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Pathways of long-term effects of an early intervention program on educational attainment: Findings from the Chicago longitudinal study

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Abstract

The present study investigated pathways that might explain the observed linkage between participation in early intervention programs and later educational attainment using a sample from the Chicago Longitudinal Study, an on-going investigation of low-income minority children growing up in high-poverty neighborhoods in Chicago. A review of literature on pathways of early intervention programs on educational attainment was provided. Five mechanisms derived from previous studies, i.e., cognitive advantage, family support, social adjustment, motivational advantage, and school support, were investigated as predictors of educational attainment at age 22 years. LISREL analyses revealed that the relation between participation in the Chicago Child–Parent Center (CPC) program in early childhood and subsequent educational attainment was best predicted by cognitive advantage effects, followed by family support and school support effects. The findings indicated that environmental factors, such as family and school, as well as personal characteristics that may be affected by the intervention, play important roles in predicting educational outcomes. The discussion focuses on how environmental factors such as promoting family-school partnerships and attention to family influences in early intervention programs might maintain and enhance the effects of early intervention so as to promote higher educational attainment much later in development.

Keywords: Pathways; Long-term intervention effects; Early intervention programs; Family; School; Educational attainment

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1. Introduction

Early intervention programs have been linked to better school achievement and higher educational attainment in many studies (e.g., Barnett, 1995; Campbell, Helms, Sparling, & Ramey, 1998; Reynolds, Temple, Robertson, & Mann, 2001). However, the pathways explaining the linkage between early intervention programs and educational attainment have only been studied recently. The present study investigated these processes using a sample from the Chicago Longitudinal Study (CLS), an ongoing investigation of the social, academic, and economic adjustment of a panel of low-income minority children growing up in high-poverty neighborhoods in Chicago.

The present study is unique from three perspectives. First, this study provided a comprehensive review regarding pathways of effects of early intervention programs on subsequent educational attainment. Although mechanisms and pathways through which the effects of early childhood intervention promote long-term success have been discussed and examined in some studies, findings and hypotheses are scattered. Several comprehensive reviews have provided information regarding various effects of early childhood intervention (e.g., Barnett, 1995; Farran, 1990, 2000; Guralnick, 1997; Reynolds, Mann, Miedel, & Smokowski, 1997), but an investigation of the mechanisms and pathways of effects of early childhood intervention on later educational attainment has not been reported. Second, instead of testing a single hypothesis regarding effects as previous studies have done, a comprehensive framework including multiple hypotheses was provided and tested in the present study. These hypotheses, derived from previous research, were tested simultaneously in a structural equation model. Finally, unlike previous studies that focused on model programs, a large-scale public program was examined in the present study.

1.1. Pathways of effects of early intervention programs

Significant associations between participation in early intervention programs and positive outcomes, such as school competence and achievement, have been demonstrated (Barnett, 1995; Barnett, Young, & Schweinhart, 1998; Bryant & Maxwell, 1997; Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2001; Campbell, Ramey, Pungello, Sparling, & Miller-Johnson, 2002; Ou & Reynolds, 2004; Reynolds, Mavrogenes, Bezruczko, & Hagemann, 1996; Reynolds et al., 2001). Such evident associations are prerequisites for exploring the pathways that link the program efforts with subsequent achievements, that is, how the effects of interventions occur and what factors mediate the associations between the intervention and the anticipated outcomes. Research from four early childhood intervention projects, the High/Scope Perry Preschool Program, the Carolina Abecedarian Project, the Chicago Child–Parent Center program, and the Consortium for Longitudinal Study, have provided rationales and findings that suggest some hypotheses concerning possible pathways of effects of high quality early intervention on later outcomes.

1.1.1. High/Scope Perry Preschool Program

The High/Scope Perry Preschool Program is a model program. Model programs are conducted in a single site to demonstrate benefits for the first time. They are subject to more intensive supervision than large-scale programs. Thus, they are usually of better quality than large-scale programs. Studies on model programs typically use an experimental design and have fewer than 500 participants. Large-scale programs, on the other hand, usually are conducted in multiple sites,

employ quasi-experimental designs, and have hundreds of participants (Oden, Schweinhart, & Weikart, 2000).

The participants of the High/Scope Perry Preschool Program have been followed longitudinally since 1962, and long-term effects at different ages have been found (Berrueta-Clement, Schweinhart, Barnett, Epstein, & Weikart, 1984; Schweinhart, Barnes, & Weikart, 1993; Schweinhart & Weikart, 1980, 1997). In the early 1980s researchers started to propose pathways for effects of the High/Scope Perry Preschool Program on subsequent developmental outcomes. Schweinhart & Weikart (1980) proposed a causal model to explain the associations between participation in the preschool program and subsequent school achievement and delinquency offenses at age 15. In that model, cognitive ability was the only pathway proposed and supported for the outcome of school achievement. Berrueta-Clement et al. (1984) used a similar multiple regression model to examine predictors of outcomes at age 19. Their findings linked participation in the preschool program to cognitive ability, which in turn predicted highest grade completed at age 19. In later models commitment to schooling and/or school motivation were used as outcomes of the preschool program participation and served as the link to school achievement, i.e., highest grade completed (Berrueta-Clement et al., 1984; Schweinhart et al., 1993).

Barnett et al. (1998) departed from these earlier models of the 1980s that focused only on cognitive ability as explanatory factors. They identified four different possible pathways of program effects on educational achievement: a socialization model, a parent involvement model, a teacher's expectation model, and the cognitive model. Each of those models was examined separately to explain how the High/Scope Perry Preschool Program was linked to subsequent educational attainment.

The socialization model assumed that preschool intervention influenced children's motivations and behaviors, which in turn led to improved test performance and more favorable assessments by teachers. The parent involvement model assumed that the preschool intervention influenced parents, e.g., affected parents' beliefs, expectations, and values regarding education for their children, which improved parenting practices; the improved parenting then had a positive impact on the children's educational attainment. The teacher's expectation model assumed that long-term effects were a result of teachers' altered expectations about the effects of participation in preschool programs. These three models (socialization, parent involvement, teacher expectation) of the pathways through which high quality preschool intervention is related to school attainment were not supported, but the cognitive model was supported as a pathway to long term school attainment.

The cognitive model predicted that preschool experience affected children's cognitive abilities, which then affected later cognitive abilities through impacts on learning. The increased cognitive abilities led to early academic success, which increased motivation, improved socialization, and increased parental expectations for long-term school success. This model suggests that cognitive abilities influence school success through socialization and parent involvement. The cognitive model has been supported in a number of studies (Barnett et al., 1998; Berrueta-Clement et al., 1984; Schweinhart & Weikart, 1980; Schweinhart et al., 1993).

One issue in all four models (the socialization, the parent involvement, the teacher's expectation, and the cognitive models) is that later IQ (age 9–11) was not linked directly to educational attainment (measured as highest grade completed at age 19), and it was linked directly to later achievement (age 9–11, California Achievement test scores) only in the cognitive model. This might need to be modified because positive relations between IQ and later achievement and educational attainment have been found in other studies (Herrnstein & Murray, 1996).

1.1.2. Carolina Abecedarian project

The Abecedarian Project is a model program similar to the High/Scope Perry Preschool Program. Although few studies have focused on pathways through which the Abecedarian Project predicted future outcomes for children, Campbell et al. (1998) discussed some hypotheses concerning pathways of possible effects based on previously observed patterns of multiple partial correlations. These hypotheses are consistent in many aspects with hypotheses proposed in other studies. First, they proposed that later academic success is built on a cognitive basis provided by early experience. This explanation is similar to the cognitive model applied in the Perry Preschool Study: early intervention programs enhance cognitive development, which then in turn affects later academic performance. Second, early home environment is related to later academic achievement, so improving home environment in early childhood by providing resources at home could make substantial differences for children. This connection is similar to the parent involvement model in the Perry Preschool Study. Parents' attitudes and behaviors toward learning or education might influence the home environment, because parents can be more or less supportive to learning, and parents can decide what learning materials will be provided at home. These factors can be mediating processes from infancy through adolescence.

Only the first model, the cognitive model, was tested and supported. Analyses indicated that cognitive performance explained approximately half of the effect of the program on later academic achievement (Campbell et al., 2001), and academic achievement mediated the effect of early intervention on educational attainment (Pungello & Poe, 2003).

1.1.3. Chicago Child–Parent Center (CPC) program

Unlike the High/Scope Perry Preschool Program or the Carolina Abecedarian Project, the Chicago Child–Parent Center (CPC) Program is a large-scale federally funded program. This longitudinal study has followed the participants of the CPC Program since 1985, and long-term effects have been presented for participants through age 21 (Reynolds, 1994, 1998a, 1998b, 2000; Reynolds & Temple, 1995, 1998; Reynolds, Temple, Robertson, & Mann, 2002; Temple, Reynolds, & Miedel, 2000). Reynolds began to examine the pathways that explain the association between participation in the CPC Program and school achievement in 1989. Early achievement and parent involvement were the main factors found to mediate the association between participation in the CPC Program and first grade school achievement (Reynolds, 1989, 1991). Other factors, such as cognitive ability, social adjustment, grade retention, special education placement, and school mobility, were included in subsequent studies to examine the pathways through which third grade and eighth grade school achievements were predicted (Reynolds, 1992).

In Reynolds et al. (1996), two hypotheses, cognitive advantage and family support, were proposed to examine the mechanisms through which the CPC program might affect outcomes for the participant children. Later, Reynolds proposed a comprehensive model, formulating five hypotheses: cognitive advantage, family support, school support, social adjustment, and motivational advantage (Reynolds, 1999, 2000, 2004; Reynolds et al., 2001; Reynolds, Ou, & Topitzes, 2004).

The cognitive advantage hypothesis predicted that the program affects early cognitive development, which in turn affects educational attainment. The cognitive advantage hypothesis was derived from the assumption that early childhood intervention improves disadvantaged children's intelligence, which in turn enhances their school performance. Although short-term gains in intelligence through early childhood education programs have been reported, the effects have been observed to fade soon after children exit the programs (Barnett, 1995; Lazar & Darlington, 1982; Lee & Loeb, 1995). Early childhood programs, however, have been associated with better school achievement beyond elementary schools (Barnett, 1995;

Woodhead, 1988). Children who were participants in early intervention programs were expected to start school with greater readiness to learn and with smaller gaps between their learning readiness and that of their more advantaged peers. This cognitive advantage hypothesis proposed as one explanation for outcomes for children in the CPC program was similar to the cognitive model of the High/Scope Perry Preschool Program and the Carolina Abecedarian Project; but the cognitive advantage hypothesis differed from the prior cognitive model in its specific focus on cognitive skills enhanced through the CPC program rather than on IQ scores as predictors of academic performance. Instead of improvement in intelligence, the cognitive advantage hypothesis was focused on those cognitive skills and scholastic development that were expected to affect future academic performance.

The family support hypothesis predicted that the early intervention program would enhance parenting practices, such as parent involvement in school, and further affect educational attainment. This hypothesis was similar to the parent involvement model in the High/Scope Perry Preschool Program and the home environment model in the Carolina Abecedarian project.

The school support hypothesis predicted that the early intervention program would increase the probability of children's attendance in good schools and would reduce the probability of subsequent school changes (mobility), and these would in turn affect educational attainment.

The social adjustment hypothesis predicted that the program would influence children's social development, such as socio-emotional adjustment. This social development would then improve the ultimate child's outcome—educational attainment.

The motivational advantage hypothesis predicted that the program would enhance children's motivational development, such as children's persistence, self-efficacy, perceived competence, and that increased motivation would influence educational attainment. The social adjustment and the motivational advantage hypotheses together are similar to the socialization model in the High/Scope Perry Preschool Program.

In early studies, results indicated that the factors of early cognitive ability, parent involvement, and social adjustment mediated the association between participation in the CPC Program and school achievement (Reynolds, 1989, 1991, 1992). Studies of educational attainment later in the child's life showed that cognitive advantage and the family support factors mediated the association between participation in the CPC Program, and school achievement at age 11 (6th grade) and grade retention at age 10 (5th grade) (Reynolds et al., 1996). All five hypotheses considered simultaneously were first examined in relation to school achievement at age 14 and high school dropout at age 19 (Reynolds, 1999). In both cases, cognitive advantage and family support were mediating variables in the associations between participation in the CPC Program and school achievement outcomes. School support mediated these associations as well.

More recent results (Reynolds, 2000; Reynolds et al., 2004) revealed that social adjustment and motivational advantage did not significantly mediate the effects of the CPC Program, but school support, family support and cognitive advantage significantly mediated the effects of the CPC Program. This is consistent with previous findings regarding the mechanisms of the CPC Program (Reynolds et al., 1996). The cognitive advantage hypothesis was the strongest mediator of effects of early intervention on child outcomes.

1.1.4. The Consortium for Longitudinal Studies

Although no specified model was examined in the Consortium Study, a preliminary hypothesis of a pathway of effects was presented (Royce, Darlington, & Murray, 1983). This hypothesis is similar to the

cognitive hypothesis proposed in studies previously reviewed: preschool programs enhance early development of intelligence, which then facilitates better school achievement and increases commitment to school, which thereby affects educational attainment.

As the research literature review has shown, the theory behind early intervention for economically disadvantaged children has been discussed and tested in some studies (Barnett et al., 1998; Berrueta-Clement et al., 1984; Campbell et al., 2001; Reynolds, 2000; Reynolds et al., 2001; Schweinhart et al., 1993; Schweinhart & Weikart, 1980, 1997). Several hypotheses explaining long-term effects of early intervention have been proposed and the two major hypotheses mentioned most often are the cognitive advantage hypothesis and the family support hypothesis. According to the former hypothesis, positive effects of preschool on cognitive development at school entry launch children toward positive scholastic development and commitment that facilitates improved developmental outcomes in adolescence and beyond. The cognitive advantage hypothesis has been consistently supported as a mechanism through which high quality early intervention affects outcomes, as measured by IQ scores and achievement scores. The latter hypothesis, family support, posits that positive long-term effects of interventions occur for children within families whose functioning has been improved. These hypotheses suggest that cognitive enhancement and parent involvement are important components of early intervention programs, which lead to positive long-term effects. In addition to the cognitive advantage and the family support hypotheses, other hypotheses have been proposed to explain the long-term effects of early intervention programs. Table 1 shows a summary of findings from previous studies that addressed this question. However, there have been few studies that examined such multiple hypotheses simultaneously in a single model. In the present study, the five hypotheses, cognitive advantage, family support, motivational advantage, social adjustment, and school support, were used as a framework for investigating how early intervention programs might affect subsequent educational outcomes.

1.2. Theoretical perspectives

Although these hypotheses have not been associated with specific theories, they are consistent with the ecological systems theory and the resiliency theory. These two theories, which emphasize the framework of person-within-context within a comprehensive developmental approach and individual differences in people's ability to overcome life obstacles, respectively, help explain how early childhood education intervention could affect long term outcomes.

The five hypotheses, cognitive advantage, family support, motivational advantage, social adjustment, and school support, cover different individual and environmental dimensions, which are consistent with ecological systems theory, because that theory specifies that one's environment influences proximal and distal development. That is, the magnitude of program effects will be a function of the interactions among the individual, family, and other environmental factors that directly impact on the child, and such functions could be mechanisms that mediate the associations between participation in early intervention programs and positive outcomes. According to the resiliency theory, individual responses to risk and protective factors influence developmental outcomes. A major focus of the resiliency theory is to identify protective mechanisms that lead one to overcome adversity and adjust successfully. Both theories provide insight into understanding predictors of educational attainment by identifying factors and processes that contribute to educational attainment for groups of children who are at risk, and thus, help to explain the mechanisms of long-term effects of early intervention programs on educational attainment. Therefore, they are applied in the present study.

Table 1
Summary findings of mediating processes on effects of early intervention programs

Studies/mediators (variables)	Sample and findings
High/Scope Perry Preschool Project (Barnett et al., 1998; Berrueta-Clement et al., 1984; Schweinhart & Weikart, 1980, 1997; Schweinhart et al., 1993)	*N* ranges from 108 to 123.
Cognitive model (Early and later IQ *z* scores on Stanford–Binet, and early and later Achievement scores on California Achievement Test)	Significant
Parent involvement model (Mother's participation: average of teacher ratings of a scale of parent involvement from kindergarten through third grade)	Not significant
Socialization model (Motivation: average of teacher ratings on a scale of child's academic motivation in kindergarten through third-grade; behavior: Average of teacher ratings on a scale of child's personal behavior in kindergarten through third-grade)	Not significant
Teacher's expectation model	Not tested
Abecedarian Project (Campbell et al., 1998; Campbell et al., 2001; Pungello & Poe, 2003; Ramey, Campbell, and Ramey, 1999)	*N* = 104
Cognitive model (IQ scores on Stanford-Binet at ages 3 and 4, Wechsler Intelligence Scale for Children—Revised at ages 6.5, 8, 12, and 15, and test scores on Woodcock–Johnson Psycho-Educational Battery at ages 8, 12, and 15)	Significant
Home environment model	Not tested
Chicago Child–Parent Center (Reynolds, 1989, 1991, 1992, 1999, 2000; Reynolds et al., 1996, 2004)	*N* ranges from 391 to 1539
Cognitive advantaged hypothesis (ITBS scores at age 5 and age 9, and grade retention)	Significant
Family support hypothesis (Parents and teachers' rating of parent participation in school from ages 8 to 12, and incidence of child abuse/neglect from age 4–12)	Significant
Social adjustment hypothesis (Teacher rating of classroom adjustment at age 9)	Not significant
Motivational advantage hypothesis (Child ratings of perceived school competence at age 9, students' expectation to attend college, and school commitment at age 10 or 15)	Not significant
School support hypothesis (Number of years of participation in schools with a relatively large proportion of students performing at national norms between ages 10–14 and number of times the participants changed schools between ages 10–13)	Significant
The Consortium for Longitudinal Studies (Royce et al., 1983)	
Cognitive hypothesis	Not tested

Note. Measures used in the studies are included in parentheses under each hypothesis.

1.2.1. Ecological systems theory

A full elaboration of Bronfenbrenner's (1979, 1986a, 1986b) ecological systems theory is beyond the scope of this paper, but it is important to emphasize that this perspective suggests that features of the individual, family, and the environment, and interactions among them, all influence a child's development. Educational attainment is a socio-psychological phenomenon rather than an intellectual achievement within this framework.

The five hypothesized pathways through which early intervention affects educational attainment can be understood through this theory. For example, when we think of the child, some types of personal characteristics are related to educational attainment. Cognitive characteristics, such as intelligence, can place a person either in a better starting position or in a disadvantaged condition for educational attainment. However, high intelligence alone does not necessary lead to higher educational attainment because other environmental factors contribute to development as well. Rather than focusing solely on intellectual abilities children may be born with, the cognitive advantage hypothesis focuses on enhancing cognitive development through early childhood programs. In addition, some personal characteristics can promote resiliency so that a child might achieve higher educational attainment despite other disadvantaged conditions in their environment (to be addressed more fully in the section on resiliency theory). Such personal characteristics are consistent with the motivational advantage hypothesis, which suggests that increasing children's motivations, self-efficacy, or perceived competence will help them achieve higher educational attainment.

Second, resources in different aspects of the child's environment, such as family and school, interact with individual characteristics, to influence the developmental outcome – educational attainment. Shortages of resources in families might place children at risk of delayed development. For example, economic hardship might cause the family to lack materials that could inspire the children's learning, such as books, or might mean that parents do not have enough time to interact with their children or might neglect their children. Such interaction effects can be derived from hypotheses proposed in the literature to explain differences in educational attainment, such as social adjustment, family support, and hypotheses about the role of school support.

The factors contributing to educational attainment come from different sources, such as parents, personal features, and school policy. The overall impact of the environment emerges from the dynamic balance among all levels of influence. Early intervention programs mainly aim at enhancing the development of children's cognitive skills and family functioning. According to the ecological systems theory, cognitive advantage should not be the only explanation for the association between participation in early intervention programs and higher educational attainment. Other factors in the environment should provide explanatory power as well.

1.2.2. Resiliency theory

The resiliency theory has been increasingly useful in educational approaches addressing positive outcomes for disadvantaged children. Derived from psychopathology, the theory was developed to explain observations that some children exposed to adverse conditions who were at risk for poor developmental outcomes showed little or no sign of developmental impairment (Garmezy, 1985; Masten, 1987, 2001; Masten & Coatsworth, 1998; Masten & Garmezy, 1985; Peng, 1994; Rutter, 1979; Wang, Haertel, & Walberg, 1994). According to the resiliency theory, educational attainment results from interactions among several factors, including the individual's vulnerability, risk factors, and protective factors. This is similar to the ecological systems theory in that it emphasizes interactions among factors in environment.

Individuals differ in vulnerability. Some characteristics, such as low intelligence and low self-esteem, make it easier for one child than another to fail in school. In addition, the presence of environmental risk factors increases the likelihood of school failure. For example, a person living in poverty or having many siblings might be more likely to fail in school than others who do not have these risks. Multiple/

cumulative risk factors can greatly increase the likelihood of dropping out of school. However, protective factors may reduce negative impacts of risk factors on educational attainment and even change a risk trajectory into a protective one. A positive disposition, a strong social support system, or a harmonious family environment are examples of protective factors that can mitigate risk effects. For example, a good extended support system might help a child overcome difficulties such as problems with teachers in school or a bad grade. Early intervention programs can be considered to be protective factors for children in at-risk groups. The five hypotheses reviewed earlier can be viewed as protective mechanisms.

For instance, school factors can play an important role in heightening risk or in increasing protection of at-risk children (Garmezy, 1991; Rutter, 1979). Positive school factors, such as school climate or teacher expectations, can serve as protective factors for students when they face adverse family situations. Such factors also serve as predictors of higher educational attainment. Furthermore, the cumulative effects of these school factors will influence the quality of school functioning (Garmezy, 1991). Therefore, when these factors are present, the likelihood of higher educational attainment might increase; but when these factors are absent, the likelihood of higher educational attainment might decrease.

The resiliency theory addresses individual differences in developmental paths, as well as interactions between individual characteristics and the environment during development. Researchers have used the resiliency theory to determine risk factors, that is, characteristics that are associated with a high possibility of negative outcomes, and protective factors, characteristics that facilitate better outcomes (Masten, 1994). Risk and protective factors can concern the individual, the family, or the context of schools or communities. Targeting enhanced cognitive development, the significant association between participation in early intervention programs and higher educational attainment allow us to treat early intervention programs as protective factors, factors that can initiate protective mechanisms that may change a developmental trajectory.

1.3. Chicago Child–Parent Center (CPC) program and the five hypotheses

In the present study, a hypothesized model based on the five aspects of cognitive advantage, family support, social adjustment, motivational advantage, and school support, potential mediators of the effects of the Child–Parent Center (CPC) program on educational attainment was tested. The components and features of the CPC Program are discussed here because they represent the rationale behind the CPC Program. These components thus provide connections between the program and the five hypotheses.

The CPC Program is a center-based early intervention that serves three- and four-year-olds who come from families in high-poverty neighborhoods that are not being served by Head Start or other early intervention programs. The CPC program was designed to promote children's school competence, especially school readiness and academic achievement, and the services are provided to children from the preschool years to early elementary school. The components of the CPC Program include parental involvement, comprehensive services and a child-centered focus on the development of reading/language skills (Reynolds et al. 1996; Sullivan, 1971). Currently, the CPC program is conducted in 24 centers throughout the Chicago public schools. Eighteen centers are located in separate buildings close to the elementary school, and six are attached to the wings of the parent elementary school (Reynolds, 2000).

The CPCs have three important features. First, they are part of the school system, in contrast to Head Start programs that usually link to social service or community agencies. Second, eligibility for the CPCs is based on neighborhood poverty, while for Head Start it is based on family-level poverty. CPCs are located in the highest poverty neighborhoods. Therefore, the participants might be more disadvantaged than participants in other programs. Finally, the CPCs provide services for up to six years for children from ages 3 to 9, whereas Head Start provides only preschool programs. Therefore, the CPC program has the potential to provide a stable school environment during preschool and the early primary-grade years (Reynolds, 2000).

The components of the CPC program include a structured half-day preschool program for three- and four-year-olds, a half-day or an all-day kindergarten program for five-year-olds, with a child-centered focus on the development of reading/language skills, literacy skills, and other family support services. The centers operate on the regular nine-month school year calendar. An eight-week summer program is also provided. The program is offered in different sites; however, it has no uniform curriculum. Each site tailors its program to children's needs through a unified philosophy of literacy and a common core of activities that include individualized instruction, small group activities, and field trips.

A central assumption of the program is that parental involvement is an important socializing force in young children's development. Parents are required to be involved in the center at least one half-day per week. Involvement may include a wide variety of activities, such as parents volunteering as classroom aides, interacting with other parents in the center's parent resource room, participating in educational workshops and courses, attending school events, accompanying classes on field trips, and attending parent–teacher meetings on behalf of the child (Reynolds, 2000; Reynolds et al. 1996).

The CPC Program also provides comprehensive services, including outreach services (e.g., home visiting, resource mobilization, and parent conference) and health services (e.g., health screening, nursing services, and free or reduced price meals). The comprehensive services help to improve home environments, and hope to change the context in which the child lives, which might promote environmental stability as well.

The effect of preschool participation is conceptualized as a chain reaction with environmental factors rather than a direct effect on developmental outcomes. As Bronfenbrenner & Morris (1998) stated, "The degree of stability, consistency, and predictability over time in any element of the systems constituting the ecology of human development is critical for the effective operation of the system in question (p. 1020)". The effects of preschool participation are embedded in a broader context of family, community, and school processes rather than affect the children as isolated aspects of the environment (Woodhead, 1988). Consistent with the snowball hypothesis proposed for Head Start effects, it is presumed that any gain achieved in early childhood would be unlikely to last if such a gain cannot interact with a positive environment and result in chain effects (Zigler & Muenchow, 1992; Zigler & Styfco, 1993). The snowball hypothesis predicts that early intervention provides disadvantaged children with an advantage of enabling them to get along well with their teachers. Consequently, preschool graduates interact better with their kindergarten teachers than their peers. One positive experience such as this in turn leads to a better one at the next grade level, and the accumulation of slightly better experiences increases the child's chance of completing school. The snowball hypothesis can be applied to the association between parent–child interaction and later school completion as well. The cumulative effect of positive experiences (cumulative advantage) corresponds with the Matthew effect, which hypothesizes that early advantages children had from

either their family or educative experiences would help them perform better later and then lead to cumulative positive effects (Walberg & Tsai, 1983).

1.4. Hypothesized model

Fig. 1 presents the hypothesized model. The figure is presented in a time sequence from left to right: early childhood, ages 3–5, to adolescence, ages 18 and beyond. The boxes in the figure represent concepts, and indicators of concepts are listed in the boxes as well. The arrows indicate the relations among concepts. Because most indicators can either hinder or facilitate higher educational attainment, the particular direction of indicators in the model is not specified. Times of measurement suggest a unidirectional model, although Bronfenbrenner & Morris (1998) suggested two-way interactions. The sequence is arranged according to previous studies and the developmental sequence.

The model is based on the framework of cognitive advantage, social adjustment, family support, motivational advantage, and school support reviewed earlier. These represent five sets of mediators between high quality preschool participation and subsequent educational attainment, shown in the center boxes. The indicators of the hypotheses are shown under each mediator. The boxes on the extreme left and right represent covariates, preschool participation, and educational attainment. Overall, participation in early intervention programs was expected to be associated with all concepts in the model, and all other concepts were expected to be associated with educational attainment.

The model shows that starting with early childhood (age 3–5; on the left side), sociodemographic factors, including gender, social environmental risk, and race, serve as covariates in the model. According to the ecological systems theory, these factors, which reside in the organism, are personal characteristics and family resources. Factors such as being a member of a minority ethnic/racial group and living in a low socioeconomic status neighborhood could increase the risks that are associated with educational attainment (Alexander, Entwisle, & Horsey, 1997; Cairns, Cairns, & Neckerman, 1989; Rumberger & Larson, 1998; Steinberg, Blinde, & Chan, 1984). Sociodemographic factors are related to all other concepts in the model. To simplify the model, most of these relations are not shown in Fig. 1. The exception is the connection with participation in early intervention programs, which is displayed in the model. The association between sociodemographic factors and participation in early intervention programs exists because the eligibility of participation in early intervention programs usually depends on SES status. It is also possible that participation in early intervention programs decreases the socio-environmental risk over time.

Certain factors can mediate the effect of early intervention programs on educational attainment. Between the ages of 5 and 9, cognitive advantage (kindergarten achievement) resulting from participation in early intervention programs can influence family support, motivational advantage, school support, and educational attainment directly, as suggested by Barnett et al. (1998). One purpose of early intervention programs is to assist children in acquiring skills necessary to perform similarly to other children who are not at risk. Therefore, enhancement of cognitive development should be a major mechanism of long-term effects of early intervention programs on educational attainment.

Social adjustment is associated with school support, motivational advantage, and later measures of cognitive advantage. Participation in early intervention programs aims at helping children to be ready for school so they might show better adjustment after they enter school or have more motivation in

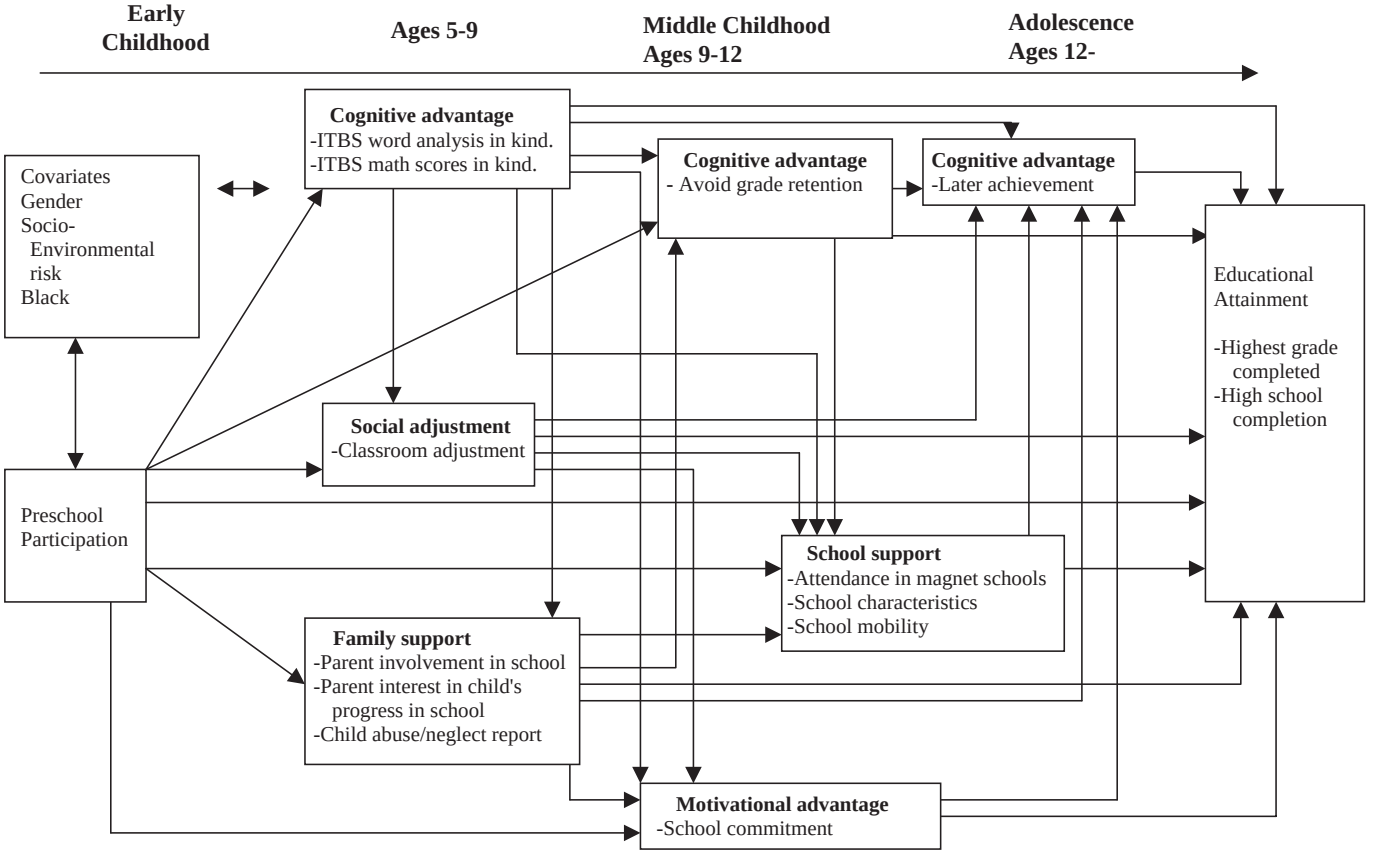

Fig. 1. Model of long-term effects of preschool participation on educational attainment. All covariates have paths to program participation, mediators, and outcome. To simplify the figure, those paths are not shown except for the path to program participation.

schooling. Also, family support is associated with motivational advantage and school support. Between ages 9 and 15, cognitive skills (grade retention and later achievement), motivational advantage, and factors of school support are associated with educational attainment.

A mediator explains how effects of programs on later outcomes occur, and it has to be associated significantly with both predictors and outcomes to qualify as a mediator. When a mediator is entered in a model, a previously significant relationship between predictors (independent variables) and outcomes (dependent variables) is no longer significant or is substantially reduced in size (Baron & Kenny, 1986). Therefore, there should be no direct pathway expected from participation in the CPC Program to educational attainment once mediators are entered into the model.

2. Method

2.1. Sample

The study sample was drawn from the Chicago Longitudinal Study (CLS, 1999; see Reynolds, 2000 for more details), an ongoing evaluation of the effects of the Chicago Child–Parent Center (CPC) Program. The original sample (N = 1539) included 989 children who entered the CPC program in preschool and graduated from kindergarten in 1985–1986 from 20 Child–Parent Centers, and 550 children (a comparison group) who came from five randomly selected Chicago public schools with kindergarten programs in 1985–1986 without CPC preschool experience. Because they lived in Title I eligible neighborhoods, all children in this cohort were eligible for and participated in government-funded early childhood programs. The study sample included 1334 youth (86.7% of the original sample) for whom educational attainment could be determined by May 2002 (mean age = 22.0, SD = .32, range = 20.9 − 23.4). This sample included 87.9% of the original CPC preschool group and 84.6% of the comparison group.

Table 2 shows the similarity of the study sample (N = 1334) attributes for the preschool group and the comparison group at the time of program entry or as soon afterwards as possible. Attributes include background information, such as gender, race, parents' educational attainment, and family structure. The p-values for the original sample are provided for comparison between the original sample and the study sample.

There were no significant differences between the CPC and the comparison groups in more than half of the attributes. But there were significant differences for some individual and family characteristics, such as gender, parents' education, and family size. There were also significant differences in one neighborhood indicator, percentage of children in the school area in which 60% or more of children resided in low-income families. In the original sample, there were significant differences between groups for those attributes as well, with the exception of gender differences. In the study sample, the CPC preschool group had a greater proportion of females than the comparison group, but in the original sample, numbers of females and males were evenly spilt. Parents were more likely to have completed high school at child's age 8 in the CPC preschool group than the comparison group, which was the same pattern observed in the original sample. The CPC group had a smaller average family size than the comparison group. In addition, the CPC group participants were more likely than children in the comparison group to live in a high poverty neighborhood, and the parents were more likely to be not employed by child's age 8.

Table 2
Characteristics of preschool group and comparison group ($N = 1334$)

Characteristics	N	CPC Preschool Group ($N = 869$)	No-Preschool Group ($N = 465$)	p-value	Original sample p-value
Percent females	1334	53.0	47.0	.031*	.100
Percent Black	1334	94.1	92.3	.187	.949
Family risk index (0–6) by child's age 8	1334	3.1	3.0	.565	.176
Percent either parent completed high school at child's age 8[a,c]	1110	59.3	53.7	.044*	.036*
Percent single parent by child's age 8[a]	1031	57.3	59.3	.542	.386
Percent parent not employed by child's age 8[a]	1029	59.7	53.3	.053	.039*
Percent ever reported receiving free lunch by child's age 8[a]	1317	73.3	69.4	.130	.080
Percent having 4 or more children at home[a]	1281	32.5	41.0	.002**	.002*
Percentage children in school area in which 60% or more of children reside in low-income families	1334	77.2	71.8	.030*	.037*
Percent of low-income families in school region	1334	66.5	66.8	.631	.146
Percent abuse/neglect report by child's age 3[b]	1334	1.04	0.86	.756	.704
Percent low birth weight	1273	7.1	9.8	.089	.084
Percent parent were teen at child's birth	1164	17.7	18.2	.851	.484
Percent missing data from parents' education or free lunch report	1334	5.4	6.7	.364	.008**

[a] Means reported before imputation for missing data.
[b] Data were from court records. The numbers for any indicated abuse or neglect from court or DCFS are as follows. Preschool group = 1.15%, comparison group = 2.58%, and p-value = .051.
[c] The numbers for percent either parent completed high school at child's birth are as follows: preschool group = 62.8%, comparison group = 54.9%, and p-value = .006.
* $p < .05$. ** $p < .01$.

2.2. Measures

2.2.1. Educational attainment

High school completion and highest grade completed were used as outcome measures in the present study. Data were obtained from administrative records in all schools that youth attended and were supplemented by interviews with family members. Data were also collected in schools youth were likely to attend.

2.2.1.1. High school completion. This dichotomously coded variable indicated whether youths completed their secondary education with an official diploma or were awarded a General Education Development (GED) credential by May 2002. All others were coded as non-completers. The reliability was set at .95 in the model.

2.2.1.2. Highest grade completed. This was coded as a continuous variable, ranging from 7 to 16. Obtaining a GED was coded 12, and college attendance was coded depending on credits that one earned. Thirty credits were treated as one year of college attendance. For example, 30 earned credits was coded 13, and 60 earned credits was coded 14. The sample size was 1315 due to missing values. The reliability was set at .90 in the model.

2.2.2. Explanatory variables

Table 3 presents descriptive information for each of explanatory variables. The correlations among the measures are provided in Appendix A.

2.2.2.1. Cognitive advantage. Researchers have used intellectual performance and test scores to measure cognitive skills. In the present study, measures for cognitive-scholastic development included three parts: cognitive skills in kindergarten, grade retention, and later school achievement.

Cognitive skills in kindergarten were measured through scores on the Iowa Test of Basic Skills (ITBS) word analysis and ITBS math subtest scores at age 6. The word analysis scale contained 35 items

Table 3
Descriptive statistics for study variables (N = 1334)

Variables	N	Age	Preschool group	Comparison group	Total	SD
			Mean	Mean	Mean	
Preschool participation	1334	5	1	0	.651	.48
Race	1334	5	.941	.923	.935	.24
Risk index	1334	8	3.07	3.02	3.05	1.53
Sex	1334	5	.53	.47	.51	.50
ITBS word analysis (K)	1330	6	65.98	59.46	63.71	13.40
ITBS math scores (K)	1330	6	58.89	52.41	56.65	14.89
Socio-emot. maturity(3–4)	1169	9–10	19.27	18.14	18.88	4.94
Parent participation in school	1334	8–12	1.77	1.41	1.65	1.38
Parent interests in child	1299	7–11	2.67	2.38	2.57	1.38
Abuse/ neglect	1334	4–12	.044	.071	.053	.22
Retention	1334	15	.229	.351	.271	.44
School mobility	1268	10–14	.82	1.18	.95	1.0
Magnet school attendance	1334	10–14	.138	.045	.106	.31
School characteristics	1175	11	.03	−.05	.00	.72
School commitment	1172	11–15	51.06	50.04	50.71	5.65
ITBS reading scores (8)	1254	14	147.10	140.26	144.75	22.01
ITBS math scores (8)	1254	14	149.46	143.59	147.43	18.38
Highest grade completed	1315	By 22	11.33	10.92	11.19	1.71
High school completion	1334	By 22	.658	.542	.618	.49

*If ITBS reading and math scores were missing in 8th grade, ITBS reading and math scores in 7th or 6th grade were used to estimate the scores in 8th grade.

evaluating pre-reading skills, such as letter–sound recognition and rhyming. The math subtest scale included 33 items assessing numbering, classification, and quantification. Internal consistency reliability (Cronbach's alpha) was .87 for word analysis and .82 for math test. Research has confirmed the measure's predictive validity for later achievement (Reynolds, 1989, 1991, 2000). These two indicators were significantly correlated with each other (r = .60).

Grade retention was defined dichotomously as whether or not the participant was ever retained in grade between kindergarten and grade 8 (ages 5 through 14), and was considered to be a later indicator of cognitive advantage. Participants who had ever been retained during this period were coded 1, and those never retained (continuously promoted) were coded 0.

Later school achievement was measured through ITBS reading and math scores in eighth grade. The reading test contained 58 items and emphasized understanding of text passages. Cronbach's alpha was .92. The math test consisted of 117 items that assessed conceptual domains, computation, and problem solving. Cronbach's alpha was .95 (Reynolds, 2000). The two ITBS scores were significantly correlated with each other (r = .78).

2.2.2.2. Family support. Factors in the family environment that can facilitate children's development are indicators of family support. In the present study, measures for family support included parent involvement and recorded incidences of child abuse/neglect. The two measures represent two different concepts of family support, one positive and one negative, so they were treated separately in the model rather than two indicators of one latent variable.

Two indicators were used for parent involvement: parent participation in school and parents' interest in child's progress. Parent involvement in school from grades 2 through 6 was assessed by both teacher and parent reports in order to minimize reporter bias. Teachers rated "parent's participation in school activities" in each of grades 2 to 6 using a scale that ranged from poor/not at all (1) to excellent/much (5). For subsequent analysis, the frequency of "average or better" ratings (a score of 3 or higher; Min. = 0, Max. = 5) was used. The parents responded to the item "How often do you participate in school activities?" in grades 2, 4 and 6, using a scale of 1 (less than monthly) to 3 (weekly or more). The average rating was computed. For parents who did not return surveys for one year, their single rating was used. For subsequent analyses, parent reports of participation consisted of a dummy measure that represented more than monthly participation.

For parents' interest in the child's progress, teachers rated the item "Parent's interest in the child's progress" in each of grades 1 to 5 from poor/not at all (1) to excellent/much (5). For subsequent analysis, the frequency of "average or better" ratings (Min. = 0, Max. = 5) was used. The correlation between the two indicators of parent participation and parent interest in the child's progress was significant (r = .60).

The other measure of family support was whether there was a substantiated juvenile court report of abuse or neglect during ages 4 to 12 (from 1984 to 1992). Data were collected through record searches at the juvenile court by researchers without knowledge of youths' program participation. Searches were repeated twice for 5% random samples and verified against computer records.

2.2.2.3. Social adjustment. Social-emotional adjustment to the school context was assessed using a six-item scale that teachers completed at grades 3 and 4. The items were: "concentrates on work," "follows direction," "is self-confident," "participates in group discussion," "gets along well with others," and "takes responsibility for actions." They were coded as poor/not at all (1) to excellent/very much (5) (Cronbach's alpha = .91). There were 19% missing scores due to teachers' non-response at 3rd grade,

which were nonsystematic in the study sample. Because of missing values, the average of the third and fourth grade scores was used. If youth did not have scores for both years, their score for a single year was used.

2.2.2.4. Motivational advantage. Motivation was measured through a 12-item school commitment scale rated by students at grades 5, 6, and 10. Examples for the items included in the scale were "I try hard in school," "I like school," "I give up when school work gets hard." Two items were asked only in 10th grade: "I learn a lot at school" and "There are many things about school I don't like." The items were rated on a four-point scale coded from strongly disagree (1) to strongly agree (4) (Cronbach's alphas = .74 for fifth grade, .78 for sixth grade, and .79 for tenth grade). Because of missing values, the average of 5th grade and 6th grade scores was used, and if one was missing from both 5th and 6th grades, the 10th grade score was used. Overall, the scores ranged from 25 to 62 with a higher score indicating greater motivation.

2.2.2.5. School support. Measures of school quality and school mobility were defined as school support because they were viewed as potential sources of influence on student educational attainment. School quality was defined as any attendance in a magnet school from grades 4 through 8, and an assessment of school characteristics in fifth grade. Attendance in a magnet school was coded dichotomously and was included because the quality of magnet schools was viewed as higher than that of other types of schools. The other indicator, school characteristics, was measured as the average percentage of low-income families, mobility, and truancy at the school level in fifth grade. The school-level data were matched to individual students of the school. Because these three indices were negative features of schools, the variable was reverse scored to match the direction of the other indicator of school quality. These two measures formed a latent variable of school quality.

School mobility was measured by the number of times participants changed schools between grades four and eight. It was obtained from a grade-by-grade analysis of school system records. School mobility was found to predict educational attainment and mediated the effect of an early intervention program (Temple & Reynolds, 1999). Thus it was used as an indicator of the school support hypothesis.

2.3. CPC preschool program participation

Participation in the Child–Parent Center Preschool Program one year or two years was coded as 1. Children who did not attend the CPC Preschool Program were coded 0. The data were obtained from school records at the time of participation.

2.4. Covariates

Several measures were used as covariates in order to examine the relative contribution of the predictors of interest to educational attainment with these aspects of the students' backgrounds and experience controlled. There were three covariates used in the tests of the models.

2.4.1. Sex

Females were coded 1; males were coded 0, as obtained from school records.

2.4.2. Race/ethnicity

African-American children were coded 1, and Hispanic-American children were coded 0, as obtained from school records.

2.4.3. Family risk status

Six items formed a composite index of risk. Items included were (1) single-parent family status by the child's age 8, (2) parent unemployment by the child's age 8, (3) attendance at a kindergarten program in a school in which 60% or more of children in the attendance area resided in low-income families, (4) eligibility for a subsidized lunch, (5) the parent was not a graduate of high school by the child's age 8, and (6) four or more children lived in the household. These risk factors have been found to be consistently associated with children's school success and educational attainment in prior studies (Alexander, Entwisle, & Kabbani, 2001; Masten & Garmezy, 1985). The family risk index ranged from 0 to 6, and the mean was 3.05 (SD = 1.53).

2.5. Data analysis

Methods used in previous research include descriptive statistics, t tests, regression analyses, growth curve modeling, and path analyses to show the relations between participation in early intervention programs, and school achievement and high school graduation (Barnett, 1990, 1995; Oden et al., 2000; Reynolds et al., 1996, 2001; Royce et al., 1983; Schweinhart & Weikart, 1997). Most methods used in previous research are adequate to examine whether a direct effect exists. However, to answer questions regarding mediation, it is necessary to define a model containing several pathways to see how the effects occurred. Studies by Barnett et al. (1998) and Reynolds (2000) that investigated causal models of the effects of early intervention programs employed structural equation modeling (SEM) to estimate causal relations. This method has been used increasingly in social science research because of its capacity to address more complicated research questions. It is especially important for SEM studies that researchers designate relations among variables based on theories. The method offers several advantages over other analytic approaches, such as taking into account measurement errors and constructing latent variables (Hoyle, 1995; Kline, 1998), which made it especially suitable for the present study.

Structural equation models were estimated using the computer software Linear Structural Relations 8.5 (LISREL8, Jöreskog & Sörbom, 1996). For latent variables that had only one indicator, the measurement errors were estimated according to their internal consistency in the data as well as from previously reported findings.

Outcomes from the model-fitting program are examined to see how adequately the model explains the data. Two indicators of model-fit were used in the present study: the root mean square error of approximation (*RMSEA*) and the adjusted goodness of fit index (*AGFI*).[1] Jöreskog & Sörbom (1989) developed the goodness-of-fit indices *GFI* and *AGFI*, which do not rely on sample sizes. A value of *GFI* or *AGFI* close to 1.00 indicates a good fit (Byrne, 1998). The *RMSEA* takes into account the error of approximation in the population (Browne & Cudeck, 1993). An *RMSEA* value that is less than 0.05

[1] More detailed information regarding justified models, data preparation and screening, model analyses, and model evaluation and respecification can be found in Byrne (1998), Duncan (1975), Hoyle (1995), Jöreskog & Sörbom (1996), Kline (1998), and Loehlin (1998).

indicates a good fit, and values as high as 0.08 represent reasonable errors of approximation in the population.

In addition to the model presented in Fig. 1, several other models were tested in the present study. Because the five hypotheses (cognitive advantage, social adjustment, motivation, family support, and school support) were of interest, they were tested separately and cumulatively. The five hypotheses were assigned as single mediators of preschool participation on educational attainment in each model and tested separately. Cumulative mediator models, that is, alternative models in which the five hypotheses were added to the main-effect model one at a time in chronological sequence (e.g., the first mediator, cognitive advantage, would be the first mediator added because it was measured in kindergarten) were estimated. When a mediator was added to the model, hypothesized relations between the mediator and other mediators were also designated. Covariates were included in all models. A final model that had the best fit among all alternative models was obtained in the last step of the cumulative mediator models.

The overall model fit is the first step of evaluating a model. When the fit indices indicate acceptable overall fit of a model, the next step is to examine the path coefficients. The path coefficients are standardized partial regression coefficients, which show the change measured in standard deviation units while controlling other variables in the model. The significance of path coefficients is judged in the same way as a z statistic, so a path coefficient has to exceed 1.96 to be considered reliably different from zero (Hoyle, 1995). These coefficients aid in the interpretation of the size of the effect, because they correspond to effect-size estimates (Hoyle, 1995).

3. Results

The results showed a similar pattern for the two outcome variables, highest grade completed and high school completion. Therefore only one outcome, highest grade completed, is reported in detail here. The results of the SEM analysis with high school completion as the outcome variable are available upon request.

The statistics for model fit for the highest grade completed are presented in Table 4. Among all models tested, the model with all mediators fit the data best (*RMSEA* = .048, *AGFI* = .94). See Appendix B for factor loadings and test statistics for indicators of the latent variables in the model.

Fig. 2 illustrates the result of the LISREL structural equation model, which tested the hypothesized model in Fig. 1 for predictors of the highest grade completed. The emboldened arrows denote that the intervening factors directly mediated the effect of CPC preschool participation. The coefficients are standardized and significant at the .01 level. This model explained 30% of variation in highest grade completed. The goodness-of-fit statistics indicated a good fit (*RMSEA* = .048, *AGFI* = .94). The relation between preschool participation and highest grade completed was no longer significant when mediators were entered in the model.

3.1. Cognitive advantage

Cognitive advantage was a significant mediator of the effect of preschool participation on educational attainment, as assessed by highest grade completed. Preschool participation was associated with higher Iowa Test Basic Skills (ITBS) scores in kindergarten (b = .36), which led to a lower risk of grade retention in subsequent grades (b = −.46). Grade retention was in turn associated with lower later school

Table 4
LISREL goodness of fit statistics for alternative models for highest grade completed

Model	*df*	*df* Change	χ^2/df	χ^2	χ^2 Change	*RMSEA*	Std. *RMR*	*AGFI*
1. Null model	145	–	27.24	3949.55	–	.17	.21	.63
Single mediator models								
2. Main effect	139	–	29.71	4129.07	–	.18	.21	.58
3. Cognitive advantage	121	18	19.51	2361.28	1767.79	.13	.17	.74
4. Family support	127	12	29.42	3735.91	393.16	.17	.20	.61
5. Socio-emotional adjustment	134	5	28.81	3860.24	268.83	.17	.21	.61
6. Motivation	134	5	30.28	4058.06	71.01	.18	.21	.58
7. School support	127	12	29.96	3805.43	323.64	.18	.21	.59
Cumulative mediator models								
8. Direct effects	105	–	23.61	2478.77	–	.14	.16	.70
9.+ ITBS scores at kindergarten	103	2	22.42	2309.04	169.73	.13	.16	.72
10. + Socio-emotional adjustment	100	3	21.67	2166.56	142.48	.13	.15	.73
11. + Parent involvement	97	3	20.86	2023.83	142.73	.12	.14	.75
12. + Abuse and neglect	95	2	20.96	1991.55	32.28	.12	.13	.76
13. + Promotion (retention)	91	4	12.63	1149.03	842.52	.093	.10	.84
14. + Mobility	87	4	10.57	919.54	229.49	.084	.086	.86
15. + School quality	81	6	10.19	825.53	94.01	.081	.071	.87
16. + Motivation	75	6	8.48	635.69	189.84	.073	.050	.89
17. + Later achievement (full)	66	11	4.30	283.84	351.85	.048	.023	.94

Note. Covariates (gender, risk index, and race/ethnic) and their paths to mediators were included in the direct effects model. The full model included direct effect, ITBS scores at kindergarten, socio-emotional adjustment, parent involvement, abuse/neglect, retention, mobility, school quality, motivation and later achievement.

achievement ($b = -.46$), and this level of later school achievement was associated with a higher grade completed ($b = .21$). Other than those single mediators, some dual/multiple mediators through ITBS scores in kindergarten need to be noted.

The positive association between preschool participation and ITBS scores in kindergarten ($b = .36$) were predictive of three later experiences: (a) a higher rate of attending better quality schools ($b = .19$), which in turn was predictive of a higher grade completed ($b = .12$); (b) higher levels of parent involvement in school in later grades ($b = .27$), which then was predictive of a higher grade completed ($b = .14$; the thick arrow between parents' involvement and highest grade completed in Fig. 2) or (c) better classroom adjustment ($b = .44$), which in turn was predictive of greater later achievement ($b = .21$), which was then associated with a higher grade completed ($b = .21$).

3.2. Family support

In addition to cognitive advantage, one indicator of family support, i.e., parent involvement, was a significant mediator. There were significant paths from preschool participation to parent involvement ($b = .08$), and from parent involvement to highest grade completed ($b = .14$). In other words, preschool participation was associated with greater parent involvement, which was then associated with a higher grade completed.

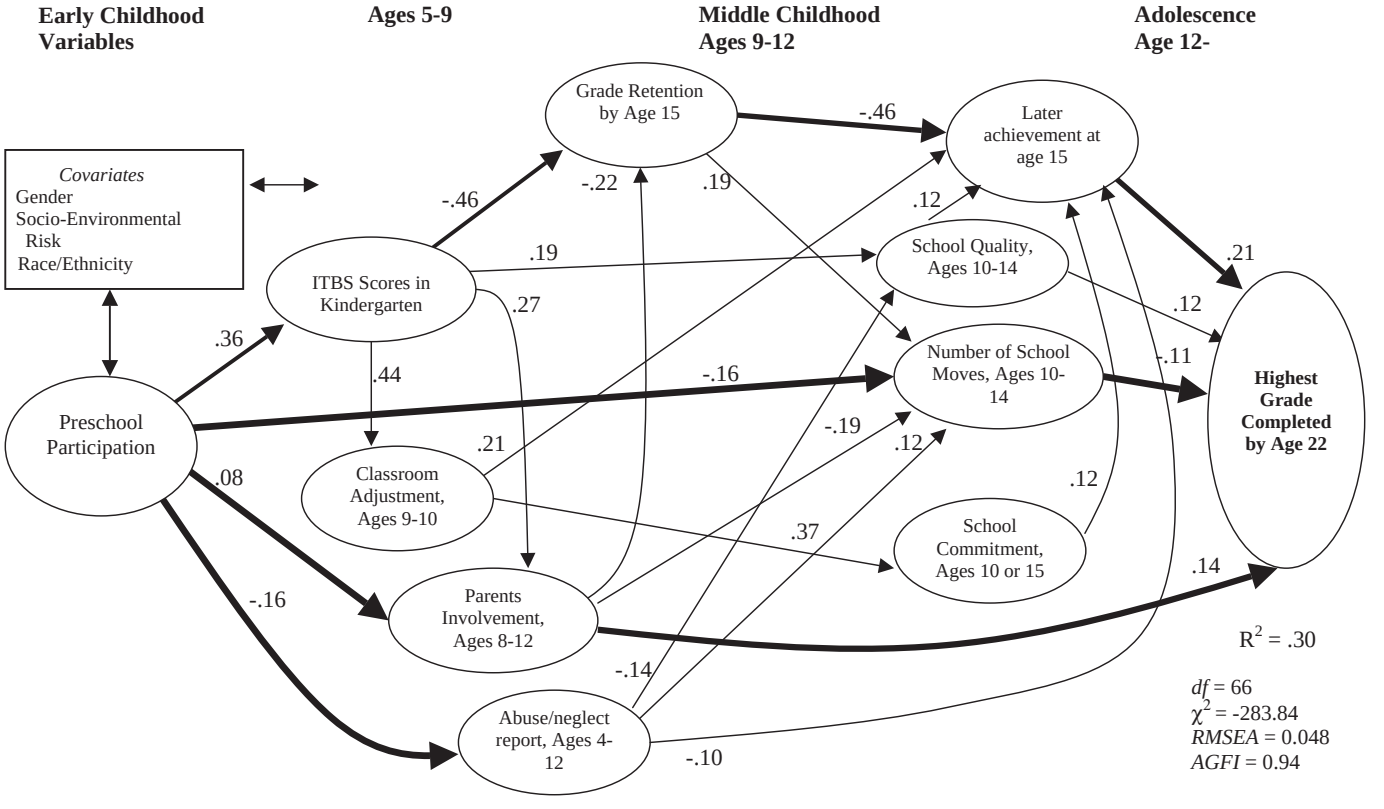

Fig. 2. LISREL mediation model for highest grade completed, coefficients are standardized and adjusted for measurement errors. All covariates have paths to program participation, mediators, and outcome. To simplify the figure, those paths are not shown for the path to program participation.

As was the case for cognitive advantage, there were dual/multiple mediators for family support, through both indicators of family support, on highest grade achieved in school. First, the positive association between preschool participation and parent involvement ($b = .08$) was associated with two later experiences: (a) fewer school moves ($b = -.19$), and then a higher grade completed ($b = -.11$), or (b) a lower risk of grade retention ($b = -.22$), and then higher levels of achievement at age 15 ($b = -.46$), which was in turn associated with a higher grade completed ($b = .21$). Second, the negative association between preschool participation and incidence of abuse/neglect ($b = -.16$) was associated with three later experiences: (a) a higher rate of attending better quality school ($b = -.14$), and then a higher grade completed ($b = .12$), (b) fewer school moves ($b = .12$), and then a higher grade completed ($b = -.11$), or (c) higher levels of achievement at age 15 ($b = -.10$), which were then predictive of a higher grade completed ($b = .21$).

3.3. School support

Number of school moves, one indicator of school support, was a significant mediator. Another indicator of school support, school quality, was a dual mediator through which ITBS scores in kindergarten and abuse/neglect reports were associated with educational attainment (highest grade completed). Preschool participation was associated with fewer school moves ($b = -.16$), which was then associated with a higher grade completed ($b = -.11$).

3.4. Social adjustment and motivational advantage

Although social adjustment and motivational advantage contributed to the overall model fit, they were not significant mediators. Social adjustment was a mediator for ITBS scores in kindergarten, and it was also positively associated with later achievement and school commitment, but it was not significantly associated with either preschool participation or with highest grade completed.

3.5. Contributions of mediators

The findings showed that all mediators contributed to the improvement of the model fit. The model with all mediators included showed the best fit. Mediators provided links between preschool participation and educational attainment. That is, instead of a direct effect of preschool participation on educational attainment, the indirect effect of preschool participation on educational attainment through those mediators provided the best explanation for the association between preschool participation and educational attainment.

Which mediators contributed most to these indirect effects of preschool participation on educational attainment? Table 5 summarizes the major pathways that contributed to the long-term effects of the CPC Preschool Program as a proportion of the total indirect effect. The total indirect effect is the sum of all paths leading to the outcome of educational attainment, assessed as highest grade completed and as high school completion. The total indirect effect denotes the effect of CPC participation through all the mediators of influence. Overall, 68.6% of the indirect program effect on highest grade completed ($b = .13$) was accounted for by cognitive advantage, family support, and school support. The largest contributor was cognitive advantage. ITBS scores in kindergarten, combined with other mediators, accounted for more than half of the total indirect effect of preschool participation on highest grade

Table 5
Total indirect effects of program indicators on educational attainment

Key pathways	Highest grade completed	High school completion
Preschool participation	.13	.13
Percentage due to:		
Family support	17.9	22.7
Parent involvement	8.6	11.1
Parent involvement and school mobility	1.3	1.3
Parent involvement retention and later achievement	1.3	2.1
Abuse/neglect and school mobility	1.6	1.6
Abuse/neglect and school quality	2.1	1.7
Abuse/neglect and later achievement	2.6	4.2
Abuse/neglect, school quality and later achievement	0.4	0.7
School support	13.5	13.5
School quality	–	–
School mobility	13.5	13.5
Cognitive advantage	37.2	49.8
ITBS scores in kindergarten and parent involvement	10.5	13.5
ITBS scores in kindergarten and later achievement	–	–
ITBS scores in kindergarten adjustment and later achievement	5.4	8.7
ITBS scores in kindergaten and quality	6.3	5.0
ITBS scores in kindergarten retention and later achievement	12.3	19.9
ITBS scores in kindergarten, retention and mobility	2.7	2.7
Total	68.6	86

Note. Only significant coefficients are calculated.

completed (37.2%; see lower portion of Table 5). The second largest contributor was family support. Two indicators of family support, (parent involvement and incidence of child abuse/neglect) combined with other mediators, explained 17.9% of the indirect preschool effect. School mobility explained 13.5% of the indirect effect of preschool on highest grade completed. Results for the model predicting high school completion had a similar pattern. For example, cognitive advantage combined with other mediators accounted for almost three fifths of the total indirect effect of preschool program on high school completion (49.8%; see the lower portion of Table 5).

After the contributions of the mediators to the total indirect effect of preschool on educational attainment were examined, the final model was compared with the main effect model, with respect to the coefficient for the association between preschool participation and educational attainment. With mediators in the model, the standardized coefficient between preschool participation and highest grade completed became nonsignificant (b = .14 vs. b = .02, an 85.7% reduction of the main effect). This indicated that the mediators significantly accounted for the effect of preschool participation on highest grade completed. The same pattern occurred in the model for high school completion, although the extent of mediation was lower than it was for highest grade completed. With mediators in the model, the standardized coefficient between preschool participation and high school completion dropped from .19 to .05, which indicated a 73.7% reduction of the main effect of preschool participation on high school completion.

Among the five hypotheses, the cognitive advantage hypothesis contributed most to the indirect effect of preschool participation on highest school grade completed, followed by the family support and the school support hypotheses.

4. Discussion

4.1. Cognitive advantage hypothesis

The major rationale behind early childhood intervention is to help children obtain prerequisite learning skills that will enable them to benefit better from subsequent schooling. Such learning prerequisites include not only intellectual skills, such as acquisition of language and of quantitative concepts, but also increased motivation to achieve, positive attitudes, academic interests, enhanced self-concept, adaptive reactions to frustration, and other personal-social characteristics (Anastasi & Urbina, 1997; Zigler & Berman, 1983).

The results from the present study indicate that the cognitive advantage observed in kindergarten (i.e., intellectual skills, assessed through ITBS word analysis and math scores) alone did not lead directly to a higher rate of high school completion; instead these associations were mediated by lower grade retention rates, higher levels of later school achievement, and by classroom adjustment as well as other factors. Pathways from preschool participation to highest grade completed were first set in motion by ITBS scores in kindergarten and then were linked to highest grade completed through later experiences explained by 37.2% of the indirect effect of the preschool program on highest grade completed. The results of the analyses suggest that early cognitive advantage combined with other factors can have larger long-term positive effects on educational attainment than just having early cognitive advantage alone. This is consistent with findings from the Consortium for Longitudinal Studies (1983) and the High/Scope Perry Preschool Program (Barnett et al., 1998), and reports that preschool participation was associated with educational attainment through the mediating variables of grade retention, subsequent measures of cognitive ability (IQ), or later school achievement (Campbell et al., 2001).

The Consortium for Longitudinal Studies (1983) presented pathways of early intervention programs. These early childhood programs were associated with higher IQ test scores at age 6, which in turn were predictive of special education placement or grade retention, which were in turn associated with high school graduation (see Fig. 3). Fig. 4 shows selective pathways from the High/Scope Perry Preschool Program. Educational attainment was accomplished through two paths (Barnett et al., 1998). As seen in Fig. 4, the preschool program was associated positively with early IQ, which was then positively with later IQ, which in turn was predictive of later school achievement, which was ultimately associated with educational attainment. An alternative path was the association between the preschool program and early IQ, which was then predictive of early school achievement, which in turn was associated with greater motivation and behavior as well as with later achievement; ultimately, achievement in later school years was associated with educational attainment.

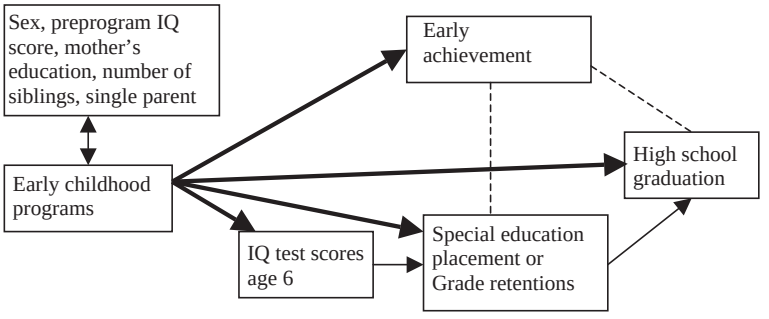

Fig. 3. Selected paths of effects of programs from the Consortium for Longitudinal Studies.

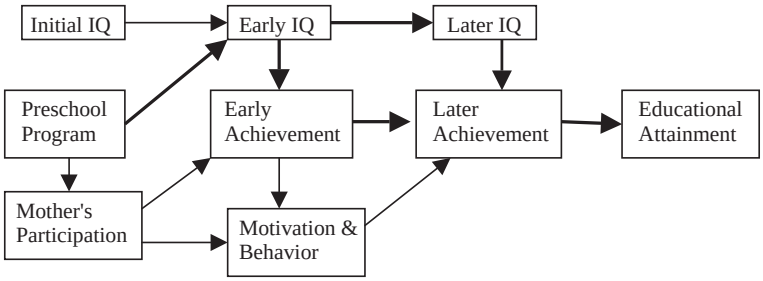

Fig. 4. Selected paths of effects of the High/Scope Perry Center Programs.

Fig. 5 shows selected pathways from the present study. The preschool program was associated with educational attainment through three paths: cognitive advantage (ITBS scores and so on through the center of the figure), family support (see arrows through the upper portion of the figure), and school support (see arrows through the lower portion of the figure). In the present study, the finding regarding the cognitive advantage hypothesis is consistent with findings from other studies.

4.2. Family support hypothesis

Pathways initiated by family support explained 17.9% of the indirect effect of the preschool program on highest grade completed. The preschool program was associated with greater parental involvement, or with a lower rate of abuse/neglect, which in turn was associated with higher educational attainment. This finding is consistent with other studies: the positive association between preschool participation and parent involvement, and the positive association between parent involvement and student's academic achievement or educational attainment have been found in many studies (e.g., Barnard, 2001; Fan & Chen, 2001; Miedel & Reynolds, 1999; Reynolds, 1999, 2000).

In addition to cognitive advantage, family and school play important roles in the link between the CPC program and educational attainment. Family support corresponds to the parent component in the CPC program. The CPCs required parent involvement, which was expected to enhance parent–child interactions, parent and child attachment to school, and social support among parents, thereby promoting children's school readiness and social adjustment (Reynolds, 2000). Parental involvement might change

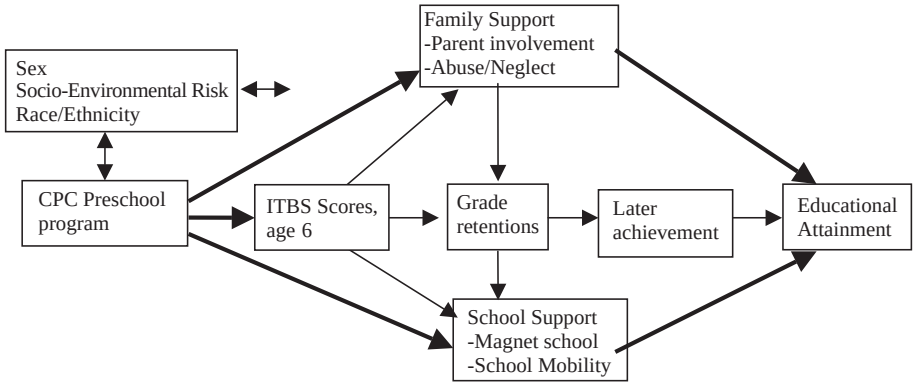

Fig. 5. Selected paths of effects of the Child–Parent Center program.

the home environment for children, such as higher aspirations from parents, which means that the child's environment is affected generally rather than in the only context of the preschool program. Such environmental change is important for early childhood intervention to have lasting effects, because cognitive skills obtained through early intervention will be hard to maintain if one's home environment stay deprived (Bronfenbrenner, 1975).

4.3. School support hypothesis

Pathways initiated by school support explained 13.5% of the indirect effect of the preschool program on highest grade completed. Preschool participation was associated with higher educational attainment through fewer school moves during elementary grades. Temple & Reynolds (1999) found that school mobility mediated the effect of early intervention programs on school achievement, although the linkage was mediated by kindergarten achievement. School quality, another indicator of school support, has been related to whether or not the advantages obtained from early intervention programs last (Currie & Thomas, 2000; Lee & Loeb, 1995).

Preschool participation might be associated with fewer school moves because the program was designed to promote family and school stability and get children ready for schooling. First, parents' participation in the CPC program increased interactions between parents and teachers. Parents might keep involved in school activities even after exit from the program, and thus they might pay more attention to school environment. Children who participated in the preschool program might have fewer school changes and greater possibilities to attend better quality schools because their experiences in the preschool program project a more positive image to their teachers and schools; then the positive experiences might be transformed into positive interactions with schools later. Second, school–community representatives in the CPC program provided outreach services: to identify families in the neighborhood who were in most need of the educational services, conducting a home or school visit, holding informal conferences with the parents, mobilizing resources by referring families to community and social service agencies, and organizing transportation and related services for families (Reynolds, 2000).

Third, the CPC centers were either next to the elementary schools or in wings of elementary schools, so when students moved on to elementary schools, they usually only needed to move across the street. Thus they were in the same neighborhood and they did not have to adjust to a new environment. They might have tended to stay in the same school throughout elementary school. In addition to location, the CPCs helped prepare children for schooling by enhancing cognitive and adjustment skills so that they might have a smooth transition into elementary school and adjust better to elementary school (Entwisle, 1995). That might be one reason that the preschool program was associated with low school mobility.

Finally, parents might prefer to let children stay in the neighborhood due to the positive experience in the CPC centers or any positive experiences regarding the elementary schools that they might have heard about from the CPC centers. Not only was preschool participation associated with fewer school moves, but greater parent involvement was associated with fewer school moves as well. There was a strong association between preschool participation and school mobility even after controlling for the association between parent involvement and school mobility. In addition to parent involvement, other components of the CPC program, such as outreach services, might play a strong role in accounting for this association. These factors need further investigation in order to identify the processes through which preschool participation might lead to such positive outcomes.

The other indicator of school support, school quality, was a dual/multiple mediator rather than a single mediator in the present study, although it was a single mediator in earlier studies (Ou, 2002; Reynolds et al., 2004). The definitions of school quality include composition of students, academic performance, safety, and social relationships. In the present study, school-level characteristics and attendance in magnet schools were used to indicate school quality. School-level characteristics included percentage of low-income families, mobility, and truancy. Cognitive advantage in kindergarten promoted enrollment in better quality schools, and attendance in better quality schools was associated with better educational attainment. This is consistent with findings from previous studies that showed that the fading of Head Start effects was related to attendance in lower quality elementary schools (Currie & Thomas, 2000; Lee & Loeb, 1995). School quality therefore appears to play an important role in lasting effects of early intervention programs.

4.4. Social adjustment and motivational advantage hypotheses

There was less support for social adjustment and motivational advantage as mediators of early intervention on educational attainment. However, they were found to be predictors of educational attainment in some earlier studies (Lloyd, 1978; Rosenthal, 1998). Social adjustment and motivation were associated with some mediators, but they were not associated with preschool participation or outcomes independently, which is consistent with findings from several previous studies (Barnett et al., 1998; Reynolds, 1999, 2000; Reynolds et al., 2004). Although researchers have proposed that the two hypotheses might be able to explain the process of how preschool participation is associated with better developmental outcomes, the present analyses showed that the two hypotheses function as part of dual/multiple mediator of ITBS scores in kindergarten, but not as single mediators. Their influences were contained in the other measures, such as ITBS scores in kindergarten and later achievement. Thus, it might be difficult to fully distinguish their independent influences.

4.5. Limitations of the present study

Although the present study overcame many problems of previous studies because of its improved method and longitudinal design, there were some limitations. They concerned the correlational nature of the data, possible alternative models, and generalizability.

First, this study investigated correlations among variables with a quasi-experimental design. Although the longitudinal design, the theory-driven approach, structural equation modeling, and alternative models used in the present study strengthened the validity of findings, the relations in the model can be viewed as predictors but not causes. The second limitation concerns alternative models. Alternative models might include other alterable predictors of educational attainment (Rosenthal, 1998), such as children's attitudes toward school, children's problem behaviors in school, and school discipline policies. These factors might also mediate the effects of preschool program, although no researchers have suggested that. They were not included in the analysis because the focus of the present study was on the five hypotheses and/or because the data were unavailable.

Another limitation is generalizability. The majority of the study sample was comprised of African Americans living in an inner city. Therefore the findings should not be broadly generalized to other populations or other contexts, although the study supports findings from other early intervention programs conducted in other locations. Other replications are needed to establish the generalizability of the model. Similar findings about cognitive advantage have been reported in other studies despite

differences between programs and contexts. The cognitive advantage hypothesis does not seem to rely on environmental factors as much as the school support hypothesis does. School support as a mediating factor, especially school quality, has been supported in other studies (Currie & Thomas, 2000; Lee & Loeb, 1995), but should be applied to other early intervention programs with caution. The findings regarding family support and school support might not be generalized because the findings might be due to specific components of the CPC program, such as parent involvement. Finally, the outcome in the study was educational attainment, and the identified mechanisms should only be applied to similar outcomes rather than outcomes in different dimensions, such as delinquency and employment. Replication of the study to different outcomes in the future might increase its generalizability.

5. Conclusions

The findings showed that the mechanisms of effects of the CPC program are diverse and complex rather than representing a direct association between the preschool participation and educational attainment. The findings indicated the usefulness of the ecological systems theory and the resiliency theory, as well as support for hypotheses based on findings of prior studies.

According to the ecological systems theory, interactions between persons and their context occur over time, and thus shape development. The findings indicated that cognitive advantage alone would not last into adulthood if the environment did not provide positive reinforcement over time. For example, the gain in kindergarten was associated with educational attainment through a lower rate of grade retention, greater parental involvement, greater later achievement, or a higher rate of attendance in better quality schools. Without changing the environment simultaneously, the benefits of promoting a child's skills are limited and unlikely to last over time and contexts. Therefore, the effect of preschool participation should be examined as a chain of reaction with environmental factors rather than a direct effect on developmental outcomes. The findings also support the snowball hypothesis (Zigler & Muenchow, 1992; Zigler & Styfco, 1993) and the Matthew effect (cumulative advantage, Walberg & Tsai, 1983), which describe cumulative effects over time and experiences.

According to the resiliency theory, the preschool program acts as a protective mechanism for the participants because the preschool initiates positive associations with factors such as better cognitive skills and social adjustment, greater parental involvement, a higher rate of attending better quality schools, a lower rate of grade retention and abuse/neglect, and fewer school moves. Those protective factors are then associated with higher educational attainment.

The findings indicated that although personal characteristics are important to development, environmental factors, such as family and school, also play important roles in shaping developmental outcomes. Programs that focus on changing individuals without addressing associated environmental changes might not demonstrate long-term effects.

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Appendix A

Correlation matrix for indicators in the structural model

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Preschool	1.00																			
2. Race	.073	1.00																		
3. Risk index	.025	.100	1.00																	
4. Gender	.076	.027	.023	1.00																
5. ITBS Word analysis (K)	.297	.031	−.088	.079	1.00															
6. ITBS math scores (K)	.270	.073	−.105	.064	.600	1.00														
7. Socio-emotional maturity (3–4)	.141	−.133	−.138	.236	.335	.332	.572	1.00												
8. Parent participation	.169	−.071	−.021	.103	.186	.203	.294	.384	1.00											
9. Parent interests in child	.131	−.103	−.080	.069	.195	.203	.351	.388	.652	1.00										
10. Abuse/ neglect	−.148	.048	.062	.024	−.045	−.088	−.093	−.017	−.233	−.286	1.00									
11. Retention	−.218	.024	.155	−.227	−.427	−.419	−.541	−.515	−.292	−.322	.095	1.00								
12. School mobility	−.238	.013	.081	−.077	−.172	−.133	−.185	−.211	−.325	−.203	.209	.286	1.00							
13. Magnet school attendance	.196	−.051	−.099	.097	.193	.117	.091	.097	.121	.010	−.139	−.229	−.171	1.00						
14. School characterisitcs	.068	.030	−.197	.018	.214	.107	.045.	.084	.082	.016	−.095	−.121	−.223	.559	1.00					
15. School commitment	.111	−.015	−.041	.134	.173	.174	.311	.352	.181	.176	−.071	−.208	−.103	.007	.013	1.00				
16. ITBS reading scores (8)	.190	−.079	−.175	.188	.436	.438	.554	.527	.336	.302	−.161	−.643	−.228	.227	.211	.319	1.00			
17. ITBS math scores (8)	.195	−.096	−.205	.145	.467	.475	.603	.566	.329	.306	−.167	−.694	−.238	.246	.211	.305	.779	1.00		
18. Highest grade completed	.145	−.085	−.163	.192	.253	.176	.323	.355	.272	.269	−.119	−.366	−.272	.168	.207	.187	.382	.388	1.00	
19. High schl. completion	.184	−.109	−.189	.207	.275	.196	.361	.368	.316	.318	−.173	−.407	−.298	.206	.207	.163	.444.	.445	1.00	1.00

Note. With the exception of race, sex, magnet school attendance, college 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 (minimum $N = 1065$, maximum $N = 1334$).

Appendix B

The factor loadings and test statistics for indicators of the latent variables are presented in this Appendix. The factor loadings indicate the extent to which the indicators index their respective latent variables, and significant factor loadings indicate confirmation of the relations between indicators and latent variables, and thus support the construct validity of the latent variables. In the present study, four latent variables had more than one indicator: kindergarten achievement, parent involvement, school quality, and later achievement.

All indicators shown were significantly related to their respective latent variables (test statistics >3.0), which confirmed that the indicator variables were good representations of their respective latent variables. Goodness-of-fit indices (***RMSEA*** = .053, ***AGFI*** = .93) also indicate that the measurement model fit the data well.

Standardized factor loadings and test statistic for indicators of latent variables

Latent factor and indicator	Factor loadings	Test statistic
Kindergarten achievement		
ITBS word analysis (K)	0.78	28.85
ITBS math score (K)	0.77	28.39
Parent involvement		
Parent participation in school	0.80	29.36
Parent interests in child's progress	0.81	29.64
School quality		
Magnet school attendance	0.71	20.48
School characteristics	0.79	21.93
Later achievement		
ITBS reading score	0.85	37.62
ITBS math score	0.91	41.61

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