of a comprehensive set of mediators of intervention effects (see Figure 1).

Outcomes. The use of alternative measures of educational attainment and delinquency also yielded findings that were similar to those reported in this section. These outcomes included the highest grade completed by age 20 (see Appendix D), high school completion by age 21, a combined measure of official juvenile arrest and self-reports of arrest, and the incidence of multiple arrests (see Appendix D). Finally, we estimated a model that combined juvenile arrest and high school completion under the controversial but common specification that juvenile arrest negatively predicts high school completion and not vice versa (Campbell, 1998). This model yielded results with many similarities but the fit was not as good, and the pattern of findings was more difficult to interpret. Juvenile arrest was a predictor of school completion, however.

Discussion

In one of the most underinvestigated areas of research in early childhood, we identified mechanisms through which the effects of participation in preschool intervention come about. Our major findings were that (a) preschool participation in the federally funded CPCs was associated with significantly higher rates of high school completion and lower rates of juvenile delinquency, (b) the cognitive boost at the end of the program and the school support and family support experiences during the intervening years were most responsible for the transmission of long-term effects, and (c) the model that included all five hypotheses of mediation fit the data better than the tested alternatives. These findings were consistent across a range of analyses. The school support hypothesis, primarily school quality, accounted for the largest share of the mediated effects, especially for juvenile arrest. The family support, school support, and cognitive advantage hypotheses contributed about equally to high school completion.

Unique Contributions

Our study makes three major contributions to the field of early childhood research. First, it is the first study to investigate systematically a comprehensive set of plausible mediators of the effects of preschool participation on educational and social well-being during the transition to adulthood. Most previous studies have tested one or two major hypotheses of intervention effects. The cognitive advantage hypothesis alone has been the most commonly investigated. Consequently, many alternative explanations to the findings of these studies are possible. By implementing the methodology of CPE, our five-hypothesis model of intervention effects fit the data well compared with alternative models and accounted for a large proportion of the direct effects of preschool. In order of overall contribution, measures of school support, family support, and cognitive advantage had substantial influence. The contribu-

tion of each was established only after the influence of alternative hypotheses was taken into account. These findings increase confidence that our tested mediators account for the long-term effects of intervention. Findings that each of the hypotheses contributed to the model indicate that each should be accounted for in studies of mediation. Such systematic tests of mediation are part of the CPE approach (Reynolds, 1998).

The second major contribution is that the study examined two of the most important long-term outcomes of early childhood intervention: educational attainment and delinquency. Both have personal and economic significance that go well beyond the commonly investigated outcomes of cognitive ability and school achievement. Thus, our findings provide much-needed information on the contribution of early childhood experiences to young adult outcomes. Nearly all of the previous studies of long-term effects of intervention have not investigated mediation. The few that have (see Barnett et al., 1998; Consortium for Longitudinal Studies, 1983; Schweinhart et al., 1993) limited their focus to educational attainment and economic well-being. We are aware of no previous studies that have investigated the mediators of juvenile crime. Studies of large-scale programs such as Head Start have been almost exclusively investigated short-term outcomes and only recently have examined educational attainment and crime (Garces et al., 2002).

The third major contribution is that because we investigated an established large-scale program similar to Head Start, our findings are more generalizable to current programs than most previous studies. The large sample size also increases confidence in the stability of estimates across contexts. The CPCs have many features in common with state and federally funded preschools, and as a public school program, its administrative system can be widely used. Moreover, our findings that program participation was associated with significantly higher school completion and reduced delinquency indicate that the effects of established programs administered through school districts can mirror those of model programs.

Paths of Program Effects in Context

The defining feature of this study was the systematic testing of several hypotheses of how the longer term effects of the program come about. This is a unique feature of CPE. The pattern of findings corroborating several intervention hypotheses is consistent with program theory and thereby strengthens the interpretation that our estimates are real effects of CPC participation. Although the paths of program effectiveness were diverse, findings supported cognitive advantage as one major source of longer term effects on high school completion and delinquency prevention net of other sources of effects. This is largely consistent with previous analyses in the CLS (Reynolds, 1992, 2000; Reynolds et al., 1996) and in other studies (Berrueta-Clement, Schweinhart, Barnett, Epstein, & Weikart, 1984; Campbell et al., 2001; Consortium for Longitudinal Studies, 1983; Schweinhart et al., 1993).

As a foundation for learning, developed abilities have widespread impact on the process of adjustment. Unlike previous studies of the CLS, early cognitive development did not predict the major outcomes directly. Program participation enhances children's early cognitive and language development so that they are more likely to begin school ready to learn, and this greater readiness provides cumulative advantages in achieving social competence. These children are often rated higher by classroom teachers, are more likely to attend magnet schools, are less likely to be retained, and are less likely to change schools. This process is central to the theory behind the CPC program in which the stability of early childhood learning environment provides later opportunities for cognitive and social development. These initial differences between groups at school entry that culminate in long-term performance advantages illustrate the Matthew effects (Walberg & Tsai, 1983), the process of how early advantages grow over time into larger advantages. Avoidance of grade retention after the end of the intervention also contributed to long-term effects early through cognitive status. Grade retention is a major predictor of school dropout (Shepard & Smith, 1989; Temple et al., 2000).

However, a key finding of the study is that as important as the cognitive advantage hypothesis continues to be in the transmission of effects, the school and family support hypotheses contributed more to the explanation of the effects on juvenile arrest and about as much to educational attainment. The cognitive advantage hypothesis had a greater impact on earlier child outcomes, such as school achievement (Reynolds, 2000; Reynolds et al., 1996). It is not surprising that as the spheres of influence expand during adolescence, the mediators would be more diffuse and there would be less dependency on early cognitive development.

Thus, for long-term outcomes such as educational attainment, the cognitive advantage hypothesis, when considered with other hypotheses, is only one

of several explanations. Of course, the ordering of hypotheses may differ by program. The cognitive advantage hypothesis, for example, appears to have a greater role in the long-term effects in the Perry Preschool Study and the Abecedarian Project than in the CPCs. This could be due to the different constellations of services provided by the programs; the CPCs provide more comprehensive family and school-based services. It could also be due to the differences in models used to investigate mediation. Studies of the Abecedarian Project have been limited to the cognitive advantage hypothesis. The Perry Preschool Study has investigated several hypotheses but not school support. The increasing complexity in understanding the sources of intervention effects warrants greater attention to alternative models.

The strong support for the school support hypothesis in accounting for the long-term effects of preschool participation is a major finding of the study. Both attendance in magnet elementary schools and avoidance of school mobility were significant mediators of the link between preschool and high school completion even after the influence of other mediators was taken into account. This study is the first to link directly the long-term effects of participation with the quality of schools. Findings support the ecological perspective that the maintenance of effects is significantly dependent on the quality of the postprogram learning environment. These findings are largely consistent with those in the age 15 follow-up study of the Chicago project in which Reynolds (2000) found that school quality mediated the effects of preschool on school achievement and on school-reported delinquency infractions. The difference in the present study is that school support experiences contributed more to the later measures of educational attainment and juvenile arrest than did the other mediators. The important contribution of schools to the long-term effects of early childhood intervention has been corroborated by Currie and Thomas (2000) and Lee and Loeb (1995), who found that achievement gains from participation in Head Start faded over time, due in part to attendance in lower quality schools. The benefits of school support are not limited to measures of school quality because participation that extends into the primary grades provides educational advantages and promotes the stability of intervention effects (Reynolds & Temple, 1998).

Why did attendance in magnet schools mediate the impact of preschool participation on delinquency so substantially? As a measure of school quality, magnet school attendance accounted for nearly half of the main effect of preschool participation on juvenile arrest. Students that attend high-quality schools benefit in several ways. Because of the greater opportunities to learn and higher expectations of performance, students on average learn more in high-quality schools than in lower quality schools. Magnet schools and other selective schools also have a higher proportion of students that are performing above the national norms and place high value on school success (Gamoran, 1996; Wang, Haertel, & Walberg, 1993). Consequently, not only is the learning environment more supportive of academic and prosocial behavior, which reduces the likelihood of behavioral problems, but the peer environment is more likely to nurture prosocial behavior and reduce association with peers engaging in antisocial behavior. We note that although the positive impact of magnet school attendance is partly academic and partly social, these findings occurred after taking into account the influence of the other hypotheses, such as cognitive advantage and family support. Thus, our comprehensive model substantially reduces the likelihood that our findings are due to selection.

As expected, the family support hypothesis played a significant role in explaining the long-term effects of preschool participation. Extending on previous studies in the CLS demonstrating that parent involvement in children's education mediates the effects of participation on school achievement, remedial education, and school infractions (Reynolds, 2000; Reynolds et al., 1996), our findings reveal that parent involvement is a major mechanism of effects leading to school completion and delinquency prevention. Through an intensive parent program in the centers, CPC intervention encourages parent involvement in school and in children's education so that when the intervention ends parents are more likely to continue to provide the nurturance and support necessary to maintain benefits, which makes later school attainment more likely and antisocial behavior less likely. That parent involvement directly predicted the rate of juvenile arrest is especially significant because this has not been documented previously. Parent involvement is a frequent predictor of educational outcomes (Fan & Chen, 2001). In the High/Scope Perry Preschool Study (Barnett et al., 1998), parent involvement was an independent predictor of later educational attainment but did not mediate the effects of preschool. Nevertheless, family support was a major component of the program through biweekly home visits. Indeed, the only early childhood programs that have shown effectiveness in preventing delinquency are interventions that have significant family support components (Yoshikawa, 1995; Zigler et al., 1992). Our findings indicate that

school-based parent involvement provides another avenue to enhance family support behaviors.

Finally, findings showed some support for the social adjustment and motivational advantage hypotheses in mediating the long-term effects of intervention. That teacher ratings of social adjustment in the classroom partially mediated the effects of program participation on high school completion and delinquency indicates that they play a role in the transmission of long-term effects. Indeed, the overall model fit was best when both social adjustment and motivational measures were included. Classroom adjustment was predicted by kindergarten achievement and operated through school commitment to affect school completion and delinquency. Thus, social adjustment is a significant link between cognitive advantage and motivational development in adolescence (Barnett et al., 1998; Reynolds, 2000).

The motivational advantage hypothesis also contributed to the outcomes. It is not surprising that our measure of motivation—youth commitment to school—directly predicted juvenile arrest. Links to educational attainment were weaker. It also partially mediated the impact of preschool on juvenile arrest, which has not been found previously. The contribution of motivation is greater in this study than in the age 15 follow-up study that examined the processes leading to school achievement. In the present study, early literacy and classroom adjustment led to higher school commitment, which in turn predicted school completion and delinquency. These findings demonstrate that indicators of motivation are not only important determinants of youth outcomes but help mediate the effects of early childhood experiences (Seitz, Apfel, Rosenbaum, & Zigler, 1983; Zigler & Berman, 1983). Additional measures of social adjustment and motivation from peer relations to self-efficacy deserve investigation.

Limitations

Our findings should be viewed in the context of four limitations. First, as with all studies using SEM techniques, the pattern of results is correlational. Strong causal inferences concerning the estimated direct effects and the mediators of preschool impact should be avoided. At best, our findings demonstrate that the hypothesized mediators contribute substantially to the explanation of the link between preschool participation and children's later educational and social development. In addition, it is possible that models including other mediators may fit the data as well or better than the models we tested (Byrne, 1998). We did not attempt to identify superordinate mediators such as responsiveness to the environment or micro-level factors such as information processing or family interaction mechanisms that may ''mediate'' the mediators. Both kinds of processes should be investigated in future studies.

Nevertheless, we tested a comprehensive set of mediators that have been identified over the past three decades. Their influence was estimated jointly. We followed a confirmatory approach to model estimation that strengthens causal inference. We are aware of no other studies that have examined five sets of hypotheses of the long-term effects of preschool. Models with additional variables did not have improved fit. Thus, confidence is high that our findings are valid explanations for the estimated effects of preschool intervention.

A second limitation is that indicators of some of the intervention hypotheses were defined narrowly. Parent involvement in school is only one of many dimensions of family support behavior. School commitment also is part of a larger constellation of indicators of motivation, self-perceptions, and commitment to learning. In future studies, direct measures of parent–child interactions and a wider array of indicators of motivation and social adjustment (e.g., peer relations) will complement and extend those in our study. Motivation and social adjustment are difficult to separate from cognitive development. Multiple indicators of latent variables also should be investigated. On the positive side, we used measures that were strongly connected to the theory of the CPC program and that had empirical support as potential mediators. Our findings also accounted for measurement errors among variables. Moreover, the use of alternative measures of motivation, including expectations for educational attainment, led to a pattern of findings that was similar to that reported here.

A third limitation is that the validity of the demonstrated main effect link between program participation and long-term outcomes is based on an alternative-intervention, quasi-experimental design. Potential threats to internal validity are more difficult to rule out in quasi-experimental designs than in experimental designs, even when the comparison group, as in our study, participated in an alternative kindergarten intervention (treatment as usual). Two sets of findings strengthen the validity of results, however. First, our findings that the cognitive advantage, family support, and school support hypotheses accounted for most of the long-term effects of CPC participation are consistent with the theory of the program. A major tenet of CPE, and of causal inference more generally, is that identification of the mechanisms linking explanatory and outcome

variables strengthens validity (Bunge, 1997; Rosenbaum, 1995). Second, findings in this study and in many previous reports of the CLS using contemporary techniques of bias reduction, ranging from econometric simultaneous equation modeling to latent-variable structural modeling, show no evidence of selection bias associated with group assignment or attrition (Reynolds, 2000; Reynolds & Temple, 1995, 1998; Reynolds et al., 2002; Temple et al., 2000).

A final limitation is that findings of our study may have limited generalizability. Our sample included low-income, minority children in a large urban school district. The extent to which our findings directly apply to broader populations and subgroups, different programs, and social contexts needs further study. Moreover, we investigated only educational attainment and delinquency and variants of these measures. Extensions to economic well-being and broader measures of social development are warranted. Judging from previous reports in our study (Reynolds, 2000; Reynolds et al., 1996) and in other studies (Barnett et al., 1998; Consortium for Longitudinal Studies, 1983), the five hypotheses are inclusive enough to be likely contributors to a wide range of outcomes.

Implications

The findings of this study indicate that the long-term effects of early childhood intervention were traceable to a combination of school support, cognitive scholastic, family support experiences. The widely held belief that enhanced cognitive skills are the sole or primary source of effects was not supported. Although the mechanisms are complex, factors influencing the long-term effects of intervention can be modified by educators, parents, and policymakers. Policy initiatives that encourage the identified factors and processes are likely to benefit children's development. Alternatively, if family and school experiences after the end of intervention are not of sufficient quality, the long-term effects of intervention will be less likely to occur (Currie & Thomas, 2000; Lee & Loeb, 1995). As shown in Figures 2 and 3, for example, school mobility, grade retention, and low parent involvement during the intervening years reduced the transmission of effects to school completion. School commitment also contributed to lower delinquency.

Given that federal and state investments in early education continue to increase (U.S. General Accounting Office, 1999), progress in several areas deserve attention. Because of the importance of entering kindergarten with good literacy skills, improving the quality of preschool programs and increasing their length would be expected to strengthen the paths leading to long-term educational and social performance. As a public school program, teachers in the CPCs have bachelor's degrees with certificates in early childhood. Participation begins at age 3, and the program has an integrated kindergarten component. The philosophy of the education component is to learn basic skills. These features are key to the 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 a variety of activities inside and outside the centers. A school-community representative also conducts outreach. Most early childhood programs do not provide this intensity of services to families, yet it appears to be a major source of long-term effects.

Finally, improvements in the quality of elementary schools are likely to encourage the transmission of long-term effects of early intervention. These changes would extend beyond improving school performance to promoting positive learning environments through models such as the Schools of the 21st Century (Zigler & Styfco, 1993) and School Development Program (Comer, Ben-Avie, Haynes, & Joyner, 1999). Reduced class sizes in the early elementary grades also have been shown especially to benefit low-income children (Krueger, 1997; Mosteller, 1995). To promote smooth transitions, the school-age component of the CPCs provides reduced class sizes and continuing family support activities in elementary schools. This participation after preschool and kindergarten is associated with greater school success (Reynolds & Temple, 1998).

The next step for research is to examine the processes by which children in different programs and with different attributes benefit from early education with our model and others. Continued identification of the program features and environmental conditions that promote success will help ensure that the benefits of early intervention endure.

Appendix A

Correlation Matrix for Observed Variables in the Structural Model for High School Completion (N = 1,286) and Juvenile Arrest (N = 1,404)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Preschool	**1.00**	.020	.004	.070	.290	.110	.170	− .124	− .187	− .237	.347	.122	− .170
2. Race/ethnicity	.036	**1.00**	.096	.038	.045	− .139	-.069	.030	.035	.015	.102	− .016	.062
3. Risk index	.023	.097	**.95**	.011	− .107	− .169	-.120	.072	.164	.089	− .190	− .043	.122
4. Gender	.086	.027	.019	**1.00**	.095	.213	.122	.025	− .256	− .076	.153	.144	− .455
5. ITBS word analysis (kindergarten)	.304	.034	− .103	.090	**.86**	.325	.200	− .048	− .426	− .166	.310	.175	− .144
6. Classroom adjustment	.120	− .160	− .159	.214	.322	**.90**	.369	− .063	− .471	− .176	.135	.316	− .213
7. Parent participation	.175	− .074	− .099	.099	.189	.365	**.90**	− .265	− .314	− .322	.203	.185	− .232
8. Abuse/neglect	− .133	.043	.074	.028	− .057	− .074	− .243	**.90**	.079	.208	− .299	− .087	.167
9. Retention	− .223	.043	.161	− .246	− .433	− .488	− .322	.101	**.95**	.266	− .382	− .222	.252
10. School mobility	− .239	.023	.102	− .075	− .181	− .193	− .325	.207	.291	**.95**	− .295	− .106	.204
11. Magnet school attendance	.347	.090	− .199	.180	.324	.130	.191	− .287	− .427	− .290	**.90**	.019	− .308
12. School commitment	.122	− .021	− .044	.130	.175	.317	.175	− .075	− .217	− .104	.030	**.80**	− .218
13. High school completion	.131	− .083	− .174	.208	.217	.345	.308	− .239	− .398	− .311	.335	.190	**.95**
Preschool group for high school completion: (*N* = 1,286).													
M		.94	3.22	.53	65.96	19.26	1.80	.05	.23	.81	.14	52.12	.56
(*SD*)		(.24)	(1.41)	(.50)	(12.89)	(5.34)	(1.43)	(.21)	(.42)	(.92)	(.35)	(6.13)	(.50)
No preschool group													
M		.93	3.16	.46	59.31	18.22	1.42	.07	.36	1.17	.05	50.72	.47
(*SD*)		(.26)	(1.53)	(.50)	(13.19)	(5.27)	(1.28)	(.26)	(.48)	(1.09)	(.21)	(6.06)	(.50)
Preschool group for juvenile arrest (*N* = 1,404)													
M		.94	3.21	.52	65.87	19.27	1.77	.05	.24	.84	.14	52.05	.17
(*SD*)		(.25)	(1.42)	(.50)	(12.87)	(5.42)	(1.42)	(.21)	(.43)	(.92)	(.34)	(6.14)	(.38)
No preschool group													
M		.93	3.20	.46	59.51	18.32	1.41	.07	.34	1.19	.05	50.66	.25
(*SD*)		(.26)	(1.51)	(.50)	(13.32)	(5.23)	(1.27)	(.25)	(.48)	(1.06)	(.21)	(6.10)	(.43)

Note. The upper diagonal matrix is correlation for juvenile arrest, and the lower diagonal matrix is correlation for high school completion. With the exception of race/ethnicity, gender, magnet school attendance, and continuous variables (which were estimated as Pearson's correlations), 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 Chicago Longitudinal Study reliabilities.

Appendix B

Main Effects of Program on Outcomes from Alternative Models

Outcome	*N*	CPC preschool	No CPCpreschool	Diff.
High school completion				
Age 20 (September 2000), %[a]	1,286	56.1	47.3	8.8**
Age 20 (September 2000), %[b]	1,286	55.3	47.3	8.0**
Age 21 (March 2001), %[a]	1,314	62.2	51.8	10.4**
Age 21 (March 2001), %[b]	1,314	69.0	51.8	17.2**
Age 21 (September 2001), %[a]	1,315	63.7	53.7	10.0**
Age 21 (September 2001), %[b]	1,315	70.5	53.7	16.8**
Highest grade completed				
Age 20 (September 2000)[a]	1,265	11.09	10.76	0.33**
Age 20 (September 2000)[b]	1,265	11.03	10.76	0.27**
Age 21 (March 2001)[a]	1,295	11.25	10.91	0.34**
Age 21 (March 2001)[b]	1,295	11.33	10.91	0.42**
Age 21 (September 2001)[a]	1,296	11.25	10.91	0.34**
Age 21 (September 2001)[b]	1,296	11.33	10.91	0.42**
Juvenile arrest by age 18				
Any, %[a]	1,404	12.9	21.7	− 8.8**
Any, %[b]	1,404	11.0	22.3	− 10.7**
Any violent offense, %[a]	1,404	6.8	13.7	− 6.9**
Any violent offense, %[b]	1,404	—	—	—
Total number[a]	1,404	.43	.77	− .34**
Total number[b]	1,404	.39	.77	− .38**

Note. CPC = Child-Parent Center.
[a]Adjusted for gender, single parent, free lunch eligibility, parent education, number of children, race/ethnicity, school-age participation, and program sites.
[b]Adjusted for same covariates as Model A; except for program sites, measurement errors were accounted by LISREL. Except for highest grade completion, all effects from model a were estimated by probit regression or negative binomial regression (total number of arrest).
**$p < .01$.

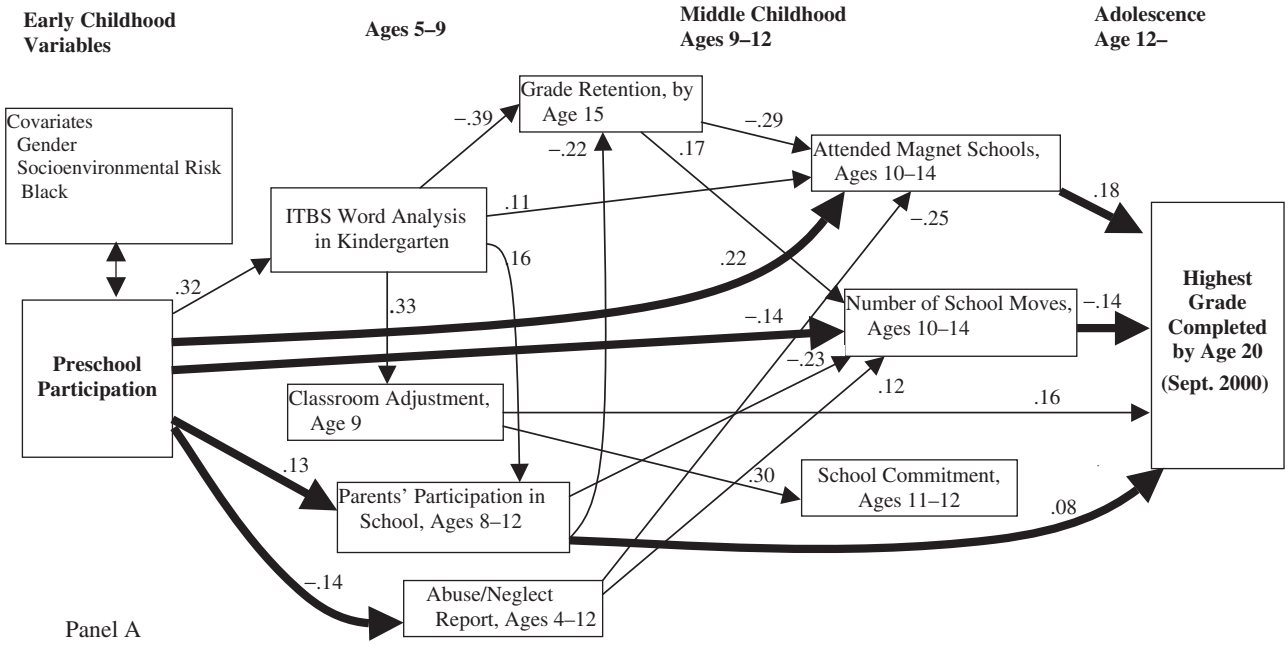
Appendix C

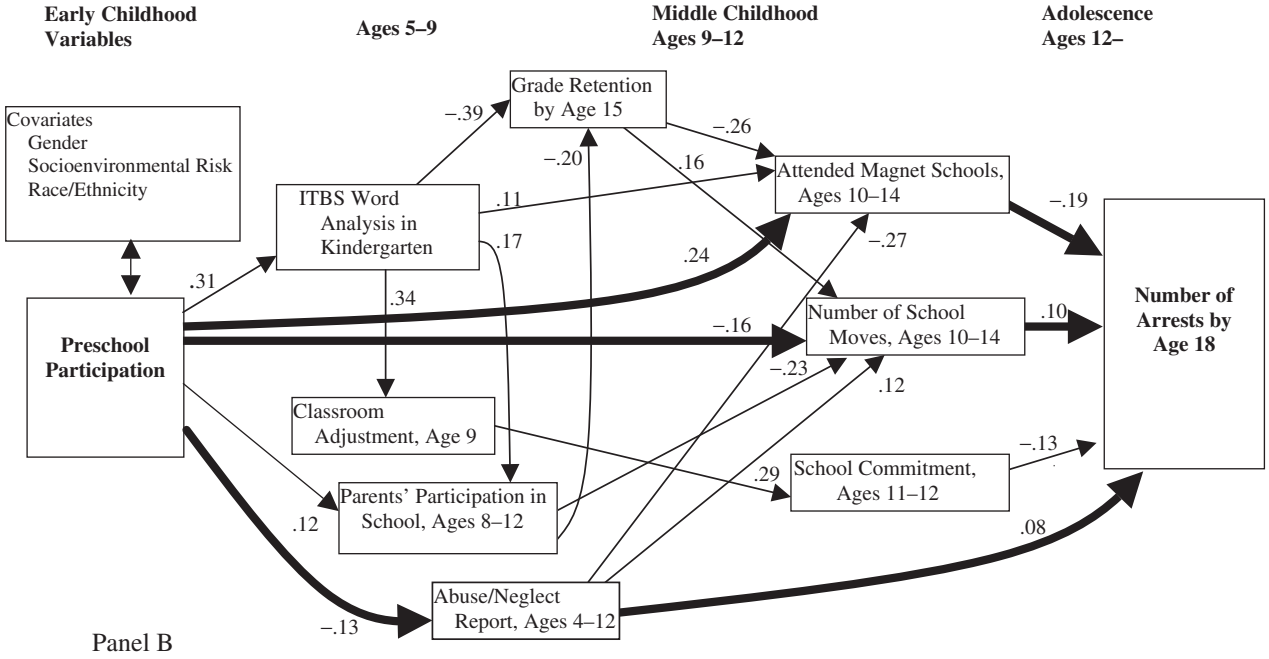
Total Indirect Effects of Program Indicators for Outcomes From Alternative Models

Key pathway	Age 20 high school completion	Age 18 juvenile arrest
Preschool participation	0.14**	− 0.09**
Percentage due to:		
Family support	23.4	24.1
School support	26	54.8
Cognitive advantage	28.4	18.5
Motivation advantage	5.5	11.0
Social adjustment	0.4	0.0
Total	83.7	108.4
Fit statistics	RMSEA = .065 AGFI = .916	RMSEA = .060 AGFI = .927

Note. Social adjustment is not significant for either high school completion or juvenile arrest. In the alternative models, individual risk indicators were used. RMSEA = root mean square error of approximation; AGFI = adjusted goodness-of-fit index.
**$p < .01$.

Appendix D





Panel A: LISREL mediation model for highest grade completed, coefficients standardized and adjusted for measurement errors. $R^2 = .26$; root mean square error of approximation = 0.054; adjusted goodness-of-fit index = 0.95. Panel B: LISREL mediation model for number of arrests by age 18, coefficients standardized and adjusted for measurement errors. $R^2 = .36$; root mean square error of approximation = 0.048; adjusted goodness-of-fit index = 0.96. ITBS = Iowa Test of Basic Skills. All covariates have paths to program participation, mediators, and developmental outcomes. To simplify the figure, those paths are not shown except for the path to program participation.

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