Effects of Early Intervention and Stimulation on the Preterm Infant

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ABSTRACT. To test the hypothesis that early intervention can enhance the development of high-risk preterm infants, a prescribed multimodal sensory enrichment program, within a regional neonatal intensive care unit, was designed and implemented. Twenty-eight appropriate-for-gestational age infants with birth weights between 1,200 and 1,800 gm were selected for study. To prevent control group contamination by the enrichment procedure, the first 14 infants were designated as the control group, and the next 14 as the treatment group. Treated infants had significantly higher developmental status than control infants, as measured by the Bayley Scales of Infant Development, at six months past the maternal expected date of confinement ($F = 14.98$, $P < .001$, and $F = 16.46$, $P < .001$ for the mental and motor scales, respectively). Mean infant weight gain per day and mean total weight gain during the hospitalization were not significantly different for the two groups although the treatment group received significantly less calories per kilogram per day than the control group ($F = 9.02$ $P < .006$). Our data suggest that a prescribed intervention program for high-risk preterm infants appears to enhance the quality of development as measured at six months past the expected date of confinement. Further studies are necessary to determine the long-term value of early intervention and the apparent ability of infants receiving an enrichment program to utilize calories more efficiently than control infants. *Pediatrics* 66:83–90, 1980; *infant, premature newborn child development.*

Approximately 177,000 preterm infants are born annually in the United States,[1] a large portion of whom are transported to distant regional centers for special care.[2] The first home for most of these infants is the well controlled artificial environment of an incubator where it appears that the infant receives minimal sensory and emotional stimulation including limited parent contact for up to several weeks.

An increasing number of investigators have studied the effects of early intervention on the behavior and development of the preterm infant,[3,4] based upon the rationale that preterm infants are at high risk for biologic and psychological disabilities and that early care for the preterm infant may not include "adequate" environmental stimulation.[5]

Although several studies have focused attention on the possible role of sensory deprivation in producing or contributing to some of the impairments associated with low birth weight,[6-8] Korones[9] showed that the preterm infant in an intensive care unit is intermittently bombarded with a variety of sensory input.

To test the hypothesis that appropriate early intervention can enhance the development of high-risk preterm infants, we designed and implemented a prescribed multimodal sensory enrichment program within a regional neonatal intensive care unit and examined the effects of this program prior to discharge and at six months past the expected date of confinement (EDC).

BACKGROUND AND METHODS

The sample was drawn from the Children's Hospital Medical Center of Akron, Regional Neonatal Intensive Care Unit, which is specifically for referral and serves approximately 30 community hospitals within a 17-county area in northeastern Ohio. Utilizing an ambulance and helicopter transport service, these critically ill infants are often referred directly from the outlying community hospital de-

Received for publication May 17, 1979; accepted Dec 28, 1979.

This paper was adapted from a thesis submitted in partial fulfillment of a PhD degree from the Kent State University, Kent OH, and was presented in part to the International Conference on Infant Studies, March 10, 1978, Providence, RI.

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PEDIATRICS (ISSN 0031 4005).

livery room or nursery prior to the establishment of maternal, paternal, or sibling contact. The average daily census in the unit during the period of study was 35 patients per day. Open visiting for parents and grandparents, and access to a toll-free wide area telephone service (WATS) line directly into the unit existed during the period of study.

Sample Selection

The following criteria were used to select infants for admission to the study: (1) birth weight between 1,200 gm and 1,800 gm; (2) head circumference, length, and weight on admission between the 10th and 90th percentile for gestational age[10];(3) absence of major congenital malformations, chromosomal abnormalities, history of seizures, or multiple births; (4) two parents living at home.

Gestational age was determined at the time of admission by Ballard's revision of the Dubowitz examination,[11] and agreement was found within ± two weeks of maternal EDC. Infants with a very poor prognosis for survival or those exhibiting rapid deterioration of neurologic function while receiving intensive care were not included.

Study Group

Between March 1975 and July 1976, 28 appropriate-for-gestational age, preterm infants met the selection criteria and were assigned to one of two groups as follows: (1) control group (seven boys and seven girls) infants who received standard preterm nursery care, or (2) treatment group (eight boys and six girls) infants who received a prescribed enrichment program in addition to standard preterm nursery care.

The first 14 infants who met the selection criteria were assigned to the control group. Following discharge of the last control infant, the next 14 infants who met the selection criteria were assigned to the treatment group.

Family Characteristics

The families were all white and predominantly middle class. Although all but one parent in each group graduated from high school, ten parents of infants in the control group graduated from college vs four parents in the treatment group. In the control group, two mothers were nurses with experience working in newborn nurseries and two fathers were PhD candidates, one in Special Education. There were no significant differences between families of control and treatment groups with regards to maternal or paternal age, gravida, parity, route of delivery, number of prenatal visits, or calling and visiting patterns during intensive, intermediate, and convalescent care (t-tests between independent means, $P > .05$; additional family characteristic information may be obtained from the authors by request).

All of the families of each infant who met the study criteria agreed to participate by giving informed written consent.

Infant Characteristics

Pretreatment characteristics of the control and treatment groups are shown in Table 1. The infants in both groups were referred primarily due to prematurity and respiratory distress at a mean age of 6.7 hours and 3.1 hours, respectively, for the control and treatment groups. Four infants in each group required resuscitation at the time of birth. Three infants in each group experienced apnea during the hospitalization. Total parenteral nutrition via central venous catheter (hyperalimentation) was administered to three infants in the control group and four infants in the treatment group. Nine infants in the control group and eight infants in the treatment group required umbilical catheterization for the administration of intravenous fluids and blood gas monitoring. Six control and three treatment infants required continuous positive airway pressure and

TABLE 1. Group Comparisons—Infant Pretreatment Variables*

	Control Group	Treatment Group
Birth weight (gm)	1,533.07 ± 161.18	1,590.93 ± 186.66
Apgar score at 1 min	5.71 ± 2.30	5.29 ± 2.43
Apgar score at 5 min	7.29 ± 1.73	6.57 ± 1.85
Gestational age (wk)	32.50 ± 1.91	32.79 ± 1.85
Admission length (cm)	41.75 ± 1.26	42.54 ± 2.29
Admission head circumference (cm)	28.66 ± 1.36	28.44 ± 1.47
Duration of supplemental oxygen (hr)	64.61 ± 66.11	53.93 ± 52.97
Peak FIO_2†	0.56 ± 0.27	0.48 ± 0.57
Peak bilirubin (mg/100 ml)	11.31 ± 4.33	13.35 ± 2.50

* No significant differences were found using 2 × 2 analysis of variance between control and experimental groups and sex and two-tailed t-tests between independent means (P value all >.05). F and t values are available from the authors upon request. Values are means ± SD.

† FIO_2, Forced inspiratory oxygen.

one infant in the control group required respirator assistance. There were no significant differences for minimum hemoglobin ($\bar{x} = 10.22 \pm 2.05$ SD, and $\bar{x} = 11.27 \pm 2.34$ SD for the control and experimental group, respectively) and days in incubator ($\bar{x} = 29.14 \pm 8.49$ SD and $\bar{x}$ 29.93 ± 8.19 SD for the control and experimental group, respectively).

Nursing Staff Orientation

Without mentioning the enrichment program for the treatment group, we first oriented the nursing staff prior to beginning the study. The nurses were not specifically instructed concerning the care for the control group. They were told that we were doing a special evaluation of a group of babies. The nurses were not aware that a treatment group would follow. Following discharge of the last control group patient, we then oriented the nursing staff for a second time and introduced the enrichment procedures applicable to the treatment group. We used this sequence to ensure that enrichment procedures designed for the treatment group would not be applied to the control group.

Standard Preterm Nursery Care

During the period of study, standard preterm nursery care included the following.

1. Independent of the study, feeding orders were written by attending physicians and resident staff to meet each patient's requirement for adequate growth. Feeding orders were based on the following: (*a*) how well the infants tolerated their feedings; (*b*) weight gain per day; and (*c*) input from nurses caring for the infants.
2. Infants received 20 calories/oz formula as standard procedure in the nursery.
3. According to standard nursery policy, each infant was weaned from the incubator at a weight of approximately 1,800 gm and was discharged at approximately 2,240 gm. Additional discharge criteria included maintenance of body temperature while in a crib, adequate weight gain, and feeding well with active parent involvement.
4. Standard preterm nursery care included the availability for parents to see, touch, and hold their infants during intermediate and convalescent care. Parents could feed their infants, as desired, during nipple feeding.
5. At the time of infant discharge, all the parents in both groups were given standard discharge instructions for infant care by the staff.

Neonatal Enrichment Program

The prescribed enrichment program, administered by the nurses during feeding times, was designed to provide an environment more like the one the infant would receive at home. We defined two levels of infant care once each infant was in room air as follows:

Intermediate Care Period. In this interval each infant remained in the incubator and received every 2- or 3-hour gavage feeding. The enrichment program began in this care period after the infant weighed approximately 1,700 to 1,800 gm. The program included: (1) visual stimulation—a brightly colored single object from a mobile was hung inside the incubator approximately 6 to 8 in from the infant's eye level; and (2) tactile stimulation—the infant received five minutes of soothing and rubbing during each gavage feeding (nurse put her hand through the incubator porthole and gently touched the infant's extremities, back, and cheek).

Convalescent Care Period. In this interval each infant was in an open crib and was nipple-fed every three hours. The program included: (1) visual stimulation—a brightly-colored single object from a mobile was hung between 6 to 8 in from the infant at eye level; (2) tactile stimulation—the nurses soothed and rubbed the infant during nipple feeding; (3) kinesthetic stimulation—each infant was fed by his nurse while she was seated in a rocking chair, and assumed, when possible, an enface position (eye-to-eye contact with infant); and (4) auditory stimulation—each nurse talked and/or sang to the infant while nipple feeding. After each feeding the infant was placed back into an open crib and a music box was played (the song "This Old Man") for approximately five minutes (once fully wound).

After each feeding, the nurses recorded the infant state changes before, during, and after the enrichment procedures, and any additional comments on the Infant Project Log. Daily records were kept of each infant's treatments and progress while in the nursery.

Neonatal Assessment in Nursery

The Neonatal Behavior Assessment Scale (NBAS),[12] which assesses infant behavioral and neurologic functioning, was administered to the control and treatment groups immediately prior to treatment and just prior to discharge from the nursery. Pretreatment assessment occurred when the infants were receiving intermediate care and weighed approximately 1,700 to 1,800 gm. At that time, they were removed from the incubator, dressed, covered with a blanket, placed in an open crib, immediately taken to a quiet, dimly lit nearby room and examined in two to three sessions while under a Servo-control overhead radiant heater (Servo Corp of America, Hicksville, Long Island, NY). The examination usually began approximately midway between feedings with the infant asleep.

TABLE 2. Pre- and Posttreatment Comparison of Infant Age and Weight Characteristics*

	Control Group		Treatment Group	
	Mean	Range	Mean	Range
Pretreatment				
Chronologic age (days)	24.08	12–30	25.14	13–43
Equivalent gestational age (wk)	35.64	33–38	36.36	33–40
Weight (gm)	1,772.31	1,700–1,910	1,738.57	1,700–1,840
Posttreatment				
Chronologic age (days)	37.29	20–49	37.93	29–51
Equivalent gestational age (wk)	37.64	35–40	38.14	36–42
Weight (gm)	2,110.0	1,930–2,280	2,127.14	1,940–2,280

* No significant differences between control and treatment groups were found using two-tailed t-tests (P values all $> .05$). The t values are available from the authors upon request.

Following each examination, the infant was taken back to the nursery, undressed, and placed in the incubator. Similarly, each infant was examined just prior to discharge.

Scores were obtained on the NBAS for 26 behavioral items and 20 elicited reflexes and were interpreted by Brazelton's four conceptual a priori scoring dimensions. (Appendix: Details of the scoring analyses can be obtained from T. B. Brazelton, MD, Child Development Unit, Children's Hospital, Boston, MA 02115).

Follow-up Evaluation

In order to correct for the varying degrees of prematurity within the study group, parents were requested to return for a six-month past EDC follow-up evaluation which included a physical examination and growth assessement by one of two pediatricians. In addition, a developmental assessment using the Bayley Scales of Infant Development was performed by one of the authors, a licensed psychologist.

Data Analyses

Since all infants scored "0" on dimension IV, which measures physiologic responses to stress, we only analyzed the first three dimensions of the NBAS. The relationship between weight gain during the infant's hospitalization and selected weight-related variables, measured at discharge, were analyzed in 2 × 2 analyses of variance in relation to group membership and sex. Infant development at six months past EDC was measured by the Bayley Scales of Infant Development and these data were analyzed in 2 × 2 analyses of variance (ANOVA) and a multivariant analysis of covariance.

RESULTS

Major findings include pre- and posttreatment results on the NBAS, nutritional intake as related to weight gain, and developmental evaluation at six months past EDC.

TABLE 3. Pre- and Posttreatment Comparison of Neonatal Behavior Assessment Scale Using Dimensions I, II, and III*

	Control Group	Treatment Group	F
Pretreatment			
I	2.71 ± 0.47	2.14 ± 0.36	11.77†
II	2.79 ± 0.43	2.79 ± 0.43	0.001
III	2.14 ± 0.77	1.71 ± 0.73	2.45
Posttreatment			
I	2.00 ± 0.68	1.29 ± 0.47	9.76‡
II	1.64 ± 0.63	1.50 ± 0.52	0.39
III	1.79 ± 0.70	1.71 ± 0.47	0.20

* Values are means ± SD.
† $P < .002$.
‡ $P < .005$.

Neonatal Assessment

Pre- and posttreatment comparisons of infant age and weight and the NBAS results are shown in Tables 2 and 3, respectively. The treated infants performed significantly better than the control infants on dimension I (Interactive Processes) prior to and following intervention. (See "Six-Month Developmental Assessment" below for clarification). Both control and treatment groups demonstrated similar functioning on dimensions II (Motoric Processes) and III (Organizational Processes; state control) at pre- and posttesting.

Nutritional Intake and Weight Gain

We found no significant differences between control and treatment groups in number of days the infants receive peripheral intravenous, gavage, or nipple feedings or the duration of hospitalization (t-tests and ANOVA). (Results of the statistical analyses are available from the authors upon request.) There were no significant differences between groups on weight gain per kilogram per day (control mean weight gain per day 15.78 gm ± 20.90, treated mean weight gain per day 14.04 gm ± 20.77) or total weight gain during the hospitalization (control mean total weight gain 620.50 gm ± 146.93 and treated mean total weight gain 575.50 gm ± 215.50); yet, infants in the treatment group received significantly fewer calories per kilogram per day than control infants. (Control mean calories per kilogram per day 111.74 ± 8.47 and treated mean calories per kilogram per day 101.46 ± 8.63. $F = 9.03$, $P < .006$).

Six-Month Developmental Assessment

All infants returned for follow-up at six months past the EDC at a mean age of 7 months, 3 days (range 6 months, 11 days to 8 months, 3 days) for the control group, and 7 months, 3 days (range 6 months, 17 days to 8 months, 5 days) for the treatment group. A 93% agreement was found between pediatrician's and psychologist's independent ratings of the infant's current level of development. Follow-up growth measurements included: mean length, 64.31 cm ± 4.12; mean weight 7,128.15 gm ± 649.91; and mean head circumference 41.67 cm ± 0.81 for the control group and mean length, 64.79 ± 2.71; mean weight, 6,982.43 gm ± 606.59; and mean head circumference, 42.21 cm ± 0.41 for the treatment group. We found no significant group differences for growth variables as determined by *t*-tests between independent means. (Results of the statistical analyses are available from the authors upon request.)

Treated infants had significantly higher developmental status than control infants on both the mental and motor scales, as measured by the Bayley Scales of Infant Development (Table 4). The treatment group was functioning approximately at their chronologic age level, whereas the control group was functioning below their chronologic age level. When corrections were made for the degree of prematurity, the treatment group performance was considerably above the expected norm, whereas the control group performance was approximately at the expected norm for corrected gestational age of 5½ to 6½ months. Thus, observed differences related to mental and motor maturity rather than to physical growth. There were no sex differences on these assessments.

Because the treated infants performed significantly better than the control infants on dimension I prior to and following intervention, a multivariant analysis of covariance was used to analyze these data at the time of the six-month follow-up. Controlling the initial differences on the pretreatment dimension I, the following pretreatment variables served as covariates: birth weight, Apgar score at one and five minutes, gestational age, and dimensions I, II, and III. The three dependent posttreatment variables included dimension I, and Bayley Mental and Motor Scales. Significant differences were again found between control and treatment groups on the Bayley Mental ($F = 7.93$, $P < .01$) and Bayley Motor Scales ($F = 6.20$, $P < .02$). Therefore, the initial differences on dimension I between the control and treated groups does not account for the significant differences found between the two groups on the Bayley Mental and Motor Scales at six months.

DISCUSSION AND IMPLICATIONS

Systematic early intervention programs for preterm infants have produced developmental gains whether the type of intervention attempted to simulate intrauterine sensory experiences [8,13–17] or an environment similar to that experienced by full-term neonates following birth.[6,7] While a systematic approach to early intervention seems important for achieving higher levels of mental and motor functioning, questions remain concerning the optimal type, duration, and amount of stimulation as well as the issue of whether "critical periods" for intervention exist. The crucial question of long-term benefits from early intervention requires additional follow-up studies.

In two previously reported intervention studies, treated and control infants simultaneously received

TABLE 4. Group Comparison of Bayley Scales of Infant Development at Six-Month Follow-up

	Development Index*		F
	Control Group	Treatment Group	
Bayley mental			
Uncorrected for gestational age	76.50 ± 16.09	98.93 ± 14.12	14.98†
Corrected for gestational age	105.21 ± 20.94	125.36 ± 15.47	14.98†
Bayley motor			
Uncorrected for gestational age	78.86 ± 13.85	97.86 ± 11.14	16.46†
Corrected for gestational age	104.93 ± 16.51	121.86 ± 10.63	16.46†

* Values are means ± SD.
† $P < .001$.

care in the same nursery,[14,18] increasing the risk of well-meaning caretakers applying intervention procedures to control infants. In contrast, we minimized the risk of control group contamination by sampling sequentially and by orienting the nursery staff to the treatment procedures after the control group was discharged. Following orientation of caretakers, our program was readily accepted by nursing personnel and easily adapted to nursery routines.

Surprisingly, we found no significant difference between control and treated groups in the rate of growth or total weight gain while hospitalized even though the treated group received significantly less calories per kilogram per day than infants in the control group. Of further interest is the fact that previously published intervention studies have tended to ignore caloric intake as a correlate of infant growth. Those studies in which growth rates were compared tended to yield inconclusive or contradictory results.[14,19-21] In our study, both groups were similar in length of hospitalization and duration of peripheral intravenous, gavage, and nipple feedings. For reasons that are unclear, the treated infants in our study seemed to utilize calories more efficiently than control infants. We speculate that the control group may have responded to the stress of a disorganized newborn intensive care unit environment by requiring significantly more calories to achieve the same growth as the systematically treated infants. This possibility suggests that there may exist a link between early environmental intervention, caloric intake and short-term growth. Further study is necessary to clarify our observation.

Preterm infants appear to respond differently to stress than the full-term newborn as indicated by all infants receiving a "0" score on dimension IV on the NBAS (Appendix). In comparison to the full-term newborn who manifests tremulousness, startles, and skin color lability, in response to stress, our preterm infants responded to prolonged neurologic and behavioral evaluation with hiccupping, sneezing, and state changes tending toward either sleep states or prolonged maintenance of an alert state. Because of these differences, we adapted the NBAS for the preterm infant and examined the infants for shorter periods of time, in two to three sessions within a 24-hour period. Since the preterm infant fluctuates markedly in response to a single assessment of behavioral and neurologic status, repeated shortened periods of assessments are recommended to furnish a curve of recovery or non-recovery during the hospitalization. The development of additional assessment techniques are needed to evaluate at-risk infants, environments, and infant-environment interaction. An assessment of the following characteristics is recommended for further understanding of the uniqueness of preterm infants: the difficulty of eliciting responses as well as the quality of responses obtained, the infant's self-organization, appropriateness of state measures during the examination, the examiner's involvement in state manipulation to obtain optimal performance from the baby, and the infant's endurance and exhaustion at the end of the session.

The broader issue of whether hospitalized preterm infants are deprived of stimulation per se or suffer from inappropriate patterns of stimulation remains unanswered. It would seem important, when designing an intervention program, to survey existing environmental conditions within a unit such as levels of illumination, sound pressure levels, caretaker routines, and the amount, duration, and quality of nursery and parental involvement with each infant prior to discharge. Once armed with a complete profile of the nursery environment, systematic enrichment programs can then be designed and implemented to suit the patients within a given unit.

A program designed to provide the preterm infant with appropriate stimulation, in a neonatal intensive care unit, may enhance an infant's capability to respond behaviorally to his environment. If early intervention enhances an infant's responsiveness, this in turn may effect his interaction with his "caregivers "in a reciprocal fashion. For example, an active, alert, responsive infant may elicit a different caregiver response than a passive, unresponsive infant.

Generalizations for our study should be tentative for at least two reasons: (1) Sample size was small and, due to the constraints of our selection criteria, time for patient selection within the two groups was extended. (2) Although parents did not participate in the intervention program, one can speculate that the parents of the treated group, having observed the intervention program in the nursery, may have modeled their subsequent behavior after the caretaking observed in the nursery and influenced short-term results. This area needs further investigation and may include home observations of parent-infant interaction, to determine the similarity of post-discharge parental behavior for parents of infants in control and treatment groups.

Parents may vary markedly in their capacity to cope with the birth and referral of their critically ill infants to a regional center.[22] The infant may look unattractive and exhibit few normal newborn social behaviors. This may contribute to the difficulties encountered in the establishment of parent-infant bonding.[23] Including parent participation in a prescribed intervention program may aid parents to accept that their baby is not going to die while simultaneously preparing them to care for their baby at home. Parents may become aware of their infant's individuality and behavioral repertoire, and this may facilitate and nurture the affectional bonding and attachment process during this early acquaintance period as parents begin interacting with their recovering infant. Parent participation might include activities such as feeding, diapering, and dressing the infant, as well as providing appropriate play activities which may enhance parent-infant interaction. Increased social interaction between parents and infants may help infants achieve more robust development.

Though not part of our evaluation, participation in our intervention program seemed to positively influence nursing attitudes and behaviors. For example, involved nurses appeared more sensitive to infants' needs and more aware of the uniqueness and behavioral repertoire of each preterm infant. This aspect of early intervention requires further study.

ACKNOWLEDGMENTS

This project was supported by Ohio Department of Health, Maternal and Child Health Grant No. 523.

We are indebted to T. Berry Brazelton, MD, Child Development Unit, Harvard University, for his critical review of the manuscript and his willingness to share his ideas; to Richard Flaksman, MD, Jane Timmons, BA, and Virginia Wade for their technical assistance; to Thomas Kehle, PhD, Kent State University, who served as statistical consultant; to Jeanette Reuter, PhD, Kent State University, who provided consultation and guidance. Special appreciation is extended to the nursery nurses and the babies' parents without whom this study would not have been possible.

APPENDIX

Neonatal Behavior Assessment Scale

Dimension I—Social Interactive Process. The infant's capacity to respond to social or potentially social stimuli, especially during the alert state. The orientation items, cuddliness and consolability with intervention, were selected to evaluate this dimension.

Dimension II—Motoric Processes. The infant's ability to maintain adequate tone, to control motor behavior, and to perform integrated motor actions. Items representing this dimension include motor tone, activity, hand-to-mouth, defensive reaction, motor maturity, pull-to-sit, and the reflex items.

Dimension III—Organizational Processes: State Control. The infant's ability to organize his states, and to shut out disturbing stimuli when asleep (habituation). State modulation is assessed using the following items: rapidity of buildup, peak of excitement, irritability, self-quieting, and state lability.

Dimension IV—Organizational Processes: Physiological Response to Stress. The infant's reaction to stress is assessed using the items tremulousness, startles, and skin color lability.

Dimensions I to III are each scored on a three-point scale (1 = optimal, 2 = average, and 3 = worrisome performance). Dimension IV is a dichotomy, and is scored with 0 indicating limited physiologic response to stress and 1 indicating extensive responses to stress.

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BOOK REVIEW

The Early Window: Effect of TV on Children and Youth by Robert M. Liebert, John M. Neale, and Emily S. Davidson. New York, Pergamon Press, 1973, $9.50, 193 pp.

"... a child born today will, by the age of 18, have spent more time watching television than in any other single activity but sleep." The question is, of course, what are the effects of this "treatment?" These authors review the relevant data, especially of the effects of TV violence on children. It is a gross oversimplification to say that violence on TV does increase children's violent behavior, for there are many caveats required. But the power of TV to do ill to some children is made clear in this book. The potential beneficial effects are also reviewed in another chapter. For the prevention-oriented pediatricians, this section is most hopeful. "... television has a great—though largely unrealized—potential for educating and teaching positive lessons to our young."

The final sections examine why the potential has not been realized. These authors conclude that the reason is largely because of the way we finance television in this country—from advertising revenue. Suggestions for alternatives are presented such as tax support, rotation of advertisers through different programs, and election of consumers' councils to approve programs. Experiences in other countries with such alternatives give considerable hope for improvement over our current state.

This brief summary does not do justice to the scholarly analysis presented in this book, but hopefully will stimulate readers to examine the book itself. It does not contain final answers to the problems and potential of television. I was disappointed that it contained no new data. But it analyzes what is known. All who are concerned with children "must bear the responsibility for what is being taught on television." I trust that pediatricians are concerned enough to examine the evidence and bear more responsibility for improving this potent influence on children.

R.J.H.