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# Effectiveness of Early Educational Intervention

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50. R. Salden, V. Aleven, R. Schwonke, A. Renkl, *Instr. Sci.* **38**, 289 (2010).
51. J. Pellegrino, N. Chudowsky, R. Glaser, Eds., *Knowing What Students Know* (National Academies Press, Washington, DC, 2001)
52. R. J. Shavelson, L. Towne, Eds., *Scientific Research in Education* (National Academies Press, Washington, DC, 2002).
53. S. A. Siler, D. Klahr, C. Magaro, K. Willows, D. Mowery, in *Proceedings of the 10th International Conference on Intelligent Tutoring Systems, ITS 2010*, Lecture Notes in Computer Science 6095, V. Aleven, J. Kay, J. Mostow, Eds. (Springer, Berlin, 2010), vol. 2, pp. 198–208.
54. The following publications cited in this brief review are themselves extended literature reviews, often NRC monographs on the specific topic: (*4*, *6*, *17*, *21*, *29*, *30*, *41*, *51*, *52*).

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REVIEW

# Effectiveness of Early Educational Intervention

**W. S. Barnett**

**Early educational intervention has been proposed to partially offset the impacts of poverty and inadequate learning environments on child development and school success. A broad range of early educational interventions are found to produce meaningful, lasting effects on cognitive, social, and schooling outcomes. However, all interventions are not equally effective. Two major U.S. programs perform relatively poorly. Research provides some guidance regarding the features of highly effective programs, but much remains to be learned. New experimental studies of key program features would have a high payoff.**

In the developing world, over 200 million children under age 5 suffer from poverty, poor health and nutrition, and inadequate education (*1*). In the United States, between 35 and 45 percent of first-time kindergarteners are ill-prepared to succeed in school (*2*). Early educational interventions have been recommended as one means of addressing these problems. Provision of early education has been increasing throughout the developing world but is far from complete or uniform (*1*). Provision in the United States remains incomplete as well. One reason that early educational intervention may not be more widely provided is that its effectiveness continues to be debated. Can enriched preschool education produce substantial long-term gains in learning and development? Or, are gains at best short-lived? Can large-scale public programs replicate the results of small-scale research programs, and, if so, under what conditions? These questions, of keen interest to policy-makers as well as scientists, are addressed here with detailed consideration of individual studies and meta-analytic reviews.

"Can large-scale public programs replicate the results of small-scale research programs, and, if so, under what conditions?"

## Longitudinal Randomized Trials

Randomized trials with longitudinal follow-up of both intensive, small-scale programs and large-scale public programs provide key insights into the production of long-term effects. Such studies offer the greatest confidence that estimated effects are due to the program and not to other factors.

In the early 1960s, an experiment randomly assigned 123 [58 experiment (E) and 65 control (C)] low-income African-American children in one southeastern Michigan neighborhood to the Perry Preschool program or to a control group (*3*). Perry classes met 2.5 hours per day, 5 days per week, over a 30-week school year. Most children attended for 2 years beginning at age 3, free of charge, before entering kindergarten. Controls entered kindergarten at age 5. Perry teachers had at least baccalaureate degrees in education and were licensed public school teachers. The curriculum emphasized broad development, with teacher-directed activities accounting for about half the time and child-initiated activities about a quarter of the time. A teacher-student ratio of 1 to 5 or 6 facilitated frequent, highly individualized educational interactions. Home visits with each child (and parents) were conducted weekly.

Treatment and control groups did not differ on measured intelligence quotient (IQ) to start, but the preschool group was 0.87 standard deviation (SD) higher than controls by the end of the program. For comparability across studies, effects are reported as fractions of SDs, typically calculated as the difference between treatment and control groups, divided by control group SD. The IQ gain disappeared by age 8, but positive effects on achievement tests (e.g., 0.33 SD on reading and math at age 14) were found through age 27. To put these effects in context, reading and math achievement gaps at kindergarten entry between low-income and middle-income children are about 0.50 SD (*4*). In addition, the preschool group had better classroom and personal behavior as reported by teachers, less youth misconduct and crime, fewer years of special education, and a higher high school graduation rate. Adult outcomes include increased earnings, decreased dependency on social welfare programs, reduced arrests, and improved health behaviors.

The Abecedarian study used a randomized trial to evaluate effects of full-day, year-round educational child care provided from about 4 months of age to kindergarten entry in North Carolina (*5*). The preschool program did not include home visits, although family support services were provided to both treatment and control groups. The study followed 104 (54 E, 51 C) low-income children from program entry through age 21. Gains in IQ averaged 1.1 SD from age 18 months to age 54 months, declined after school entry, and remained about 0.33 SD from ages 12 through 21. Effects on reading and math achievement were roughly constant at about 0.50 SD from ages 8 to 21. Intervention recipients also had lower rates of repeating grades and special education, and they attained higher levels of education. Positive effects were also found for health-related behaviors and symptoms of depression (*6*).

Studies in lower-income countries have similar long-term findings. A randomized trial ($n$ = 129) of an intervention beginning at age 9 months and continuing to 24 months in Jamaica that taught mothers how to interact with their young, growth-stunted children found gains in child IQ and academic achievement tests and decreases in violent crime and depression through age 22 (*7*). In Mauritius, researchers randomly assigned children (83 E, 255 C) at age 3 to an educational preschool staffed by well-trained and supervised

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student teachers with a pupil:teacher ratio of 5.5:1, nutritious meals, and health screenings and referrals or to typical preschools staffed by untrained child minders with a pupil:teacher ratio of 30:1 and providing no meals (*8*). At ages 17 to 26, the intervention children had lower rates of behavior problems and crime. The Mauritius study could not separate effects of program elements, but the Jamaican study found these long-term effects associated with the educational program but not with nutritional supplementation.

It may be more difficult to produce results like those above through large-scale public programs, and studies of such public programs have more mixed results. A recent randomized trial ($n = 4667$ initially) evaluated 1 year of Head Start (HS), the U.S. federal preschool program for children in poverty that provides education and broader services, including parent education and social and health services (*9*). After 1 year of HS at age 3 or 4, 13 of 22 measures of language, literacy, and math effects were significant; these 13 averaged 0.18 SD. At the end of kindergarten and grade one, no significant cognitive or grade repetition effects were found. No positive effects were found on any teacher-reported measure of socioemotional development or behavior.

A randomized trial ($n = 3001$ initially) of Early Head Start (EHS), the federal early intervention program for infants and toddlers in poverty, produced results similar to those for HS (*10*). EHS provided child care, parent-child activities, parenting and adult education, and other social services. Most children participated for 2 or more years. At ages 2 and 3, some cognitive and social-emotional benefits were found (0.10 to 0.15 SD). By age 5, no effects were found for cognition, and only one positive socioemotional effect remained, a reduction in aggression (*11*). At grade 5 follow-up, no effects were found on any of 49 measures, including grade repetition and special education (*12*).

### Persistence, Fade-Out, and Sleeper Effects

In all four U.S. studies, effect sizes declined over time. However, the magnitude and persistence of effects differs greatly. HS and EHS effect sizes start small and disappear shortly after school entry, whereas Perry and Abecedarian effects are relatively large and long-lasting. One proposed explanation is control-group participation in other preschool programs, which was 35% at age 4 and 25% at age 3 in the HS study. However, HS controls at age 3 and EHS controls likely experienced only child care of very limited educational value (*13*). Furthermore, 68% of Abecedarian study controls attended relatively high quality child-care centers for more than 12 months before kindergarten, and the treatment group's cognitive advantage over these children was smaller from ages 2 to 4 than for those not in such centers (*14*). The problem of control access to other services is not unique to HS and EHS.

Another possible explanation is that the quality of small-scale interventions cannot be maintained by large public programs. That hypothesis is contradicted by studies of U.S. public school pre-kindergarten (pre-K) programs that find gains two or more times greater than for HS (*15*–*18*) and by studies abroad finding similarly large gains and persistent effects for public preschool programs (*19*–*21*). Table 1 compares effects at age 4 for 1 year of HS and several public-school pre-K programs. The best-known follow-up study of public school pre-K, featuring a quasi-experimental design and extensive follow-up, is the Chicago Child-Parent Centers (CPC) study ($n > 1000$), which found that cognitive effects declined but persisted into high school (*18*). Reductions in grade repetition and improved rates of high school completion were also seen. Essentially all of the Perry and Abecedarian effects are replicated, although CPC effects often are smaller (*22*).

Another explanation offered for the fade-out of immediate effects is that the limited effectiveness of the public schools attended by HS graduates erodes the program's impact. This explanation is inconsistent with findings that cognitive growth was slow for both HS and control groups in the preschool years, whereas math and literacy achievement accelerated in kindergarten and first grade for both groups (*9*).

It has been suggested that HS and other intervention programs might produce "sleeper effects" or delayed effects that appear later in life despite the fade-out of initial cognitive gains (*23*). Multiple paths have been suggested through which the initial effects of early intervention may become biologically embedded and produce later impacts on development, especially mental and physical health (*24*, *25*). However, sleeper effects are not found in the Perry, Abecedarian, and CPC studies, which find continuity in effects over time; cognitive effects may decline, but there is no hiatus. These findings contrast sharply with lack of effects for EHS from age 5 to grade 5 and for HS in kindergarten and first grade. Nonexperimental findings of positive long-term HS effects on nonhealth outcomes are inconsistent with this evidence and with each other (*26*). Apparent sleeper effects may be explained by the high probability of false positives when many researchers conduct such studies (*27*).

A somewhat different explanation is that, if early educational interventions have only small initial impacts, the compensatory efforts of public schools for children who enter school behind may succeed in offsetting the entire advantage (*28*). Such efforts gradually equate achievement over time so that what is observed is "catch-up" rather than "fade-out." There is, of course, a cost for compensatory efforts partly documented in economic analyses of the Perry and Abecedarian studies (*29*). For example, preschool study control groups had higher rates of grade repetition and special education (*3*, *6*, *22*, *29*). As discussed below, the pattern of declining effects of interventions is not observed in low-income countries, perhaps indicating weaker compensatory effects of less-well-resourced primary education systems.

An explanation for differences in initial effects between programs can be found in differences in program features. HS and EHS provide comprehensive services, whereas the public school programs in Table 1 focus their resources more on the classroom. HS and EHS teachers are less educated and less well-paid; the other programs in Table 1 require bachelor of arts degrees and pay public-school salaries (*15*–*18*). Nearly 40 percent of HS teachers report mild to severe depression, a condition not conducive to enriching interactions with young children (*30*). Findings regarding the effects of teacher characteristics are mixed, and it is unlikely that more highly qualified teachers alone are sufficient to produce strong results (*31*). However, one study finds HS employing licensed teachers at public school salaries to produce much larger effects than reported in the national randomized trial (*16*). Differences in how teachers teach between HS and the public schools also may influence the results (*16*). Curriculum influences a wide range of program impacts, including social behavior as well as cognitive development (*32*, *33*).

### Overview from Meta-Analysis

Comprehensive quantitative summaries, or meta-analyses, provide a basis for assessing the whole empirical literature and its consistency with the studies discussed above. Meta-analyses convert all measures of effects to SD units so that they can be summarized across studies. One recent meta-analysis included 123 quasi-experimental and experimental studies of U.S. center-based educational interventions, including children from ages 3 to 5 and published between 1960 and 2003 (*34*, *35*). Estimated effects are reported for three

**Table 1.** Achievement gains at age 5 from pre-K and HS. Effects in SDs. HS estimates adjusted for subject noncompliance are in parentheses (*9*); na indicates not applicable. Differences in methodology could favor the other programs over HS if, for example, the HS impact study suffers more from control participation in other programs. On the other hand, HS effects are measured in the spring before kindergarten, whereas other program effects are measured after kindergarten entry, which favors HS if effects decline over the summer. Data sources are as follows: for CPC, (*39*); Tulsa, (*16*); OK (Oklahoma), (*15*); NJ (New Jersey), average of estimates from two different years (*15*, *17*); HS, (*9*).

| Domain | CPC | Tulsa | OK | NJ | HS |
|---|---|---|---|---|---|
| Language | na | na | 0.28 | 0.32 | 0.09 (0.13) |
| Math | 0.33 | 0.36 | 0.34 | 0.30 | 0.12 (0.18) |
| Literacy | na | 0.99 | 0.42 | 0.44 | 0.25 (0.34) |

broad categories: cognitive development, school progress (e.g., grade repetition, special education, and high school graduation), and socioemotional development. This review included all studies with a comparison group regardless of research design but did examine how effects varied with quality of study design. Another meta-analysis reviewed 30 studies of non-U.S. early educational programs (mostly in low-income countries), including only randomized trials and stronger quasi-experimental designs (*36*). The international meta-analysis classified outcomes as cognition, social behavior, health, and school progress.

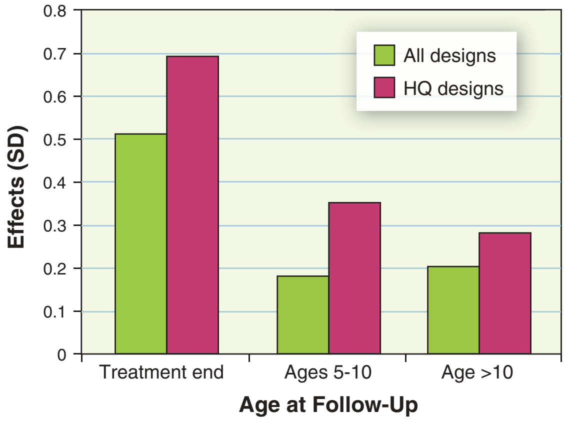


**Fig. 1.** Cognitive effects of early education by age and study design quality [all studies versus high-quality (HQ) designs]. Treatment end varies from ages 3 to 5. Effects for high-quality designs based on estimated effect of design quality on effect sizes evaluated at means for each follow-up time (*3*, *4*).

The U.S. meta-analysis found average effects of 0.23 SD for cognition, 0.14 SD for school progress, and 0.16 SD for social-emotional development from age 3 to adulthood (*34*). Effects on cognition were larger before age 5 than in later follow-up and when higher-quality research designs (e.g., randomized trials) were used (Fig. 1). No significant associations were found between effects and age at start, program duration, or economic background of children served. However, the vast majority of programs focused on disadvantaged children. Larger cognitive effects were found for programs that emphasized direct instruction (+0.25 SD) and individualized (one-to-one or small group) teaching (+0.16 SD) and that did not offer comprehensive social services (+0.19 SD).

The international meta-analysis only examined results from relatively rigorous studies and found average effects for early educational interventions of 0.35 SD for cognition, 0.41 SD for school progress, 0.27 SD for behavior, and 0.23 SD for health (*36*). Many educational interventions included a nutritional component, reflecting the circumstances of children in low-income countries. However, cognitive effects did not vary by age (before and after age 7). The 0.35 SD cognitive effect is very similar to the follow-up results from high-quality studies in the United States (Fig. 1). No association was found between effects on cognition or school progress and age at start or duration. Effect sizes for cognition and school progress did not differ between higher- and lower-income countries, echoing the consistency with cognitive results from the U.S. meta-analysis.

### What Program Characteristics Matter?

Clearly, not all early educational interventions are equally effective, with substantial variation in outcomes for parenting education as well as classroom programs (*37*). Despite oft-heard claims that earlier is better, starting education interventions before age 3 does not appear to be a major contributor to effectiveness, although health and early nutrition components may be more effective when begun earlier (*7*, *38*). The effects of many other program features, including intensity and duration, are uncertain. Few program design questions have been systematically addressed in randomized trials. However, some strong associations are found. Findings that comprehensive services are neither necessary nor sufficient for large, sustained gains and that direct instruction is associated with greater cognitive gains also challenge conventional views.

Direct instruction was associated with greater cognitive gains in the CPC study as well as the U.S. meta-analysis (*18*, *34*). Direct instruction is teacher-directed, is focused on specific skills, and may be highly scripted. It is one type of intentional teaching, which goes beyond discrete skills and, if unscripted, requires teachers to plan carefully what they will teach, to whom, and in what manner. Perry and Abecedarian used intentional teaching, including direct instruction (*3*, *5*). Examples include working with children to compare weights of classroom objects on a balance scale, follow recipes, and take dictation to write captions for artwork. Effective intentional teaching is not whole-class instruction but one-on-one and in small groups (*34*). Large gains in other important domains such as executive function (e.g., focused attention) and social-emotional development likely require a balance of teacher-directed and child-initiated activities, including dramatic play (e.g., role playing) (*3*, *18*, *31*–*34*).

### Conclusions

Early educational intervention can have substantive short- and long-term effects on cognition, social-emotional development, school progress, antisocial behavior, and even crime. A broad range of approaches, including large public programs, have demonstrated effectiveness. Long-term effects may be smaller than initial effects, but they are not insubstantial. These findings are quite robust with respect to social and economic contexts. Early educational intervention can improve the development and adult success of disadvantaged children in the developing world as well as in advanced economies. The potential return to societies on such investments is high (*29*), and huge numbers of children in the developing world could benefit (*1*, *7*, *8*, *36*). Yet, not every program has been effective, and some have produced cognitive gains but not other important effects such as reductions in crime. Expanded coverage should be guided by models found to be highly effective and by new research.

Randomized trials raise questions about the effectiveness of two major public programs in the United States, HS and EHS. The poor results cannot likely be ascribed to insufficient duration. EHS provided multiple years of services. One year of some other large public programs—typically operated through the public schools—produced larger and more lasting effects in quasi-experimental studies using designs likely to produce results similar to those of randomized trials (*15*, *22*). These other programs more closely resemble programs that produced large gains in small-scale experiments (e.g., Perry and Abecedarian) with respect to teacher characteristics and a focus on education. This is not true of all public school pre-K programs, because they vary considerably from state to state.

Both individual study comparisons and the U.S. meta-analysis suggest potentially large improvements in public early educational interventions. EHS and HS might improve their results by providing richer educational experiences. EHS could increase and improve both parenting education and direct classroom experiences. HS may need to focus more resources on the classroom to recruit and retain better teachers. Improving teaching practices may also require increased spending on supervision and coaching of teaching staff. Without budget increases, these changes would require a reduction in program resources devoted to other activities (for example, social services and adult education). There is no consensus among researchers regarding the value of teacher qualifications (*31*), but a systematic statewide reform that included raising teacher qualifications and pay greatly improved preschool program quality (*17*). Given the limitations of the literature, reforms should be guided by systematic experimentation, with design alternatives based on what has produced large gains in the past and little deference to current program doctrine.

Programs of experimental research investigating the contributions of program features to short- and long-term impacts of early educational intervention are recommended for both developed and developing countries. Relatively few studies inform policy and practice in the developing world. Considerable investment in program improvement research is justifiable, because well-designed programs have generated benefits 10 times greater than their costs whereas poorly designed programs may not even return their costs (*29*). This research should investigate such costly features as duration, length of day, teacher-child ratio, teacher qualifications, and in-service teacher development. It also should investigate curricula and teaching practices, including parenting education approaches, that might yield large gains in learning and development with little impact on cost. Studies should allow time for full implementation of complex reforms, and at least some studies should follow up into primary school. Wealthier countries should consider investing in research on large-scale programs in lower-income countries that could inform all countries, keeping in mind that the value of all program components, including nutritional supplementation, depends on what is available to children without the program and is likely greatest for the poorest children globally.

### References and Notes


1. P. L. Engle *et al.*, *Lancet* **369**, 229 (2007).
2. E. Hair, T. Halle, E. Terry-Humen, B. Lavelle, J. Calkins, *Early Child. Res. Q.* **21**, 431 (2006).
3. L. J. Schweinhart *et al.*, *Lifetime Effects: The High/Scope Perry Preschool Study Through Age 40 (Monographs of the High/Scope Educational Research Foundation, 14)* (High/Scope Press, Ypsilanti, MI, 2005).
4. V. Lee, D. Burkam, *Inequality at the Starting Gate* (Economic Policy Institute, Washington, DC, 2002).
5. C. T. Ramey *et al.*, *Appl. Dev. Sci.* **4**, 2 (2000).
6. A. E. McLaughlin, F. A. Campbell, E. P. Pungello, M. Skinner, *Child Dev.* **78**, 746 (2007).
7. S. P. Walker, S. M. Chang, M. Vera-Hernández, S. Grantham-McGregor, *Pediatrics* **127**, 849 (2011).
8. A. Raine, K. Mellingen, J. Liu, P. Venables, S. A. Mednick, *Am. J. Psychiatry* **160**, 1627 (2003).
9. U.S. Department of Health and Human Services (HHS), Administration for Children and Families, *Head Start Impact Study. Final Report* (HHS, Washington, DC, 2010).
10. J. M. Love *et al.*, "Making a difference in the lives of infants and toddlers and their families: The impacts of Early Head Start" (Administration on Children, Youth, and Families, HHS, Washington, DC, 2002).
11. Administration for Children and Families, HHS, *Research to Practice: Preliminary Findings from the Early Head Start Prekindergarten Follow-Up, Early Head Start Research and Evaluation Project* (HHS, Washington, DC, 2006).
12. C. A. Vogel, Y. Xue, E. M. Moiduddin, B. L. Carlson, E. E. Kisker, "Early Head Start children in grade 5: Long-term follow-up of the Early Head Start Research and Evaluation Study sample" (OPRE Report No. 2011-8, Office of Planning, Research, and Evaluation, Administration for Children and Families, HHS, Washington, DC, 2010).
13. C. M. Herbst, E. Tekin, *Econ. Educ. Rev.* **29**, 618 (2010).
14. M. Burchinal, M. Lee, C. Ramey, *Child Dev.* **60**, 128 (1989).
15. V. Wong, T. Cook, W. S. Barnett, K. Jung, *J. Policy Anal. Manage.* **27**, 122 (2008).
16. W. T. Gormley Jr., D. Phillips, T. Gayer, *Science* **320**, 1723 (2008).
17. E. C. Frede, W. S. Barnett, K. Jung, C. Esposito-Lamy, A. Figueras, in *Childhood Programs and Practices in the First Decade of Life: A Human Capital Integration*, A. Reynolds, A. Rolnick, M. Englund, J. Temple, Eds. (Cambridge Univ. Press, New York, 2010), chap. 11, pp. 214–231.
18. A. J. Reynolds, *Success in Early Intervention: The Chicago Child-Parent Centers* (Univ. of Nebraska Press, Lincoln, 2000).
19. E. C. Melhuish *et al.*, *Science* **321**, 1161 (2008).
20. C. K. Spiess, F. Buchel, G. G. Wagner, *Early Child. Res. Q.* **18**, 255 (2003).
21. S. Berlinski, S. Galiani, P. Gertler, *J. Public Econ.* **93**, 219 (2009).
22. A. J. Reynolds, J. A. Temple, S.-R. Ou, I. A. Arteaga, B. A. B. White, *Science* **333**, 360 (2011).
23. A. D. B. Clarke, A. M. Clarke, *Dev. Rev.* **1**, 344 (1981).
24. C. Hertzman, T. Boyce, *Annu. Rev. Public Health* **31**, 329, 3p, 347 (2010).
25. J. K. Kiecolt-Glaser *et al.*, *Psychosom. Med.* **73**, 16 (2011).
26. J. Ludwig, D. A. Phillips, *Ann. N. Y. Acad. Sci.* **1136**, 257 (2008).
27. J. P. A. Ioannidis, *PLoS Med.* **2**, e1240696 (2005).
28. K. A. Magnuson, C. Ruhm, J. Waldfogel, *Early Child. Res. Q.* **22**, 18 (2007).
29. W. S. Barnett, L. N. Masse, *Econ. Educ. Rev.* **26**, 113 (2007).
30. N. Aikens *et al.*, "ACF-OPRE report: A year in Head Start: Children, families and programs" (HHS, Administration for Children and Families, Office of Planning, Research and Evaluation, Washington, DC, 2010).
31. R. C. Pianta, W. S. Barnett, M. Burchinal, K. R. Thornburg, *Psychol. Sci. Public Interest* **10**, 49 (2009).
32. A. Diamond, W. S. Barnett, J. Thomas, S. Munro, *Science* **318**, 1387 (2007).
33. J. W. Fantuzzo, V. L. Gadsen, P. A. McDermott, *Am. Educ. Res. J.* **48**, 763 (2011).
34. G. Camilli, S. Vargas, S. Ryan, W. S. Barnett, *Teach. Coll. Rec.* **112**, 579 (2010).
35. A review (*40*) of 32 recent studies (1990 to 2008) is highly consistent with (*34*) in its conclusions.
36. M. Nores, W. S. Barnett, *Econ. Educ. Rev.* **29**, 271 (2010).
37. M. A. Sweet, M. I. Appelbaum, *Child Dev.* **75**, 1435 (2004).
38. H. J. Kitzman *et al.*, *Arch. Pediatr. Adolesc. Med.* **164**, 412 (2010).
39. A. J. Reynolds, *Early Child. Res. Q.* **10**, 1 (1995).
40. K. Burger, *Early Child. Res. Q.* **25**, 140 (2010).


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REVIEW

# From Science to Policy in Early Childhood Education

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**This paper examines the relationship between scientific research and public policy. After explaining why the simple conversion of research into public law is unlikely, several factors are identified that can promote the use of research by public officials. Examples of use and non-use are cited from early childhood education, where empirical evidence on program effects is relatively strong. Some specific suggestions are offered for improving the connection between science and public policy.**

In early childhood education, as in many other domains, scientific research informs public policy. Researchers and public officials frequently collaborate in promoting or challenging early childhood education programs. Of course, public policy also depends on public opinion, interest groups, political parties, the mass media, elected officials, judges, and bureaucrats (Fig. 1). In addition, economic conditions, social mores, and "focusing events" such as scandals and natural disasters can advance or sabotage a policy proposal (*1*). As a result, scientists sometimes believe that their influence is limited at best.

I discuss here the connection between scientific research and public policy, focusing on early childhood education, an area characterized by relatively strong scientific evidence. First, I discuss reasons why scientific research may not be directly translated into public policy. Second, I identify situations and practices that facilitate the conversion of scientific research into public policy. Third, I cite examples of early childhood education research impacts on public policy. Fourth, I discuss specific cases where early childhood education policy proposals justified by scientific research were rejected by public officials. Fifth, I offer suggestions for strengthening the connection between science and policy.

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## Expectations

A simple view of the relationship between science and public policy holds that a well-crafted piece of policy-relevant research should convince public officials to alter their policy preferences. They should champion the adoption and sustenance of legislation consistent with the findings of that research. They should translate good science into good public policy.

This view, which draws on the Progressives' faith in technical expertise for solving social problems (*2*) and scientists' own faith in their published work, has some basis in fact. Science is among the most admired professions (*3*). Scientists enjoy a privileged position in determining what types of analysis are perceived as valid and legitimate (*4*). Lawmakers often welcome scientific advice, in the hope of moving beyond "just guesses and hunches." (*5*)

Nevertheless, a hypodermic needle theory of scientific impact on policy, which anticipates direct, immediate, and powerful effects, is flawed for several reasons. First, scientific research is one of many inputs into the policy process. In one study of the U.S. federal policymaking process, researchers, academics, and consultants were judged to be "very important" by only 15% of knowledgeable respondents, including congressional staff members, civil servants, and others (*1*). In contrast, 33% of respondents viewed interest groups as very important, and legislators and executive branch officials were judged very important by even higher percentages of respondents (*1*). In a crowded political arena, scientists can be eclipsed by other actors, events, and trends.

Second, scientific knowledge accumulates through multiple studies, some of which reach