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Economic Outcomes in Young Adulthood for Extremely Low Birth Weight Survivors

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Economic Outcomes in Young Adulthood for Extremely Low Birth Weight Survivors

WHAT'S KNOWN ON THIS SUBJECT: Extremely small and extremely preterm infants are known to experience significant rates of neurosensory impairment, and large proportions have difficulties in school. Only a few studies have evidence on adult outcomes such as educational attainment and earnings.

WHAT THIS STUDY ADDS: This study compares educational and labor market outcomes for a cohort of extremely low birth weight survivors and a normal birth weight control group, controlling for family background. Survivors experience some deficits, but deficits typically are not large.

abstract

OBJECTIVE: The goal was to compare educational attainment and labor market outcomes in young adulthood (21–26 years of age) for a Canadian, population-based cohort of 149 extremely low birth weight (ELBW) (<1000 g) survivors and a normal birth weight (NBW) cohort of 133 young adults from the same geographic area who were matched to the ELBW cohort in childhood.

METHODS: We estimated the effects of ELBW status, according to gender, on continuous outcomes through least-squares regression and those on binary outcomes through logistic regression. We controlled for family background and considered neurosensory impairment and IQ as mediating variables.

RESULTS: Controlling for family background, ELBW male subjects were less likely to complete high school or to attend a university than were their NBW counterparts, and their educational attainment was reduced by >1 year. Among subjects who were working, weekly earnings were ~27% lower. ELBW female effects on education were not significant, but ELBW female subjects were less likely than NBWsubjects to be employed or in school and they also seemed to experience lower earnings.

CONCLUSION: Our findings suggested that ELBW survivors are somewhat less productive as adults, on average, than are subjects born NBW and that effects are not confined to subjects with severe neurosensory impairments. In accord with other studies, however, we found that productivity deficits for most ELBW subjects were not large. *Pediatrics* 2010;126:e1102–e1108

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KEY WORDS
low birth weight, preterm birth, child development, earnings, education

ABBREVIATIONS
ELBW—extremely low birth weight
NBW—normal birth weight
NSI—neurosensory impairment

Results referred to but not presented are available on request.

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Rates of survival of extremely small and very preterm infants have improved dramatically with advances in neonatal intensive care since the 1970s. Although much is known about outcomes for survivors in childhood, evidence is limited with respect to adult outcomes, including effects on economic productivity.[1] Typically, approximately one-fourth of survivors born at extremely low birth weight (ELBW) (≤1000 g) have serious neurosensory impairments (NSIs), and more than one-half are in special education or have repeated a grade in school by age 9.[2] Are these early life difficulties associated with lower levels of educational attainment and ultimately lower earnings?

Our team has monitored a population-based cohort of ELBW survivors who were born between 1977 and 1982 in central-west Ontario, Canada. Outcomes at 3 and 5 years were reported,[3,4] and outcomes were compared with those of a term control group at 8 years,[5] adolescence,[6–8] and young adulthood.[9–11] The aim of this report is to explore the differences between ELBW and control subjects with respect to young adult outcomes related to economic productivity, including educational attainment, earnings, and disability.

Although subjects were early in their labor market careers at the time of the interviews and some were still in school, the outcomes we examined are associated with earnings later in life. Voluminous literature finds that educational attainment is strongly related to earnings.[12,13] Early career earnings also are an indicator of later earnings, although the correlation coefficient is much less than 1.[14,15]

There are several reasons for interest in the long-term outcomes of ELBW survivors. Knowing the difficulties, if any, that ELBW survivors are likely to encounter in the transition to adulthood may inform policy decisions regarding public support for ELBW survivors and their families. Understanding the consequences of ELBW also is relevant for estimating the benefits of policies that would reduce its incidence. Finally, information on long-term outcomes is one input for economic evaluations of interventions that improve survival rates among these infants.

METHODS

Study Groups and Data Collection

Participants and data collection methods were described elsewhere.[9] The original cohort included 397 infants who weighed 501 to 1000 g at birth, 179 of whom (45%) survived to hospital discharge. There have been 13 subsequent deaths. Of the 166 survivors eligible to participate at young adulthood, 149 (90%) did so. Parents provided information for 7 severely disabled ELBW subjects. No deaths have occurred in the normal birth weight (NBW) cohort of 145 term-born children recruited at 8 years of age and matched to the ELBW cohort according to age, gender, and family socioeconomic status; 133 of the NBW subjects (92%) participated at young adulthood. Information was obtained through face-to-face interviews conducted by trained interviewers between January 2002 and April 2004. Written informed consent was obtained from all young adults. The study was approved by the ethics review board of Hamilton Health Sciences.

Statistical Analyses

We analyzed continuous outcome variables through least-squares regression, reporting heteroskedasticity-robust SEs.[16] For binary outcome variables, we used logistic regression. Results reported for the logistic regression analyses are estimates of the change in probability of the outcome variable associated with a change in the explanatory variable (marginal effect). Results expressed as relative risks and odds ratios are included in Appendix 1.

We pooled data for all subjects, allowing the ELBW effect to differ according to gender. Regressors were included to control for differences in family background and for the age of the subject at the time of the interview. We also explored the possibility that the effects of ELBW status might be mediated by effects on IQ or on the presence of NSIs. In a few instances, values for missing variables were imputed. We performed single imputation by using the Markov chain Monte Carlo iterative method in SPSS 18 (SPSS, Chicago, IL) to fit a univariate (single-dependent variable) model, with all other available variables in the model as predictors.[17]

Outcome Variables

Educational Attainment

Three measures were used, namely, high school completion, whether an individual had ever attended university, and years of schooling. We defined years of schooling completed as the sum of the highest grade of elementary or secondary school completed (maximum of 13), years of education completed at a community college, technical institute, or trade school, and years completed at a university.[18] In Ontario during the relevant period, most students who went on to a university completed a 5-year high school program (Ontario Academic Credits); for others, high school was typically 4 years. Nine of the ELBW subjects (or their proxy respondents) indicated that schooling was in a special program different from mainstream schools. The average IQ in this group was 47, and 7 subjects had significant NSIs. We imputed values for years of schooling for these subjects.

Labor Market Variables

For young adults of this age (mean: 23.4 years), we considered being neither employed nor in school to be a negative indicator of future earnings. Individuals were classified as employed or in school if, in the previous week, they were enrolled in or attended school, worked at a job or business, or did not work because of vacation or acute illness or injury. For employed subjects, we computed usual weekly earnings on the basis of the usual wage or salary from all jobs before taxes and other deductions. In our main analyses, this variable is in logarithmic form. We also examined 2 indicators of disability, namely, receipt of a government disability pension in the past year and activity limits (ie, a health condition limiting normal activities at home, at a job, or in school).

Control Variables

Age was the difference between the interview date and the birth date and was allowed to take noninteger values (range: 21.2–26.5 years; SD: 1.1 years). Controls for family background were based on interviews conducted at ~8 years of age, the earliest time at which we had such information. Mother married indicated that the child's mother was married at that time (not necessarily to the biological father). Mother's education was grouped into 3 categories, that is, less than high school, high school only, or more than high school. We imputed values for 10 ELBW subjects for whom information on mother's education and mother's marital status was missing.

Mediating Variables

We considered NSIs, defined as cerebral palsy, mental retardation (IQ score >2 SD below the population normative value), blindness, or deafness, and IQ scores measured at 8 years of age as potentially mediating the effects of ELBW.

TABLE 1 Characteristics of Birth Weight Groups

	ELBW ($N = 149$)	NBW ($N = 133$)
Birth weight, mean ± SD, g	841 ± 124	3384 ± 487
Gestational age, mean ± SD, wk	27.1 ± 2.3	NA
Male, %	45.0	45.1
White, %	94.0	97.0
Age, mean ± SD, y	23.3 ± 1.2	23.6 ± 1.0
Mother married, %[a,b]	90.0 ($N = 140$); 90.6	89.5
Mother's education less than high school, %[a,b]	31.7 ($N = 139$); 31.5	24.8
Mother's education more than high school, %[a,b]	37.4 ($N = 139$); 36.9	50.4
IQ score, mean ± SD[a,b]	90.7 ± 18.4 ($N = 140$); 90.5 ± 18.3	104.2 ± 12.4
NSI, %	26.9	2.3
High school completion, %	81.9	87.2
Duration of schooling, mean ± SD, y[b]	14.0 ± 2.3 ($N = 140$); 13.7 ± 2.5	14.5 ± 2.3
Attended university, %	26.8	43.6
Employed or in school, %	73.8	85.0
Usual weekly earnings, mean ± SD, $[c]	398 ± 241 ($N = 88$)	487 ± 264 ($N = 98$)
Disability pension, %	18.8	0.8
Activity limits, %[b]	20.9 ($N = 148$); 20.8%	11.3

NA indicates not applicable. Variable definitions are provided in the text.

[a] Assessed at age 8.

[b] *N* indicates nonimputed values for ELBW subjects; the first number reported for ELBW subjects excludes imputations and the second number includes them.

[c] *N* values include only subjects reporting positive earnings.

IQ scores were imputed for 9 ELBW subjects, all of whom also had mother's background information missing.

RESULTS

Group Characteristics

Table 1 presents means for some important variables for the 2 groups, with and without missing values imputed. The groups were well matched with respect to gender distribution and race (nearly all subjects in both groups were white), and similarly large proportions in both groups came from 2-parent households. Levels of maternal education were somewhat higher for the NBW group, and the NBW subjects were slightly older, on average, at the time of the interview. Forty ELBW subjects and 3 NBW subjects were classified as having NSIs. The mean IQ was 12.5 points lower for ELBW subjects, with exclusion of the 9 ELBW subjects for whom IQ data were not obtained (all of whom attended regular schools).

Educational Attainment

Table 2 presents results of logistic regression analysis of high school completion. On the whole, these results provide weak evidence that ELBW status reduced the probability of completion for male subjects but not for female subjects. The baseline estimate for male subjects was a 14.8-percentage point decrease in the probability of completion ($P = .03$). Including NSI as a regressor reduced the size of the effect, and statistical significance was lost. The baseline plus IQ analysis suggested that the effect was mediated through IQ. In results not shown, an additional 10 points of IQ increased the probability of high school completion by ~5 percentage points ($P < .001$).

Table 2 also shows that ELBW male subjects were ~22 percentage points less likely to attend a university, compared with NBW male subjects, in the baseline model ($P = .01$). As with high school completion, the effect was mediated through IQ. Results for years of schooling were consistent with those for high school and university schooling in showing a substantial negative effect for ELBW male subjects, with a ~1.1-year reduction in schooling ($P < .01$) in the baseline case. When, instead

TABLE 2 ELBW Effects on Various Outcomes According to Gender

	Marginal Effect, Mean ± SE				
	High School Completion ($N = 282$)[a]	Attended University ($N = 282$)[a]	Duration of Schooling ($N = 282$)[b]	Employed or in School ($N = 282$)[a]	Log(Weekly Earnings) ($N = 186$)[b]
Baseline					
ELBW female	0.014 ± 0.044	−0.075 ± 0.084	−0.223 ± 0.354	−0.152 ± 0.067[c]	−0.156 ± 0.172
ELBW male	−0.148 ± 0.069[c]	−0.218 ± 0.080[d]	−1.134 ± 0.415[d]	−0.097 ± 0.064	−0.308 ± 0.139[c]
Baseline plus NSI					
ELBW female	0.041 ± 0.045	−0.057 ± 0.087	0.005 ± 0.351	−0.097 ± 0.070	−0.137 ± 0.176
ELBW male	−0.095 ± 0.074	−0.200 ± 0.084[c]	−0.843 ± 0.412[c]	−0.038 ± 0.069	−0.259 ± 0.144
Baseline plus IQ					
ELBW female	0.068 ± 0.045	0.038 ± 0.085	0.438 ± 0.349	−0.119 ± 0.070	−0.116 ± 0.174
ELBW male	−0.015 ± 0.063	−0.030 ± 0.086	0.118 ± 0.382	−0.047 ± 0.066	−0.231 ± 0.151

Baseline covariates were male, mother married, mother's education less than high school, mother's education more than high school, and age. In logistic regression analyses, ELBW female marginal effects were calculated at male = 0, ELBW male = 0, and other covariates at their means; ELBW male marginal effects were calculated at male = 1, ELBW female = 0, and other covariates at their means. Robust SEs are presented for least-squares regressions.

[a] Logistic regression.

[b] Least-squares regression.

[c] Significant at 5%.

[d] Significant at 1%.

of using the imputed values, we considered those who attended only special schools as having 6 years of schooling, the ELBW effect for male subjects was a 1.36-year reduction, whereas the estimate for female subjects remained insignificantly different from 0.

Labor Market Variables

In contrast to the results for educational attainment, the ELBW female effect on the outcome of employed or in school was stronger than the ELBW male effect. The ELBW female effect was a ~15-percentage point reduction in the baseline model ($P = .02$). (Among female subjects who were neither employed nor in school, 2 of the 12 NBW subjects and 1 of the 25 ELBW subjects were married, and 5 in each group were parents.) In the other specifications, the estimated effect remained negative but was somewhat smaller and statistically insignificant. Estimates of the effect for male subjects also were negative, although not statistically significant. Log(weekly earnings) among the employed (all who were currently working for pay, including part-time work) ($n = 186$) also were analyzed. The results showed a large, negative, statistically significant effect for ELBW male subjects, which translated to a ~27% reduction in the baseline specification.[19] Inclusion of NSI or IQ reduced the size of this effect. With the ELBW male and female effects constrained to be the same, the coefficient estimate was −0.22 ($P = .05$), an estimated 20% reduction in earnings. Interestingly, the estimate was −0.17 even when NSI, IQ, and years of schooling were all included, although P increased to .17.

We performed some additional robustness checks of the results for earnings, as presented in Table 3. The first used total earnings (including business income) that the subjects reported for the previous year as the dependent variable. The second used current weekly earnings but restricted the sample to subjects who considered themselves permanently employed, with employment their primary activity. The third variation used hourly wages (computed from information on earnings and hours when wages were not reported on a per-hour basis). In all of these analyses, the dependent variable was in logarithmic form. Finally, we reanalyzed usual weekly earnings by entering the dependent variable in dollar rather than log(dollar) form.

Table 3 shows results for these dependent variables by using the same specifications as in Table 2. Results showed consistently large negative effects for ELBW male subjects, which were sometimes but not always statistically significant. Controlling for NSI reduced the magnitude of the male ELBW effects only modestly. Estimated effects for ELBW female subjects were smaller and never significant. Exclusion from the earnings analysis of 4 ELBW subjects who received disability pensions but also had earnings reduced the estimated ELBW effects but did not

TABLE 3 ELBW Effects on Other Earnings Variables

	Effect, Mean ± SE			
	Log (Earnings in Previous Year) ($N = 211$)	Log (Weekly Earnings for Permanently Employed) ($N = 143$)	Log (Hourly Wage) ($N = 184$)[a]	Weekly Earnings ($N = 186$)
Baseline				
ELBW female	0.051 ± 0.180	−0.106 ± 0.179	−0.065 ± 0.091	−32.4 ± 52.8
ELBW male	−0.229 ± 0.193	−0.220 ± 0.120	−0.253 ± 0.093[b]	−119.2 ± 52.2[c]
Baseline plus NSI				
ELBW female	0.065 ± 0.181	−0.092 ± 0.183	−0.043 ± 0.092	−26.9 ± 53.2
ELBW male	−0.135 ± 0.202	−0.263 ± 0.119[c]	−0.194 ± 0.096[c]	−104.6 ± 53.7
Baseline plus IQ				
ELBW female	0.077 ± 0.177	−0.014 ± 0.176	−0.032 ± 0.097	−43.5 ± 52.7
ELBW male	−0.161 ± 0.210	−0.071 ± 0.139	−0.186 ± 0.103	−98.7 ± 55.7

Least-squares regression results are presented. Baseline covariates were male, mother married, mother's education less than high school, mother's education more than high school, and age. SEs are robust.

[a] Data for 2 NBW subjects who reported hourly wages of more than $100 per hour for ≤10 hours per week were omitted.

[b] Significant at 1%.

[c] Significant at 5%.

change conclusions substantially (results not shown).

Fifty-five percent of the ELBW subjects with NSIs and 5.5% of the subjects without NSIs reported receiving a disability pension (only 1 NBW subject, without a NSI, reported such a pension). Those not employed or in school were more likely to receive a disability pension. Controlling for NSIs, ELBW and NBW results for activity limits were similar. Forty-four percent of the ELBW subjects with NSIs (and 1 of the 3 among the NBW subjects) reported health-related activity limitations; the proportions were 12.8% for ELBW subjects and 10.8% for NBW subjects among subjects without NSIs.

DISCUSSION

Rates of survival of ELBW infants have improved markedly over time. In the United States, infant mortality rates for infants born at 500 to 999 g decreased from 58% in 1983 to 31% in 2005.[20] Adult outcomes of our cohort remain relevant, however, because similar data are not yet available for cohorts born in more-recent years and because, on the basis of evidence in childhood, the distribution of outcomes for ELBW survivors seems not to have changed substantially.[21,22]

An emerging body of evidence suggests that survivors born ELBW, or at least several weeks preterm, achieve lower educational attainment and poorer labor market outcomes than do those born at term, but also that the deficits are not extremely large for most survivors. Several European studies used data from national registers, grouped individuals according to gestational age, and compared outcomes for various groups of preterm infants with those for infants born at term (>36 weeks of gestation), with adjustment for potentially confounding family background variables.

A Swedish study considered infants born in 1973–1979, with outcomes tracked in 2002.[23] Disabled subjects (6.4% of subjects born at gestational ages of <33 weeks and 1.5% of subjects born at term) were excluded from analyses of educational outcomes or earnings. The authors found a relative risk of 0.92 of having some postsecondary education for the <33-week group. The estimated deficit in earnings for the <33-week group was ~2% of median earnings (model 2 or 3).

A Norwegian study considered infants born in 1967–1983 and monitored through 2003.[24] The authors excluded subjects with disabilities that affected working capacity severely (5.2% of subjects born at <34 weeks of gestation and 1.7% of subjects born at term). Educational attainment increased with gestational age in multivariate models when gestational age was included as a continuous variable, but relative risks for higher attainment levels were not statistically different according to gestational age groupings. Similar results were found for earnings. For subjects born at <31 weeks of gestation, the unadjusted relative risk of being in the bottom quintile of earnings was 1.15 and that of being in the top quintile was 0.87. The results of a Danish study[25] were similar to those of the other 2 studies.

All of the infants in our ELBW group were born several weeks preterm; therefore, it seems reasonable to compare our results with those of the national studies. Unlike those studies, we reported separate effects for male and female subjects and found indications of some differences according to gender. We found an ELBW effect for male subjects but not for female subjects with respect to educational attainment. There also was stronger evidence of negative earnings effects for ELBW male subjects than for ELBW female subjects. Taken as a whole, the results on employed or in-school status and earnings suggest that less-productive female ELBW subjects were more likely to be out of the labor force, whereas their male counterparts experienced a greater reduction in earnings, compared with their NBW peers.

Although they were not estimated with great precision, some of our point estimates of ELBW effects are rather large (eg, ~15-percentage point reduction in the likelihood that female subjects were employed or in school and ~27% reduction in weekly earnings among employed male subjects). On the whole, however, our findings seem consistent with other studies in suggesting that the long-term economic impact of being born ELBW is not very large for typical survivors. The contrast with somewhat more-pessimistic conclusions drawn from results at younger ages could partly reflect a catch-up effect but also may reflect the fact that we examined different outcomes.[26]

In our results, the family background variables had important independent effects on most outcomes. These associations may reflect in part correlated genetic traits inherited across generations or other correlated environmental factors, rather than the effects of a 2-parent family or mother's education per se. To test whether favorable family background might mitigate the effects of low birth weight (as found in other research[27,28]), we estimated additional models by adding interaction terms between ELBW status (not differentiated according to gender) and family background variables for our Table 2 outcome variables. In each case, we failed to reject the hypothesis that the interaction terms were jointly insignificant at the .1 level but, because of sample size, we had limited statistical power.

A limitation of our study is that earnings were observed at a relatively young age. One issue is that some sub-

jects had not yet completed their schooling. However, approximately the same proportions of NBW subjects (33.8%) and ELBW subjects (31.5%) were enrolled in school either full or part-time at the time of interview. Although young adult earnings do not correlate closely with earnings later in life, we have no reason to think that differences between ELBW and NBW earnings in young adulthood would overstate later differences.

Other issues relate to generalizability. We should be cautious about applying our results, representing averages over a particular ELBW population born 3 decades ago, to questions about the consequences of more- or less-aggressive treatment for infants truly at the margins of viability today. Given findings from other research on the importance of environmental factors for long-term outcomes, results also might be dependent on the social context in which the survivors live.[26–28] The relatively favorable results summarized here, from Canada and several high-income European countries, might not be replicated in the United States, where income inequality is greater and social programs to support the disadvantaged are not as strong.

CONCLUSIONS

Saving infants who are extremely small or extremely preterm is very expensive, and some survivors experience severe NSIs, whereas a large fraction experience more-minor behavioral and cognitive difficulties. Studies of advances in neonatal care have concluded that the added costs per quality-adjusted life year have been highly acceptable by the standards of high-income countries, even when the focus is on ELBW infants.[29,30] Until recently, evaluations of advances in care have been conducted without empirical data on adult outcomes for survivors. Our study is among the first to examine adult outcomes, particularly those related to economic productivity, for a population-based sample of ELBW or extremely preterm survivors.

In conjunction with other recent studies, our results indicate that, although ELBW status may lead to somewhat-lower educational attainment and reduced earnings (not confined to those with severe NSIs), the effects are not large. Most survivors become productive adults. Our work reinforces the conclusion that, on the whole, advances in neonatal care have had benefits far greater than costs.

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APPENDIX 1 ELBW Relative Risks and Odds Ratios According to Gender[31]

	Completed High School ($N = 282$)	Attended University ($N = 282$)	Employed or in School ($N = 282$)
Relative risk (95% confidence interval)			
Baseline			
ELBW female	1.01 (0.91–1.13)	0.84 (0.57–1.23)	0.82 (0.69–0.97)
ELBW male	0.84 (0.71–1.00)	0.47 (0.26–0.83)	0.88 (0.75–1.04)
Baseline plus NSI			
ELBW female	1.06 (0.95–1.18)	0.88 (0.59–1.31)	0.88 (0.74–1.04)
ELBW male	0.89 (0.75–1.05)	0.50 (0.27–0.91)	0.96 (0.82–1.13)
Baseline plus IQ			
ELBW female	1.10 (0.98–1.23)	1.14 (0.76–1.69)	0.85 (0.72–1.02)
ELBW male	1.00 (0.84–1.19)	0.89 (0.49–1.64)	0.96 (0.80–1.15)
Odds ratio (95% confidence interval)			
Baseline			
ELBW female	1.19 (0.42–3.33)	0.73 (0.36–1.46)	0.41 (0.18–0.91)
ELBW male	0.34 (0.12–0.96)	0.31 (0.14–0.74)	0.48 (0.18–1.29)
Baseline plus NSI			
ELBW female	1.69 (0.56–5.12)	0.78 (0.38–1.62)	0.55 (0.24–1.29)
ELBW male	0.50 (0.17–1.51)	0.34 (0.14–0.84)	0.75 (0.25–2.17)
Baseline plus IQ			
ELBW female	2.70 (0.31–3.29)	1.19 (0.56–2.53)	0.50 (0.22–1.14)
ELBW male	0.87 (0.29–2.81)	0.85 (0.33–2.18)	0.68 (0.24–1.97)

Relative risks were estimated with a modified Poisson regression method, implemented in Stata 9 (Stata Corp, College Station, TX) by using the glm command. Baseline covariates were male, mother married, mother's education less than high school, mother's education more than high school, and age.

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