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ABSTRACT

This paper synthesizes findings of major research studies on development of learning impairment and its prevention in children from birth to age 5. The paper's scope does not include children who died or suffered major retardation. The paper attempts to demystify the language of research and medicine to clarify the prevalence of health, environmental, and poverty-based risk factors; their impact on a child's ability; and ways to prevent the risk factor or ameliorate the learning impairment once it occurs. Major preventable factors associated with learning impairment are low birthweight, prenatal alcohol exposure, maternal smoking, prenatal exposure to drugs, lead poisoning, child abuse and neglect, and malnutrition: each of these factors is discussed in turn. Prevention strategies include, among others, access for all women to early and informative prenatal care, health care before pregnancy and between pregnancies, developmentally stimulating infant day care with parent involvement, school health education, and societal commitment to diminish poverty. A separately printed 3-page summary is appended. (JDD)

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REDUCING RISKS OF LEARNING IMPAIRMENT DURING PREGNANCY AND INFANCY

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Every Child a Learner:

Reducing Risks of Learning Impairment During Pregnancy and Infancy

by

Lucile Newman
and
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1990

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PREFACE

This study synthesizes findings of major research studies on development of learning impairment in children from birth to age 5. It is the first project to compile data from many current sources to identify the primary *preventable* conditions associated with the development of learning problems.

These data sound an alarm for state and federal policy makers in education, health and the environment. Health, environmental and poverty-based hazards are compromising many children's ability to learn. Yet, some of these hazards can be prevented through enlightened policy making and programs attentive to the particular vulnerability of children.

The report attempts to demystify the language of research and medicine to make clear how prevalent these factors are, how each one affects a child's ability to function and what can be done to prevent the risk factor or ameliorate learning impairment once it occurs. This is complicated by the fact that many children are affected by more than one factor. Mothers who drank alcohol while pregnant, for example, may also have smoked or taken drugs. In addition, poverty exacerbates the problems in many cases. Children who could be helped to overcome some of their learning problems find needed services out of reach. The cumulative effects of several factors can have devastating consequences.

For every suggested cause of learning impairment, there are successful programs of prevention. There is, however, no coordinated effort under way nationally or in individual states to deal with these problems. Much work remains to fashion policy options that build on these programs and give adequate attention to eliminating or lessening the effect of each risk factor. This paper suggests some options that can be used to address these problems.

It also recognizes that failure to deal with these preventable problems will continue to add an enormous burden to the schools and to the lives of many children and their families.

INTRODUCTION

One of the national objectives identified in the Education Summit of 1989 was for every child to arrive at the schoolhouse door ready to learn. Yet new evidence indicates that by school age a troubling 12% of children — *more than 450,000 additional children each year* — suffer damage that prevents them from learning as well as their natural endowment would allow.

The major preventable factors associated with learning impairment are: (1) low birthweight, (2) prenatal alcohol exposure, (3) maternal smoking, (4) prenatal exposure to drugs, (5) lead poisoning, (6) child abuse and neglect and (7) malnutrition. For example:

- About 6.9% — 260,000 children each year — are born at below-normal weights.
- About 40,000 a year are born with alcohol-related impairments.
- Drug abuse during pregnancy affects 11% of newborns each year — more than 425,000 infants in 1988.
- About 1.5 million children have been physically, sexually or mentally abused or neglected, most of them under age 5.
- Approximately 14 million children of all ages have been exposed to lead in the environment.

The learning problems that result from these factors are varied. They may include delayed speech, difficulty in paying attention or concentrating, hyperactivity, lowered IQ — all characteristics that lead to poor school performance.

Previously, each of these risk factors has been identified and studied in isolation from the others. However, their cumulative impact is an important issue in understanding the major risks for learning limitation, estimating the additional effects of poverty and disadvantage and identifying possible strategies for prevention or amelioration (Bane and Ellwood, 1989; Lewis, 1986; Pueschel and Mulic, 1990).

What impact each risk factor has on learning is difficult to measure for several reasons. First, risk factors often are intertwined. For example, low birthweight results from many of the factors described in this report, such as smoking, cocaine and "crack," alcohol, prenatal lead exposure and maternal malnutrition. At the same time, the data suggest that being born too soon, or especially too small, creates a risk for learning impairment even in otherwise risk-free children.

Second, because risk factors tend to cluster in certain segments of society, the same child may be subject to multiple conditions. This adds to the severity of learning problems and makes it difficult to estimate the total number of children affected.

Third, risk factors have different effects depending on the intensity of exposure and at what point in the child's development exposure takes place. And not every exposure results in impairment. Some children are simply more resistent and resilient than others.

Fourth, learning problems are compounded for many children by social factors such as poverty, social disadvantage and parental disinterest. An estimated 3.3 million children live in poverty in the United States. Lack of adequate health insurance and child care make prenatal care beyond the reach of many poor women and contribute to prematurity and infant morbidity, according to the Children's Defense Fund and others. The result is that schools in poor neighborhoods see much higher percentages of their children who are affected. In addition, school-age pregnancy continues to contribute to pre-term birth and to increase the number of single-parent families. However, not all children with learning disorders or suffering from these conditions come from disadvantaged families.

The Study

For each risk factor, this study looked at: (1) How common or prevalent is the risk factor? (2) How does it affect the child? (3) How many children are affected? (4) What has worked in preventing the risk factor or helping children affected by it?

The study did not include children who died or suffered major retardation. It included only those children still within the normal range of intelligence but whose learning capacities have been so compromised that they are at risk of school failure.

MAJOR FACTORS ASSOCIATED WITH LEARNING IMPAIRMENT

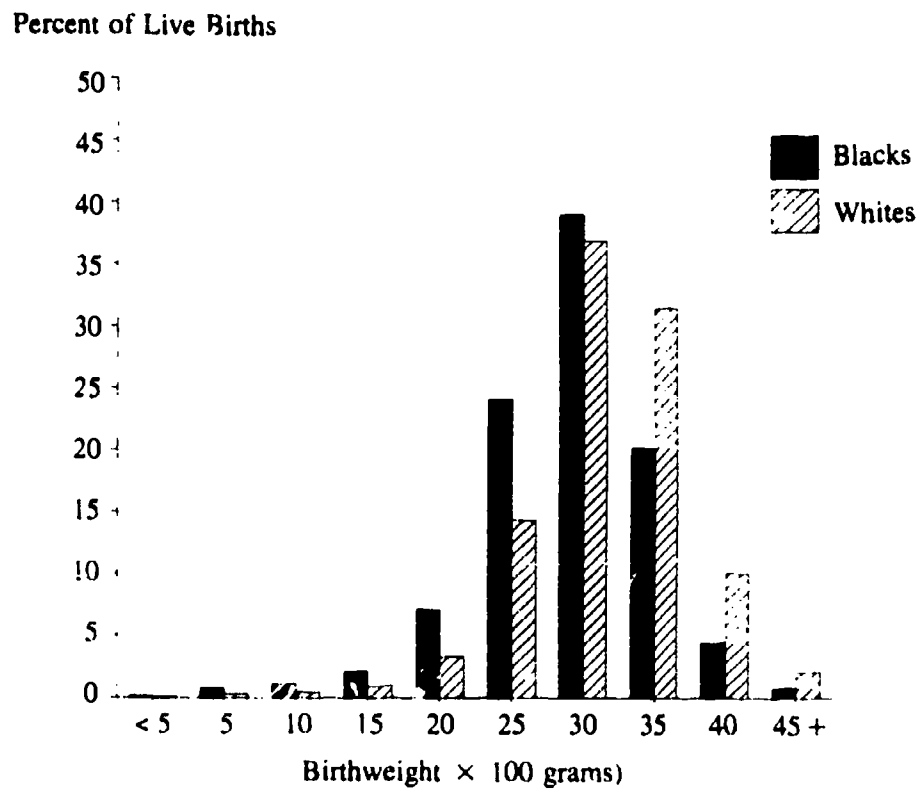
1. Low Birthweight

Around 6.9% of babies born in the United States weigh less than 5.5 pounds (2500 grams) at birth and are considered "low-birthweight" babies. In 1987, this accounted for some 269,100 infants. Low birthweight may result when babies are born too early or fail to grow properly in the womb because of placental insufficiency, maternal malnutrition or actions that restrict blood flow to the fetus, such as smoking or drug use. Low birthweight rates declined until 1985, but have increased slightly since that time (*MMWR*, 1990).

Very-low-birthweight infants weigh less than 3.25 pounds (1500 grams) at birth. Extremely low-birthweight babies, about 1% of births, weigh less than two pounds, three ounces (1000 grams).[1] Figure 1 indicates the distribution by birthweight of babies born in 1980. Black newborns generally weigh less than white infants and are more than twice as likely to be born at very low birthweights.

Figure 1

Distribution of Live Births by Birthweight and Race, 1980



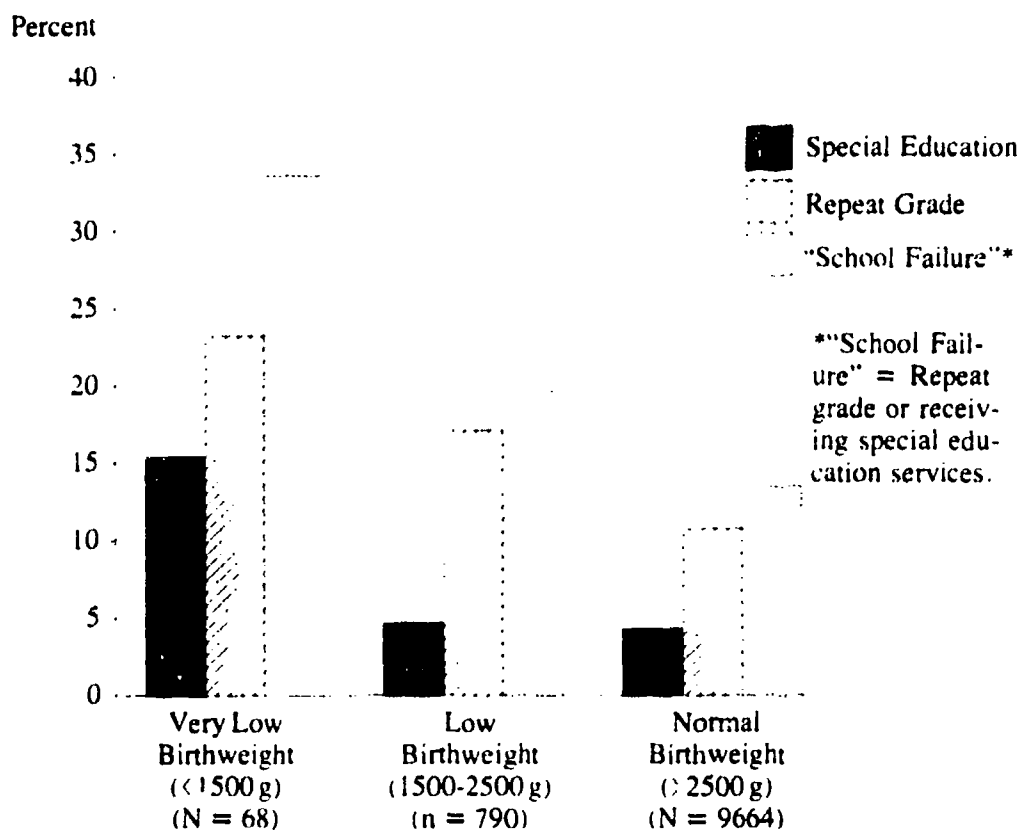
Source: *MMWR*, March 1990.

In 1987, about 48,750 babies were born at very low birthweights. Research studies estimate that 6-8% experience major handicaps such as severe mental retardation or cerebral palsy (Eilers et al., 1986; Hack and Breslau, 1986). Another 25-28% have borderline IQ scores, problems in understanding and expressing language or other deficits (Hack and Breslau, 1986; Lefebvre et al., 1988; Nickel et al., 1982; Vohr et al., 1988).[2] Although these children may enter the public school system, many of them show intellectual disabilities and require special educational assistance. Reading, spelling, handwriting, arts, crafts and mathematics cause them difficulties in school. Many have delayed speech and language problems. Children born at very-low-birthweights are more likely than those born at normal weights to be inattentive, hyperactive, depressed, socially withdrawn or aggressive (Breslau et al., 1988).

New technologies and the spread of neonatal intensive care over the past decade have improved survival rates of babies born at weights ranging from 3.25 pounds to 5.5 pounds. As Figure 2 shows, however, those born at low birthweights still are at increased risk of school failure. The chart illustrates how birthweight is related to various measures of learning impairment, including grade repetition, assignment to special education classes or the overall designation of "school failure" (either of the above). Figure 3 is based on intelligence and academic achievement scores. Both figures demonstrate a striking increase of impairment with decreasing birthweights.

Figure 2

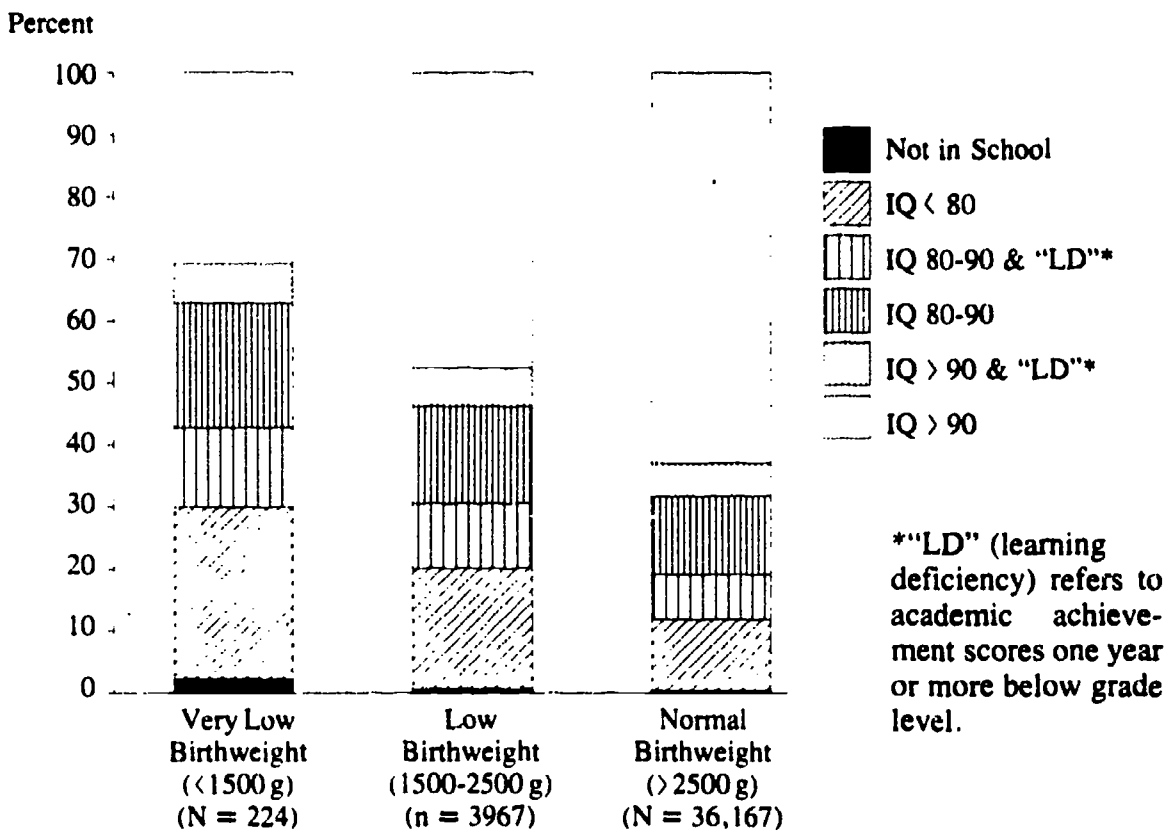
Relation of Birthweight to Various Measures of "School Failure" among Children Aged 4-17



Source: McCormick, Gortmaker and Sobol, 1990. Based on 10,522 children in the National Health Interview Survey, Child Health Supplement.

Figure 3

Relation of Birthweight to Intelligence and Achievement Scores at Age 7



Source: Buka et al., 1990. Based on 40,000 children followed from birth (1960-66) to age 7 in the National Collaborative Perinatal Project.

However, follow-up studies of low birthweight infants at school age concluded "the influence of the environment far outweighs most effects of non-optimal prenatal or perinatal factors on outcome" (Aylward et al., 1989). This finding suggests that early assistance can improve the intellectual functioning of children at risk for learning delay or impairment (Richmond, 1990).

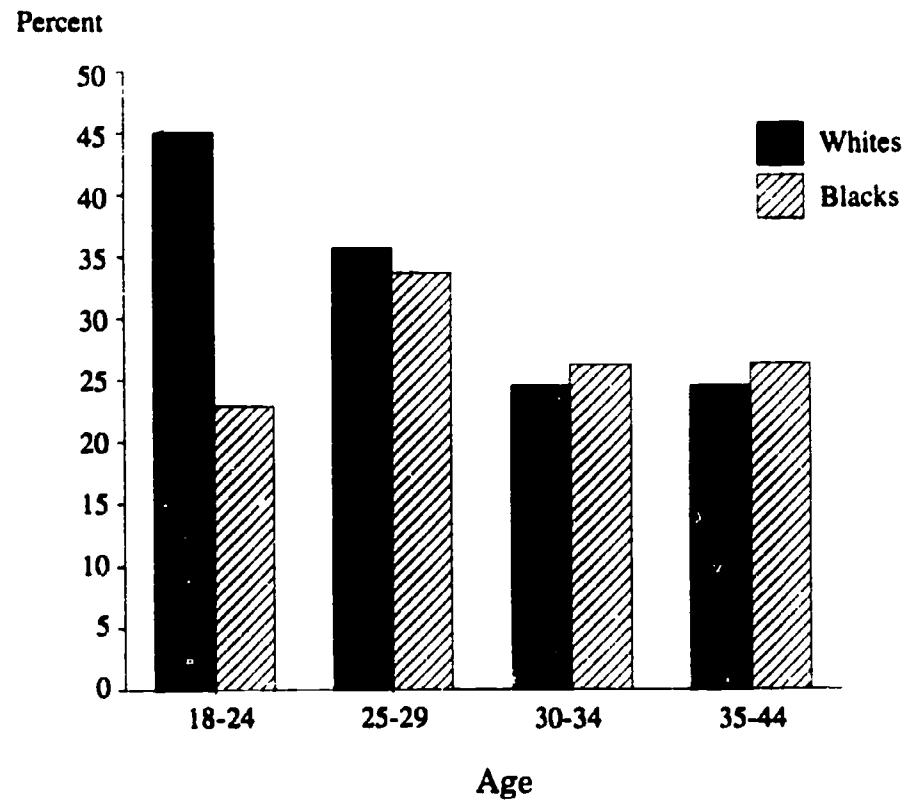
2. Maternal Smoking

Maternal smoking during pregnancy has long been known to be related to low birthweight, growth retardation before birth and long-term growth reduction (Abel, 1980), as well as an increased cancer risk in offspring (Stjernfeldt et al., 1986). One of the earliest postnatal effects noted by researchers was the association of maternal smoking and early and persistent asthma, leading to, among other problems, frequent hospitalization and loss of days in school (Streissguth, 1986). A growing number of new studies have shown that children of smokers are smaller in stature and lag behind other children in cognitive development and educational achievement. These children are particularly subject to hyperactivity and inattention (Rush and Callahan, 1989).

Relationships between maternal smoking and learning difficulties are complex. While smoking may not be the sole cause, it is associated with later learning problems. To illustrate how different factors work together, smoking is related to low-birthweight because it constricts blood flow to the placenta. It also is difficult to differentiate the effects of exposure to smoke from the mother before birth and from either parent after birth. Figure 4 indicates the percent of women of child-bearing age smoking in 1985.

Figure 4

Percent of Women Who Had Given Birth to a Child Within the Past 5 Years Who Reported Having Smoked Cigarettes at Any Time in the 12 Months Preceding the Birth, by Age and Race, 1985



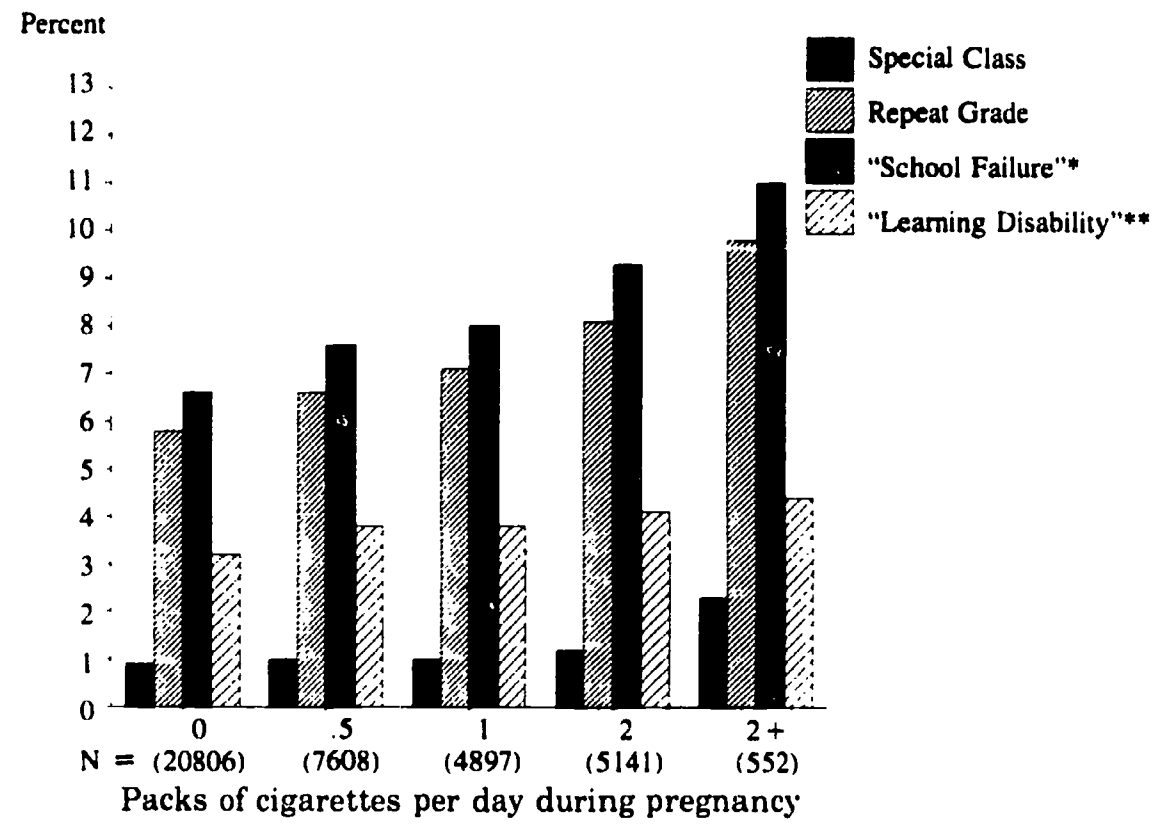
Source: U.S. Department of Health and Human Services, 1988.

One study attempted to measure the effects of smoking alone, separated from the effects of poverty, by examining middle-class children whose mothers smoked during pregnancy (Fried and Watkinson, 1990). That study, along with others, found that smoking has a cumulative effect. The infants showed differences in responsiveness beginning at one week of age. Later tests at 1, 2, 3 and 4 years of age found poor performance on verbal tests; "the children of the heavy smokers had mean test scores that were lower than those born to lighter smokers, who in turn did not perform as well as those born to non-smokers." The study also indicated that the effects of smoke exposure, whether in the womb or after birth, may not be identifiable until later ages when a child needs to perform complex cognitive functions, such as problem solving or reading and interpretation.

Data from the National Collaborative Perinatal Project on births from 1960 to 1966 measured, among other things, the amount pregnant women smoked at each prenatal visit and how their children functioned in school at age 7. Compared to offspring of non-smokers, children of heavy smokers (more than two packs per day) were 1.7 times more likely to experience school failure by age 7 (see Figure 5). The impact of heavy smoking increases the earlier it occurs during pregnancy. Children of women who smoked heavily during the first trimester of pregnancy were more than twice as likely to fail than children whose mothers did not smoke during the first trimester. During the second and third trimesters, these risks dropped. In all of these analyses, it is difficult to disentangle the effects of smoke from the socioeconomic setting of the smoker. There is, however, a consistent pattern of association of smoking and learning impairment.

Figure 5

Relation of Maternal Cigarette Smoking During Pregnancy and Various Measures of "School Failure" and "Learning Disability" at Age 7



*"School Failure" = repeat grade or enrolled in special class.
**"Learning Disability" = normal intelligence (IQ > 90) and reading or spelling scores one year or more below grade level.

Source: Buka et al., 1990. Based on 40,000 pregnancies with infants followed to age 7 in the National Collaborative Perinatal Project.

3. Prenatal Alcohol Exposure

Around 40,000 babies per year are born with fetal-alcohol effect resulting from alcohol abuse during pregnancy (Fitzgerald, 1988). In 1984, an estimated 7,024 of these infants were diagnosed with fetal alcohol syndrome (FAS), a condition so severe that it results in major retardation and is therefore beyond the scope of this study The incidence of FAS is 2.2 per 1,000 births (Abel and Sokol, 1987 . The three main features of FAS in its extreme form are facial malformation, intrauterine growth retardation and dysfunctions of the central nervous system, including mental retardation.

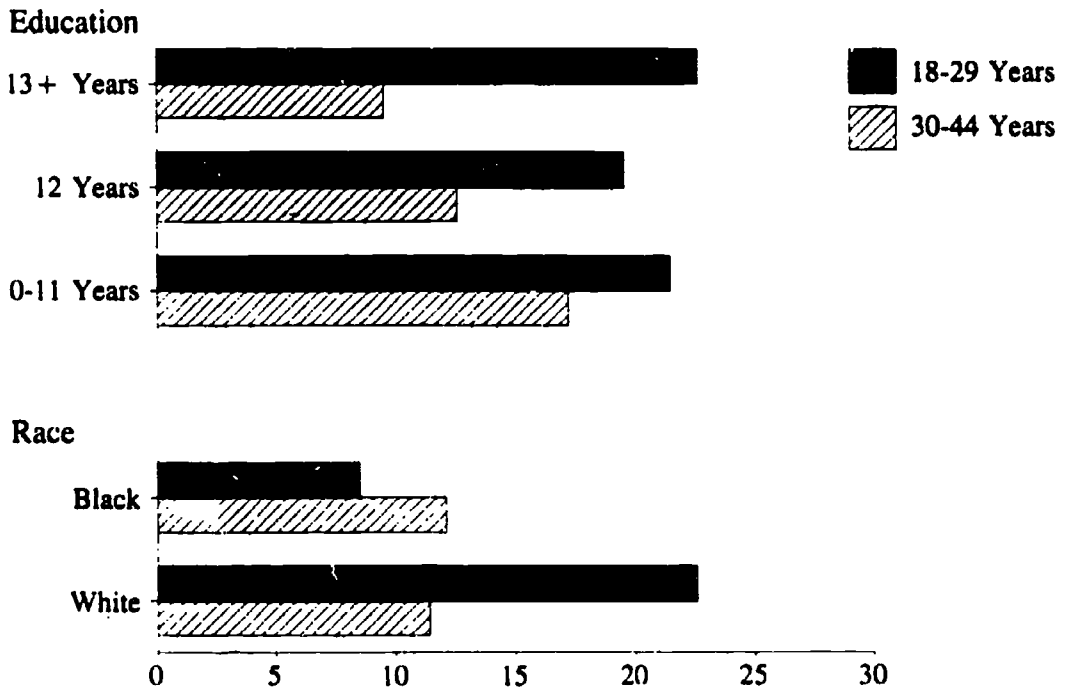
There are, in addition, about 33,000 children each year who suffer from less severe effects of alcohol. The more prominent among these learning impairments are problems in attention ("attention deficit disorders") and speech and language and hyperactivity. General school failure also is connected to a history of fetal alcohol exposure (Abel and Sokol, 1987; Ernhart et al., 1985). Figure 6 shows the drinking habits of women of child-bearing age by race and education.

Nearly one in four (23%) white women, 18-29, reported "binge" drinking (five drinks or more a day at least five times in the past year). This was nearly three times the rate for black women of that age (about 8%). Fewer women (around 3% for both black and white) reported steady alcohol use (two drinks or more per day in the past two weeks).

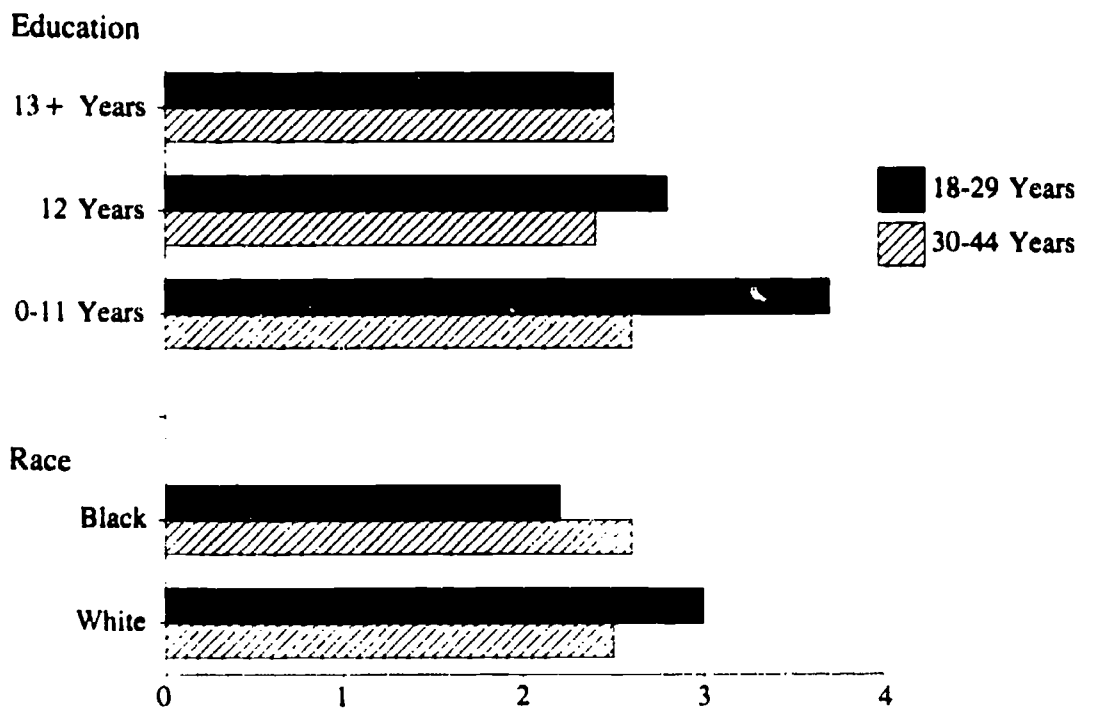
When consumed in pregnancy, alcohol easily crosses the placenta, but exactly how it affects the fetus is not well known. The effects of alcohol vary according to how far along in the pregnancy the drinking occurs. The first trimester of pregnancy is a period of brain growth and organ and limb formation. The embryo is most susceptible to alcohol from week two to week eight of development, a point at which a woman may not even know she is pregnant (Hovseth and Jones, 1989). Researchers have yet to determine how much alcohol it takes to cause problems in development and how alcohol affects each critical gestational period. It appears that the more alcohol consumed during pregnancy, the worse the effect. And many of the effects do not appear until ages 4 to 7, when children enter school.

Figure 6

Drinking Habits of Women Aged 18-44, by Age, Race and Education Level, 1985



Percent* of women who had consumed five drinks or more in one day at least five times in the past year



Percent* of women who had consumed an average of two drinks or more per day in the past two weeks

*Note different scales

Source: U.S. Department of Health and Human Services, 1988.

4. Fetal Drug Exposure

The abuse of drugs of all kinds — marijuana, cocaine, crack, heroin or amphetamines — by pregnant women affects about 11% of newborns every year, 425,000 in 1988 (Weston et al., 1989). Figure 7 indicates lifetime use of marijuana and cocaine of women ages 22-44 by ethnic group and educational level, as reported in a national study. As with alcohol use, white women and those with the most education reported the greatest use of cocaine — 16-19% used the drug at some time in their life. Marijuana use showed the same pattern, with 48% of white women reporting use during their lifetime. Drug use during the past month followed similar trends.

Cocaine and "crack" use during pregnancy are consistently associated with lower birthweight, lower gestational age and smaller head circumference in comparison with babies whose mothers were free of these drugs (Chasnoff et al., 1989; Cherukuri et al., 1988; Doberczak et al., 1987; Keith et al., 1989; Zuckerman et al., 1989). In a study of 1,226 women attending a prenatal clinic, 27% tested positive for marijuana and 18% for cocaine. Infants of those who had used marijuana weighed an average of 2.8 ounces (79 grams) less at birth and were half a centimeter shorter in length. Infants of mothers who had used cocaine averaged 3.3 ounces (93 grams) less in weight and .7 of a centimeter in length and also had a smaller head circumference than babies of non-users (Zuckerman et al., 1989). The study concluded that "marijuana use and cocaine use during pregnancy are each independently associated with impaired fetal growth" (Zuckerman et al., 1989).

Figure 7

Prevalence of Marijuana Use Among Women Aged 22-44 Years by Race and Education Level

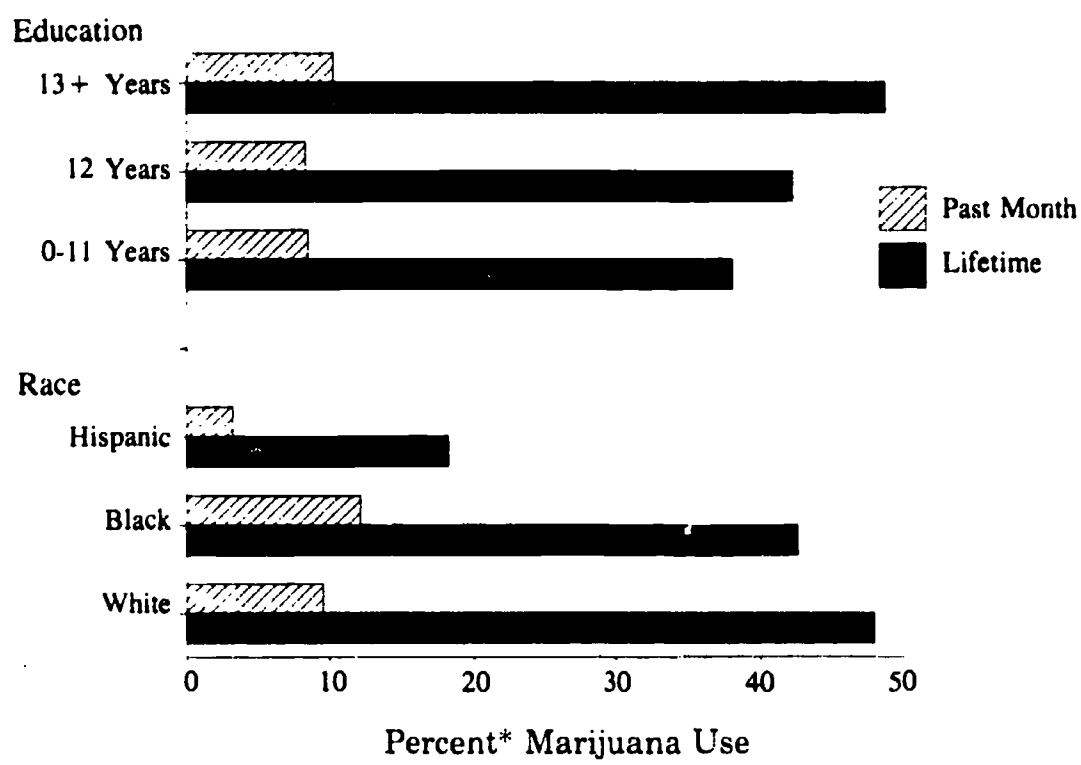
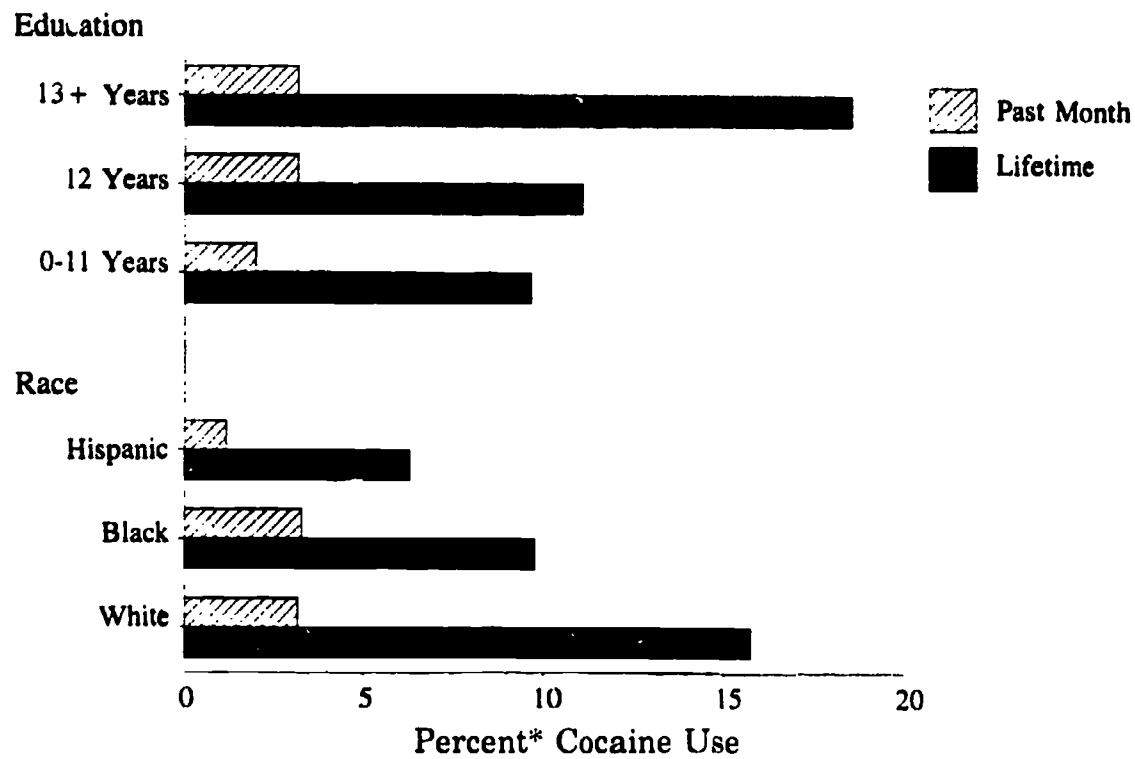


Figure 7 (Continued)

Prevalence of Cocaine Use Among Women Aged 22-44 Years by Race and Education Level



*Note different scales

Source: Adams, 1989. Based on 2,125 respondents to 1985 National Household Survey on Drug Abuse, National Institute on Drug Abuse.

In addition, women who use these substances are likely to smoke and to gain less weight during pregnancy, two factors associated with low birthweight. The cumulative effect of these risk factors is demonstrated by the finding that infants born to women who gained little weight, who had smoked one pack of cigarettes a day and who tested positive for marijuana and cocaine averaged nearly a pound (14.6 ounces or 416 grams) smaller than those born to women who had normal weight gain and did not use cigarettes, marijuana and cocaine (see Table 1). The effect of these substances on size is more than the sum of the risk factors combined.

Like alcohol use, drug use has different effects at different points in fetal development. Use in very early pregnancy is more likely to cause birth defects affecting organ formation and basic functions of the endocrine, metabolic and central nervous systems. Later use may result in preterm birth and intrauterine growth retardation (Kaye et al., 1989; MacGregor et al., 1987; Petitti and Coleman, 1990). While some symptoms may be immediately visible, others may not be apparent until later childhood (Weston et al., 1989; Gray and Yaffe, 1986; Frank et al., 1988).

Previously unrecognized effects of prenatal drug exposure appear in the areas of central nervous system and behavioral development.[3] In infancy, these include problems in such taken-for-granted functions as sleeping

and waking, resulting in exhaustion and poor development. In childhood, problems are found in vision, motor control and in social interaction (Weston et al., 1989). Such problems may be caused not only by fetal drug exposure but also by insufficient prenatal care for the mother or by an unstimulating or difficult home environment for the infant (Lifschitz et al., 1985). Early intervention is especially important in programs to enhance cognitive and social abilities of these children by placing them in a calm but stimulating day-care environment at an early age and in involving the mother when possible in the day-care program.

Table 1

Infant Weight Differences Associated with Substance Abuse

Substance Use During Pregnancy at One Prenatal Clinic:

N = 1,226
Marijuana (n = 330) (27%)
Cocaine (n = 221) (18%)

	Birthweight difference:
Marijuana users only vs. non-users	- 2.8 oz.
Cocaine users only vs. non-users	- 3.3 oz.
Combination users (marijuana, cocaine, one pack of cigarettes a day, low maternal weight gain) vs. non-users	- 14.6 oz.

Source: Zuckerman et al., 1989.

5. Lead Poisoning

Lead is the most pervasive pediatric environmental hazard in the United States (Bellinger et al., 1987).[4] It is of special concern because most U.S. communities contain the amount of lead found to cause poisoning (Bellinger, 1989), and it has been known for decades that lead is damaging to children.

Lead exposure comes from industrial contamination, leaded paint and gasoline, ceramics, household dust and soil, lead-soldered water pipes, water and tinned food. Lead does not degrade in the environment; but it becomes dust, making it easier to ingest, particularly for small children playing on floors or in yards. Fetal or early postnatal exposure

to lead is especially damaging when a child is at risk in other ways, such as being born at low birthweight or being socially disadvantaged. Children of all socioeconomic and geographic groups are at risk, though urban environments with pre-World War II housing and residence near major roads or industrial sites provide more sources of lead exposure than others.

The effect of lead in the body occurs at many different levels from cell to structure. Lead levels can be measured in several ways. Blood tests indicate the number of micrograms per deciliter of blood (µg/dl), the usual clinical measurement for individual children. Lead measured by analyzing dentin levels in baby teeth of a number of children is used to indicate lead is present in a particular environmental setting. Studies have shown consistently that the highest levels in children still occur in inner cities.[5]

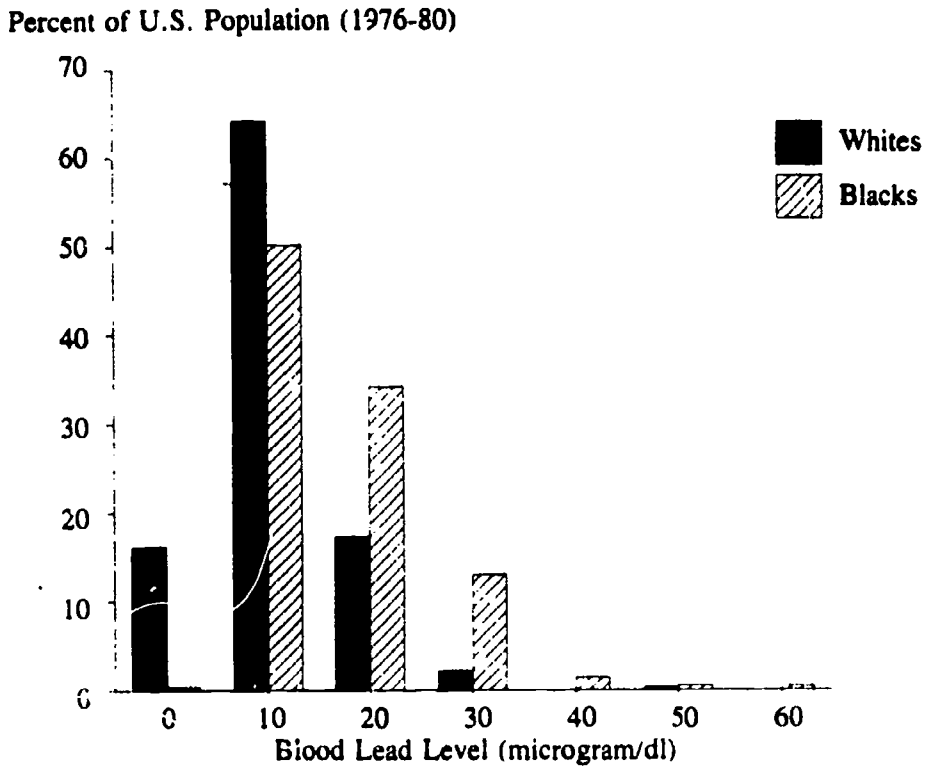
No amount of lead in the body other than zero is healthy, however, and researchers have found in the past few years that lead is damaging at much lower levels than previously thought. At a blood lead level above 40 µg/dl, injury may affect all body systems and require hospitalization (Mushak et al., 1989). The Agency for Toxic Substances and Disease Registry estimated that in 1984, more than 200,700 children 6 months to 5 years of age had blood lead levels above 25 µg/dl. About 2,380,600 (17% of school-age children) were above 15 µg/dl. Even at low blood levels of lead, various neurological processes are impaired, resulting in lowered abilities at school.

There seems to be no level of lead that does not damage a child's development. The most apparent damage occurs in the nervous system that is still developing to the age of 6. Even extremely low levels of lead can lead to lower intelligence, deficits in speech and auditory processing, attention and behavior disorders, increased distractability and day-dreaming, lack of persistence and organization and inability to follow directions (Needleman et al., 1979; Schroeder and Hawk, 1987). Even through age 18, early lead exposure has been associated with school failure and diminished cognitive functioning (Needleman et al., 1990).

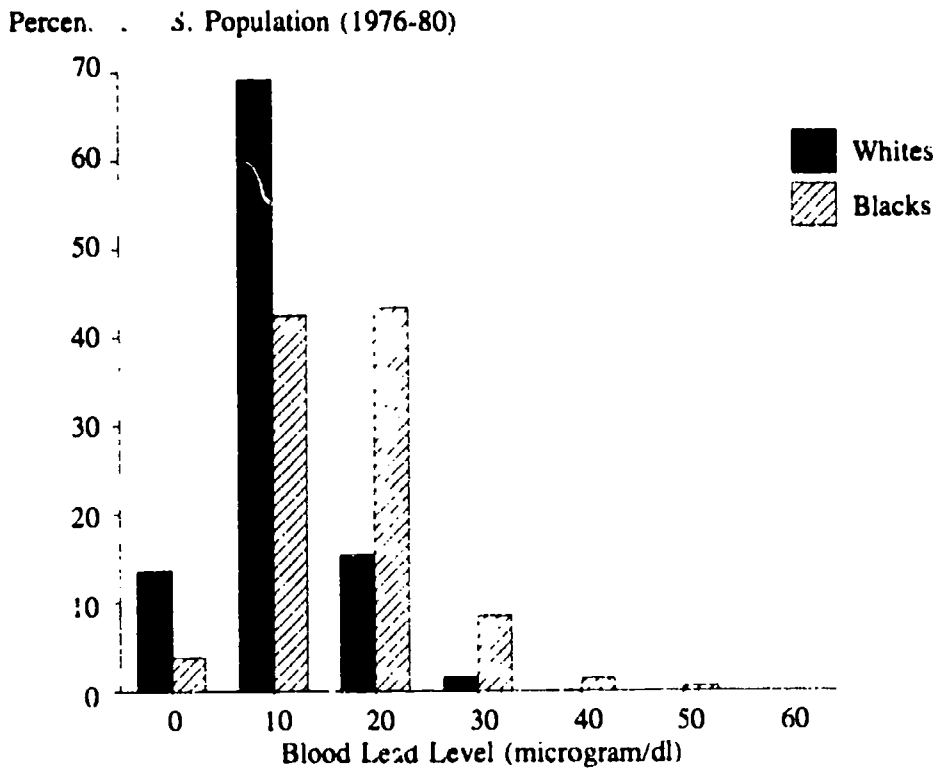
Figure 8 shows blood lead levels of children 6 months to 2 years and 3 to 5 years of age, indicating the early age at which children are exposed to this environmental hazard (Mahaffey et al., 1982). Figure 9 demonstrates differences in elevated lead levels between whites and blacks by family income and rural or urban residence. Figure 10 relates dentin lead levels to school performance, including reading level and dropping out of high school (Needleman et al., 1990). It demonstrates the striking increase in learning problems associated with early lead exposure.

Figure 8
Blood Lead Levels by Race and Age, 1976-80

Children, 6 months - 2 years



Children, 3-5 years

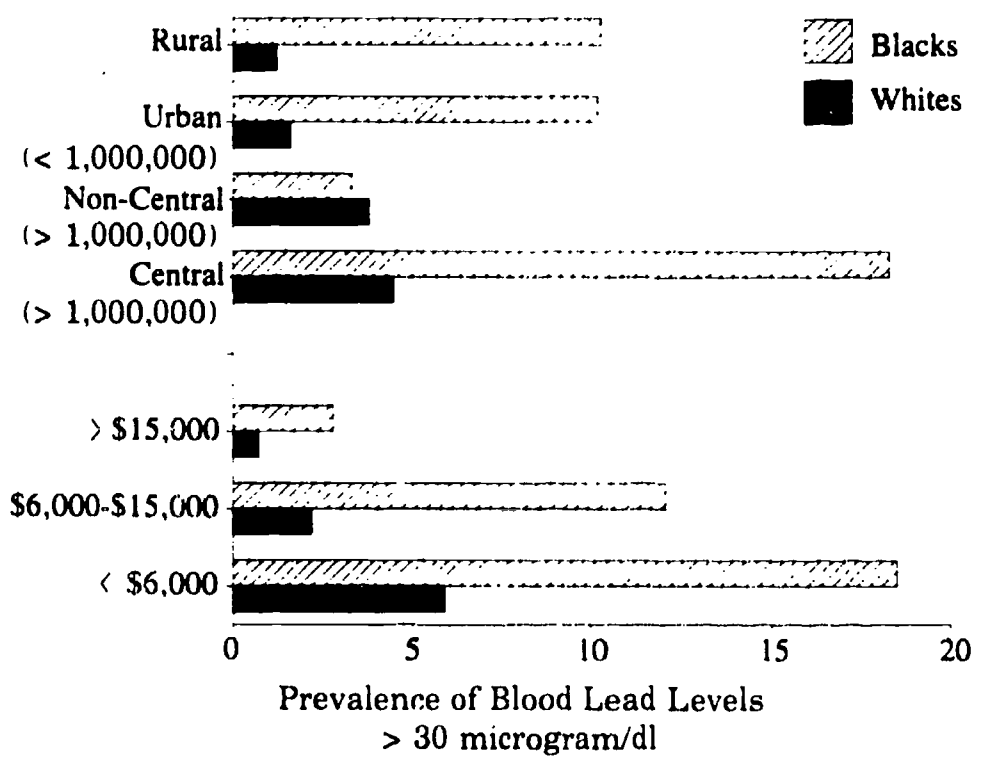


Source: Mahaffey et al., 1982.

Because lead poisoning has no signs and symptoms until the level becomes extremely high, resulting in hospitalization and extensive therapy. Therefore, primary prevention, such as eliminating additional lead in the environment, is required. Most states control leaded paint. Gasoline is increasingly regulated. Lead abatement programs, including soil and dust removal in high-risk areas, exist in a few states. The extent of the exposure indicates the need for a widespread abatement plan and for mandatory screening to determine each child's lead level and what environmental or therapeutic interventions are needed for those at greatest risk.

Figure 9

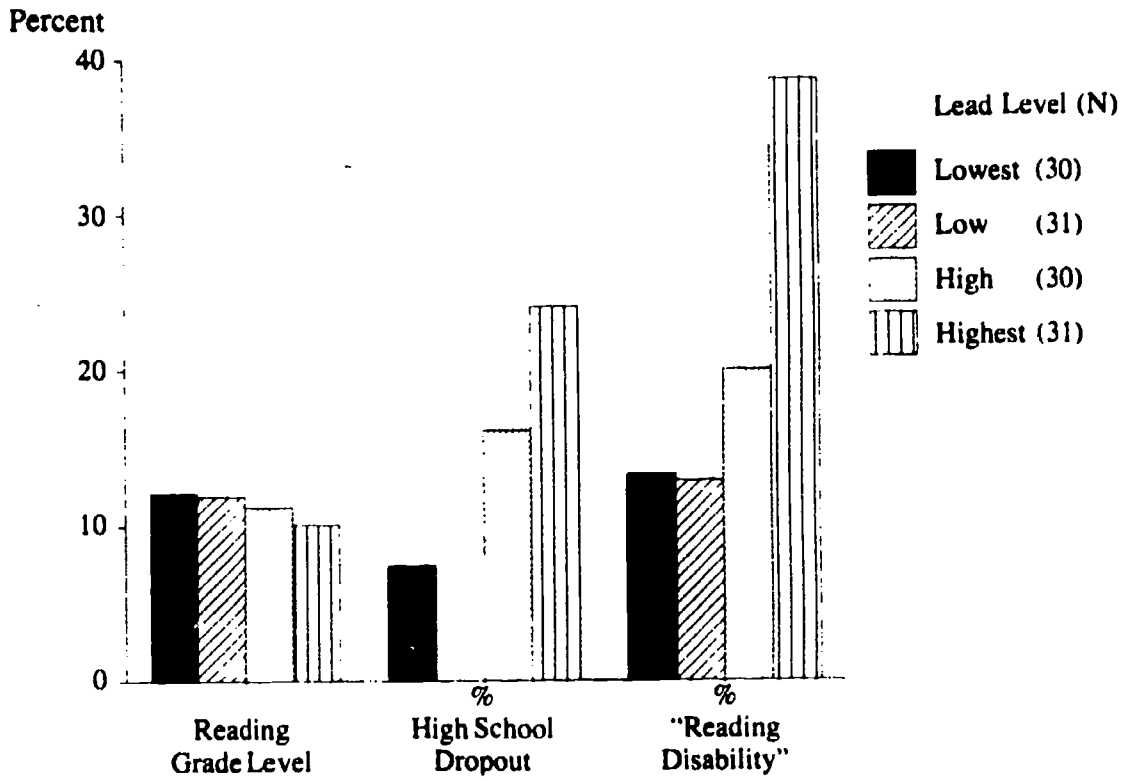
Blood Lead Levels in Children, 6 Months - 5 Years, by Annual Family Income and Place of Residence, 1976-80



Source: Mahaffey et al., 1982

Figure 10

Relation of Dentin Lead Levels to Various Academic Outcomes



Source: Needleman et al., 1990. Based on 132 children studied, ages 7-18.

6. Child Abuse and Neglect

In 1986, more than one million children were reported to have been physically, sexually or mentally abused or neglected, according to the Study of National Incidence of Child Abuse and Neglect.[6] Of these, about 580,400 (56%) were abused and about 498,000 neglected (48%). There was no significant difference between males and females in neglect, but females were sexually abused four times as often as males.

Families with at least four children were more at risk for child abuse and neglect, but neither race and ethnicity nor urban, suburban or rural residence had any significant impact on the incidence of maltreatment. Child abuse and neglect are found across all socioeconomic levels as well. However, high-income families may be underreported in these statistics because they are more likely to use private health care providers, who are less likely to report abuse or neglect.

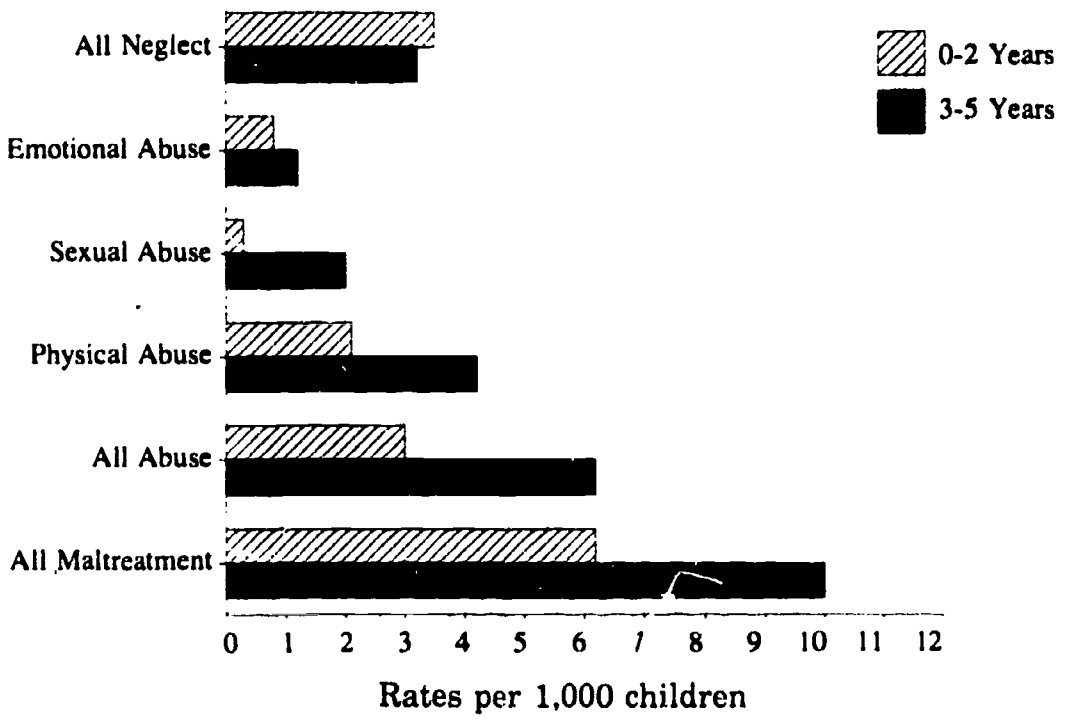
Because most (69%) of the abused and neglected children are under age 5, language impairment is one of the major consequences (Fox et al., 1988). Abuse or neglect at this age also results in behavioral, physiological and academic problems (Widom, 1989). Often, these children are aggressive and distractable and have poor self-control (Wolfe, 1987). Many suffer depression and low self-esteem, all of which can result in learning problems. In addition, limited stimulation from the parents may result in a delay of cognitive development. Abused or neglected children

have IQs that average 20 points below those of normally treated children (Wolfe, 1987).

Figure 11 indicates rates per 1,000 children of reported child abuse, neglect and total maltreatment for children less than 5 years of age.

Figure 11

Child Maltreatment Rates by Type of Maltreatment and Age, 1986



Source: U.S. Department of Health and Human Services, 1988.

Child abuse is often measured through intentional injuries in childhood (*MMWR*, 1986). One study looked at 14 Massachusetts communities with populations of 100,000 or less and found that intentional injuries made up 3.4% of all injuries in children (Guyer et al., 1989). They led to nearly one in 10 of the hospitalizations and 15.7% of injury-related deaths. Of the 736 cases studied, 30 children were found to have been hospitalized twice with intentional injuries. These data are cause for alarm because small cities are considered lower-risk populations than those in large inner-city areas where the incidence of injuries remains uncounted.

7. Malnutrition

Research on how malnutrition affects human functioning is limited by the complexity of the social circumstances within which it occurs. Malnutrition cannot be easily separated from other poverty conditions, for example. Fetal malnutrition affects 3-10% of babies as determined by birthweight, length and head circumference at birth (Metcoff et al., 1981). This results in large part from maternal cocaine use or smoking or lead exposure that constricts blood vessels in the placenta and

decreases nutrients reaching the fetus. In addition, lifestyle, including drugs, smoking and alcohol use, affects dietary intake and has a cumulative effect on birthweight (Hingson et al., 1981).

Certain effects of nutritional deprivation are reversible, but some are not. Damage caused by lack of nourishment during the 12th to 24th weeks of gestation, a time of critical brain growth, is not reversible. Once the time for a particular aspect of cell growth has passed, nothing can be done to regain it (Morgan, 1990).[7] Various aspects of mental function are different or deficient in children who did not receive adequate nourishment prenatally or immediately after birth (Dobbing, 1985; Galler, 1986). The apathy resulting from the lack of protein and calories makes it harder for them to learn and decreases their general curiosity and ability to be an active participant in school.[8]

There is a bright side to the consequences of early malnutrition, however. With proper nutrition, children can recover from many of the effects of earlier deprivation, except for brain damage during gestation (Winick, Meyer and Harris, 1975). In addition, a more stimulating environment can help children overcome learning deficits. While undernourished children often have a reduced head circumference indicating smaller brain size, they do not always show intellectual impairment (Winick, 1976). The combination of nutritional supplements, such as that of the federal Women, Infants and Children (WIC) program, and environmental enrichment, such as that provided in educational day-care programs, has been shown to counteract some effects of malnutrition.

PREVENTION

What can be done to prevent risks of learning limitation and to ameliorate the condition in children already affected?

Prevention of low birthweight lies mainly in *access for all women to early and informative prenatal care*. Basic components of this care include individual assessments early in pregnancy to determine risk, information on and promotion of healthy practices, medical treatment and follow-up and social support services such as home health visitors or involving the mother in group activities. The 1989 report of the Public Health Service Expert Panel on the Content of Prenatal Care recommends more focused care for high-risk women and reduced care for those less at risk who also have an intact family or network to support them.

The panel also emphasizes health care before pregnancy and between pregnancies so that every woman is as healthy as possible if she becomes pregnant. The idea of care before pregnancy reinforces the importance of school-age health education, both to emphasize the benefits of health promotion and to reduce behaviors that put young women, and thus their future babies, at risk (NASBE, 1990).

Efforts to help infants born too early or too small have demonstrated the success of intensive but developmentally stimulating infant day care with parent involvement. A University of California at Los Angeles project emphasized parent-infant involvement in the program which provided weekly meetings between staff and parents and infants over a period of four years. The result was that the low-birthweight babies were able to catch up in mental function to the control group of normal birthweight children (Rauh et al., 1988). The Infant Health and Development Project, which included pediatric follow-up and an educational curriculum with family support for one group of children, demonstrated that intensive efforts during the first three years of life can improve the cognitive and behavioral development of low birthweight infants. Scores for these children increased from 13 points for low-birthweight children to more than six points for children born at very low birthweights.

Yet another project targeted poor single teenage mothers whose infants were at high risk for intellectual impairment (Martin, Ramey and Ramey, 1990). One group of children was enrolled in educational day care from 6-12 weeks of age to 4 1/2 years for five days a week, 50 weeks a year. By 4 1/2 years of age, the children's IQ scores were in the normal range and 10 points higher than a control group. In addition, by the time their children were 4 1/2, mothers in the experimental group were more likely to have graduated from high school and be self-supporting than were mothers in the control group, the study noted.

These studies indicate that some disadvantages of poverty and low birthweight can be mitigated and intellectual impairment avoided. The key is *attention to the cognitive development of young children, in conjunction with social support of their families.* Programs that strengthen the family, enhance mother-infant interaction and provide early stimulation from birth to age 3 have dramatic effects, not only on the educational achievement of the child, but also on the self-esteem and capacity of the mother.

School health education toward a sound mind in a sound body also is imperative for young people. It assists them in their role as students and later as parents themselves. What a woman does during pregnancy has an impact on the resulting child. The message must go out to students that "it matters what you do."

Where To Start

The unexpected prevalence and severity of the factors cited call for new ways to address these problems. These include:

1. Eliminating the risk factors (for example, lead abatement, nutritional supplements)

2. Intensifying work with children already affected (as in educational day care) to help them develop learning skills despite their impairments

3. Restructuring schools to create active rather than passive learning so that all children's learning will be improved and so that these children in particular will benefit

Integration of these studies of risk factors for learning impairment has suggested some strategies for prevention. In summary, they include:

In education:

- Vigorous K-12 health education, including self-care, nutrition, substance abuse and sex education

- Reproductive health education integrated with self-esteem, decision making and accessible contraception to decrease sexual risk-taking and unwanted or unintended pregnancies

- Expansion of comprehensive community-based early childhood programs in compliance with the Education of the Handicapped Act Amendments of 1965 (P.L. 99-457, Part H.). This federal law supports programs to train parents, school staff and others to help handicapped children.

In pregnancy and at birth:

- Informative health care for all women before and between pregnancies, including preventive and contraceptive services
- Comprehensive and informative prenatal care for all pregnant women
- Prevention campaigns to address all substances affecting mothers and children — tobacco, alcohol and illicit drugs
- Accessible, effective programs for women using illicit drugs — cocaine, "crack," heroin, marijuana and others
- Enriched intensive early-childhood programs for infants affected by drugs, alcohol and abuse and their parents

In early childhood:

- Flexible family-centered early-childhood programs widely available in all communities
- Extension and strengthening of successful nutritional entitlement programs
- Comprehensive attention to the primary prevention of lead poisoning and the identification of all children with lead exposure

In society at large:

- Societal commitment to address the unmet health and development needs of young children and their parents[9]
- Societal commitment to rapidly diminish poverty and its special damages to children
- Lead testing and abatement in living environments

NOTES

1. Two national studies focus on the relation of preterm birth to learning impairment — the National Collaborative Perinatal Study carried out in 12 urban centers of children born from 1960-1966, and the National Health Interview Survey, 1981 Child Health Supplement, a representative sample of 10,522 4-to-17-year-olds Learning impairment has been indicated by children having repeated a grade in school or having been placed in special classes for particular learning disabilities. Children born at low birthweights (1500-2500 grams) have been consistently more at risk for these indicators than children of normal birthweight. Indeed, most at risk are those who were born at very low birthweights (under 1500 grams).

2. The range of IQ (Stanford-Binet, 4th edition) is as follows:

Very superior	132 and above
Superior	121-131
High average	111-120
Average	89-110
Low average	78-68
Slow learner	68*-78

*Below 70 is often designated as mentally retarded

The Bayley Scales of Infant Development are made up of indexes of mental and motor development. Most often used in the studies reported here is the Mental Development Index, or MDI, designed to evaluate "sensory-perceptual activities, discriminations and the ability to respond to these; the early acquisition of 'object constancy' and memory, learning and problem-solving ability; vocalizations and the beginnings of verbal communication; and early evidence of the ability to form generalizations and classification, which is the basis of abstract thinking" (Bayley, 1969:3). These scales are most often used for children ages 6-24 months.

3. Howard et al. (1989) compared 18-month-old drug-exposed children to non-drug-exposed toddlers. The effects are subtle, but the effects of drugs include sparse and disorganized play, less representational play, insecure attachment and problems of emotional development.

4. The most severe form of lead poisoning was noted early in the now classic picture of the small child eating paint chips. This exposure, at 80 µg/dl, was often lethal, but chelation therapy introduced in the 1970s was effective in reducing the death rate. Those who survived often suffered permanent neurological damage, including mental retardation, seizures and behavioral dysfunctions or vision or sensory-motor deficits (Marshall et al., 1989.)

5. There is no national ongoing data collection on lead. The NHANES II (1976-1980) was the first national survey. The Centers for Disease Control reported from 1972-1982 data from screening programs in high-risk areas, but discontinued in 1983. "The decrease in reporting programs occurred once lead funds were shifted to MCH block grants, which resulted in elimination of many programs and changed reporting from mandatory to voluntary" (Miller et al., 1986:67).

6. The Study of National Incidence of Child Abuse and Neglect (NIS-1) was conducted by the Children's Bureau of the Administration for Children, Youth and Families, U.S. Department of Health and Human Services, in 1980. Its questions were replicated in 1986 based on *demonstrable* child abuse (16.3/1000), about 1 million cases. The NIS-2, also in 1986, extended the definition to include children *at risk* of child abuse (25.2/1000), about 1.5 million cases. We have referenced the more conservative NIS-1 definition of countable cases. The known mortality for abuse and neglect in 1986 was 1,100 children. The incidence rate increased about 10% from 1980 to 1986. Fatalities represent 0.1% in both NIS-1 and NIS-2.

7. Cell division in the brain occurs until at least 6 weeks of age, but there are two critical periods — one peaks at 18-26 weeks of gestation at the highest point of neuron development; the second occurs around birth, at the high point of glial cell division (Dobbing and Sands, 1973). "In the human brain, the number of neurons is only reduced when undernutrition is imposed early in gestation, as rapid neuronal division is completed by about 26 weeks of gestation. If it is imposed late in gestation, only glial cell numbers are affected. A reduction in glial cells does not affect intelligence as much as loss of neurons" (Morgan 1990:270).

8. Certain forms of micronutrient deprivation can have particular behavioral effects on children. For example, vitamin A deficiency affects vision, and iron deficiency affects attentional processes, thus diminishing attention to environmental cues that help in problem-solving (Morgan 1990; Simopoulos, 1986).

9. Public concern was aroused in 1966 by a Selective Service System study that found more than 15% of 18-year-olds examined for military service were rejected because of health-related conditions including dental, eye and ear problems and emotional and developmental disorders. A Department of Health, Education and Welfare task force on maternal and child health estimated that 62% of these conditions could have been prevented or corrected by comprehensive and continuous health care, and that 33% could have been prevented or corrected through periodic screening and treatment.

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EDUCATION COMMISSION OF THE STATES

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EVERY CHILD A LEARNER:

REDUCING RISKS OF LEARNING IMPAIRMENT DURING PREGNANCY AND INFANCY

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"If we wait until children reach school, it's too late. We will have missed the opportunity to act and diminish the consequences of these preventable causes of learning impairment. We're forced to play a costly game of 'catch-up' and remediation which cannot be won."

— Stephen Buka, Epidemiologist and Instructor, Harvard Medical School/ Harvard School of Public Health

One of the national objectives identified in the Education Summit of 1989 was for every child to arrive at the schoolhouse door ready to learn. Yet new evidence indicates that by school age a troubling 12% of children — *more than 450,000 additional children each year* — suffer damage that prevents them from learning as well as their natural endowment would allow.

Additional children are so severely damaged that they experience severe mental retardation or even death, but they are not included in this study. This study synthesizes findings of major research studies on development of learning impairment in children from birth to age 5. It is the first project to compile data from many current sources to identify the major *preventable* conditions associated with the development of learning problems.

The Risk Factors

Those factors are: (1) low birthweight, (2) maternal smoking, (3) prenatal alcohol exposure, (4) prenatal exposure to drugs, (5) lead poisoning, (6) child abuse and neglect and (7) malnutrition.

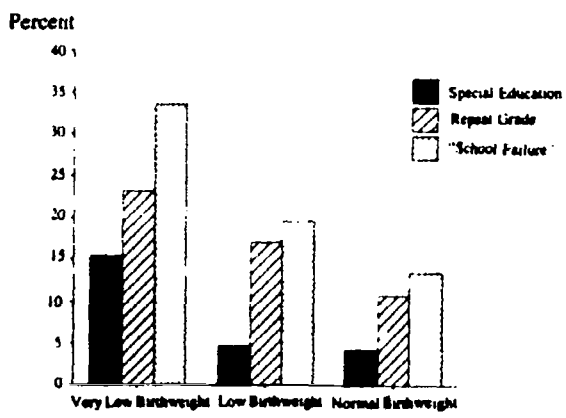
1. *Low Birthweight*

About 6.9% — 260,000 children each year — are born at below-normal weights, i.e., less than 5.5 pounds, and are at increased risk of school failure. Children born below 3.25 pounds are at particularly high risk for visual and auditory impairment and learning disorders, including impaired language skills requiring remedial instruction.

"There are a number of situations which, if corrected before conception, would have a major impact on the outcome of pregnancy."

— Bonnie Worthington-Roberts, Professor of Nutritional Sciences, University of Washington

Relation of Birthweight to Various Measures of "School Failure" among Children Ages 4-17



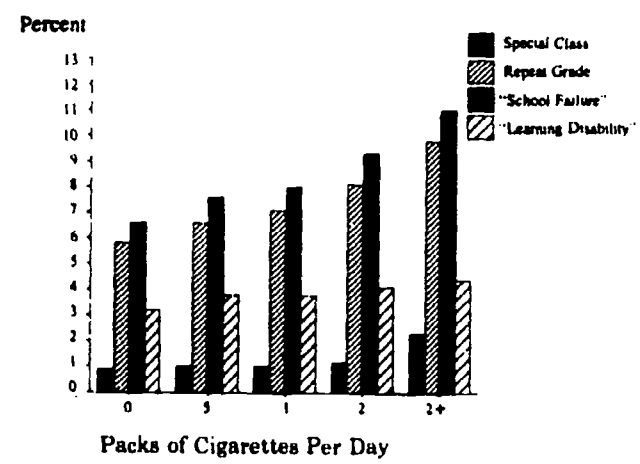
*"School Failure" = repeat grade or receiving special education services

They also are more likely to be inattentive, hyperactive, depressed, socially withdrawn or aggressive. A fairly large proportion have borderline IQ scores and intellectual disabilities that require special educational assistance when they enter school.

2. *Maternal Smoking*

Maternal smoking during pregnancy has long been known to be related to low birthweight, asthma, growth retardation before birth and long-term growth reduction, as well as an increased cancer risk in offspring. New studies show that children of smokers also are smaller in stature and lag behind other children in cognitive development and educational achievement. These children are particularly subject to hyperactivity and inattention. Maternal smoking also has been found to have a cumulative effect. Children of heavy smokers score lower on verbal tests than children of lighter smokers, who in turn score lower than children born to non-smokers.

Relation of Maternal Cigarette Smoking During Pregnancy and Various Measures of "School Failure" and "Learning Disability" at Age 7



3. *Fetal Alcohol Exposure*

Around 40,000 babies per year are born with fetal alcohol effects resulting from alcohol use during pregnancy. About 7,000 of these infants have fetal alcohol syndrome, a condition so severe that it results in major retardation. Another 33,000 children suffer from less severe effects of alcohol, including problems in attention

"What is disturbing and very concerning is the cumulative nature of many of these problems. The child who lives in a high lead area may have been born at a low birthweight because his mother was exposed to lead during pregnancy. If the family is poor, there may indeed have been other insults, also, such as malnutrition. These problems are not just additive. They are cumulative."

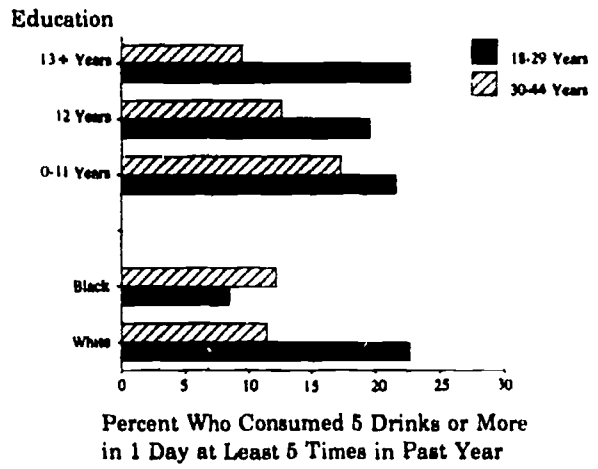
— Lucile Newman, Professor of Community Health and Anthropology, Brown University

"We've been using children the way that miners used canaries — when the canaries keeled over, the miners knew they were at risk of oxygen depletion. We've been using children as biological monitors of lead — we wait until a child gets sick to tell us where the lead is, then abate it. It's all backward."

— David Bellinger, Assistant Professor of Neurology, Harvard Medical School

("attention deficit disorders"), speech and language and hyperactivity. General school failure is often connected to a history of fetal alcohol exposure.

Drinking Habits of Women Ages 18-44, by Age, Race and Education Level, 1985

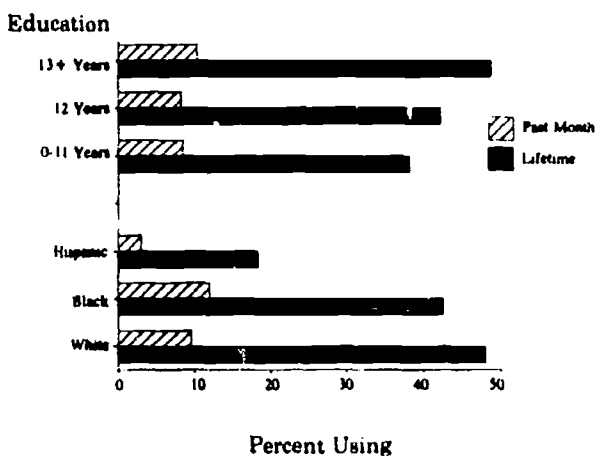


4. *Fetal Drug Exposure*

The abuse of drugs of all kinds — marijuana, cocaine, "crack," heroin or amphetamines — during pregnancy affects about 11% of newborns every year (425,000 in 1988). Cocaine and "crack" use during pregnancy are consistently associated with lower birthweight, lower gestational age and smaller head circumference in comparison with babies whose mothers were free of these drugs.

In addition, women who use these substances are likely to smoke and to gain less weight during pregnancy, both of which are associated with low birthweight.

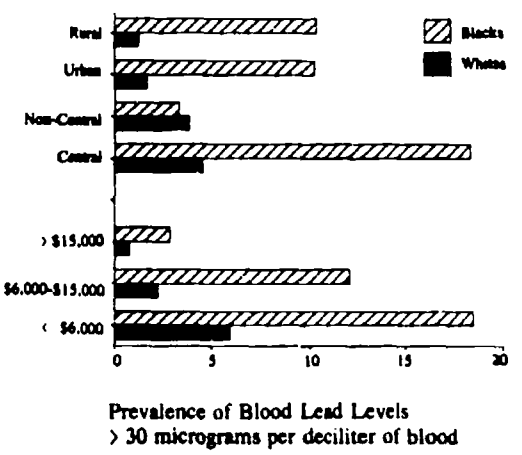
Prevalence of Marijuana Use Among Women Ages 22-44 Years, by Race and Education Level



5. *Lead Poisoning*

Lead is the most pervasive pediatric environmental hazard in the United States. It is of special concern because most communities contain the amount found to cause poisoning, and it has been known for decades that lead is damaging to children. Approximately 14 million children of all ages have been exposed to damaging levels of lead. The most apparent damage occurs in the nervous system that is still developing to the age of 6. Even extremely low levels of lead can lead to lower intelligence, deficits in speech and hearing, attention and behavior disorders, increased distractability and daydreaming, lack of persistence and organization and inability to follow directions.

Blood Lead Levels in Children, 6 Months to 5 Years, by Annual Family Income and Place of Residence, 1976-80



6. *Child Abuse and Neglect*

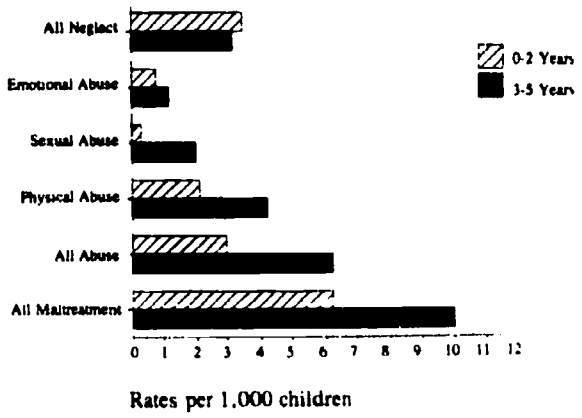
In 1986, more than one million children were reported to have been physically, sexually or mentally abused or neglected. Because most (69%) of the abused and neglected children are under age 5, language impairment is one of the major consequences. Abuse or neglect at this age also results in behavioral, physiological and academic problems. In addition, limited stimulation from the parents may result in a delay of cognitive development.

"For every dollar invested in the WIC program, $3 are saved in short-term hospital costs... For every dollar spent on immunization vaccines, $10 are saved in later medical costs... For every dollar invested in early childhood programs, combined with health and other social services, $5 are saved through lower costs for special education, public assistance and crime... "Quality child care decreases welfare payments and increases the safety of children."
— Debra Lipson, Children's Defense Fund

"Information on maternal risk factors [such as those] associated with economic insecurity, powerlessness and stressful conditions in the work place, home or neighborhood would be helpful. Barriers..., such as low literacy, lack of motivation related to pessimism about the future and fear of impersonal and degrading treatment by providers, need to be better documented. We should turn our scientific skills to the study of these questions and the timely translation of the conclusions into policy."
— P. Braveman (letter to the *New England Journal of Medicine*, Feb. 8, 1990, p. 406)

Abused or neglected children have IQs that average 20 points below those of normally treated children.

Child Maltreatment Rates by Type of Maltreatment and Age, 1986



7. *Malnutrition*

While malnutrition cannot be easily separated from other poverty conditions, studies show fetal malnutrition affects 3% to 10% of babies. Lifestyle, including drugs, smoking and alcohol use, affects the mother's dietary intake and has a cumulative effect on birthweight. In addition, maternal cocaine use, smoking or lead exposure constricts blood vessels in the placenta and decreases nutrients reaching the fetus. Certain effects of nutritional deprivation are reversible, and some are not. Damage caused by lack of nourishment during the 12th to 24th weeks of gestation, a time of critical brain growth, is not reversible.

Prevention

These data sound an alarm for state and federal policy makers in education, health and the environment. Health, environmental and poverty-based hazards are compromising many children's ability to learn. Social problems such as poverty, social disadvantage and parental disinterest are compounding the problems. Yet there is no coordinated effort under way nationally or in individual states to deal with these problems.

The unexpected prevalence and severity of the risk factors call for new ways to address these problems. These include:

1. Eliminating the causes (for example, lead abatement, nutritional supplements)
2. Intensifying work with children already affected (as in educational day care) to help them develop learning skills despite their impairments
3. Restructuring schools to create active rather than passive learning so that *all* children's learning will be improved and so that these children in particular will benefit

Integration of these studies of risk factors for learning impairment also suggests some strategies for prevention. They include:

- Vigorous K-12 health education; reproductive health education integrated with self-esteem, decision making and accessible contraception; and expansion of comprehensive community-based early childhood programs
- Informative health care for all women before, during and between pregnancies; campaigns to prevent use of all substances affecting mothers and children — tobacco, alcohol and illicit drugs; accessible, effective programs for women using illicit drugs; and enriched intensive early childhood programs for infants and parents affected by drugs, alcohol and abuse
- Flexible family-centered early childhood programs widely available in all communities; extension and strengthening of successful nutritional entitlement programs; lead testing and abatement to prevent poisoning; and identification of all children with lead exposure
- Societal commitment to address the unmet health, social and development needs of young children

For more information about the risk factors and their effects on learning, see the full report, *Every Child a Learner: Reducing Risks of Learning Impairment During Pregnancy and Infancy*, available from the Education Commission of the States, 707 17th Street, Suite 2700, Denver, Colorado 80202, for $5 (SI-90-90). The report also cites all the research studies used for this compilation by Lucile Newman and Stephen L. Buka.

SI-90-9S