

Polydrug-using adolescent mothers and their infants receiving early intervention.

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The incidence of cocaine use among pregnant women has been reported at about 10%, although in some areas it is as high as 28% (Singer, Garber, & Kliegman, 1991). Polydrug use has also become more frequent, with the majority of cocaine users also abusing marijuana, alcohol, or cigarettes, or a combination of these (Chasnoff, 1988; Gibson, Baghurst, & Colby, 1983). Cocaine use during pregnancy is associated with a number of perinatal complications, including premature birth, intrauterine growth retardation, diminished head circumference, and major congenital malformations (Burkett, Yasin, & Palow, 1990; Coles, Platzman, Smith, James, & Falek, 1991; Hadeed & Siegel, 1989; Porat & Brodsky, 1991; Rosenak, Diamont, Yaffe, & Hornstein, 1990). No specific cocaine syndrome has yet been described (cf. fetal alcohol syndrome), and the deficits that have been observed may relate to the higher incidence of SGA (small for gestational age), lower Apgar scores, lower birthweight, and smaller head circumference reported for cocaine-exposed infants. Nonetheless, the signs of fetal stress, including increased heart rate, lower vagal tone, and lower Apgar scores, do suggest central nervous system involvement (Richards, Kulkarni, & Bremner, 1990). Less subtle abnormalities include cerebral infarction and EEG, BAER, and ultrasonographic or pneumographic abnormalities (Chasnoff, Hevet, Kletter, & Kaplan, 1989; Dixon & Bejar, 1989; Doberczak, Shanzer, Senie, & Kandall, 1989).

Despite these less optimal neonatal outcomes, there is a paucity of developmental follow-up studies on cocaine-exposed infants. Those studies suggest the importance of using more sensitive measures than standardized tests, because the early delays/deficits are more subtle. For example, unlike other drug-exposed newborns, very few withdrawal symptoms have been reported for cocaine-exposed neonates, although some have reported tremulousness, irritability, wakefulness/restlessness, hypertonia, and abnormal reflexes (Livesay, Ehrlick, & Finnegan, 1987; Rosecan & Gross, 1986), highlighting the importance of observing sleep patterns and reflex behaviors. While neonates exposed to cocaine display fewer overt withdrawal signs than do infants exposed to heroin or methadone, aberrations in neurobehavioral status, motor tone, and crying, feeding, and cardiorespiratory patterns have been noted (Chasnoff, Burns, & Burns, 1987; Chasnoff, Burns, Schnoll, & Burns, 1985).

A recent observational study on the behavior of cocaine-exposed newborns noted more obstetric complications, smaller head circumference, and a greater number of withdrawal symptoms (Eisen, Field, Bandstra, Roberts, Morrow, Larson & Steele, 1991). In addition, these polydrug-exposed infants were

slower to habituate. In a pilot study by Larson and Field (1989), cocaine-exposed infants were found to have depressed vagal tone, suggesting a parasympathetic-sympathetic imbalance. Given the literature on the relationship between low vagal tone and low developmental scores later in infancy, this group may be at risk for delays in cognitive development. It is also noteworthy that dopamine levels were depressed in the cocaine-exposed newborns. Dopamine depletion has recently been implicated in habituation disturbances in the rat model (Simonik, Robinson, & Smotherman, 1994). It is interesting in that light that both dopamine depletion and habituation deficits were reported for cocaine-exposed infants.

In a recent study (Wheeden, Scafidi, Field, Ironson, Bandstra, Schanberg, & Valdeon, 1993), cocaine-exposed infants were massaged (30 minutes per day for 10 days). Compared with cocaine-exposed infants who were not massaged and preintervention baseline data, they gained more weight (8 grams more per day), they were less irritable, they showed superior habituation scores, their vagal tone was higher following massage, and their norepinephrine and dopamine levels significantly increased over the 10-day period (much like the normal developmental increase expected at this time).

Apparently even infants born to mothers who discontinue cocaine use after the first trimester display abnormal neurobehavioral cluster scores on the Brazelton Neonatal Behavioral Assessment Scale, as compared with drug-free controls (Chasnoff, Griffith, & MacGregor, 1989). These infants have shown significantly worse scores on the state organization cluster, suggesting that they had more difficulty staying in an alert state and remaining behaviorally organized (Chasnoff et al., 1985). In another study, inferior performance was noted for cocaine-exposed infants on four of the Brazelton clusters: orientation, motor, state regulation, and abnormal reflexes (Griffith, Chasnoff, Dirkes, & Burns, 1989; Burns, 1987). Different patterns of state control were noted, including infants falling into deep sleep in response to stimulation; infants attempting to fall into deep sleep to avoid stimulation, but showing some disorganization, such as startling and irregular breathing; and infants who vacillated between using both sleeping and crying to shut themselves off from excessive stimulation. The orientation abilities of these infants were also limited.

Others have reported inferior performance on the Brazelton scale during the first month of life, including poorer motor responses and poorer autonomic regulation and more abnormal reflexes (Coles et al., 1991). Both the terms excitable and depressed, or overstimulated and underaroused, have been used to describe cocaine-exposed infants (Lester, Corwin, Sepkoski, Seiper, Peucker, McLaughlin, & Golub, 1991; Singer, Farkas, & Kliegman, 1992). Lester et al. (1991), for example, described two types of cries, one being higher intensity/high frequency and the second being lower intensity. Griffith, Chasnoff, Dirkes, and Burns (1989) reported that cocaine-exposed infants were highly aroused, while Magnano, Gardner, and Karmel (1992) noted that these infants looked in the direction of high-intensity sounds as if seeking additional stimulation.

Chasnoff, Bussey, Savich, and Stack (1986) noted subtle delays in motor development in later infancy. Schneider (1988) found that cocaine-exposed infants had significantly poorer scores on muscle tone, primitive reflexes, and volitional movement; 43% of these infants were at high risk for motor development delays and dysfunction. Rodning, Beckwith, and Howard (1989) noted that toddlers who were prenatally exposed to drugs demonstrated difficulty modulating arousal and abnormal emotional responses. For example, these toddlers did not show typical distress responses when separated from attachment figures. In a study on grade school children, those who were exposed to cocaine were compared with ADHD children; more disturbed classroom behaviors were observed for the former, including more fidgeting, staring into space, off-task behavior, attention-seeking, noncompliant behavior with teachers, and aggressive behavior with peers (Field, 1994). Their Achenbach and Conners scores were also more problematic and in the clinical range for externalizing problems, and they scored high on

the Center for Epidemiologic Studies Depression Scale.

MATERNAL DEPRESSION Depression is a serious problem in drug-using mothers, and compounds the effects of drugs on their infants (Finnegan, 1988; Regan, Rudranf, & Finnegan, 1980; Reynolds & Gould, 1981; Burns, Melamed, Burns, Chasnoff, & Hatcher, 1985; Zuckerman, Amaroh, & Cabral, 1989). Across studies, more than 50% of the drug-using mothers were moderately to severely depressed (as indicated by Beck Depression Inventory scores above 16), which is not surprising given the problems they experienced, including poverty, legal difficulties, homelessness, lack of social support, loss of children to foster care, and ongoing relationships with drug-abusing or alcoholic men (Finnegan, 1988).

Depressed women have been found to be less involved and affectionate with their infants (Weissman, Paykel, & Clerman, 1972). During mother-infant interactions, depressed mothers are less spontaneous, happy, vocal, proximal, and reciprocal (Cohn, Campbell, Matias, & Hopkins, 1990; Sameroff, Seifer, & Zacks, 1982). Because social interactions between mothers and infants are thought to be critical to language development, problem-solving ability, mastery motivation, and social competence, research on the effects of maternal depression has focused on these early interaction disturbances (Clarke-Stewart, 1973; Ratner & Brunner, 1978; Yarrow, Rubenstein, & Pederson, 1973; Waters, Whippman, & Sroufe, 1979). Although most infants and children of depressed mothers are at risk for significant social, emotional, and cognitive deficits, the potential for these problems in the drug-exposed infants of depressed mothers is even greater because there are now two disturbed members of the dyad, the drug use affecting both the mother and the infant (Burns & Burns, 1988).

EARLY INTERVENTIONS Most interventions for cocaine-using women have been directed at the prenatal period, with significant positive effects (Chasnoff, 1988). More recent programs feature postpartum intervention components (Zuckerman, Frank, & Hingson, 1989; Zuckerman, Amaroh, & Cabral, 1989). In contrast to the absence of data on postpartum interventions for cocaine-using mothers and their infants, there is a rapidly growing literature on drug rehabilitation programs for cocaine-abusing adults. A recent review of this literature has suggested that outpatient treatment is at least as effective as inpatient treatment (Gawin & Ellinwood, 1988). In three studies, two on alcohol (Fink, Longabaugh, McCrady, Stout, Beattie, Ruggieri-Authalet, & McNeil, 1985; Hayashida, Alterman, McLellan, O'Brien, Purtill, Volpicelli, Raphaelson, & Hall, 1989) and one on cocaine (Rawson, Obert, McCann, & Mann, 1986), follow-up clinical outcome was superior, treatment was shorter, and costs were lower for outpatients than for inpatients. In addition, several studies have suggested that hospitalization is not necessary, since stimulants such as cocaine do not produce medically dangerous withdrawal symptoms. However, a wide range of success (abstinence) has been reported (from 30% to 90%) (Gawin & Ellinwood, 1988). The absence of data on interventions for cocaine-using mothers, particularly teenagers, and their infants highlights the importance of further research.

Field, Widmayer, Stringer, and Ignatoff (1980) studied the effects of a school-based intervention of low-SES teenage mothers (who were not drug users) and their infants. The intervention program provided parent training, job training, and a minimum-wage income for the teenage mothers. The mothers served as teacher aide trainees in a nursery that provided daytime care for infants of medical school faculty and staff. The 6-month on-the-job training took place during the teenage mothers' nonschool hours. The mothers not only received training in infant stimulation exercises, but also were exposed to modeling of parenting and child-care techniques by the staff, were involved in caregiving for their own and other infants for extended periods, and received the socioeconomic benefits of job training and a steady income. At one year of age, the intervention infants' weight, interactions, and motor skills had improved. The mothers also benefited; their rate of employment or return to school was higher and the incidence of repeat pregnancy was lower. The nursery intervention was cost-effective inasmuch as it

provided a service for medical faculty and staff and facilitated improvement in both the socioeconomic status of teenage mothers and the development of their infants. The purpose of the present study was to assess the effects of a similar intervention program on polydrug-using adolescent mothers and their infants.

METHODS**SAMPLE**The sample included 126 young mothers (ages 16-21) who had not completed high school and who had or had not used drugs during pregnancy. Urine toxicology screens were used to assess drug exposure near the time of delivery. Specific immunoassays (EMIT, Syva) for cocaine metabolite (benzylecgonine), opiates, and marijuana were performed. Infant urine screens were limited to three assays: cocaine metabolite, cannabinoids, and opiates. Based on these urine screens, mothers and infants were assigned to a nondrug, drug control, or drug intervention group at the neonatal period. The mothers, on average, were 18 years old, had 10.3 years of education, and their socioeconomic status was 4.4 on the Hollingshead Index. Approximately 64% were African American, 27% Hispanic, and 10% non-Hispanic White.

MATERNAL DEMOGRAPHIC AND INTERVIEW MEASURESMaternal depression was determined by the mothers' responses on the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mach, & Erbaugh, 1961) and the Depression Inventory Schedule (DISC; Robins et al., 1981). The DISC allows lay interviewers or clinicians to make psychiatric diagnoses according to DSM-III and other recognized criteria. Its psychometric properties have been established by a set of epidemiological studies sponsored by the National Institute of Mental Health. It includes all diagnoses of the Research Diagnostic Criteria and several of the DSM-III, which allowed confounding diagnoses in the depressed cocaine-exposed group to be identified (e.g., antisocial personality). It was also used to classify other drug dependencies (e.g., alcohol, tobacco, and marijuana).

The BDI is a 21-item questionnaire, with each item scored on a 4-point scale indicating the presence and severity of depressed feelings/behaviors/symptoms. It is among the most commonly employed instruments in research on nonclinically depressed samples. Mothers who receive a score of less than 9 on the BDI are typically classified as nondepressed, and mothers with a score of greater than 12 are usually classified as depressed.

The Background Stress Interview (Field, 1980) was administered to determine whether the mothers were depressed as a function of differences in background stress. This 42-item interview yields an estimate of socioeconomic status and a composite score based on items assessing the amount of social support the mother is currently receiving, the degree of stress she is experiencing in her child-rearing role, the self-recalled stress from her own childhood, as well as currently stressful home environment features, such as crowding (Field, Healy, Goldstein, Perry, Bendell, Schanberg, Zimmerman, & Kuhn, 1988). All of these scales were administered in an interview format to avoid problems associated with subjects' different reading levels.

The Problem Oriented Screening Instrument for Teenagers (POSIT; National Institute on Drug Abuse, 1987) was administered to the mothers to screen for social, emotional, and behavioral problems. This 139-item questionnaire measures various social, familial, physical, and mental stressors. Items are grouped into ten subscales (functional areas): Substance Use/Abuse, Physical Health Status, Mental Health Status, Family Relations, Peer Relations, Educational Status, Vocational Status, Social Skills, Leisure and Recreation, and Aggressive Behavior/Delinquency. The POSIT reportedly is a good measure for discriminating between adolescents known to have problems (in treatment) and those without problems (National Institute on Drug Abuse, 1987). Subjects scoring above the clinical cutoff or having "flagged" items are administered a series of additional scales (the Comprehensive Assessment Battery) for

more extensive assessment.

Measures of drug rehab progress, including random checks of maternal urine, were administered at 1-month intervals and at all assessment periods to ensure compliance with the program and to assess abstinence. Screens included an EMIT for cocaine, a thin layer chromatography on narcotics, and an alcohol screen.

Life tasks behavior was also assessed, including attendance at the drug rehab program, progress on GED/high school diploma completion, vocational training opportunities pursued, full-time employment, work missed or job loss due to alcohol/drug use, arrests, and residential stability.

NEONATAL ASSESSMENT Perinatal and postnatal complications were assessed using the Littman and Parmelee Obstetric and Postnatal Complications Scales (Littman & Parmelee, 1978). These scales have been widely used with high-risk infants. The Pediatric Complications Scale, designed by the same authors, quantifies continuing medical problems (e.g., respiratory illnesses) that require pediatric and hospital care. This scale was completed at the follow-up assessments.

Growth was measured (weight, length, and head circumference) and neurological exams were performed at each assessment period.

The Brazelton Neonatal Behavioral Assessment Scale (BNBAS; Brazelton, 1973) was administered midway between feedings and following the sleep session observations. The scale consists of 20 neurological reflex items and 27 items constituting 7 factors: habituation, orientation, motor behavior, range of state, state regulation, autonomic stability, and abnormal reflexes (Lester, Als, & Brazelton, 1982).

Infants' withdrawal symptoms were assessed as positive or negative on the 12 items of the abbreviated Neonatal Withdrawal Syndrome (NWS) Checklist (Eisen et al., 1991) based on their behavior during administration of the Brazelton scale. The items were compiled from previous studies that looked at the behaviors of infants experiencing ethanol and narcotic withdrawal.

Cortisol, catecholamines (norepinephrine, epinephrine, and dopamine), 5-HIAA, and creatinine were assayed from urine. The focus was on norepinephrine, dopamine, and serotonin, as cocaine is thought to inhibit uptake of these neurotransmitters both in the central and peripheral nervous systems and because dopamine depletion was noted in a pilot study. Twenty-four-hour urine collections from each assessment period were analyzed for norepinephrine, epinephrine, and cortisol as correlates of hypothalamic pituitary adreno activation, and 5-HIAA as a measure of serotonin turnover. While these measures provide an estimate of released neurotransmitters, several factors must be kept in mind in evaluating the significance of urine analyses. First, an unchanged neurotransmitter reflects a small percentage of total excretion, although for catecholamines the correlation with physiologically released norepinephrine and epinephrine is quite good across development (Kuhn, Schanberg, Field, Symanski, Zimmerman, Scafidi, & Roberts, 1991). Second, norepinephrine and 5-HIAA reflect release from both peripheral and central neurons. As cocaine affects both similarly, this presents less of a problem in evaluating cocaine effects globally. These assays were performed as described previously (Kuhn et al., 1991).

Vagal tone was recorded during the last 15-minute period of the sleep session when the infant was in a sleep state. The physiological data were quantified by playing the tape-recorded EKG into a vagal tone monitor developed by Porges (1985), a procedure that revealed the heart period variability within the frequency band associated with spontaneous breathing. This measure of respiratory sinus arrhythmia is

the estimate of vagal tone. Vagal tone was assessed at both the neonatal and 3-month periods, providing an index of the development of the infants' central nervous system integrity. In addition, this validated earlier observations that vagal tone is depressed in cocaine-exposed infants.

Sleep/wake behavior was videotaped in compressed time for an interfeeding interval (2-3 hours) before the Brazelton assessment was performed. The videotapes were coded for all movements that occurred during that period, according to the procedures used in other sleep studies (Field, Schanberg, Scafidi, Bauer, Vega-Lahr, Garcia, Nystrom, & Kuhn, 1986; Scafidi, Field, Schanberg, Bauer, Vega-Lahr, Garcia, Nystrom, & Kuhn, 1986). Prior to sleep state coding, the examiner was trained to .90 reliability. An adaptation of Thoman's Sleep State Criteria was used to define sleep/wake behavior categories. Sleep state patterns were assessed because of the sleep disturbances reported for cocaine-exposed infants (Ward, Schuetz, Krishna, Bean, Wingert, Wachsmann, & Keen, 1986) and because of their predictive validity in studies of other high-risk infants (Sigman & Parmelee, 1989).

ASSESSMENTS AT 3 AND 6 MONTHS Mother-infant interactions were videotaped during feeding (newborn period) and face-to-face play (when the infants were 3 and 6 months old). For the 5-minute play interactions, the mothers were simply asked to "pretend you are playing with your infant at home." The infants were placed in an infant seat on a table approximately fifteen inches from the face of the mother, who was seated at the table. Two video cameras and a split-screen generator enabled simultaneous monitoring of the mother's face and torso and the infant's upper body. In addition, heart rate was simultaneously recorded. EKG electrodes were placed on the right scapula, the lower left lateral costal margin, and the lower left vertebral region just above the waistline of the infants and mothers. Prior to and 20 minutes following the interactions, saliva samples were taken from the mothers and infants by placing a dental swab (dipped in lemonade crystals) along the gumline to be subsequently assayed for cortisol levels to determine the stressful effects of these interactions on the mother-infant dyads.

The videotapes were subsequently coded for a number of behaviors that have been studied in previous research on depressed mother-infant dyads, including, for the mother, anger/poke, disengage, elicit, and play, and for the infant, protest, look-away, attend, and play. The videotapes were rated on the Interaction Rating Scales (Field, 1980), which are 3-point Likert-type scales measuring the following behaviors: (1) infant's state, physical activity, head orientation, gaze behavior, facial expressions, vocalizations, and fussiness; and (2) mother's state, physical activity, head orientation, gaze behavior, facial expressions, vocalizations, silence during infant gaze aversion, imitative behaviors, contingent responsivity, and game playing (Field, 1980). These scales are averaged to obtain a summary rating for the mother and for the infant. These scales have been used in many studies on early mother-infant interactions, with interrater reliabilities ranging from .81 to .96 (mean = .88).

Heart rate was analyzed using a vagal tone monitor, such that the average heart rate and vagal tone could be estimated for each interaction situation. The biochemical assays for norepinephrine, epinephrine, dopamine, 5-HIAA (serotonin), cortisol, and creatinine were again conducted.

A measure of neurological development (INFANIB; Ellison, Horn, & Browning, 1985) was administered at 3 and 6 months. This 20-item instrument (5 factors) assesses neurological integrity in infancy, categorizing development as normal, transient abnormal, or abnormal. The 5 factors include collections of abnormal reflex patterns: (1) spasticity (asymmetric tonic neck reflex, tonic labyrinthine in prone, tonic labyrinthine in supine, and hands held open or closed); (2) vestibular function (sideways, backwards, and forwards parachute); (3) head and trunk (problems pulling to a sitting position, sitting, and rotating body); (4) French angles (limited range of motion in upper and lower extremities); and (5) legs (foot grasping and flexion and standing). This scale is often used at 6 months to assess neurological and motor

development.

ASSESSMENT AT 12 MONTHSThe Early Social Communication Scales, the Bayley Scales of Infant Development, and the physical measurements, in that order, were administered after one year.

The Early Social Communication Scales were developed to measure interactive behavior of infants by developmental level/complexity (from simple to symbolic) and by communicative/pragmatic function (from social attention to self to shared attention). The assessment procedure involves a semistructured series of situations in which the tester presents individual toys and engages the child in interactive games (Seibert & Hogan, 1982; Seibert, Hogan, & Mundy, 1987).

The Bayley Scales of Infant Development include a Mental scale, a Motor scale and an Infant Behavior record (Bayley, 1969). They are well-standardized tests of infant development and measure a variety of sensorimotor and temperament functions.

INTERVENTION PROGRAMThe 4-month intervention program consisted of several components, including drug and social rehab, parenting and vocational classes, and relaxation therapy (aerobics, progressive muscle relaxation, music mood induction, and massage therapy), and took place afternoons in a vocational high school the mothers attended. Mornings were spent in high school or GED prep classes. Their infants received day care while they were in classes and the rehab program. In addition, the mothers spent approximately 1-2 hours per day in the nursery school, helping to take care of their infants. The nursery was designed for multilevel infant enrichment and was staffed by a head teacher, two assistant teachers, and three of the mothers, who served as teacher-aid trainees. It served 12 infants at a time.

Drug rehabilitation. This component followed the Rawson et al. (1986) outpatient drug rehab curriculum and consisted of group therapy, psychoeducational sessions, urine monitoring, self-help group sessions (NA/AA), and individual and drug counseling. The participants were given drug abuse, psychiatric, social, educational, and vocational evaluations, from which individual treatment plans were developed.

Group therapy sessions focused on denial of drug use, problem-solving, coping skills, altering life-styles, and the twelve-step philosophy. The psychoeducational sessions included presentations on addiction theories, medical complications of substance dependency, family relationships, male-female interactions, interpersonal skills, communication skills, assertiveness training, empowerment, HIV and AIDS, sex education (including effective forms of contraception, such as Norplant) and sexually transmitted diseases, 12-step programs, spirituality, and accessing health care/social/vocational services.

Educational / vocational counseling. Since the mothers agreed to complete high school or obtain a general equivalency diploma in order to participate in this program, educational/vocational counseling, like drug rehabilitation, was given top priority. They attended either high school or GED prep classes in the morning, and were also provided job counseling and referrals for job training at their vocational high school and at the medical school (e.g., x-ray technician, nurse, day-care teacher aid, computer operator). Every effort was made to place mothers in vocational training programs prior to the end of the 4-month intervention program. Similarly, at the end of the program, they were provided assistance in finding stable living arrangements and affordable day care for their infants.

Parenting classes. Mothers attended parenting classes two hours each week. The classes were designed to educate the mothers on developmental milestones and child-rearing practices, teach exercises and age-appropriate stimulation for facilitating sensorimotor and cognitive development of their infants, and facilitate mother-infant interactions in order to develop communication skills and foster harmonious

mother-infant relationships (e.g., interaction coaching enhanced the mothers' sensitivity to their infants' behaviors).

Social rehab. This group was also scheduled for two hours per week. It focused on daily living tasks and problems involving social support, living arrangements, school, parenting, and relationships with parents, friends, infants, and other group members. The teenagers' parents, boyfriends, and friends were invited whenever it seemed indicated.

Relaxation therapy. This included progressive muscle relaxation, music mood induction and visual imagery, massage therapy, and aerobics classes. Significant positive effects of these types of relaxation have been reported for adolescent psychiatric patients, including reduced anxiety, depression, and cortisol levels (Platania-Solazzo, Field, Blank, Seligman, Kuhn, Schanberg, & Saab, 1992), and reduced norepinephrine and enhanced sleep (Field, Morrow, Valdeon, Larson, Kuhn, & Schanberg, 1992).

RESULTS Multivariate analyses of variance were conducted, followed by univariate ANOVAs and post hoc Bonferroni t tests.

DEMOGRAPHIC VARIABLES First, demographic variables were analyzed to determine whether any background variables should be entered as covariates in the analyses. As can be seen in Table 1, the mothers in the drug control, drug rehab, and nondrug groups did not significantly differ in regard to maternal age, education, socioeconomic status, and ethnic distribution.

MATERNAL DEPRESSION As can be seen in Table 1, the drug groups had significantly higher scores on the Beck Depression Inventory and significantly greater incidence of major depression and dysthymia as measured by the DISC. They also had more problematic background stress scores and higher scores on the POSIT, indicating problems in the areas of substance abuse, physical health, mental health, family relations, peer relations, educational status, vocational status, social skills, leisure/recreation, and aggressive behavior.

BIRTH MEASURES MANOVA for the birth measures was not significant. The groups were equivalent on the standard birth measures, including gestational age, birth weight, birth length, head circumference, ponderal index, 5-minute Apgar score, and obstetric and postnatal complications (see Table 2).

NEONATAL BEHAVIOR ASSESSMENT Despite the similarity on the standard birth measures, a MANOVA revealed significant differences on the Neonatal Behavioral Assessment Scale. Subsequent ANOVAs and Bonferroni t tests suggested that the drug groups received inferior scores on habituation, orientation, abnormal reflexes, general irritability, and regulatory capacity (see Table 3).

SLEEP / WAKE BEHAVIORS AND INTERACTION RATINGS The MANOVA for the sleep/wake behaviors and interaction ratings was also significant, and post hoc ANOVAs and Bonferroni t tests suggested that quiet sleep occurred less frequently for the drug groups, and crying and stress behaviors occurred more frequently (see Table 4). The drug groups also had less optimal Interaction Rating Scale scores for both the mothers and the infants.

BIOCHEMICAL MEASURES As can be seen in Table 5, there were also drug-nondrug differences on the biochemical measures. The results of a MANOVA for the mothers' values were significant, and post hoc ANOVAs indicated that the drug groups had significantly higher levels of dopamine and serotonin and lower levels of cortisol. The MANOVA for the infants was also significant, and post hoc ANOVAs indicated that the infants in the drug groups had higher norepinephrine levels and lower cortisol levels.

FINDINGS AT 3 MONTHS ANOVAs and Bonferroni t tests revealed that the Beck Depression Inventory and background stress scores at 3 months were significantly less optimal for the drug groups than for the nondrug group. However, a MANOVA and the ANOVAs and Bonferroni t tests revealed that the mothers and infants of the drug rehab and nondrug groups had superior interaction ratings to those of the drug control group. Vagal tone values were also higher for the drug rehab and nondrug mothers than they were for the drug control group. In addition, salivary cortisol levels and change scores for the drug rehab mothers and infants approximated those for the nondrug group, with values for both groups lower than those for the drug control group, suggesting lower stress levels. The results of a MANOVA for the infants' physical measures were not significant.

FINDINGS AT 6 MONTHS MANOVA, ANOVAs, and Bonferroni t tests performed at 6 months (see Table 6) indicated that the drug rehab group was beginning to approximate the nondrug group on Beck Depression Inventory scores as well as interaction ratings for both mothers and infants. Vagal tone values were also lower for the mothers and infants in the drug control group than they were for those in the drug rehab and nondrug groups. In addition, cortisol levels and change scores for the drug rehab mothers and infants approximated those for the nondrug group; the values for both groups were lower than those for the drug control group, suggesting lower stress levels. The results of a MANOVA for the infants' physical measurements were also significant. ANOVAs and Bonferroni t tests indicated that infants in the drug rehab and nondrug groups had superior scores on head circumference and pediatric complications. Thus, at 6 months, the drug rehab group was doing significantly better than the drug control group and was approximating the nondrug group on several measures.

The results of a MANOVA for the biochemical data at 6-month follow-up were significant (see Table 7). ANOVAs and post hoc Bonferroni t tests revealed that the drug rehab mothers were looking more like the nondrug mothers, in a sense normalizing their values for epinephrine, dopamine, and serotonin. Surprisingly, some of these values were higher for the drug rehab and nondrug groups. The infants in the drug rehab and nondrug groups had higher values than did those in the drug control group for norepinephrine, epinephrine, and cortisol.

FINDINGS AT 12 MONTHS ANOVAs and Bonferroni t tests at 12 months revealed that the drug rehab group had a lower mean Beck Depression Inventory score than did the drug control group, as well as a more optimal background stress score (see Table 8). Also, the incidence of repeat pregnancy and continued drug use was lower in the drug rehab group than in the drug control group, and higher percentages of the drug rehab mothers were continuing school, had received their GED/diploma, and had been placed in jobs. The results for the drug rehab group approximated those for the nondrug group on several of these lifestyle variables.

The results of a MANOVA for the developmental variables were significant, and ANOVAs and post hoc Bonferroni t tests revealed that the drug rehab group had more optimal scores on the Early Social Communication Scales (responding, initiating, and maintaining) than did the drug control group, with scores approximating those of the nondrug group. The drug rehab group performed significantly better on the Bayley Mental scale than did the drug control group, but had a significantly lower mean score than did the nondrug group.

Results of a MANOVA for the infants' physical measures were significant. ANOVAs and post hoc Bonferroni t tests indicated that the drug rehab group again approximated the nondrug group on head circumference and pediatric complications, and had significantly better values than did the drug control group.

DISCUSSIONAt the outset, the mothers in the drug and nondrug groups did not differ on demographic variables, such as age, education, socioeconomic status, and ethnic distribution. However, the drug-exposed mothers had a number of problems, including depression (both major depression and dysthymia) and background stress, that might place them and their infants at risk.

Despite these significant stressors for the mothers, the neonates' birth measures were apparently not compromised. The infants in the drug and nondrug groups were similar on traditional birth measures, including gestational age, birth weight, birth length, head circumference, ponderal index, Apgar score, and obstetric and postnatal complications. This was surprising inasmuch as several studies have reported shorter gestation, smaller head circumference, and perinatal complications for drug-exposed infants (Burkett et al., 1990; Coles et al., 1991; Rosenak et al., 1990). It is possible that these adolescent mothers were less drug involved than were those in other research.

The drug-exposed infants did, however, have inferior scores on the Neonatal Behavioral Assessment Scale, particularly habituation, orientation, abnormal reflexes, general irritability, and regulatory capacity. The drug-exposed infants also spent less time in quiet sleep and more time crying and showing stress behaviors.

Both the mothers and the infants in the drug groups demonstrated inferior interactions. Further, the biochemical measures revealed that dopamine and serotonin levels were significantly higher in the drug-exposed mothers. Cortisol levels, in contrast, were significantly lower for the drug-exposed mothers. This may relate to their high depression scores. Others have noted that in depressed subjects, higher severity ratings were associated with lower cortisol levels, as if cortisol conforms to an inverted U-function (Birmaher et al., 1992). For the infants, norepinephrine levels were higher and cortisol levels were lower for the drug-exposed group. Together, these behavioral, physiological, and biochemical measures suggest that the drug-exposed mothers and infants were different from the nondrug group starting from the time of birth.

At 3 months, near the end of the intervention period, the drug rehab mothers still showed more negative Beck Depression Inventory and background stress scores. However, the drug-rehab mothers and infants looked more like their nondrug counterparts in their interactions. At this stage the infants' physical measures, such as weight, length, head circumference, and neurological and pediatric complications, did not differ across groups.

By 6 months, the drug-exposed mothers and infants who received rehab looked more similar to the nondrug group on virtually every measure: Beck Depression Inventory scores, mother and infant interaction ratings, infants' head circumference, and pediatric complications. Also at this stage, the drug rehab group approximated the nondrug group on the biochemical measures.

For the mothers, epinephrine and dopamine levels were significantly higher and serotonin levels significantly lower for the drug rehab and nondrug groups than they were for the drug control group. This could be explained by the higher depression scores for the mothers in the drug control group. Depression is typically accompanied by lower dopamine and higher serotonin levels (Rogeness et al., 1992). In the case of the infants, paradoxically there was also higher norepinephrine, epinephrine, and cortisol levels for the drug rehab and nondrug groups than for the drug control group. Interestingly, this mirrors the catecholamine and cortisol levels for infants of depressed mothers. It may be that many of the effects in this study derived more from the mothers' depression than from their drug use, inasmuch as several of the findings replicated those in a study on depressed mothers and their infants (Field, Pickens,

Prodromidis, Malphurs, Fox, Schanberg, & Kuhn, in press).

At 12 months, the drug rehab mothers' mean Beck Depression Inventory score, although significantly lower than that of the drug control group, was still higher than that of the nondrug group. Similarly, the drug rehab group was feeling less background stress than was the drug control group. Their infants also showed significant advantages on the Early Social Communication Scales and the Bayley Mental scale, although the scores were still lower than for the nondrug group. Again, the drug rehab infants had significantly greater head circumference and significantly fewer pediatric complications than did the drug control group at 12 months, their scores being similar to those of the nondrug group.

Of great importance for both the rehab mothers and their infants were the mothers' lower incidence of repeat pregnancy and drug use, as well as the higher percentages continuing school, obtaining a GED or high school diploma, and being placed in jobs. These may be critical for sustaining the progress made in the intervention program.

Replication of these findings is needed, as is more mechanism-oriented research. Assessing these mothers during pregnancy might help to disentangle prenatal and genetic factors. Nonetheless, the current data suggest that a fairly cost-effective intervention can be offered to drug-exposed mothers that would significantly attenuate their infants' developmental delays.

Added material.

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Table 1 Demographic Variables.

(TABLE) Groups Drug Drug NonVariables Control Rehab Drug pMaternal BackgroundMother's Age 18.1 18.0 18.0 NSMother's Education 10.2 10.3 10.5 NSSocioeconomic Status 4.4 4.4 4.4 NSEthnic Distribution - African American 63.9 65.1 62.0 NS - Hispanic 26.2 27.1 28.0 NS - Non-Hispanic White 10.1 8.9 10.2 NSMaternal InterviewsBeck Depression Inventory(FN1) 13.8a 14.2a 6.0b .001DISC Major Depression(FN1) 22.0a 24.0a 6.0b .005DISC Dysthymia (%) (FN1) 11.0a 13.0a 1.0b .005Background Stress 16.8a 16.9a 18.9b .002POSIT(FN1) 51.4a 53.1a 29.5b .001.

FOOTNOTE1 Lower score is optimal.

Note: Different subscripts indicate significant group differences.

Table 2 Birth Measures.

(TABLE) Groups Drug Drug Non Variables Control Rehab Drug pGestational Age 39.3a 39.1a 38.9a
NSBirth Weight 3309.2a 3105.7a 3088.9a NSBirth Length 50.1a 49.2a 48.7a NSHead Circumference
33.8a 33.2a 32.8a NSPonderal Index 2.5a 2.5a 2.5a NS5-Minute Apgar 8.8a 8.7a 8.8a NSObstetric
Complications(FN1) 108.3a 107.9a 108.6a NSPostnatal Complications(FN1) 137.1a 136.9a 138.2a NS.

FOOTNOTE1 Higher score is optimal.

Table 3 Neonatal Behavior Assessment Scale Scores.

(TABLE) Groups Drug Drug Non Control Rehab Drug pHabituation 5.4a 5.5a 5.9b .05Orientation 5.3a
5.2a 5.6b .05Motor 4.4a 4.5a 4.4a NSRange of State 4.0a 4.0a 3.9a NSRegulation of State 5.1a 5.0a
5.2a NSAutonomic Stability 5.9a 5.9a 5.8a NSAbnormal Reflexes(FN1) 2.8a 3.1a 1.6b .05General
Irritability 4.9a 5.0a 5.9b .005Regulatory Capacity 5.1a 5.0a 5.7b .05.

FOOTNOTE1 Lower score is optimal.

Note: Different subscripts indicate significant group differences.

Table 4 Sleep/Wake Behaviors and Interaction Rating Scale Scores at Neonatal Period.

(TABLE) Groups Drug Drug Non Control Rehab Drug pSleep/Wake Behaviors (% Time)Quiet Sleep
11.9a 12.1a 31.8b .05Active Sleep 1.8a 1.9a 2.6a NSIndeterminate Sleep 12.0a 11.8a 8.9a NSDrowsy
13.4a 13.7a 11.0a NSInactive Alert 18.9a 19.5a 15.3a NSActive Awake 28.9a 28.8a 23.5a NSCrying
14.0a 12.8a 6.9b .05Stress Behavior 6.8a 7.9a 4.2b .05Interaction Rating ScalesMother 2.1a 2.0a 2.4b
.05Infant 1.9a 1.9a 2.5b .05.

Note: Different subscripts indicate significant group differences.

Table 5 Biochemical Measures at Neonatal Period (values expressed as ng/mg creatinine).

(TABLE) Groups Drug Drug NonMother Values Control Rehab Drug pNorepinephrine 35a 34a 37a
NSEpinephrine 6a 7a 5a NSDopamine 306a 311a 279b .055-HIAA 2914a 3016a 1986b .05Cortisol 170a
168a 280b .05Infant ValuesNorepinephrine 70a 74a 55b .01Epinephrine 9a 7a 9a NSDopamine 677a
658a 626a NSCortisol 620a 710a 902b .05.

Note: Different subscripts indicate significant group differences.

Table 6 Results at 3 and 6 Months.

(TABLE) 3 Months Groups Drug Drug Non Variables Control Rehab Drug pMaternal InterviewBeck
Depression Inv. 15.5a 11.3a 8.4b .05Background Stress 19.5a 20.3a 23.1b .05Interaction RatingsMother
2.0a 2.4b 2.6b .05Infant 1.9a 2.4b 2.5b .05Infant Physical MeasuresWeight 6419.2a 6315.8a 6661.5a
NSLength 61.9a 61.2a 62.4a NSHead Circumference 39.1a 38.2a 40.3a NSNeurological 63.1a 62.5a
64.6a NSPed. Complications 109.7a 105.6a 114.7a NSVagal ToneMother 4.6a 6.8b 6.5b .05Infant 3.6a
3.0a 4.2b .05Cortisol (ng/ml)Mother 2.7/2.4a 1.6/1.4b 1.8/1.3b .05Infant 2.3/2.3a 1.9/1.5b 1.6/1.2b .05.

(TABLE) 6 Months Groups Drug Drug Non Variables Control Rehab Drug pMaternal InterviewBeck

Depression Inv. 13.7a 9.3b 7.0b .05Background Stress 20.4a 20.9a 22.0a NSInteraction RatingsMother 1.9a 2.3b 2.5b .05Infant 1.8a 2.3b 2.4b .05Infant Physical MeasuresWeight 8246.7a 8467.4a 9692.5a NSLength 66.3a 68.3a 68.2a NSHead Circumference 41.1a 43.6b 43.8b .01Neurological 63.1a 63.8a 68.3a NSPed. Complications 89.3a 108.0b 118.3b .05Vagal ToneMother 4.9a 6.7b 6.8b .05Infant 2.8a 3.4b 3.7b .05Cortisol (ng/ml)Mother 1.8/1.8a 1.4/1.3b 1.5/1.2b .05Infant 2.0/2.8a 1.6/1.7b 1.7/1.5b .05.

Note: Different subscripts indicate significant group differences.

Table 7 Follow-up for Biochemical Variables at 6 Months (values expressed as ng/mg creatinine).

(TABLE) Groups Drug Drug NonMother Values Control Rehab Drug pNorepinephrine 36a 41a 46a NSEpinephrine 5a 9b 7b .05Dopamine 274a 323b 358b .055-HIAA 3179a 2529b 2568b .05Cortisol 94a 101a 125a NSInfant ValuesNorepinephrine 88a 108b 130b .05Epinephrine 12a 20b 16b .05Dopamine 1741a 1830a 2117a NSCortisol 287a 495b 567b .05.

Note: Different subscripts indicate significant group differences.

Table 8 Results at 12 Months.

(TABLE) Groups Drug Drug NonVariables Control Rehab Drug pMaternal InterviewBeck Depression Inventory 12.4a 10.5b 6.1c .05Background Stress 17.4a 19.8b 22.3c .05Repeat Pregnancy (%) 21.3a 9.8b 7.1b .01Continuing Drugs (%) 24.9a 17.9b 1.3c .01Continuing School (%) 19.6a 43.2b 59.5b .05GED/Diploma (%) 7.9a 14.7b 21.2c .01Job Placement (%) 12.7a 27.1b 39.3b .05Early Social Commun. ScalesResponding 1.8a 2.3b 2.5b .05Initiating 1.9a 2.3b 2.4b .05Maintaining 1.7a 2.0b 2.2b .05Bayley ScalesMental 89.0a 99.3b 108.2c .05Motor 102.1a 103.0a 112.0b .05Infant Physical MeasuresWeight 9085.0a 9387.1a 10118.0a NSLength 73.8a 74.7a 75.7a NSHead Circumference 43.2a 46.7b 47.1b .05Pediatric Complication 38.0a 52.1b 53.7b .05.

Note: Different subscripts indicate significant group differences.

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