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OUTCOMES IN YOUNG ADULTHOOD FOR VERY-LOW-BIRTH-WEIGHT INFANTS

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ABSTRACT

Background Very-low-birth-weight infants (those weighing less than 1500 g) born during the initial years of neonatal intensive care have now reached young adulthood.

Methods We compared a cohort of 242 survivors among very-low-birth-weight infants born between 1977 and 1979 (mean birth weight, 1179 g; mean gestational age at birth, 29.7 weeks) with 233 controls from the same population in Cleveland who had normal birth weights. We assessed the level of education, cognitive and academic achievement, and rates of chronic illness and risk-taking behavior at 20 years of age. Outcomes were adjusted for sex and sociodemographic status.

Results Fewer very-low-birth-weight young adults than normal-birth-weight young adults had graduated from high school (74 percent vs. 83 percent, $P=0.04$). Very-low-birth-weight men, but not women, were significantly less likely than normal-birth-weight controls to be enrolled in postsecondary study (30 percent vs. 53 percent, $P=0.002$). Very-low-birth-weight participants had a lower mean IQ (87 vs. 92) and lower academic achievement scores ($P<0.001$ for both comparisons). They had higher rates of neurosensory impairments (10 percent vs. <1 percent, $P<0.001$) and subnormal height (10 percent vs. 5 percent, $P=0.04$). The very-low-birth-weight group reported less alcohol and drug use and had lower rates of pregnancy than normal-birth-weight controls; these differences persisted when comparisons were restricted to the participants without neurosensory impairment.

Conclusions Educational disadvantage associated with very low birth weight persists into early adulthood. (N Engl J Med 2002;346:149-57.)

THE introduction of neonatal intensive care in the 1960s resulted in substantial improvements in outcomes for very-low-birth-weight infants (those weighing less than 1500 g). By the 1970s, 80 to 90 percent of survivors were reported to be free of serious handicaps.[1] However, at school age, very-low-birth-weight children have poorer cognitive function and academic performance than normal-birth-weight controls.[2-5] Learning problems at school persist into adolescence and are apparent even in children who have normal intelligence and no neurologic impairment.[6,7]

Before the era of neonatal intensive care, when few very-low-birth-weight infants survived, the majority of survivors were described as having average or above-average mental development.[8] A more recent report, however, indicated that fewer persons with birth weights of less than 1000 g than normal-birth-weight controls had graduated from high school.[9] Reports from Europe note that very-low-birth-weight young adults have similar levels of educational attainment[10,11] but more chronic illness and handicap[11-13] than members of the general population[10,12,13] or normal-birth-weight controls.[11]

We undertook a longitudinal study of very-low-birth-weight children born in 1977, 1978, or 1979, and we previously reported on outcomes at eight years of age.[2,14-17] The current report extends the follow-up to 20 years of age. We hypothesized that, as compared with normal-birth-weight controls, very-low-birth-weight young adults would have lower intelligence, lower levels of educational achievement, and

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higher rates of chronic health conditions and risk-taking behavior.

METHODS

Very-Low-Birth-Weight Group

A cohort of 490 very-low-birth-weight infants were admitted to Rainbow Babies and Children's Hospital in Cleveland between 1977 and 1979. A total of 316 children (64 percent) survived to their second year. One child died of a brain tumor between 2 and 8 years of age, and three died between 8 and 20 years of age — one from meningitis, one by drowning, and one from sequelae of severe spastic quadriplegia. Of the remaining 312 subjects, 70 were not studied: 58 could not be located, 5 lived out of state, 6 declined to participate, and 1 with severe spastic quadriplegia could not be interviewed. The study population thus included 242 very-low-birth-weight participants; this population represented 78 percent of the surviving birth cohort and included 232 (91 percent) of the 256 members of the cohort who had participated at eight years of age and an additional 10 who had not participated at eight years of age. One parent of each of 227 of the study participants (94 percent) was also interviewed. The mother was the parent interviewed in 91 percent of the cases.

The 242 very-low-birth-weight participants had a mean birth weight of 1179 g and had been born at a mean gestational age of 29.7 weeks; 110 (45 percent) had been born at the adjacent perinatal center of MacDonald Hospital for Women. Fifty-eight (24 percent) had a birth weight of less than 1000 g. Neonatal problems had included respiratory distress syndrome in 181 infants (75 percent), apnea of prematurity in 123 (51 percent), sepsis in 34 (14 percent), and necrotizing enterocolitis in 9 (4 percent). Assisted ventilation had been provided to 107 of the infants (44 percent). There were no major congenital malformations or congenital infections. The cohort was born before the advent of cerebral ultrasonography; thus, the rates of periventricular hemorrhage and leukomalacia are unknown. At the time of their birth, the mean age of their mothers was 24 years. A total of 158 of the mothers (65 percent) were married, and 59 (24 percent) had less than a high-school education.

The very-low-birth-weight young adults who participated in the study did not differ significantly from those who had been lost to follow-up since birth in terms of the sociodemographic characteristics of their mothers at the time of their birth: 35 percent of the mothers of participants were unmarried, as compared with 39 percent of the mothers of those lost to follow-up; 55 percent of the mothers were black, as compared with 46 percent among those lost to follow-up; and 24 percent had less than a high-school education, as compared with 33 percent among those lost to follow-up. More of those who participated at 20 years of age than of those who were lost to follow-up had been born at the perinatal center (46 percent vs. 31 percent, $P=0.03$). However, the mean birth weight (1179 g vs. 1187 g), the mean gestational age at birth (29.7 weeks vs. 29.8 weeks), and the incidence of neonatal problems (including respiratory distress syndrome requiring ventilator therapy, sepsis, and necrotizing enterocolitis) did not differ between the groups. The mean IQ at 8 years of age was 95 ± 18 among those who participated at 20 years of age and 91 ± 21 among those who were subsequently lost to follow-up ($P=0.27$).

Control Group

The original control group included 366 normal-birth-weight children born at term in 1977, 1978, or 1979, who were selected by means of a population-sampling procedure when they were eight years of age.[2] Three of the controls died between 8 and 20 years of age — one from a gunshot wound, one from a stab wound, and one by suicide. Of the remaining 363 controls, 130 were not studied at 20 years of age: 91 could not be located, 1 lived out of state, and 38 declined to participate. The control population thus included 233 participants — 64 percent of the cohort that had been recruited at eight years of age. One parent of each of 218 of the controls (94 percent) was also interviewed; in 95 percent of cases, the parent interviewed was the mother.

The normal-birth-weight controls who participated at 20 years of age had had a significantly higher mean IQ score on the Wechsler Intelligence Scale for Children–Revised (WISC-R) at 8 years of age than those who did not participate (104 ± 17 vs. 93 ± 14). Fewer mothers of the controls who participated at 20 years of age than mothers of those who did not participate were unmarried when the child was 8 years old (36 percent vs. 61 percent), fewer had less than a high-school education (11 percent vs. 27 percent), and fewer were black (55 percent vs. 76 percent; $P<0.001$ for all comparisons).

Measures at 20 Years of Age

All subjects provided written informed consent to participate in the study. Information concerning educational attainment, current enrollment in an educational program, and other activities was obtained from the young adults by means of interviews. High-school graduation was confirmed by means of school records. Intelligence was assessed with the Short Form of the Wechsler Adult Intelligence Scale–Revised (WAIS-R); we used the Vocabulary and Block Design subtests, which measure verbal comprehension and perceptual-organization skills, respectively.[18,19] Academic skills were assessed with the Letter–Word Identification and Applied Problems subtests of the Tests of Achievement from the Woodcock–Johnson Psycho-Educational Battery–Revised.[20] Health status was ascertained from the participants by means of questions concerning chronic medical, neurologic, or psychiatric conditions that had lasted 12 months or longer, as well as detailed questions concerning pregnancy and childbirth.[21,22] Height was measured with a Harpenden stadiometer. The extent of engagement in risk-taking behavior during the previous 12 months was ascertained by means of self-administered questionnaires — a substance-abuse checklist and a Sexual Experience Scale[23,24] — with additional questions concerning contact with the police. The subjects were asked whether they had ever been in jail, including for several hours or overnight or in juvenile detention, and whether they had been convicted of a crime, including driving under the influence of alcohol. The parents completed questionnaires regarding the young adults' health[21] and their knowledge about substance use by the participants.[23]

Statistical Analysis

Univariate comparisons between the very-low-birth-weight and normal-birth-weight groups were made with the use of Student's t-test for continuous variables and with the chi-square test or Fisher's exact test for discrete variables. Logistic regression was used for dichotomous outcomes, and multiple linear regression was used for continuous outcomes. Because of the effects of sociodemographic factors on outcomes, we controlled for sociodemographic status in the analyses.[2,4,6] Because of differences in behavior between the sexes, we performed separate analyses for each sex, comparing the groups after adjusting for sociodemographic status. We also compared the groups using pooled data from participants of both sexes with adjustment for sex and sociodemographic status. If the interaction between birth-weight groups and sex was found to be significant, indicating that the effect on the outcome differed between male participants and female participants, then the adjusted difference from the pooled analysis was not presented. A composite score representing the mother's sociodemographic status, which we used previously,[2] was calculated by assigning one point for each of the following factors: unmarried status, black race, and less than a high-school education.[2] The composite score ranged from zero to three. We used the mother's marital and educational status at the time the child was eight years old, since it was considered more relevant than her later status to the period of child de-

velopment that is critical for educational attainment. This composite had a stronger correlation with the IQ at 8 years of age[2] and at 20 years of age than did any of its components analyzed separately. In separate sets of analyses, we compared the subgroups of very-low-birth-weight and normal-birth-weight participants who did not have neurosensory impairment, subnormal IQ, or chronic conditions.

RESULTS

Sociodemographic Status and Chronic Health Conditions

The very-low-birth-weight and normal-birth-weight groups did not differ significantly with regard to maternal marital status at eight years of follow-up or maternal race. The level of maternal education was lower in the very-low-birth-weight group, but the composite index of sociodemographic status did not differ significantly between groups (Table 1). Six of the very-low-birth-weight young adults and one of the normal-birth-weight young adults were married.

Very-low-birth-weight participants had significantly higher rates of chronic conditions than the controls (33 percent vs. 21 percent, P=0.002). The difference was primarily attributable to higher rates of neurosensory impairment and subnormal height[25] (Table 2). A total of 23 percent of the very-low-birth-weight participants had one chronic condition, 9 percent had two chronic conditions, and 1 percent had three or more chronic conditions. In comparison, 17 percent of the controls had one chronic condition, and 4 percent had two chronic conditions (P=0.005).

Educational Attainment and Current Enrollment in an Educational Program

Fewer very-low-birth-weight participants than normal-birth-weight participants had graduated from high school or obtained a general equivalency diploma by 20 years of age (74 percent vs. 83 percent, P=0.04) (Table 3). Forty percent of the very-low-birth-weight participants had repeated a grade in school, as compared with 27 percent of the normal-birth-weight participants (P=0.003). Very-low-birth-weight participants who graduated from high school did so at a mean age of 18.2±0.6 years, as compared with 17.9±0.6 years among the controls (P<0.001). Fewer very-low-birth-weight men were enrolled in postsecondary studies, of whom only 16 percent were in a four-year college program, as compared with 44 percent in the control group (P<0.001).

The differences in grade repetition, educational attainment, and current enrollment in educational programs remained significant when the comparisons were restricted to participants without neurosensory impairment or subnormal IQ (<70).

Intelligence and Academic Achievement

Very-low-birth-weight participants had significantly lower mean IQ scores than the controls (87 vs. 92, P<0.001) and had lower scores on the subtests of academic achievement (Table 4).[20] They also had a higher frequency of subnormal IQ (<70) and borderline IQ (70 to 84). Fifty-one percent of the very-low-birth-weight participants had an IQ in the normal range (≥85), as compared with 67 percent of the controls (P<0.001). These differences remained significant when the comparisons were restricted to the participants without neurosensory impairment. There was a significant interaction of birth weight and sex in the scores on the Applied Problems subtest of the Woodcock–Johnson Psycho-Educational Battery–Revised, with a greater difference between groups for male participants than for female participants.

TABLE 1. MATERNAL SOCIODEMOGRAPHIC STATUS AT EIGHT YEARS OF FOLLOW-UP AND BIRTH DATA FOR VERY-LOW-BIRTH-WEIGHT AND NORMAL-BIRTH-WEIGHT PARTICIPANTS.*

VARIABLE	VERY LOW BIRTH WEIGHT (N=242)	NORMAL BIRTH WEIGHT (N=233)
Maternal characteristics — no. (%)		
Unmarried	100 (41)	84 (36)
Black race	133 (55)	128 (55)
Education†		
<High-school graduation	40 (17)	25 (11)
High-school graduation	133 (55)	118 (51)
>High-school graduation	69 (29)	90 (39)
Composite sociodemographic score‡		
0	79 (33)	90 (39)
1	73 (30)	66 (28)
2	71 (29)	60 (26)
3	19 (8)	17 (7)
Birth data		
Weight — g	1179±219	3279±584
Gestational age — wk	29.7±2	≥37§
Female sex — no. (%)	126 (52)	125 (54)
Multiple birth — no. (%)¶	32 (13)	4 (2)

*Plus–minus values are means ±SD. The maternal status at the time the participant was eight years old is given. Maternal characteristics refer to participant's primary caretaker, who was an adoptive mother in five instances in the very-low-birth-weight group and three instances in the control group, a foster mother in one instance in the very-low-birth-weight group, and a grandparent in three instances in the very-low-birth-weight group.

†P=0.03 for the comparison between groups.

‡In the calculation of this composite score, one point was assigned for each of the following factors: unmarried status, black race, and less than a high-school education.

§Specific information on gestational age was not available for the control group.

¶Data are for participants with a living twin or, in one case, two living triplets.

Substance Use, Contact with Police, and Sexual Activity

The rates of smoking did not differ significantly between the groups, but the very-low-birth-weight participants reported significantly lower rates of alcohol

TABLE 2. CHRONIC CONDITIONS AT 20 YEARS OF AGE AMONG VERY-LOW-BIRTH-WEIGHT AND NORMAL-BIRTH-WEIGHT PARTICIPANTS.*

VARIABLE	MEN		WOMEN	
	VERY LOW BIRTH WEIGHT (N=116)	NORMAL BIRTH WEIGHT (N=108)	VERY LOW BIRTH WEIGHT (N=126)	NORMAL BIRTH WEIGHT (N=125)
	no. of participants (%)			
Neurosensory condition	11 (9)	1 (1)†	14 (11)	0‡
Cerebral palsy§	6 (5)	0	9 (7)	0
Hydrocephalus necessitating the placement of a shunt	1 (1)	0	4 (3)	0
Blindness¶	3 (3)	0	1 (1)	0
Deafness‖	1 (1)	1 (1)	2 (2)	0
Medical or psychiatric illness	22 (19)	17 (16)	29 (23)	20 (16)
Asthma**	8 (7)	6 (6)	11 (9)	7 (6)
Diabetes	0	0	1 (1)	1 (1)
Sickle cell anemia	0	1 (1)	1 (1)	1 (1)
Epilepsy	1 (1)	1 (1)	3 (2)	0
Arthritis	3 (3)	2 (2)	10 (8)	6 (5)
Bone or muscle disorder	10 (9)	7 (6)	5 (4)	7 (6)
Bipolar disorder	3 (3)	2 (2)	2 (2)	0
Other††	0	0	1 (1)	2 (2)
Height <3rd percentile‡‡	9 (8)	5 (5)	14 (11)	6 (5)
Total with at least one condition	36 (31)	23 (21)	45 (36)	25 (20)§§

*Chronic conditions were defined as those with a duration of 12 months or more. Data for the general categories of neurosensory condition and medical or psychiatric illness are the numbers and percentages of participants with at least one condition in that category.

†P=0.004 for the comparison with the men in the very-low-birth-weight group.

‡P=0.005 for the comparison with the women in the very-low-birth-weight group.

§Nine of the participants had spastic diplegia, two had spastic hemiplegia, and four had spastic quadriplegia.

¶One participant had bilateral blindness, and three had unilateral blindness.

‖Data are for participants who required a hearing aid.

**Data are for participants who had had an asthma attack in the previous 12 months, were taking asthma medication, or both.

††One participant in the very-low-birth-weight group had hypertension due to Liddle's syndrome (pseudoaldosteronism); one participant in the control group had endometriosis, and one had narcolepsy.

‡‡Height percentiles from the Centers for Disease Control and Prevention growth charts[25] were used. The analysis includes 11 participants who were not measured but reported their own height.

§§P=0.006 for the comparison with the women in the very-low-birth-weight group.

and marijuana use than the controls — differences primarily attributable to differences among the women (Table 5). These differences remained significant when the comparisons were restricted to participants without neurosensory impairment, subnormal IQ, or chronic conditions. Parents also reported significantly lower rates of alcohol use for very-low-birth-weight participants but similar rates of smoking, marijuana use, and other illicit drug use (data not shown).

Fewer very-low-birth-weight men than male controls had ever had contact with the police — a difference that was primarily attributable to less contact related to truancy (5 percent vs. 14 percent, P=0.03) and less contact related to drug or alcohol use (13 percent vs. 29 percent, P=0.006). Fewer very-low-birth-weight women than female controls reported ever having intercourse, being pregnant, or delivering a live-born infant (Table 5). The differences between the groups in the rates of substance abuse, contact with the police, and pregnancy remained significant when the comparisons were restricted to participants without neurosensory impairment or subnormal IQ. There were no significant differences between the very-low-birth-weight group and the normal-birth-weight group in the rates of conviction for a crime or incarceration in jail or juvenile detention.

DISCUSSION

Fewer very-low-birth-weight participants than normal-birth-weight participants had graduated from high

TABLE 3. LEVEL OF EDUCATION AT 20 YEARS OF AGE AMONG VERY-LOW-BIRTH-WEIGHT AND NORMAL-BIRTH-WEIGHT PARTICIPANTS.*

VARIABLE	MEN			WOMEN			TOTAL POPULATION
	VERY LOW BIRTH WEIGHT (N=116)	NORMAL BIRTH WEIGHT (N=108)	ODDS RATIO (95% CI)	VERY LOW BIRTH WEIGHT (N=126)	NORMAL BIRTH WEIGHT (N=125)	ODDS RATIO (95% CI)	ODDS RATIO (95% CI)
	no. (%)			no. (%)			
High-school graduation†	77 (66)	81 (75)	0.7 (0.4–1.3)	102 (81)	112 (90)	0.5 (0.2–1.1)	0.6 (0.4–1.0)‡
Current study							
None	70 (60)	44 (41)	2.1 (1.2–3.7)§	56 (44)	53 (42)	1.1 (0.6–1.8)	1.5 (1.0–2.1)‡
High school or GED¶	11 (9)	8 (7)	1.2 (0.5–3.2)	6 (5)	4 (3)	1.4 (0.4–5.3)	1.3 (0.6–2.8)
Postsecondary study‖	35 (30)	57 (53)	0.4 (0.2–0.7)**	64 (51)	68 (54)	0.9 (0.5–1.5)	
Community college††	17 (15)	9 (8)	1.9 (0.8–4.5)	22 (17)	21 (17)	1.0 (0.5–2.0)	1.3 (0.8–2.2)
Four-year college‡‡	18 (16)	47 (44)	0.2 (0.1–0.4)§§	42 (33)	47 (38)	0.8 (0.5–1.5)	

*The odds ratios for men and for women were adjusted for sociodemographic status; the odds ratios for the total population were adjusted for sociodemographic status and sex. CI denotes confidence interval, and GED general equivalency diploma.

†Data include 12 participants in the very-low-birth-weight group and 17 controls who had obtained a GED.

‡P=0.04 for the comparison between groups.

§P=0.007 for the comparison between groups.

¶Twelve very-low-birth-weight participants and seven controls were in high school, and five very-low-birth-weight participants and five controls were in a GED program.

‖P=0.04 for the interaction between birth weight and sex. Because this interaction was significant, the adjusted difference from the pooled analysis is not presented.

**P=0.002 for the comparison between groups.

††Data include 2 very-low-birth-weight participants and 4 controls who were in business school and 15 very-low-birth-weight participants and 7 controls who were in technical school.

‡‡P=0.004 for the interaction between birth weight and sex. Because this interaction was significant, the adjusted difference from the pooled analysis is not presented.

§§P<0.001 for the comparison between groups.

school or obtained an equivalency diploma by 20 years of age. Very-low-birth-weight participants were less likely to be enrolled in a postsecondary educational program — a difference primarily attributable to the difference between the men in the two groups. The very-low-birth-weight participants had a higher incidence of chronic medical conditions, mainly because of higher rates of neurosensory impairment and subnormal height. Contrary to our expectations, the very-low-birth-weight group reported less risk-taking behavior than the control group, including less use of alcohol and illicit substances. Fewer very-low-birth-weight men than control men had ever had contact with the police, and fewer very-low-birth-weight women than control women had ever had intercourse, been pregnant, or had a baby.

Data have been lacking on the follow-up into adulthood of very-low-birth-weight survivors of neonatal intensive care in the United States. The very-low-birth-weight participants in our study had been treated in an urban perinatal center, and our study population thus included more persons of lower socioeconomic status and minority race or ethnic group than the United States as a whole. The rates of chronic illness in our normal-birth-weight control population are similar to those reported for young adults nationally,[21] and their rates of substance abuse, contact with the police, and childbirth are in keeping with data from similar urban populations.[26-30]

We followed 78 percent of the birth cohort of very-low-birth-weight subjects to 20 years of age, but only 64 percent of the normal-birth-weight subjects enrolled at 8 years of age remained in the study until they were 20 years old. The loss of very-low-birth-weight subjects occurred mainly between birth and eight years of age. Those who were followed to 20 years of age were similar to the original birth cohort in terms of birth weight, gestational age at birth, and neonatal morbidity, although their mothers tended to have a higher level of education. The very-low-birth-weight and normal-birth-weight groups were similar in terms of maternal sociodemographic charac-

TABLE 4. COGNITIVE TEST RESULTS AT 20 YEARS OF AGE AMONG VERY-LOW-BIRTH-WEIGHT AND NORMAL-BIRTH-WEIGHT PARTICIPANTS.*

VARIABLE	MEN				WOMEN				TOTAL POPULATION	
	VERY LOW BIRTH WEIGHT (N=113)	NORMAL BIRTH WEIGHT (N=106)	ODDS RATIO (95% CI)	P VALUE	VERY LOW BIRTH WEIGHT (N=123)	NORMAL BIRTH WEIGHT (N=125)	ODDS RATIO (95% CI)	P VALUE	ODDS RATIO (95% CI)	P VALUE
	no. (%)				no. (%)					
IQ range										
<70	9 (8)	2 (2)	4.6 (0.9 to 22.6)		7 (6)	2 (2)	3.6 (0.7 to 18.0)		4.0 (1.3 to 12.2)	0.02
70–84	44 (39)	23 (22)	2.3 (1.2 to 4.3)	0.01	56 (46)	49 (39)	1.3 (0.8 to 2.2)		1.7 (1.1 to 2.5)	0.02
≥85	60 (53)	81 (76)	0.3 (0.2 to 0.6)	0.001	60 (49)	74 (59)	0.6 (0.4 to 1.1)		0.5 (0.3 to 0.7)	<0.001
	VERY LOW BIRTH WEIGHT	NORMAL BIRTH WEIGHT	DIFFERENCE (95% CI)		VERY LOW BIRTH WEIGHT	NORMAL BIRTH WEIGHT	DIFFERENCE (95% CI)		DIFFERENCE (95% CI)	
IQ score	87.6±15.1	94.7±14.9	−5.9 (−9.2 to −2.6)	0.001	86.2±13.4	89.8±14.0	−3.4 (−6.5 to −0.4)	0.03	−4.6 (−6.9 to −2.4)	<0.001
Academic achievement scores										
Letter–Word Identification	94.4±19.8	103.2±20.2	−7.6 (−12.4 to −2.9)	0.002	97.1±19.2	102.3±21.7	−5.0 (−9.7 to −0.2)	0.04	−6.3 (−9.6 to −2.9)	<0.001
Applied Problems†	89.0±14.2	98.4±16.8	−8.0 (−11.6 to −4.5)	<0.001	89.0±12.3	92.4±12.4	−3.1 (−6.0 to −0.3)	0.03		

*The IQ was measured by the Short Form of the Wechsler Adult Intelligence Scale–Revised,[18] which includes the Vocabulary and Block Design subscales.[18,19] The standard score has a mean of 100 and a standard deviation of 15. Academic achievement was assessed by the Tests of Achievement from the Woodstock–Johnson Psycho-Educational Battery–Revised.[20] The standard score has a mean of 100 and a standard deviation of 15. Scores on the Letter–Word Identification subtest were available for 235 very-low-birth-weight participants and 228 controls; scores on the Applied Problems subtest were available for 238 very-low-birth-weight participants and 230 controls. Plus–minus values are means ±SD. The values shown are unadjusted. The odds ratios for men and for women were adjusted for sociodemographic status; the odds ratios for the total population were adjusted for sociodemographic status and sex. The differences in score between groups were calculated by first adjusting the mean values among men and among women for sociodemographic status and adjusting the mean values in the total population for sociodemographic status and sex and then subtracting the adjusted mean value for normal-birth-weight participants from the adjusted mean value for very-low-birth-weight participants. CI denotes confidence interval.

†P=0.02 for the interaction between birth weight and sex. Because this interaction was significant, the adjusted difference from the pooled analysis is not presented.

TABLE 5. SELF-REPORTED SUBSTANCE USE, CRIMINAL ACTIVITY, AND SEXUAL ACTIVITY AT 20 YEARS OF AGE AMONG VERY-LOW-BIRTH-WEIGHT AND NORMAL-BIRTH-WEIGHT PARTICIPANTS.*

VARIABLE	MEN				WOMEN				TOTAL POPULATION	
	VERY LOW BIRTH WEIGHT (N=116)	NORMAL BIRTH WEIGHT (N=108)	ODDS RATIO (95% CI)	P VALUE	VERY LOW BIRTH WEIGHT (N=126)	NORMAL BIRTH WEIGHT (N=124)	ODDS RATIO (95% CI)	P VALUE	ODDS RATIO (95% CI)	P VALUE
	no. (%)				no. (%)					
Substance use during the previous year										
Tobacco	66 (57)	64 (59)	0.9 (0.5–1.6)		50 (40)	59 (48)	0.7 (0.4–1.2)		0.8 (0.6–1.2)	
Alcohol	84 (72)	89 (82)	0.6 (0.3–1.1)		77 (61)	103 (83)	0.3 (0.2–0.6)	<0.001	0.4 (0.3–0.6)	<0.001
Illicit drugs	49 (42)	57 (53)	0.6 (0.4–1.1)		38 (30)	54 (44)	0.6 (0.3–0.9)	0.03	0.6 (0.4–0.9)	0.007
Marijuana	49 (42)	56 (52)	0.7 (0.4–1.1)		37 (29)	52 (42)	0.6 (0.3–1.0)	0.04	0.6 (0.4–0.9)	0.01
Other†	10 (9)	9 (8)	1.1 (0.4–2.9)		5 (4)	9 (7)	0.5 (0.2–1.7)		0.8 (0.4–1.7)	
Contact with the police										
Violation of law (excluding traffic laws)	43 (37)	56 (52)	0.5 (0.3–0.9)	0.03	30 (24)	29 (23)	1.0 (0.6–1.8)		0.7 (0.5–1.1)	
Convicted of crime‡	23 (20)	29 (27)	0.7 (0.4–1.2)		3 (2)	4 (3)	0.7 (0.1–3.2)		0.7 (0.4–1.2)	
Incarcerated§	30 (26)	28 (26)	0.9 (0.5–1.7)		8 (6)	7 (6)	1.1 (0.4–3.2)		0.9 (0.6–1.6)	
Sexual activity¶										
Intercourse	96 (83)	88 (81)	0.8 (0.4–1.7)		82 (65)	97 (78)	0.5 (0.2–0.8)	0.01	0.6 (0.4–0.9)	0.02
Pregnancy‖	30 (26)	25 (23)	1.1 (0.6–2.0)		36 (29)	51 (41)	0.5 (0.3–0.9)	0.02	0.7 (0.5–1.1)	
Live birth**	17 (15)	19 (18)	0.7 (0.4–1.5)		17 (13)	30 (24)	0.4 (0.2–0.9)	0.02	0.6 (0.3–0.9)	0.02

*The odds ratios for men and for women were adjusted for sociodemographic status; the odds ratios for the total population were adjusted for sociodemographic status and sex. CI denotes confidence interval.

†Data include the use of inhalants (by four very-low-birth-weight men, one male control, and one female control), amphetamines (by five very-low-birth-weight men, three very-low-birth weight women, three male controls, and five female controls), cocaine (by two very-low-birth-weight men, one very-low-birth-weight woman, two male controls, and three female controls), and hallucinogens (by three very-low-birth-weight men, three very-low-birth-weight women, seven male controls, and seven female controls).

‡Data include convictions for driving under the influence of alcohol.

§Incarceration was defined as ever being held in jail, including for several hours or overnight, or in juvenile detention.

¶For men, the data for pregnancy or live birth indicate pregnancy in the man's partner or live birth of a child fathered by the man.

‖Data include 13 very-low-birth-weight women and 9 female controls who were pregnant at the time of the interview.

**Data include three very-low-birth-weight women and five female controls who had had more than one live birth.

teristics at eight years of age, when the normal-birth-weight group was recruited.[2] From 8 to 20 years of age, both groups had greater losses to follow-up among children whose mothers had less education, but more of these losses occurred in the control group than in the very-low-birth-weight group. This imbalance explains the discrepancy in maternal education between the very-low-birth-weight participants and the controls at 20 years of age. Previous studies of very-low-birth-weight infants have similarly had greater loss to follow-up among participants with lower IQs and those whose mothers had lower levels of education and were of lower social class.[31,32] To control for this bias, we adjusted for maternal sociodemographic status, which included maternal educational level, in all the analyses. A weakness of the study is that we did not measure maternal IQ, an important predictor of children's educational outcomes.[33]

The findings that fewer very-low-birth-weight participants than normal-birth-weight participants had graduated from high school and that they were less likely to be enrolled in a postsecondary educational program are not surprising, considering their lower IQs and academic achievement scores and higher rates of grade repetition. A disadvantage in school performance among boys has been previously reported in studies of very-low-birth-weight subjects.[34,35] Our finding of a lower rate of enrollment in four-year colleges among the very-low-birth-weight men, even after sociodemographic factors had been controlled for, indicates that this disadvantage extends into young adulthood. These findings suggest that men who had very low birth weight will lag behind their normal-birth-weight peers in their ultimate educational and occupational achievement, and thus in earning ability, social status, and prestige.[36]

Lower rates of alcohol and drug use among very-low-birth-weight subjects have not previously been re-

ported. Bjerager et al. noted similar rates of alcohol and drug use for very-low-birth-weight young adults and controls.[11] Chilcoat and Breslau reported an increase in early drug use among 11-year-old low-birth-weight children that was associated with attention-deficit–hyperactivity disorder rather than with birth weight per se.[37] Risk-taking behavior in children is associated with externalizing behavior,[37] low intelligence and academic performance,[38] negative peer influences,[39] early puberty,[24] poor self-esteem, and poor parental monitoring.[23,40-42] We do not have information on all of these correlated factors, but we postulate that the more limited risk-taking behavior that we have documented may result from increased parental monitoring of very-low-birth-weight children.

A problem inherent in the long-term follow-up of preterm infants is that outcomes might not be relevant to survivors of current neonatal intensive care. Recent survivors who weighed less than 1000 g at birth have poorer outcomes than were previously reported.[43,44] There is, however, no evidence that the incidence of neurodevelopmental sequelae of very low birth weight among children who weighed between 1000 and 1500 g at birth has changed since the late 1970s.[45] The majority of our 20-year-old cohort had birth weights in this range. We thus suggest that our results have relevance to current survivors with birth weights in the same range.

In summary, the results of this study indicate that the neurodevelopmental and growth-related sequelae of very low birth weight and the poor school achievement that have been reported for very-low-birth-weight children persist into young adulthood. The results are reassuring, however, in that these problems are not associated with increased risk-taking behavior or criminal activity. Further follow-up will be important to examine the ultimate educational attainment and choice of occupation of the cohort as they reach mature adulthood.

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