Higher quality child care during infancy and early childhood (6–54 months of age) was examined as a moderator of associations between family economic status and children’s \( (N = 1,364) \) math and reading achievement in middle childhood (4.5–11 years of age). Low income was less strongly predictive of underachievement for children who had been in higher quality care than for those who had not. Consistent with a cognitive advantage hypothesis, higher quality care appeared to promote achievement indirectly via early school readiness skills. Family characteristics associated with selection into child care also appeared to promote the achievement of low-income children, but the moderating effect of higher quality care per se remained evident when controlling for selection using covariates and propensity scores.

By fifth grade, poor children are as much as 2 times more likely to lack proficiency in math and reading skills than children who are not poor (U.S. Department of Education, National Center for Education Statistics, 2007). In turn, these developmental disadvantages contribute to the societal costs of childhood poverty, estimated to be as high as $500 billion per year, through processes such as reduced lifetime earnings (Holzer, Schanzenbach, Duncan, & Ludwig, 2007). Importantly, achievement in middle childhood appears to be a particularly strong predictor of earnings in adulthood for children who have grown up poor (Feinstein & Bynner, 2004). Yet, higher quality early child care may act as an intervention, helping promote the achievement of low-income children through middle childhood.

**Higher Quality Early Child Care: A Cognitive Advantage for Low-Income Children?**

Following more general theory on the significance of early rearing environments, child-care researchers have argued that nonmaternal care experiences may stimulate and support healthy development if care is of high quality, as evidenced by: (a) high levels of language stimulation, (b) access to developmentally appropriate learning materials, (c) a positive emotional climate with sensitive and responsive caregivers, and (d) opportunities for children to explore their environments (e.g., McCartney, 1984; National Institute of Child Health and Human Development [NICHD] Early Child Care Research Network, 2000). Compared with children who attend relatively lower quality child care during early childhood, children who attend higher quality child care do, in fact, display higher average levels of mathematics and reading achievement from early childhood through adolescence as well as higher earnings in adulthood (e.g., Barnett, 1995; Campbell, Ramey, Pungello, Sparling, & Miller-Johnson, 2002; Lamb, 1998; NICHD Early Child Care Research Network & Duncan, 2003; Schweinhart et al., 2005). Beyond these average group differences, higher quality child care may be an effective means of promoting the achievement of children growing up poor; higher quality child care may help compensate for the otherwise deprived developmental contexts in which many poor children live.
Low family income also has consequences for children's achievement, in part because poverty places constraints on families' investments in material resources (e.g., books) necessary for cognitive and language development (Becker & Tomes, 1986; Dearing & Taylor, 2007; Votruba-Drzal, 2003; Yeung, Linver, & Brooks-Gunn, 2002). Moreover, economic pressures associated with poverty impair parent psychological well-being, thereby decreasing positive parenting behaviors (e.g., stimulation, support, and responsiveness) and increasing negative parenting behaviors (e.g., harsh and/or inconsistent responses; Conger, Rueter, & Conger, 2000; Dearing, Taylor, & McCartney, 2004; Elder & Caspi, 1988). Yet, both of these pathways may be interrupted, or at least mitigated, by higher quality child-care experiences.

Higher quality child care may offer direct benefits to low-income children through material (e.g., learning materials) and psychosocial (e.g., stimulating and responsive caregivers) investments that compensate for limited investments provided in home environments. Moreover, higher quality child care may have indirect benefits for children, providing parents informal and formal social supports that, in turn, are translated into more material and psychosocial investments in children within their home environments (McCartney, Dearing, Taylor, & Bub, 2007). Regarding math and reading achievement, improved access to learning materials and learning stimulation may be particularly crucial for low-income children because deprivation in this area is the primary mechanism by which low income leads to underachievement (e.g., Yeung et al., 2002). More specifically, by directly and indirectly improving their learning environments, higher quality child care may provide a cognitive advantage for low-income children, promoting their acquisition of early skills and knowledge that are a prerequisite for later success in math and reading (Burchinal, Peisner-Feinberg, Bryant, & Clifford, 2000; McCartney et al., 2007; Reynolds, Ou, & Topitzes, 2004). As has been posited for early education interventions, higher quality child care may promote children's learning of basic numerical knowledge and literacy skills and thereby set the stage for “a positive cycle of performance” through the school years (Reynolds et al., 2004, p. 1300).

Evidence From Randomized, Matched-Groups, and Nonrandomized Designs

Model child-care programs (e.g., Abecedarian Project and High/Scope Perry Preschool) and early education intervention programs have proven effective for promoting the achievement of low-income children (Barnett, 1995), with evaluation evidence from studies using random assignment (Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2001; Love et al., 2005; Schweinhart, Barnes, Weikart, Barnett, & Epstein, 1993) and nonrandomized matched-groups designs (Reynolds, Temple, Robertson, & Mann, 2002). These positive effects on low-income children's achievement persist through adolescence and into adulthood, as evidenced by intelligence scores as well as educational attainment, employment, and earnings (e.g., Campbell et al., 2002; Schweinhart et al., 2005; Smokowski, Mann, Reynolds, & Fraser, 2005). In addition, experimental evaluations of poverty reduction interventions that include child-care subsidies have demonstrated benefits for poor children's achievement through middle childhood and into adolescence (Huston et al., 2006).

It is not clear, however, whether model child-care programs could be effectively scaled up while retaining the quality these programs evidenced under the direction of researchers. By design, these model programs also included theoretically informed curricula targeting children's cognitive growth. It is difficult, therefore, to generalize from these programs to child care more commonly available to low-income families, even though some low-income families may manage to access relatively good care (Phillips, Voran, Kisker, Howes, & Whitebrook, 1994). In addition, early education and poverty reduction interventions have generally included comprehensive child and family services that extend beyond child care (e.g., home visits); disentangling the unique effects of child-care quality per se from the cumulative effects of combined services is also difficult.

In nonrandomized studies of child-care effects, results have been mixed; some studies report that higher quality care is most beneficial for children in low-income families (e.g., Currie, 2001; Desai, Chase-Lansdale, & Michael, 1989; Lamb, 1998), but other studies report no variation in the effectiveness of care across economic strata (e.g., Burchinal et al., 2000). When samples have been limited primarily to low-income families, children in higher quality care achieve better than those in lower quality care (e.g., Burchinal et al., 2000), although the achievement benefits may be greater for some poor children (e.g., those who come from higher quality home environments) than others (Votruba-Drzal, Coley, & Chase-Lansdale, 2004). In addition, higher quality child care has demonstrated apparent protective effects for mathematics achievement in middle childhood.
for children exposed to social and contextual risks often correlated with low income such as low parent education (Peisner-Feinberg et al., 2001). Indeed, when researchers have created risk indexes using low income and correlated risk factors, the estimated benefits of higher quality child care for math achievement appear greatest for children facing the greatest risk (e.g., Burchinal, Roberts, Zeisel, Hennon, & Hooper, 2006). This is an important finding given that poverty is generally accompanied by a host of other risks for children’s development beyond low family income.

It is also worth noting two methodological approaches that researchers have taken to answer two closely related questions in the child-care and poverty literatures. The first approach has been to determine whether the association between quality of child care and children’s achievement varies as a function of family income (e.g., NICHD Early Child Care Research Network, 2000, 2002). The second approach has been to determine whether the association between family income and child achievement varies as a function of whether children are in higher quality child care (e.g., McCartney et al., 2007) or, similarly, to compare the developmental outcomes of poor children as a function of whether they are in higher quality child care (e.g., Campbell et al., 2001). Although these two approaches are very similar, one key distinction between them is that the first is limited by design to children in child care and the second is not (i.e., the achievement of children in maternal care may also be considered).

In the NICHD Study of Early Child Care and Youth Development (SECCYD), for example, only 794 of 1,364 children (i.e., 58.2%) were included in analyses examining variations in the effects of quality across the income distribution because many children were in maternal care at 24 and 36 months of age (NICHD Early Child Care Research Network, 2002). Of those 570 children excluded from the analyses, over 40% were living in low-income families (i.e., family income less than 2 times the federal poverty threshold). In the remaining sub-sample of 794 children and families, there was no evidence that the effects of child-care quality varied as a function of family socioeconomics. Because this research team was interested primarily in family risk moderators of the association between child-care quality and child outcomes, including children in maternal care would not have been appropriate. However, for researchers interested in developmental contexts that best promote the development of children in low-income families, external validity is limited substantially if children in maternal care are not considered.

Another value of including children in higher quality care, lower quality care, and children who are not in child care is the ability to disentangle whether higher quality child care promotes the development of children in low-income families, whether lower quality child care poses a dual risk for children in low-income families (i.e., exacerbating the risk of low income), or whether both are true. If children in maternal care are excluded, it is not clear which of these three possibilities offers the best explanation for achievement differences between low-income children in higher versus lower quality care. In short, the effect of income on children in maternal care provides a useful comparison for the effects of income on children in child care.

Using this strategy with data from the NICHD SECCYD, McCartney et al. (2007) report evidence consistent with the hypothesis that higher quality child care protects low-income children, with no evidence that lower quality child care posed a dual risk. More specifically, at 36 months of age, low-income children in higher quality child care displayed higher cognitive and language achievement than those in maternal care; on the other hand, low-income children in lower quality child care performed better or at levels indistinguishable from those in maternal care. Note, however, that these results were limited to achievement during early childhood. Knowing whether they extend into middle childhood would add to considerations of the developmental value of higher quality child care for low-income children.

Importantly, however, all nonrandomized studies of child care are potentially limited by selection bias. In these studies, families of children in higher quality care have chosen this context. Without random assignment, therefore, there is the concern that higher quality child-care “effects” may not be due to higher quality child care per se but instead due to unmeasured characteristics of children and families that are associated with the propensity to use higher quality care. With this in mind, we used data from a nonrandomized longitudinal study to examine variations in the effects of family economics on math and reading achievement as a function of higher quality early child-care dosage, taking special care to control for potential selection effects.

The Present Study

In the present study, we examined whether higher quality (i.e., above average) child care
during early childhood moderated associations between family economic status and children’s achievement during middle childhood. Our expectation was that family economics would be less strongly associated with achievement during middle childhood for children who had been in higher quality child care than for those who had not. In other words, we expected low family income to have its most detrimental effects on the achievement of children who had not been in higher quality child care, primarily because we expected that higher quality child care would help compensate for the otherwise deprived learning contexts associated with low income. Furthermore, we expected this moderating effect to be evident on a dose-response level; that is, low-income children who experienced more higher quality child care during early childhood should benefit more during middle childhood than other children.

We also expected the benefits of higher quality care to function in a manner consistent with the cognitive advantage hypothesis offered for early intervention effects, whereby stimulating and supportive learning contexts promote the development of low-income children’s school readiness skills, and in turn, these skills promote achievement through middle childhood. Specifically, we expected the benefits of higher quality early child care for middle-childhood achievement to be due, at least in part, to the positive effects this care has on early school readiness skills. In other words, for low-income children, we expected an indirect pathway of association whereby higher quality child care in early childhood would be associated with better school readiness skills in early childhood, and in turn, these school readiness skills would predict better achievement through middle childhood.

Throughout our analyses, we paid special attention to the potential role of selection effects, because we utilized nonexperimental, observational data from the NICHD SECCYD. To control for potential selection bias, we included a large set of child, maternal, and family characteristics as covariates in our statistical models. We also took two further steps toward controlling for potential selection bias: (a) we used propensity scores to match participants who were and were not in higher quality child care, and (b) we controlled for the moderating effects of multivariate combinations of child, maternal, and family characteristics associated with selection into higher quality child care.

These two additional steps were taken based on the rationale that selection into higher quality child care is likely multivariate. Furthermore, if selection is responsible for the apparent moderating effects of child-care quality (rather than such effects being due to child-care quality, per se), then a correctly identified indicator of families’ propensity to select into higher quality child care should (a) moderate associations between income and child achievement, and (b) child-care quality should not moderate associations between income and achievement when controlling for these moderating effects of selection propensity. On the other hand, if the effects of child-care quality are causal, then moderating effects of care should be evident even when controlling for moderating effects of selection propensity, assuming all relevant selection mechanisms have been measured. We expected that higher quality child care would moderate associations between family economic level and achievement in middle childhood, even when controlling for moderating effects of selection propensity. In other words, we expected our results to be consistent with the hypothesis that higher quality child care promotes the achievement of poor children beyond whatever selection effects might be at work.

Finally, we also examined the interactions between higher quality child care and an index of sociocontextual risk. Although controlling for a wide array of child, maternal, and family characteristics may help reduce bias due to potential selection, it may also reduce the ecological validity of interactions between child-care quality and family income. Because low income is often accompanied by a host of other risk factors (e.g., low parent education), we estimated an alternative set of models using a risk index that included low income and correlated sociocontextual factors. Our expectation was that higher quality child care would moderate associations between sociocontextual risk and achievement in a manner consistent with the argument that higher quality care promotes the achievement of children growing up in the context of low family income and correlated risks.

To summarize, we asked two primary questions. First, does higher quality child care during early childhood moderate associations between family economic status and children’s achievement during middle childhood? Second, is there an indirect pathway of association whereby higher quality child care is associated with better school readiness skills and, in turn, these school readiness skills predict better achievement through middle childhood? In addition, we examined the robustness of our results across multiple analytic specifications, with a special emphasis on whether results for the moderating effects of higher quality child care on
associations between family economic status and middle-childhood achievement were evident when: (a) adjusting for potential selection bias using propensity scores and (b) considering low family income in combination with other correlated socio-contextual risk factors.

**Method**

The present study was based on secondary analyses of the NICHD SECCYD, a prospective longitudinal study that was originally designed to examine the developmental implications of early child care. The data used in our investigation were from the first, second, and third phases of the NICHD SECCYD, which covered children’s lives from birth through fifth grade, including data on: (a) child-care quality during infancy and early childhood, (b) family economics across the first 10 years of children’s lives, (c) early school readiness skills, and (d) child math and reading achievement during middle childhood. To address potential selection effects, we also used a large variety of child, parent, and family variables that were collected as part of the SECCYD.

**Sample and Study Phases**

Shortly after giving birth in 1991, 1,364 women and their recently born children living in or near 10 urban and suburban sites in the United States were recruited to participate in the SECCYD using a conditional random sampling method (for sampling details, see NICHD Early Child Care Research Network & Duncan, 2003). The sample is not statistically representative of any population defined a priori, and families were excluded from the study if children had a disability or mothers were < 18 years old, were not fluent in English, and/or lived in a very dangerous neighborhood. Nonetheless, the sample is economically and geographically diverse.

The first phase of the study included assessments of children and their developmental contexts at four ages: 6, 15, 24, and 36 months. Telephone interviews were used to update the status of child-care arrangements at 3- and 6-month intervals following the 6-, 15-, and 24-month assessments. The second phase of the study included assessments of these same children at 54 months, kindergarten, and first grade as well as telephone interviews when children were 42, 46, 50, 60, and 66 months of age. The third phase included assessments at third and fifth grades.

**Measures**

**Child, maternal, and family characteristics.** When children were 1 month of age, their mothers reported on several demographic characteristics, including child gender, ethnicity, and birth order. At this time, mothers also reported on their age and level of education. At 10 time points during the study, mothers also reported on their partner status and household size; we formed summary indicators from these two variables using the proportion of assessment points at which mothers were married or partnered and the mean household size across the study.

Data on maternal attitudes, behaviors, intelligence, and personality as well as the quality of the home environment were also collected. At 1 month, mothers completed the Beliefs About the Consequences of Maternal Employment for Children scale (Greenberger, Goldberg, Crawford, & Granger, 1988) and the Parental Modernity Scale (Schaefer & Edgerton, 1985), providing measures of their beliefs about the potential benefits and costs of maternal employment and childrearing. At 6 months, maternal separation anxiety was assessed using the Maternal Separation Anxiety Scale (Hock, Gnezda, & MacBride, 1983) and mothers completed three subscales from the NEO Personality Inventory (Costa & McCrae, 1985) to assess extraversion, agreeableness, and neuroticism.

At 6 months, observations were also completed of maternal sensitivity to child distress and nondistress (NICHD Early Child Care Research Network, 2007) and the quality of the home environment (Home Observation Measure of the Environment [HOME]; Caldwell & Bradley, 1984). From this latter measure, we used the total quality score that included the sum of subscale scores in the areas of: parental responsiveness toward the child, parental acceptance of the child, organization of the environment, presence of learning materials, parental involvement, and the variety of experiences provided to the child. In addition, at 36 months, mothers completed the Peabody Picture Vocabulary Test–Revised (Dunn & Dunn, 1981), an indicator of verbal intelligence. Descriptive statistics are displayed in Table 1 for all child, maternal, and family characteristics.

**Income-to-needs.** At nine time points (i.e., 6, 15, 24, 36, and 54 months as well as at kindergarten, first grade, third grade, and fifth grade), families reported on their annual household income from all sources. From these data, an income-to-needs ratio was computed at each time point, defined as
family income divided by the poverty threshold for the appropriate family size, as established by the U.S. Census Bureau. Note that an income-to-needs ratio of 1.0 denotes the poverty level, 2.0 is often considered the threshold for “near poverty” or low income, and approximately 3.0 denotes middle-class status. For our analyses, we used families’ average income-to-needs across the study. By examining income-to-needs as continuous rather than as categorical (e.g., poor vs. not poor), we were able to define more precisely the levels of family economic resources across which higher quality care might promote achievement.

Descriptive statistics for average income-to-needs are displayed in Table 1. Note, however, that income-to-needs levels were centered on the sample mean (i.e., 3.68 was subtracted from each value so that the mean of the new centered income-to-needs variable was equal to 0) for analyses, because it was included in statistical interaction terms (for a discussion of the advantages to centering predictors in interactions, see Dearing & Hamilton, 2006).

Child care. For children in nonmaternal care for 10 or more hr per week, child-care quality was assessed during two half-day visits to children’s primary child-care setting at 6, 15, 24, 36, and 54 months using the Observational Record of the Caregiving Environment (ORCE), a live observational instrument designed for the SECCYD (NICHD Early Child Care Research Network, 1996, 2000). Study children were observed for a total of four 44-min observation cycles at each age. At 6, 15, and 24 months, sensitivity to child’s nondistress expressions, positive regard, stimulation of cognitive development, detachment, and flat affect were assessed using qualitative ratings. At 36 months, two additional categories were added: fostering exploration and intrusiveness. At 54 months, ratings were focused on sensitivity and responsivity, stimulation of cognitive development, intrusiveness, and detachment. A composite variable of child-care quality was formed by summing the qualitative ratings across domains.

Internal consistencies for the composite quality indicators were above .80 at each age. Means and standard deviations for these composites are displayed in Table 2. Also presented in Table 2 are the percentages of children who were in these same arrangements 6 months later, as indicated in telephone interviews. Median time in child-care setting ranged from 7 months (at 12 and 42 months) to 14 months (at 30 and 60 months).

For the present study, a dummy variable representing higher quality child care was created for each time point at which child-care quality was observed. Higher quality care was defined such that children at or above the median (at that time point) on the quality composite were coded as 1, whereas children below the median as well as children in nonmaternal care for < 10 hr per week were coded as 0. The resulting five dummy variables were then summed across the five assessments to create an indicator of the number of episodes that children were in higher quality care, with scores ranging from 0 to 5. We created dummy variables for lower quality care (i.e., below the median at each time point) in a similar fashion; number of episodes in lower quality care was then computed by summing across these dummy variables. The mean number of episodes in higher quality child care was 1.58 (SD = 1.38) and the mean number of episodes in lower quality child care was 1.31 (SD = 1.35).

Note that using the median as a quality cut-point resulted in groupings that were theoretically meaningful. On the 4-point ORCE qualitative ratings, scores of 3.0 or higher (and 2.0 or lower on reverse scored items) indicated care that was developmentally stimulating and supportive. At each time point, children with overall quality scores at or

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**Table 1**

Descriptive Statistics for Child Characteristics, Maternal Characteristics, and Income-to-Needs

<table>
<thead>
<tr>
<th>Variables</th>
<th>M (SD)/%</th>
<th>Missing (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender = boy</td>
<td>51.69%</td>
<td>0</td>
</tr>
<tr>
<td>African American</td>
<td>12.9%</td>
<td>0</td>
</tr>
<tr>
<td>European American</td>
<td>80.43%</td>
<td>0</td>
</tr>
<tr>
<td>Latino American</td>
<td>6.09%</td>
<td>0</td>
</tr>
<tr>
<td>Birth order</td>
<td>1.83 (0.95)</td>
<td>0</td>
</tr>
<tr>
<td>Maternal characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>28.11 (5.63)</td>
<td>0</td>
</tr>
<tr>
<td>Years of education</td>
<td>14.23 (2.51)</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Average partner status</td>
<td>0.69 (0.36)</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Traditional childrearing values</td>
<td>60.34 (15.21)</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>9.21 (1.78)</td>
<td>6.8</td>
</tr>
<tr>
<td>Separation anxiety</td>
<td>66.42 (13.84)</td>
<td>6.4</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>29.77 (7.16)</td>
<td>6.7</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>46.28 (5.29)</td>
<td>6.7</td>
</tr>
<tr>
<td>Extraversion</td>
<td>42.49 (5.83)</td>
<td>6.7</td>
</tr>
<tr>
<td>Employment attitudes</td>
<td>0.85 (7.11)</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Intelligence (PPVT)</td>
<td>99.01 (18.35)</td>
<td>14.4</td>
</tr>
<tr>
<td>Household characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average household size</td>
<td>4.22 (1.01)</td>
<td>3.8</td>
</tr>
<tr>
<td>6-month HOME</td>
<td>36.55 (4.65)</td>
<td>6.2</td>
</tr>
<tr>
<td>Average income-to-needs</td>
<td>3.68 (2.98)</td>
<td>4.0</td>
</tr>
</tbody>
</table>

*Note. PPVT = Peabody Picture Vocabulary Test; HOME = Home Observation Measure of the Environment.
above the median had scores of 3.0 or higher on the majority, if not all, of the individual items.

*Sociocontextual risk.* We created an index of sociocontextual risk from income-to-needs and correlated maternal and family risk characteristics. Because our purpose in computing this risk index was to examine low family income in combination with correlated risk factors, we first examined intercorrelations between the child, maternal, and family characteristics (listed in Table 1) and family income-to-needs. Six variables were strongly associated with income-to-needs (i.e., $r > .40$): maternal age, education, verbal intelligence, sensitivity, and traditional parenting values (negatively correlated) as well as the 6th-month HOME score.

We then dichotomized each of these six indicators and family income-to-needs, with values of 1 on each variable indicating high risk. For family income-to-needs, we classified children who were low income or poorer (i.e., income-to-needs < 2.0; 29.7% of sample) as high risk. For maternal age, we used < 20 as the high-risk cut-point (7.0% of sample was younger than 20). For maternal education, we used less than high school as the cut-point (10.2% of sample). For verbal intelligence, sensitivity, and the HOME, participants with scores in the lowest third of the sample were classified as high risk. For traditional parenting values, participants with scores in the highest third of the sample were classified as high risk. Next, we summed the dichotomized variables so that risk index scores ranged from values of 0 to 7, with 7 indicating the highest total number of risks. However, < 6% of the sample had six or seven risks and a cross-tabulation of the risk index by episodes in higher quality child care revealed many empty cells (e.g., no children with seven risks were in more than three episodes of higher quality child care and no children in five episodes of higher quality care had more than four risks). Thus, we limited the risk index to four levels with similar cell sizes: 0 risks (approximately 31% of the sample), 1 risk (approximately 23% of the sample), 2–3 risks (approximately 26% of the sample), and 4 or more risks (approximately 20% of the sample).

*School readiness skills.* Children’s cognitive knowledge and skills were assessed by trained research assistants when children were 36 months of age using the School Readiness composite from the Bracken Basic Concept Scale (Bracken, 1984). This 51-item composite assesses children’s abilities in areas such as letter identification, number and counting skills, comparisons, and color and shape recognition. The measure has demonstrated excellent validity via correlations with intelligence measures and academic performance in kindergarten (Laughlin, 1995); it has also demonstrated good split-half and test–retest reliability (Bracken, 1984; Bracken, Howell, Harrison, Stanford, & Zahn, 1991). In the SECCYD, the internal consistency was excellent ($\alpha = .93$).

### Table 2

**Descriptive Statistics for Child-Care Quality**

<table>
<thead>
<tr>
<th>Quality score</th>
<th>In same arrangement 6 months later, %</th>
<th>Missing (%)</th>
<th>Percentage of children in higher quality care</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low income (n = 405)</td>
<td>Middle income (n = 501)</td>
<td>High income (n = 458)</td>
</tr>
<tr>
<td>6 months</td>
<td>14.72 (2.86)</td>
<td>64.5</td>
<td>5.6</td>
</tr>
<tr>
<td>15 months</td>
<td>14.48 (2.89)</td>
<td>68.0</td>
<td>7.0</td>
</tr>
<tr>
<td>24 months</td>
<td>13.85 (2.79)</td>
<td>69.6</td>
<td>9.3</td>
</tr>
<tr>
<td>36 months</td>
<td>19.38 (3.17)</td>
<td>60.5</td>
<td>9.9</td>
</tr>
<tr>
<td>54 months</td>
<td>11.80 (2.13)</td>
<td>79.2</td>
<td>16.8</td>
</tr>
</tbody>
</table>

*Total episodes in higher quality care*  

| Low income (n = 405) | Middle income (n = 501) | High income (n = 458) |
| 0 episodes* | 36.2 | 25.5 | 18.2 |
| 1 episode | 34.1 | 27.6 | 22.8 |
| 2 episodes | 18.5 | 21.7 | 20.9 |
| 3+ episodes | 11.2 | 25.2 | 38.1 |

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*In this column, we present the percentage of children who were still in the same child-care arrangement as reported in phone interviews 6 months later (i.e., at 12, 21, 30, 42, and 60 months, respectively). *The percentages and sample sizes in these three columns were based on averages across the five complete data sets after using multiple imputation to replace missing values. Quality scores above the sample median were classified as "higher quality." *The percentages of children in maternal care only (i.e., no higher or lower quality child care) were 12.3% for low income, 11.8% for middle income, and 9.0% for high income.*
Middle-childhood achievement and cognitive ability. In the SECCYD, a variety of achievement and cognitive ability scales from the Woodcock–Johnson Psycho-educational Battery–Revised (WJ–R; Woodcock & Johnson, 1989) were administered to children. The reliability and validity of the WJ–R has been well documented. At third and fifth grades, broad mathematics and broad reading scores were obtained as general measures of achievement in these domains. On the WJ–R, broad mathematics scores are computed from two achievement scales: calculations, a scale used to assess children’s ability to add, subtract, multiply, and divide, and applied problems, which requires children to solve practical mathematical problems. Broad reading scores are computed from two scales: letter–word identification, which requires children to match pictographic representations of words with pictures of objects, and passage completion, which requires children to select the most appropriate word to complete a passage of text.

Four scales from the WJ–R were assessed three or more times, allowing patterns of growth to be examined. Two of the achievement tests included in the broad math and reading scores (i.e., applied problems and letter–word identification) were also assessed at 54 months and fifth grade, providing four total assessments. In addition, two cognitive ability scales were assessed at three and four time points, respectively. Memory for sentences, a measure of children’s ability to remember and repeat words, phrases, and sentences, was assessed at 54 months, first grade, and third grade. Picture vocabulary, a measure of children’s ability to recognize or name objects in pictures, was assessed at 54 months, first grade, third grade, and fifth grade. Descriptive statistics for these scales are displayed in Table 3.

Multiple Imputation (MI) for Missing Values

Of the SECCYD participants, approximately 75% had complete data on all predictors and at least one achievement assessment during middle childhood. Moreover, we found very little evidence that rate of missing data varied by family economic status. On the fifth grade achievement outcomes and child-care quality variables, for example, all correlations between missing versus complete data and income-to-needs were smaller than $r = .08$. Nonetheless MI is generally a preferred method for handling missing data compared with discarding participants or observations (Schafer & Graham, 2002; Widaman, 2006). Thus, we conducted our analyses using MI to include all 1,364 children and families.

Specifically, we used MI by chained equations (i.e., MICE; Royston, 2004), computing five complete data sets that combined observed and imputed values. We then used MI estimation techniques (e.g., mifit in STATA) to run our analyses and combine estimates from these five data sets according to “Rubin’s rules” (Rubin, 1987; Schafer & Graham, 2002). Consistent with the SECCYD protocol, quality scores were imputed only if nonmissing or imputed data indicated that children were in care 10 or more hr per week. Based on averages across these five complete data sets, the percentages of children in higher quality child care at each assessment point and across the study are presented in Table 2 for families with: (a) income-to-needs $\leq 2.00$ (i.e., low income), (b) income-to-needs between 2.01 and 4.00 (i.e., middle income), and (c) income-to-needs $> 4.00$ (i.e., high income). Family income-to-needs was moderately correlated (average $r = .27$ across the five data sets) with number of episodes in higher quality care but was not associated with the number of episodes in lower quality care (average $r = -.01$ across the five data sets).

Addressing Potential Selection Bias Using Covariates and Generalized Propensity Scores

A concern for the present study is that selection processes rather than child-care quality per se may moderate the effects of family income on child achievement. Following McCartney, Bub, and Burkinal’s (2006) advice for addressing concerns over selection, we used three different methodological approaches to study questions and assessed the robustness of findings across these methods. First, we included a large set of child and parent characteristics as statistical covariates in our regression and multilevel models. The covariates that we included (listed in Table 1) have proven to be associated with selection into higher quality child care in past research (e.g., NICHD Early Child Care Research Network & Duncan, 2003), although even the most thorough set of covariates leaves open the potential for omitted variable bias (Duncan, Magnuson, & Ludwig, 2004).

As a second approach, we used propensity scores to help control for potential selection bias (Imbens, 2000; Rosenbaum & Rubin, 1984). Propensity score matching is a three-step process that can reduce as much as 90% of selection bias in non-experimental data (Leon & Hedeker, 2006). In the first step, the “treatment” of interest is regressed
on a set of covariates thought to be associated with selection; generally, logistic regression is used for this first step. Next, estimated probabilities for receiving the treatment, taken from the logistic regression analysis in the first step, are used to match participants who did receive the treatment with those who did not receive the treatment. Finally, in the third step, the effects of the treatment are then estimated for these matched participants.

Although propensity score matching has generally been reserved for studies comparing one treatment group with one comparison group, Imbens (2000) demonstrated that this method can be applied to studies of ordered dose-response data using a weighting scheme. To form the weights, dosage levels for the treatment of interest are regressed on a set of covariates using ordinal (or multinomial) logistic regression. Then, the weights are computed using the inverse of the predicted probabilities corresponding to the dosage of treatment that each participant received. Imbens refers to these weights as generalized propensity scores. To compute and use generalized propensity scores in the present study, we first regressed the number of episodes in which children were in higher quality child care on the child and maternal characteristics displayed in Table 1. Next, we used the resulting generalized propensity scores as weights in our analyses of the moderating effects of higher quality child care.

As a third methodological approach for addressing potential selection bias, we used propensity scores as variables in our analyses. Specifically, we included both the main effect of children’s propensities to receive a high dosage of higher quality child care and the interaction of these propensity scores with family income-to-needs. Thus, we were able to examine whether the propensity to receive a high dosage of higher quality child care moderated the effects of income-to-needs on child achievement and, most importantly, whether higher quality child care per se moderated income above and beyond the potential moderating effects of selection propensity. We present results for the moderating effects of selection based on children’s propensities to be in five episodes of higher quality child care, although we also used a variety of other specification strategies (e.g., propensity to be in more than one episode or more than three episodes) to examine the potential moderating effects of selection. Across all strategies, the moderating effects of higher quality care were substantively identical.

It is important to note that propensity scores ultimately rely on measured covariates, and this method is not a substitute for randomization. Although randomization can be used to balance participants on both observed and unobserved variables, propensity scores are a means of balancing participants on observed variables. The longitudinal SECCYD design, however, allowed us to balance participants on characteristics that were observed prior to collecting the child outcome data, an important advantage when using propensity scores (Rubin, 2007). Moreover, using multiple approaches to control for potential selection bias provided an indication of the robustness of our results beyond relying solely on traditional covariate methods.

## Results

### Moderating Effects of Higher Quality Child Care for Math and Reading Achievement

As a first step in our analyses, we regressed children’s math and reading achievement scores on...
family income-to-needs, number of episodes in higher quality child care, and the interaction of the two child-care quality variables with income-to-needs. To help control for potential child-care selection effects, we also included a variety of demographic, attitude, and psychological characteristics of children, mothers, and families as covariates, namely: (a) child gender, ethnicity, and birth order; (b) maternal age, years of education, average partner status, childrearing values, sensitivity, separation anxiety, personality (i.e., neuroticism, extraversion, and agreeableness), attitudes toward employment, and verbal intelligence; and (c) family household size and quality of the home environment.

For the broad math and reading outcomes, we estimated random intercept models, allowing us to examine average math and reading achievement across third and fifth grade as well as variations by grade in the estimated associations. For the four individual achievement scales that were assessed at three or more time points between 54 months and fifth grade (i.e., applied problems, letter–word identification, memory for sentences, and picture vocabulary), we estimated multilevel growth models with random intercepts and random slopes. For the applied problems, letter–word identification, and picture vocabulary scales, unconditional growth models indicated significant ($p < .01$) linear and quadratic change over time. For the memory for sentences scale, there was significant ($p < .01$) linear change over time.

In the multilevel growth models, we centered linear and quadratic achievement slopes on their grand means so that intercepts in the first levels of the models provided estimates of average achievement across middle childhood. Thus, for applied problems, letter–word identification, and picture vocabulary, predictors of interest and covariates were specified for three growth parameters: (a) average achievement between 54 months and fifth grade, (b) linear change in achievement between 54 months and fifth grade, and (c) quadratic change in achievement between 54 months and fifth grade. For memory for sentences, a similar model was estimated with the exception that average achievement was estimated between 54 months and third grade, and there was no quadratic growth parameter in the model. A summary of the results from these models is presented in Table 4. For the random intercept models, we present only the results for average broad math and reading achievement in this table, because none of the

| Table 4: The Moderating Effects of Higher Quality Child Care and Lower Quality Child Care for Associations Between Family Income-to-Needs and Achievement During Middle Childhood |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Broad math:     | Broad reading:  | Applied problems: | Picture vocabulary: | Memory for sentences: |
| Intercept Age   | Intercept Age   | Intercept Age   | Intercept Age   | Intercept Age   |
| Income-to-needs | .89*** (.29)    | .80*** (.29)    | .64*** (.29)    | .38*** (.29)    |
| Higher quality  | .05 (.04)       | .01 (.03)       | .03 (.03)       | .01 (.02)       |
| Episodes        | .14 (.08)       | .07 (.07)       | .02 (.02)       | .01 (.01)       |
| Lower quality   | .04 (.04)       | .01 (.01)       | .00 (.00)       | .00 (.00)       |
| Episodes        | .19*** (.09)    | .15*** (.09)    | .12*** (.09)    | .10*** (.09)    |
| Higher quality  | .06 (.05)       | .03 (.03)       | .01 (.01)       | .00 (.00)       |
| Episodes        | .18*** (.09)    | .15*** (.09)    | .12*** (.09)    | .10*** (.09)    |
| Lower quality   | .04 (.04)       | .01 (.01)       | .00 (.00)       | .00 (.00)       |
| Episodes        | .18*** (.09)    | .15*** (.09)    | .12*** (.09)    | .10*** (.09)    |
| Income-to-needs | .06 (.05)       | .03 (.03)       | .01 (.01)       | .00 (.00)       |
| Higher quality  | .19*** (.09)    | .15*** (.09)    | .12*** (.09)    | .10*** (.09)    |
| Episodes        | .18*** (.09)    | .15*** (.09)    | .12*** (.09)    | .10*** (.09)    |

Note. Coefficients for Age and Age 2 are associations with linear and quadratic changes in achievement. Standardized errors are in parentheses. In brackets are higher quality interaction coefficients from models in which the interaction for lower quality child care was excluded. All models included covariates for: child birth order, ethnicity, and gender; maternal age, education, partner status, childrearing values, employment attitudes, sensitivity, separation anxiety, neuroticism, extraversion, agreeableness, and verbal intelligence; and household size and Home Observation of the Environment score. **p < .01, ***p < .001.
estimated associations for our predictors of interest varied by child grade. Complete results, including coefficients for the covariates, are available from the authors upon request.

For five of the six outcomes, there was a statistically significant association between income-to-needs and average achievement. Given the inclusion of the interaction terms, these significant main effects indicated that higher levels of family income-to-needs predicted higher levels of math and reading achievement for children who were never in higher quality or lower quality child care (i.e., 0 episodes). The interaction of higher quality child care by income-to-needs, however, was statistically significant for four of the six estimates of average achievement: broad math, broad reading, applied problems, and letter–word identification. This interaction also approached significance \( p = .07 \) for picture vocabulary. As indicated by the negative sign of these interaction coefficients, the association between income-to-needs and achievement became increasingly smaller with each additional episode that children were in higher quality child care.

Interactions for average broad math and reading scores between third and fifth grades are displayed in Figure 1a and b. Interactions for average applied problem and letter–word identification scores between 54 months and fifth grade are displayed in Figure 2a and b. In these figures, associations between income-to-needs and achievement are graphed for children who were in either zero or two episodes of higher quality care, which were common dosage levels for children from both low- and high-income families. Income-to-needs values are plotted from 1 SD below the mean (i.e., 0.74) to 1 SD above the mean (i.e., 6.62). Regions of significance for the interactions are also graphed indicating the range of income-to-needs values across which children’s achievement scores differed significantly as a function of each additional episode in higher quality child care.

As is evident in the figures, the association between income-to-needs and achievement is less steep for children who were in two episodes of higher quality child care compared with those who were never in higher quality care. In fact, if children were in three or more episodes of higher quality care, the associations between income-to-needs and three of the outcomes became statistically indistinguishable from 0 (i.e., \( p = .22 \)) for children in four episodes of higher quality child care. In other words, low-income children’s achievement in these areas was similar to their wealthier peers given three or four episodes of higher quality care. Moreover, even one episode in higher quality care was associated with statistically significant benefits for low-income children’s math achievement.

The region of significance covered values on income-to-needs of 3.08 and below for average broad math scores. In other words, at 308% of the poverty line and below, even one episode of higher quality early child care was associated with
significantly better math achievement. The region of significance covered values of 194% of the poverty line and below for average applied problems, and 185% of the poverty line and below for average letter–word identification.

For children’s broad reading scores, however, the region of significance was outside possible values on income-to-needs (e.g., < 0). In other words, although income-to-needs was less strongly associated with reading achievement for children in higher quality child care than for other children, episodes in higher quality child care did not provide a statistically distinguishable advantage on broad reading achievement for children at any level of income-to-needs. In addition, although there were also regions of significance at the high end of income distribution, these regions began at extremely high levels of income-to-needs that were either not represented in the NICHD SECCYD sample or contained < 1% of the sample.

With regard to the size of achievement differences for low-income children, each additional episode in higher quality child care was associated with 5% of a standard deviation increment in broad math achievement for children in families at 200% of the poverty line (e.g., children in two episodes scored 10% of a standard deviation higher and those in three episodes scored 15% of a standard deviation higher than children in no episodes). Each episode of higher quality child care was associated with approximately 7% of a standard deviation increment in applied problems scores for children at 194% of the poverty line and approximately 6% of a standard deviation increment in letter–word identification scores at 185% of the poverty line. As a comparison, consider the estimated effect of income-to-needs on the achievement of children who were never in higher quality child care. For these children, an increase in income-to-needs from 200% to 300% of the poverty line would have corresponded to an estimated 6% of a standard deviation increase in broad math scores, 11% of a standard deviation for applied problems, and 10% of a standard deviation for letter–word identification.

There were no statistically distinguishable interactions of income-to-needs and higher quality child care for linear or quadratic change in achievement, nor did the interactions significantly differ at third and fifth grades for the broad math and reading scores. One implication of these null results is that higher levels of achievement for low-income children who attended higher quality child care compared with those who did not attend such care neither diminished nor increased in size across the study. In other words, for low-income children, the achievement advantage of attending higher quality child care was relatively stable over time. Moreover, we found no evidence that lower quality child care moderated the effects of low-income for any of the six achievement outcomes.

Indirect Effects of Higher Quality Care on Middle-Childhood Achievement via School Readiness

For the five outcomes that evidenced significant or close to significant moderating effects of
higher quality child care, we examined children’s school readiness skills as a potential mechanism linking the effects of higher quality child care with achievement in middle childhood. In these analyses, we used episodes in child care from 6 to 36 months and excluded the 54-month child-care data because school readiness skills were assessed at 36 months. We first regressed school readiness at 36 months on episodes in higher quality care between 6 and 36 months and this variable’s interaction with family income-to-needs. Then, we regressed the middle-childhood achievement outcomes on: (a) episodes in higher quality care between 6 and 36 months, (b) the interaction between episodes in higher quality care and family income-to-needs, and (c) school readiness. Finally, as a direct test of our mediation hypothesis, we estimated the product of the coefficients comprising the indirect pathways from episodes in higher quality child care to school readiness and, in turn, from school readiness to middle-childhood achievement for children at the poverty line (i.e., income-to-needs = 1.0).

These results are provided in Table 5, with three findings particularly relevant for examining the potential indirect effects of higher quality care via school readiness. First, episodes in higher quality child care significantly moderated the association between income-to-needs and school readiness. Second, school readiness was significantly and positively associated with all five outcomes, and none of the interactions were significant for the five outcomes when controlling for school readiness (as presented in brackets, four of the interactions were significant or close to significant prior to controlling for school readiness). Third, for children at the poverty line, the products of the coefficients comprising the mediated effects were statistically significant ($p < .05$) for all five outcomes. Thus, our results were consistent with a pathway of mediation whereby higher quality child care promoted low-income children’s school readiness skills and, in turn, these skills promoted their achievement through middle childhood. (These results are also consistent with mediated moderation, as described by Muller, Judd, and Yzerbyt, 2005.) The total effects of higher quality early child care on low-income children’s middle-childhood achievement, however, appeared most robust for broad math, applied problems, and letter–word identification, outcomes for which achievement differences associated with higher quality child care were discernable prior to including the intervening effects of school readiness.

Controlling for Selection Bias Using Propensity Scores

In an effort to control more stringently for potential selection bias when estimating the total effects of higher quality child care on low-income children’s achievement in middle childhood, we respecified our models that included the full range of child-care episodes (i.e., from 6 and 54 months), this time using generalized propensity scores. To compute these propensity scores, we first regressed number of episodes in higher quality child care on

<table>
<thead>
<tr>
<th>Family income-to-needs</th>
<th>0.16** (.05)</th>
<th>0.57** (.20)</th>
<th>0.33 (.26)</th>
<th>0.63* (.26)</th>
<th>0.69** (.30)</th>
<th>0.15 (.17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher quality episodes</td>
<td>0.07 (.06)</td>
<td>0.64 (.40)</td>
<td>0.45 (.24)</td>
<td>0.54 (.38)</td>
<td>0.52 (.40)</td>
<td>0.49† (.23)</td>
</tr>
<tr>
<td>Income-to-Needs × Higher Quality Episodes</td>
<td>−0.04* (.02)</td>
<td>−0.17† (.09)</td>
<td>−0.14 (.11)</td>
<td>−0.13 (.10)</td>
<td>−0.20 (.13)</td>
<td>−0.06 (.06)</td>
</tr>
<tr>
<td>School readiness</td>
<td>1.12*** (.15)</td>
<td>1.35*** (.18)</td>
<td>1.52*** (.16)</td>
<td>2.11*** (.22)</td>
<td>1.03*** (.11)</td>
<td></td>
</tr>
<tr>
<td>Indirect effect ($\delta \beta$) for children at the poverty line</td>
<td>0.21* (.10)</td>
<td>0.26* (.13)</td>
<td>0.29* (.14)</td>
<td>0.40* (.20)</td>
<td>0.20* (.10)</td>
<td></td>
</tr>
</tbody>
</table>

Note. Standard errors are presented in parentheses. The size and statistical significance of the interaction coefficients prior to controlling for school readiness are displayed in brackets.

$\delta$Coefficients are displayed only for average achievement. All models included the following covariates: child birth order, ethnicity, and gender; maternal age, education, partner status, childrearing values, employment attitudes, sensitivity, separation anxiety, neuroticism, extraversion, agreeableness, and verbal intelligence; and household size and total Home Observation of the Environment score.

$^1$p < .10, $^*p < .05, **p < .01, ***p < .001.
The results from our models that included the moderating effects of selection propensity are in the bottom half of Table 6. As indicated in this table, the significant interactions of selection propensity and higher quality child care also appear to promote achievement starting in early childhood and continuing into middle childhood. The complete results from these analyses are available upon request. The complete results from these analyses are available upon request.

### Table 6

The Moderating Effects of Higher Quality Child Care: Adjusted Estimates Using Propensity Scores

<table>
<thead>
<tr>
<th></th>
<th>Broad math: G3–G5</th>
<th>Broad reading: G3–G5</th>
<th>Applied problems: 54m–G5</th>
<th>Letter–word identification: 54m–G5</th>
<th>Memory for sentences: 54m–G3</th>
<th>Picture vocabulary: 54m–G5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercept</td>
<td>Age</td>
<td>Age&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Intercept</td>
<td>Intercept</td>
<td>Intercept</td>
</tr>
<tr>
<td>Income-to-needs</td>
<td>1.56** (.33)</td>
<td>1.61*** (.34)</td>
<td>1.94*** (.32)</td>
<td>1.94*** (.32)</td>
<td>2.11*** (.41)</td>
<td>2.11*** (.41)</td>
</tr>
<tr>
<td>Higher quality episodes</td>
<td>0.56 (3.1)</td>
<td>0.17 (.32)</td>
<td>0.20 (.33)</td>
<td>0.20 (.33)</td>
<td>0.23 (.39)</td>
<td>0.23 (.39)</td>
</tr>
<tr>
<td>Income-to-Needs × Higher Quality</td>
<td>-0.22 (.11)</td>
<td>-0.19 (.09)</td>
<td>-0.20 (.09)</td>
<td>0.01 (.07)</td>
<td>0.00 (.01)</td>
<td>0.00 (.01)</td>
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<td></td>
</tr>
<tr>
<td>Income-to-needs</td>
<td>1.56*** (.33)</td>
<td>1.61*** (.34)</td>
<td>2.11*** (.41)</td>
<td>2.11*** (.41)</td>
<td>1.77*** (.59)</td>
<td>1.77*** (.59)</td>
</tr>
<tr>
<td>Selection propensity</td>
<td>0.56 (3.1)</td>
<td>0.17 (.32)</td>
<td>0.20 (.33)</td>
<td>0.20 (.33)</td>
<td>0.23 (.39)</td>
<td>0.23 (.39)</td>
</tr>
<tr>
<td>Income-to-Needs × Higher Quality</td>
<td>-0.22 (.11)</td>
<td>-0.19 (.09)</td>
<td>-0.20 (.09)</td>
<td>0.01 (.07)</td>
<td>0.00 (.01)</td>
<td>0.00 (.01)</td>
</tr>
<tr>
<td></td>
<td>-0.19* (.09)</td>
<td>-0.16 (.11)</td>
<td>-0.20 (.10)</td>
<td>0.05 (.06)</td>
<td>-0.01 (.01)</td>
<td>-0.22 (.13)</td>
</tr>
<tr>
<td>Higher Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Models using propensity scores as weights also included the following covariates: child birth order, ethnicity, and gender; maternal age, education, partner status, childrearing values, employment attitudes, sensitivity, separation anxiety, neuromuscular, extraversion, aggression, and verbal intelligence; and household size and total Home Observation of the Environment score.

*p < .10. **p < .05. ***p < .01. ****p < .001.
pensity for higher quality child and income-to-needs for all of the outcomes we examined; associations between income-to-needs and children’s achievement were significantly smaller for children with a high predicted probability of being in higher quality child care than for children with a low predicted probability. As such, the combination of characteristics that predicted selection into higher quality care also appeared to promote the achievement of children with low family income, although this protection may have diminished over time for applied problems and letter-word identification (see the interaction coefficients for linear change).

Controlling for the moderating effects of selection propensity also provided our most conservative estimates of the number of moderator effects for higher quality child care. Nonetheless, the interaction of family income-to-needs and higher quality child care remained significant for broad math and average applied problems scores. For these outcomes, higher quality child care once again appeared to promote the achievement of low-income children, above and beyond the effects of selection characteristics. In addition, the interaction for picture vocabulary approached significance and a complex trajectory of moderating effects of higher quality child care was evident for growth in letter-word identification; beginning prior to first grade, higher quality care was associated with significantly better letter-word performance for low-income children, but this effect diminished to insignificant levels after third grade.

**Higher Quality Child Care as a Moderator of Sociocontextual Risk**

Beyond using multiple approaches to control for potential selection bias, we also explored whether higher quality care benefits children who experience a host of risks along with low income by including low income as part of a composite index of sociocontextual risk. We examined whether higher quality care moderated associations between the general indicator of sociocontextual risk and achievement, while controlling for the 12 child, maternal, and family characteristics that were not part of the risk index. A summary of these results is in Table 7.

Higher quality child care significantly moderated the association between sociocontextual risk and two outcomes: broad math and applied problems. This interaction approached significance for letter-word identification. In addition, for broad math, the association between risk and achievement varied by episodes in lower quality child care, and this interaction approached significance for applied problems. Risk was more strongly and negatively associated with achievement in these areas for children in maternal care than for either child-care group. Moreover, given a risk score of 2 or higher, each additional episode of higher quality child care was associated with significantly (\(p < .05\)) higher achievement; at the highest level of risk, two episodes of higher quality child care were associated with 27% of a standard deviation higher applied problems scores compared with children in maternal care. Although children in three episodes of lower quality child care also appeared to display higher achievement than children in maternal care at high levels of risk, this difference was not statistically significant.

**Additional Replication Strategies: Are These Results Robust to Model Respecification?**

To further examine the robustness of the evident moderating effects of higher quality child care, we...
explored a number of alternative model and variable specifications. For example, we estimated a variety of alternative specifications for the child-care variable, including the moderating effects of: (a) cumulative hours in higher quality child care rather than number of episodes; (b) a dichotomous indicator of whether children were in higher quality child care for the majority of early childhood (i.e., three or more episodes) or not; (c) episodes in higher quality child care, excluding children who were only in maternal care during the study; and (d) average child-care quality across the study (a variable on which over 37% of low-income children scored above the median), excluding children who were only in maternal care during the study. In addition, we estimated an alternative specification using average total family income (rather than family income-to-needs) and its interaction with episodes in higher quality child care. Across all of these strategies, we found consistent evidence that higher quality child care appears to promote the achievement of low-income children, with significant moderator effects most frequently evident for broad math, applied problems, and letter–word recognition.

One respecification strategy for family income-to-needs led primarily to null or not quite significant results for the moderating effects of higher quality care: using a poverty status dummy variable. This approach, however, represented a substantial loss of information relative to the continuous indicator of income-to-needs (for a discussion of the analytic costs associated with dichotomizing continuous variables, see Burchinal & Clarke-Stewart, 2007), particularly considering that the estimated benefits of higher quality care extended into middle class when using the continuous indicator of income-to-needs. In fact, when we created dummy variables based on the regions of significance thresholds (e.g., at 300% of the poverty threshold for broad math), the interactions evident for the continuous income-to-needs indicator were replicated.

Discussion

The economic costs of childhood poverty and the potential economic benefits of intervening early have received an unusual amount of interest over recent months, from both policy makers and social scientists (e.g., Committee on Ways and Means, U.S. House of Representatives, 2006; Heckman, 2006). Evidence on the developmental and economic benefits of higher quality preschool and child-care experiences is critical for these discussions (Belfield, N ores, Barnett, & Schweinhart, 2006; Ludwig & Phillips, 2007; Ramey & Ramey, 2004; Reynolds et al., 2002). With a focus on early child care and its potential achievement benefits for low-income children, we found that higher quality care during early childhood appeared to protect children in low-income families, promoting their reading and mathematics achievement through middle childhood. The more episodes that children spent in higher quality care between 6 and 54 months of age, the weaker the association between family income-to-needs and middle-childhood achievement. In some cases, in fact, the achievement of low-income children who experienced three or more episodes of higher quality child care was nearly as high as, and was statistically indistinguishable from, the achievement of affluent children.

We also found, however, that the achievement of low-income children seemed to be promoted by the same characteristics that increased the probability of these children entering higher quality child care. Adjusting for these selection effects using propensity score methods provided our most conservative estimates of the positive effects of higher quality child care. Yet, evidence that higher quality care per se promoted the reading and math achievement of low-income children was apparent across all of our modeling strategies. Studies of model child-care programs have documented the effectiveness of higher quality care for promoting the achievement of low-income children (e.g., Schweinhart et al., 2005). Adding to these findings, our results indicate that child care that is naturally selected by low-income families and is above average in quality can bolster the achievement of low-income children, with benefits continuing at least into middle childhood. Indeed, just one episode of higher quality care during early childhood appeared to promote the achievement of low-income children on some of the math and reading outcomes we examined. Although it is also important to note that while many low-income families in the SECCYD accessed higher quality care at least once during early childhood, affluent families were still more likely to use higher quality care and use it more frequently.

Placing these results alongside other recent work on the topic (Lamb, 1998; Loeb, Bridges, Bassok, Fuller, & Rumberger, 2007; McCartney et al., 2007), there is increasing support for the hypothesis that higher quality child care promotes the math and
How Much Did Higher Quality Care Appear to Promote the Achievement of Low-Income Children?

In general, the apparent benefits of higher quality child care extended from children living in the poorest families up through those living in low-income families at just < 200% of the poverty line, although in one case even the achievement of children in lower-middle class families appeared to be promoted by higher quality care. The greatest estimated benefits of higher quality care were evident for the poorest children, but even for children close to 200% of the poverty line the effects of higher quality child care compared favorably with those for family income. For these children, in fact, just one or two episodes in higher quality child care produced estimated impacts on achievement similar in size to achievement gains that would be expected if a family’s income increased enough to move them from low income to approximately middle-class. Moreover, effect sizes for episodes in higher quality child care were even larger when estimated as a moderator of more general sociocontextual risk.

Given these results, maximizing public policy benefits relative to costs may require investing primarily in higher quality care for families at the low end of the income distribution, a point relevant for discussions on universal versus targeted preschool and child-care policy initiatives (Gormley & Phillips, 2005; Greenberg, 2007). In evaluations of universal preschool, the results have been mixed: Some analyses indicate greater benefits for poor children (Gormley & Gayer, 2005) and others indicate similar benefits for poor and not-poor children (Gormley, Gayer, Phillips, & Dawson, 2005). One reason that low-income children may benefit more from higher quality child care than other children is because the home environments of low-income families are, on average, more likely to lack the material and psychosocial resources necessary for promoting early learning (Dearing & Taylor, 2007). In other words, learning stimulation in child care may help compensate for a lack of such stimulation in the home.

In our study, in fact, the exceptional benefits of higher quality care for low-income children were explained, at least in part, by a pathway of mediation consistent with a cognitive advantage hypothesis (e.g., Reynolds et al., 2004). Specifically, higher quality child care was associated with more advanced school readiness skills for low-income children, and in turn, more advanced school readiness skills predicted better middle-childhood achievement. In a previous study (McCartney et al., 2007), this first link between child care and school readiness was also demonstrated in the SECCYD sample. Our results extend this finding by demonstrating that these early skills provide a crucial link between higher quality care and low-income children’s later learning. Ultimately, however, the policy relevance of these findings depends on whether selection effects were appropriately controlled.

Are the Achievement-Promoting Effects of Higher Quality Child Care Causal?

Because children were not randomly assigned to higher quality child-care episodes, the potential bias introduced by selection effects is an important concern in the present study, limiting our ability to make causal inferences. To address this concern, we used three analytic strategies. First, we estimated the moderating effects of higher quality child care while controlling for child, maternal, and family characteristics that have proven to be associated with child-care quality in past research (e.g., NICHD Early Child Care Research Network & Duncan, 2003). For this strategy, the SECCYD data provided an unusually comprehensive set of covariates. Second, we adjusted our estimates using generalized propensity score weights, a strategy specifically designed for reducing selection bias in studies of dosage such as number of episodes in higher quality child care. Third, we examined the moderating effects of child care while controlling for the moderating effects of selection propensity.
Across these strategies, we found evidence consistent with the hypothesis that higher quality child care promotes achievement for children in low-income families. Our models in which we adjusted for the moderating effects of selection, however, provided our most conservative estimates. Although it is not possible with these data to demonstrate empirically that one method or another provided more accurate estimates of the causal effects of child-care quality, one reason that the conventional covariate strategy provided relatively liberal estimates may have been that this method undercontrolled for selection bias. Further underscoring the role of selection, in fact, the achievement of low-income children who were likely to select into higher quality child care, was apparently promoted by the multivariate combination of characteristics that increased their chances of selecting into higher quality child care. Even so, the apparent benefits of higher quality child care per se remained evident for some outcomes when controlling for the moderating effects of selection. Both the characteristics that made it more likely that a family would choose higher quality child care and higher quality care, in and of itself, appeared to promote better achievement in the context of low family income.

Nonetheless, we have two remaining areas of concern regarding potential omitted variable bias. First, all three of our analytic strategies aimed at reducing selection bias relied fundamentally on the assumption that all variables relevant to selection had been measured. To the extent that important selection mechanisms remained unmeasured, our models may have overestimated the apparent positive effects of higher quality child care (Leon & Hedeker, 2006). Second, potential omitted variable bias is a concern for the estimated effects of family income-to-needs, albeit a concern that is less important for determining the practical implications of our results. If the child-care effects in the present study are causal, policy makers and practitioners may care little about whether higher quality child care protects children from poverty per se or protects them from some omitted variable leading to underachievement.

Additional concerns for the present study include: missing data, the characteristics of low-income families in the NICHD SECCYD sample, and the number and timing of child-care observations. Missing data were most common for study outcomes; at some time points, more than one fourth of participants were missing outcome data. To help correct for potential bias introduced by attrition, we used MI to replace missing data. With regard to ethnicity, most children in the SECCYD are White, an important concern given that African American and Latino American children make up a disproportionate amount of children growing up poor in the United States. In addition, other demographic and contextual factors correlated with family income were used as exclusion criteria in this study, including: mothers younger than 18, families not fluent in English, and families living in exceptionally dangerous neighborhoods. Children in low-income families with these characteristics may not have benefited as much from higher quality child care. The sample is, nonetheless, diverse with regard to economic status and geographic region. In addition, measurement quality and frequency of assessment are largely unparalleled in other studies of early child care.

Regarding frequency of assessment, however, five intermittent observations of child-care quality are unlikely to capture all of the variability in children’s experiences with higher quality child care across early childhood. In between assessment points, some children experienced other higher or lower quality care not captured in the NICHD SECCYD, introducing measurement error. Importantly, to the extent that there was measurement error in classifying children as having higher or lower doses of higher quality care, our estimated moderating effects of higher quality child care were biased toward zero.

In summary, we found evidence consistent with the hypothesis that higher quality early child care promotes the achievement of low-income children during middle childhood. As has been suggested for early education intervention, higher quality early child care may help compensate for impoverished home environments by promoting the growth of early cognitive skills on which later achievement depends (Bogard & Takanishi, 2005; Reynolds et al., 2004). Beyond empirical work, these results give added credence to the central role that higher quality child care should play in future discussions on antipoverty policy.

References


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