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Do maternal and paternal characteristics perform similar roles in adverse pregnancy outcome and infant survival?

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Abstract: This paper is concerned with the relationship between late fetal or infant death and the following factors: maternal and paternal educational attainment, mother's and father's age, child's birth order, and sex. Maturity (combination of birth weight and duration of gestation) as intervening factors or proximate causes link social factors to fetal-infant mortality. Logistic regression has been used in order to measure the impact of individual explanatory factors on the probability of late fetal or infant death and also to control effects of all the variables. During the late fetal period, not only maturity of a child is a key predictor, but also the role of maternal and paternal age and to a lesser extent of mother's education is significant. Neonatal mortality depends primarily on birth weight/duration of gestation and child sex that was surprisingly considered to be unimportant in the late fetal period. Social determinants of child survival minimally apparent in the late fetal age markedly emerge during the postneonatal period.

Key words: stillbirth, infant mortality, social factors, Czech Republic, marital

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1. Introduction

The infant mortality rate has often been considered as a sensitive indicator reflecting a certain level of social development in a given group, population, or country. Many studies have also pointed out inequalities in infant survival within a population according to biological, social or behavioral factors (Cramer 1987; Carlson et al 1999). Marital status is one of the most important social differentials affecting infant risk of dying. To be a single mother can be considered as a sign of deprivation. Consequently, babies born to unwed mothers are more likely to have a lower birth weight (Paneth et al 1982). In the Czech Republic, the frequency of low birth weight is two times higher among infants born to single mothers and as a result, extra-marital newborns experience higher crude/ unadjusted infant mortality rate (Syrovátka, Rychtaříková 1984; Rychtaříková, Demko 2001). To avoid this complication, the present paper examines only children born to married women. Nevertheless, this restriction also enables inclusion of the father's characteristics (age and education) that are available only on birth certificates for marital births. Studying paternal factors as an adjunct to the characteristics of the mother increases the knowledge of the impact of factors on the fetal-infant life course. Characteristics of the father are not usually incorporated into investigations of infant or fetal mortality (Gourbin, Wunsch 1999).

This paper is concerned with the relationship between mortality of infants or fetuses and factors such as: maturity, sex of a child, maternal and paternal educational attainment, mother's and father's age, and infant birth order based on the number of previous births from the same woman. The purpose of the paper is to go beyond simple descriptions usually based on unadjusted rates computed for individual factors. The association between each factor and neonatal mortality or postneonatal mortality was examined by using statistical models (logistic regression) based on controlling (adjusting) for other confounding factors (variables). In addition, the impact of the factors on pregnancy outcomes (stillbirths or low birth weight) was studied. How interrelated mother's and father's age or mother's and father's education interact with pregnancy outcomes or neonatal/postneonatal mortality was also investigated and tested.

Birth weight and duration of gestation are the most important predictors of an infant's risk of dying during late fetal or postnatal periods. Birth weight and duration of gestation show strong association with the above-mentioned factors, as does mortality. Birth weight and duration of gestation are related to the health status of women and, to some degree, also of men. Social factors such as education or marital status are not direct or proximate causes, but birth weight, gestational age, nutrition, or medical care as intervening factors or proximate causes link these social factors to infant mortality. Logistic models of fetal/postnatal mortality risks (used to study the impact of the above-mentioned factors) are developed in the present paper. The models are based on a special data set prepared from vital statistics data of the Czech Republic covering the period of 1986–1990.

The following questions are examined:

- Do the investigated factors affect pregnancy outcome (stillbirth/live birth) and risk of infant death in the same way?
- Is the role of social factors (parents' education) more predominant during pregnancy than during the first year of life of a child?
- Are biological factors (age of parents or birth order) significant?
- Does interrelating age or education of parents exert a stronger effect on fetal and infant survival than keeping the maternal or paternal effect separate?
- Are maternal and paternal characteristics associated in a similar way with adverse pregnancy outcomes and infant survival?

2. Data and Methods

The data (births and deaths) utilized in this multivariate analysis are vital statistics data of the current Czech Republic, collected through Regional Statistics and centralized and processed by the Central Statistical Office. A specific data set was created based on the computerized individual records of births for the years 1986 through 1990, linked with individual records of infant deaths for the period 1986–1991. The data were linked at the Institute of Health Information and Statistics of the Ministry of Health and provide extensive information on mothers and fathers by combining items from both birth certificates and death certificates. The marital births (where maternal and paternal age was 15–44 years) are drawn from these matched birth and infant death files. The final data set includes 603 249 records of marital live births and stillbirths. From 600 892 marital live births, 6322 died before age one and 4399 during 0–27 days. The infant mortality rate in the data set was 10,5 infant deaths per 1000 marital live births. The time duration of the data covers the pre-transition period when a state-organized and guaranteed health care system was established and functioned under the former socialist government (Štembera 1993).

Studies of fetal and infant mortality have identified an increasingly extensive list of factors bearing some relationship to unfavorable outcomes (Cramer 1987; Olsen, Madsen 1999; Paneth et al 1982; Yakubovich, Barell 1988). Low birth weight and short gestation dramatically increase the risk of fetal and infant mortality (Frisbie, Forbes, Pullum 1996). Birth weight is acknowledged to be associated with social factors and its importance as an intervening variable cannot be questioned. If birth weight and gestational age are included in a statistical model, the association between social factors and infant mortality is greatly reduced or eliminated. However, birth weight and gestational age are strongly intercorrelated. In order to avoid the problems created by correlation when using regression techniques, we distinguish the three combinations of birth weight and duration of gestation (maturity): 1) birth weight lower than 2500 grams combined with length of gestation shorter than 37 weeks represents deliveries of premature babies, 2) birth weight equal or higher than 2500 grams combined with gestation of 37 weeks and more characterizes normal deliveries, 3) the residual category labelled other comprises: birth weight 2500 grams and more combined with gestation shorter than 37 weeks (hypertrophic or "heavy preemies"), or birth weight lower than 2500 grams combined with gestation of 37 weeks and more (hypotrophic or IUGR intrauterine growth retardation). The all variables were categorized for the purpose of subsequent multivariate analysis.

There exists a near universal finding in the literature dealing with unadjusted rates, about a U-shaped relationship between mortality on the one hand and mother's age or birth order on the other (Kiely, Paneth, Susser 1986; Rychtaříková 1999). In order to test U-shaped relationship between a child's mortality risk and mother's age, maternal age was divided into five-year age group categories (15–19, 20–24, ..., 40–44). There are very few studies also considering various socioeconomic characteristics of a father. Few studies have examined the impact of paternal age on fetal and child survival (Gourbin, Wunsch 1999; Wunsch, Gourbin 2002). Assuming that father's age could have similar effect as mother's has, father's age was included in the study using the same five-year age groupings. In order to have statistically valid conclusions, both maternal and paternal age was limited to 15–44 years.

Birth order is considered similarly as maternal age to display a U-shaped relationship, i.e., higher risk for the first and higher parity infants. Birth order, based on the number of all previous births (live births and stillbirths) that a woman ever had, was composed of the following four categories: 1, 2, 3, and 4+. In the Czech settings the gradient in infant mortality rate changed sharply between birth orders 2 and 3 and we therefore keep the third birth order as a separate category (Rychtaříková 1999). The residual category was four and more children.

The level of attained maternal education has consistently been shown to be an important determinant of infant mortality (Arntzen, Moum, Magnus, Bakketeig 1996; Olsen, Madsen 1999; Yakubovich, Barell 1988). Education of the mother is associated with access to information and the ability to process it, and hence to improve knowledge about the effect of behavioral choices on health. Maternal education is highly correlated with good child health outcomes. Mother's education was divided into four groups: basic education (9 years of school), technical education (12 years of school – basically vocational training), secondary education (at least 12 years of schooling resulting in "Maturita" status leading to a final grammar school examination certificate or the university entrance level), and university education. Fathers with a higher education level also can more easily adjust to a healthier lifestyle. Paternal educational attainment can therefore be included as a possible explanatory variable (Gourbin, Wunsch, 1999).

A virtually universal finding in bio-medical literature is that mortality of boys is higher than that of girls. Therefore, we also controlled for child's sex. Assuming that investigated factors could have a differential impact according to age of the child, the fetal-infant life span was decomposed into the following age segments: late fetal period, neonatal period, and postneonatal period.

This study uses the binary logistic regression technique. Logistic regression is used in order to predict a binary dependent variable (fetal death or live birth; infant death or survival) from a set of independent variables (mother's age, father's age, maternal and paternal educational attainment, birth order of a child, and maturity). In addition, logistic regression was applied in order to estimate the effects of predictors on low birth weight against normal birth weight. In logistic regression the parameters of the model are estimated using the maximum-likelihood method. The statistics used for the interpretation are: estimated odds ratios [exp(B)], confidence interval for exp(B) and the level of significance (see Tables 2, 3, 4, 5). The main effect (no interaction) logistic model was utilized. This model estimates the independent effects of each factor while controlling for the others. The logistic model has the form:

$$P(\text{infant death}=1 | X_1, X_2, \ldots X_k) = 1/[1+e^{-(A + \Sigma Bi * Xi)}]$$

where the conditional probability of infant dying equals logistic function with unknown parameters A (intercept) and Bi (slope parameters).

All explanatory variables in this model were nominal, and *k-1* dummy variables/factors, indicating *k* exposure categories, were used to distinguish the individual categories of the variable. Odds ratios were used in subsequent analyses and express the relative risk of a given category compared with a reference category (indicated with value 1) for a given variable, and simultaneously controlled for the effects of the remaining independent variables in the model.

Four model pairs were considered. Each pair consists of two models. The first model is main-effect and includes all independent factors/variables. Instead of using single effects of parent age and education, the second model in the pair contains a combination of mother's and father's age and mother's and father's education. All other factors remain single, i.e., without interactions. The four pairs of models have dependent (dichotomous) variables: fetal death/live birth (*Tables 2a,b*); neonatal death/survival (*Tables 4a,b*); postneonatal death/survival (*Table 5a,b*), and premature live birth /normal live birth (*Table 3a,b*).

3. Unadjusted fetal- infant mortality indicators

Unadjusted/crude infant mortality characteristics were calculated for cohorts of marital births born in the period of 1986–1990 (*Table 1*). Unadjusted/crude indicator means that the effects of the other variables on infant deaths were not considered. The crude rates for individual factors are primarily biased with the proportion of low birth weight and short gestational period among newborns, and to some extent with the distribution of remaining factors. The term *risk* is used when events (deaths) are relative to the number of survivors at the beginning of the investigated period. The term *rate* is used when events are only relative to live births or to all births when computing the stillbirth rate. However, both terms (rate and risk) can be used in infant and neonatal mortality.

In birth cohorts 1986–1990, stillbirth rate, neonatal rate, and postneonatal risk vary the most according to "maturity" factor (*Table 1*). Children born prematurely (birth weight < 2500 g and gestation < 37 weeks) obviously displayed the worst survival and those with normal birth weight and gestational age (birth weight > = 2500 g and gestation > = 37 weeks) had the best prediction for life (*Table 1*). Girls show a higher stillbirth rate but better survival in the neonatal and postneonatal periods. Maternal and paternal education have a similar role. A decreased risk of death has been observed in the category of higher educational attainment. A lower level of infant mortality can be clearly seen in infants born to parents with "Maturita" (secondary, university) than those without "Maturita" (basic, vocational).

Table 1 shows that mother's and father's age has virtually no effect on the risk of an infant death, until the parents are 30 years of age or older when successful completion of a pregnancy becomes increasingly less likely. Women and men over 30 years old are increasingly likely to experience the event of a late fetal or neonatal death. Instead of a U-shaped relationship, a more J-shaped form is observed in the neonatal period but not in postneonatal age. However, in most studies based on multivariate analysis, the observed relationships are no longer significant when controls for other observable factors are included. An adverse outcome is also observed for infants of the first and higher (3+) birth order. However, in the postneonatal period the J profile is not explicit and crude mortality risk steadily increases with higher parity.

In any case, birth weight and gestational age are the best predictors of pregnancy outcomes. The level of a unadjusted/crude indicator is a combination of two determinants: a) ***frequency*** of children born with low birth weight and short gestational age and b) ***mortality level*** of children born with low birth weight or short gestation. The frequency and mortality intensity by birth weight and gestational age vary across the studied factors and their categories (*Table 1*). The share of premature live births (birth weight < 2500 g and gestation < 37 weeks) in the data set was about 5% for children born to men and women with basic education while there was only 2.4% born to parents with university educational level. Mother's age and father's age showed the least important differences. When mothers and fathers were younger than 20 years, the share of premature live births was 3.7% and 4.2% respectively and when parents were aged 40–44 the percentage was 6.1% and 4.1% respectively (*Table 1*). A higher frequency of premature children (2.9%) was also observed for the first child, and for higher birth orders, i.e., for the third (3.7%), for the fourth (6.0%), and 8.4% for the fifth and more (*Table 1*).

Birth weight and gestation are the most responsible for infant survival during the late fetal period and first month of life. It is assumed that the impact of these factors mainly function irrespective of the social characteristics of parents. Therefore, unadjusted stillbirth and neonatal rate primarily reflects the different frequencies of babies born with

Table 1. Indicators of fetal and infant survival

Marital births in the Czech Republic (1986–1990 birth cohorts) where mother's and father's age is 15–44 years

	Number of Live births	Stillbirth rate ‰	Neonatal rate ‰	Postneonatal risk ‰	% live births < 2500 and < 37
Maturity					
< 2500 and < 37	17886	53.7	148.4	19.1	–
>= 2500 and < 37	10219	11.9	18.6	6.4	–
< 2500 and >= 37	11928	28.3	28.0	13.1	–
>= 2500 and >= 37	560859	1.6	2.2	2.5	–
Sex					
boys	308160	3.8	8.5	3.6	2.92
girls	292732	4.0	6.1	2.8	3.04
Mother's education					
basic	78698	5.7	10.3	6.1	4.81
vocational	229126	4.0	7.3	3.3	2.94
secondary	237499	3.4	6.6	2.4	2.52
university	55569	3.1	6.6	2.5	2.48
Father's education					
basic	48013	6.0	10.5	6.0	5.07
vocational	323865	4.0	7.4	3.4	3.00
secondary	153692	3.4	6.5	2.4	2.57
university	75322	3.2	6.7	2.4	2.37
Mother's age					
–19	73370	3.5	8.3	3.5	3.67
20–24	285250	3.3	6.6	3.2	2.71
25–29	159484	4.1	7.0	3.0	2.74
30–34	62689	5.3	8.6	3.2	3.46
35–39	18169	7.6	11.6	3.9	4.49
40–44	1930	11.8	15.5	3.7	6.06
Father's age					
–19	17547	2.9	7.9	4.0	4.18
20–24	189099	3.3	7.3	3.3	3.10
25–29	222165	3.7	6.8	3.1	2.65
30–34	114325	4.3	7.1	3.3	2.89
35–39	44537	5.6	9.0	3.4	3.51
40–44	13219	6.9	11.3	3.6	4.10
Birth order					
1	276848	3.8	7.1	2.7	2.89
2	235082	3.3	6.4	3.2	2.53
3	67467	5.2	9.0	4.7	3.71
4	15224	7.4	13.1	6.5	6.03
5+	6271	10.7	17.9	6.2	8.37
Total	**600892**	**3.9**	**7.3**	**3.2**	**2.98**

Stillbirth rate = stillbirths referred to all births
Neonatel rate = infant deaths (0–27 days) referred to live births
Postneonatal risk = infant deaths (28–364 days) referred to surviving up 28 day

Table 2a. Late fetal mortality – adjusted risks (Binary Logistic Regression: Main Effects)

Response variable: stillbirth/live birth

2357 stillbirths / 600892 live births

Marital births in the Czech Republic (1986 – 1990 birth cohorts) where mother's and father's age is 15–44 years

Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Limits	
Maturity			
Birthweight & Gestation < 2500 & <37 / >= 2500 & >= 37	**35.526 ****	32.377	38.980
Birthweight & Gestation other*) / >= 2500 & >= 37	**13.264 ****	11.840	14.860
Birthweight & Gestation >= 2500 & >= 37	**1**		
Sex			
Boys / Girls	0.998	0.920	1.084
Girls	**1**		
Mother's education			
Basic / University	**1.340 ****	1.077	1.666
Vocational / University	**1.360 ****	1.118	1.655
Secondary / University	***1.207* ***	1.004	1.452
University	**1**		
Father's education			
Basic / University	1.177	0.955	1.450
Vocational / University	1.128	0.957	1.330
Secondary / University	1.059	0.895	1.252
University	**1**		
Mother's age			
–19 / 20–24	0.902	0.775	1.049
25–29 / 20–24	**1.255 ****	1.116	1.411
30–34 / 20–24	**1.388 ****	1.178	1.636
35–39 / 20–24	**1.645 ****	1.308	2.069
40–44 / 20–24	**2.046 ****	1.287	3.253
20–24	**1**		
Father's age			
–19 / 20–24	***0.742* ***	0.552	0.997
25–29 / 20–24	**1.207 ****	1.075	1.356
30–34 / 20–24	***1.213* ***	1.045	1.408
35–39 / 20–24	***1.270* ***	1.051	1.536
40–44 / 20–24	1.285	0.984	1.678
20–24	**1**		
Birth order			
1 / 2	**1.215 ****	1.097	1.345
3 / 2	1.059	0.926	1.211
4+ / 2	0.993	0.824	1.197
2	**1**		

	Pr > ChiSq
MATURITY	**<.0001**
SEX	0.9681
MOTHER'S EDUCATION	***0.0105***
FATHER'S EDUCATION	0.3540
MOTHER'S AGE	**<.0001**
FATHER'S AGE	**0.0033**
BIRTH ORDER	**0.0021**

** alpha = 0,01   ** alpha = 0,05*   1 = reference category

other*) birthweight > 2499 and gestation < 37 or birthweight < 2500 and gestation > 37

Table 2b. Late fetal mortality when mother's and father's education and age are interrelated (Binary logistic regression: Main effect model with education and age coded as combinations)

Response variable stillbirth/live birth

2357 stillbirths / 600892 live births

Marital births in the Czech Republic (1986–1990 birth cohorts) where mother's and father's age is 15–44 years

Odds Ratio Estimates (Point Estimates)

Mother's education	**Father's education** Basic	Vocational	Secondary	University
Basic	**1.628 ****	**1.490 ****	1.167	0.911
Vocational	*1.475*	**1.507 ****	**1.507 ****	1.246
Secondary	1.355	*1.336 **	*1.265 **	1.190
University		1.345	0.931	**1**

Mother's age	**Father's age** –19	20–24	25–29	30–34	35–39	40–44
–19	**0.694 ****	0.882	1.021	1.378		
20–24	0.621	**1**	1.147	1.107	**1.743 ****	1.903
25–29	1.104	1.013	**1.529 ****	**1.545 ****	1.327	1.274
30–34		0.607	**1.890 ****	**1.662 ****	**1.814 ****	1.175
35–39		2.868	1.626	1.466	**1.878 ****	**2.819 ****
40–44			1.355	**4.788 ****	**3.962 ****	1.759

Odds Ratio Estimates for remaining single factors in the model

Effect	Point Estimate	95% Wald Confidence Limits	
Maturity			
Birthweight & Gestation < 2500 & < 37 / >= 2500 & >= 37	**35.619 ****	32.461	39.085
Birthweight & Gestation other*) >= 2500 & >= 37	**13.261 ****	11.837	14.858
Birthweight & Gestation >= 2500 & >= 37		**1**	
Sex			
Boys / Girls	0.997	0.919	1.082
Girls	**1**		
Birth order			
1 / 2	**1.219 ****	1.101	1.350
3 / 2	1.058	0.929	1.211
4+ / 2	0.980	0.812	1.182
2	**1**		

	Pr > ChiSq
MATURITY	**< .0001**
SEX	**0.9458**
BIRTH ORDER	**0.0016**
MOTHER'S and FATHER´S EDUCATION	**0.0077**
MOTHER'S and FATHER´S AGE	**< .0001**

** alpha = 0.01   * *alpha = 0.05*   1 = reference category

Table 3a. Prematurity – adjusted risks (Binary Logistic Regression: Main Effects)

Response variable live birth < 2500 grams and < 37 weeks / > 2499 grams or > 36 weeks
17886 live births < 2500 grams and < 37 weeks / 583006 live births > 2499 grams or > 36 weeks

Marital births in the Czech Republic (1986–1990 birth cohorts) where mother's and father's age is 15–44 years

Odds Ratio Estimates			
Effect	Point Estimate	95 % Wald Confidence Limits	
Sex			
Boys / Girls	**0.960****	0.932	0.989
Girls	**1**		
Mother's education			
Basic / University	**1.339 ****	1.238	1.448
Vocational / University	0.992	0.923	1.066
Secondary / University	*0.929 **	0.869	0.994
University	**1**		
Father's education			
Basic / University	**1.468 ****	1.361	1.584
Vocational / University	**1.107 ****	1.041	1.178
Secondary / University	1.027	0.965	1.094
University	**1**		
Mother's age			
–19 / 20–24	**1.190 ****	1.132	1.252
25–29 / 20–24	1.029	0.984	1.076
30–34 / 20–24	**1.126 ****	1.056	1.201
35–39 / 20–24	**1.254 ****	1.142	1.378
40–44 / 20–24	**1.551 ****	1.267	1.900
20–24	**1**		
Father's age			
–19 / 20–24	**1.163 ****	1.072	1.263
25–29 / 20–24	**0.866 ****	0.831	0.902
30–34 / 20–24	**0.822 ****	0.778	0.868
35–39 / 20–24	**0.836 ****	0.778	0.900
40–44 / 20–24	*0.893 **	0.803	0.993
20–24	**1**		
Birth order			
1 / 2	**1.060 ****	1.021	1.102
3 / 2	**1.348 ****	1.281	1.419
4+ / 2	**2.070 ****	1.932	2.218
2	**1**		
	Pr > ChiSq		
SEX	**0.008**		
MOTHER'S EDUCATION	**< .0001**		
FATHER'S EDUCATION	**< .0001**		
MOTHER'S AGE	**< .0001**		
FATHER'S AGE	**< .0001**		
BIRTH ORDER	**< .0001**		

**alpha = 0.01 **alpha = 0.05* 1 = reference category

Table 3b. Prematurity when mother's and father's education and age are interrelated
(Binary logistic regression: Main effect model with education and age coded as combinations)

Response variable live birth < 2500 grams and < 37 weeks / > 2499 grams or > 36 weeks
17886 live births < 2500 grams and < 37 weeks / 583006 live births > 2499 grams or >36 weeks
Marital births in the Czech Republic (1986–1990 birth cohorts) where mother's and father's age is 15–44 years

Odds Ratio Estimates (Point Estimates)

Mother's education	Father's education: Basic	Vocational	Secondary	University
Basic	**2.201 ****	**1.537 ****	**1.240 ****	**1.042 ****
Vocational	**1.469 ****	**1.136 ****	**1.043 ****	**1.168 ****
Secondary	**1.264 ****	**1.063 ****	**0.992 ****	**0.999 ****
University	**0.739 ****	**1.139 ****	1.208	**1**

Mother's age	Father's age: –19	20–24	25–29	30–34	35–39	40–44
–19	**1.322 ****	**1.209 ****	**1.089 ****	**0.921 ****	**1.323 ****	**1.302 ****
20–24	**1.350 ****	**1**	**0.867 ****	**0.814 ****	**0.869 ****	**0.946 ****
25–29	**1.820 ****	**1.015 ****	**0.872 ****	**0.849 ****	**0.985 ****	**0.936 ****
30–34	**4.050 ****	**1.484 ****	**1.120 ****	**0.914 ****	**0.882 ****	**1.052 ****
35–39		**1.302 ****	**0.950 ****	**1.278 ****	**1.028 ****	**1.040 ****
40–44		**1.094 ****	**3.374 ****	**0.400 ****	**1.343 ****	**1.659 ****

Odds Ratio Estimates for remaining single factors in the model

Effect	Point Estimate	95 % Wald Condifence Limits	
Sex			
Boys / Girls	**0.960 ****	0.960	0.961
Girls	**1**		
Birth order			
1 / 2	**1.058 ****	1.057	1.058
3 / 2	**1.346 ****	1.345	1.347
4+ / 2	**2.208 ****	2.205	2.211
2	**1**		

	Pr > ChiSq
SEX	**<.0001**
BIRTH ORDER	**<.0001**
MOTHER'S and FATHER'S EDUCATION	**<.0001**
MOTHER'S and FATHER'S AGE	**<.0001**

** alpha = 0.01 ** alpha = 0.05* 1 = reference category low birth weight across individual categories and the influence of socio-economic settings is essentially not evident. However, during the postneonatal period, the impact of biological/intervening factors is reduced (rates by maturity are less differentiated) and social determinants become more prevalent. Parental age does not affect postneonatal mortality risk. Children of parents with basic education or high birth order still remain more at risk. On the other hand, better infant survival is observed during the postneonatal period in children of birth order one compared with the second birth order. However, the opposite is true when comparing stillbirth and neonatal unadjusted rates *(Table 1)*.

4. Adjusted fetal-infant mortality risks

Logistic regression has been used in order to measure the impact of individual explanatory factors on the probability of infant death and simultaneously to control effects of all the variables. The main effect model (Table 2, 3, 4, 5) was applied. The estimated odds ratios (adjusted relative risks of dying) often differed from gradients based on crude/unadjusted mortality rate (Compare Table 1 and 2, 3, 4, 5).

The impact of biological and social factors on late fetal/stillbirth risk is different when compared with infant risk during the postnatal period. Birth weight and gestational age are the strongest predictors of pregnancy outcomes in late fetal age *(Table 2a)*. Against expectation, the sex of the infant and the father's education were not significant; mother's education was at a 0.05 level of significance. Women without "Maturita" were more likely to have a stillbirth. After birth weight and duration of gestation, the most significant variable is mother's age. The risk of stillbirth steadily increases with maternal age: the lowest for the youngest women and the highest for the oldest mothers. Paternal age is also significant at 0.01 level and shows the same pattern of increase across age groups. However, when individual categories are tested against a reference category (relative risk=1), the association between born as a stillbirth and father's age is weaker than in females, but still significant at 0.05 level. Therefore, paternal age also contributes to an adverse pregnancy outcome. In spite of the fact that birth order as a factor is statistically significant when looking across categories, the categories themselves do not differ significantly. A higher risk of stillbirth (0.05 level) is observed for the first pregnancy *(Table 2a)*. Because in the Czech Republic the first birth order includes all births (stillbirths and live births), the statistically significant increased risk for the first child can be interpreted as evidence of a selection process. Women able to successfully to bear a first child are usually capable of bearing subsequent children and consequently display a lower risk of an adverse pregnancy outcome for higher birth orders *(Table 2a)*. *Table 2b* shows how combined characteristics of both parents (mother's and father's education; mother's and father's age) contribute to adverse outcomes. Parents' combinations of age or education are also statistically significant. When these factors are shared, odds ratios are more apparent than when compared with singular factors. Mothers apparently play a more important role than fathers. The risk of adverse outcomes increases less across fathers' categories while the change in odds ratios is more pronounced in women's characteristics. Parents with vocational education are more at risk to have a stillbirth. However, the highest risk of late fetal death/stillbirth is when both parents have basic education or are older than 30 years, and particularly in women older than 40 years.

Spurious effect of the different frequency of premature children born according to usually examined factors and across their categories has already been shown in the literature (Cramer 1987; Paneth et all 1982). The association between the risk of having a premature child and factors is in *Table 3a,b.* All factors are statistically significant and therefore confirm their importance for the occurrence of prematurity. Odds ratios shown in Table 3a,b measure the relative risk of bearing a premature live infant (birth weight < 2500 g and gestation < 37 weeks) against having a live child with birth weight >= 2500 g or gestation >= 37 weeks. A particularly high risk of having a premature birth is associated with birth order 4+ compared to birth order 2 (to a lesser extent birth order 3 compared to birth order 2) and with basic educational attainment of fathers and mothers compared to parents with university education. Age of parents has the opposite impact when mothers and fathers are compared. While the relative risk to have a premature child increases with maternal age, it decreases when a father is older. It seems that to have a low birth weight and short gestation baby is related biologically to mothers and socially to fathers. It is known that very young and old women are biologically more at risk of delivering a premature baby. On the contrary, a young father is more likely to be facing economic difficulties that can affect the mother. A combination of maternal and paternal age (*Table 3b*) suggests the confirmation of a pattern of the increased risk when the pregnant mother is getting older and the odds ratios decrease when the father is at a higher age. Adverse outcomes (premature births) are seen primarily when a mother is older than the father. A high relative risk of having a premature birth is associated with mothers and fathers older than 35 years and when the age difference between partners is more than 15 years (mothers younger than 20; fathers older than 35). Lower educational attainment of both parents reinforces a higher relative risk of bearing a premature child *(Table 3b).*

During the neonatal period, profiles by category differ from those shown by unadjusted risks, but these are not statistically significant. Only maturity and sex are important determinants. Prematurity during a neonatal period is even more dangerous for child survival (80 times higher risk of neonatal death; *Table 4a)* than during the late fetal age (36x; *Table 2a*). Boys are more vulnerable than girls (1.5 times higher risk). In spite of the results usually anticipated in unadjusted indicators, all of the other factors have a negligible impact on neonatal mortality. It can be assumed that during the late fetal period many factors influencing fetus survival (maternal and paternal age and education, child's birth order) would have already had an effect. Parental age or parental education combined was insignificant for child survival during the neonatal period *(Table 4b).* The role of social factors appears to be less important in the four first weeks of life, particularly regarding the categories of parental education.

In the postneonatal period, the role played by prematurity (a biological factor) is diminishing and social determinants become more relevant *(Table 5a).* In addition to the weakening role of maturity, the strongest gradient is observed in mother's education and birth order. The risk of death for children born to women with a basic education is 1,4x higher than it is for children born to women with a university degree. In considering mother's education, one would expect almost no difference in adjusted risks in a relatively egalitarian society, which the Czech lands were until at least 1990. However, children of mothers with only a basic education and, to a lesser extent when the father has the lowest educational attainment, were more likely to die.

Table 4a. Neonatal mortality – adjusted risks (Binary Logistic Regression: Main Effects)

Response variable neonatal death/live birth

4399 neonatal deaths / 600892 live births

Marital births in the Czech Republic (1986–1990 birth cohorts) where mother's and father's age is 15–44 years

Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Limits	
Maturity			
Birthweight & Gestation < 2500 & < 37 / >= 2500 & >= 37	**80.438** **	74.961	86.314
Birthweight & Gestation other*) / >= 2500 & >= 37	**11.217** **	10.112	12.442
Birthweight & Gestation >= 2500 & >= 37	**1**		
Sex			
Boys / Girls	**1.493** **	1.402	1.591
Girls	**1**		
Mother's education			
Basic / University	1.022	0.869	1.201
Vocational / University	1.040	0.900	1.201
Secondary / University	1.044	0.913	1.195
University	**1**		
Father's education			
Basic / University	0.907	0.774	1.062
Vocational / University	0.944	0.836	1.065
Secondary / University	0.919	0.813	1.039
University	**1**		
Mother's age			
–19 / 20–24	1.065	0.958	1.183
25–29 / 20–24	1.062	0.969	1.163
30–34 / 20–24	1.087	0.954	1.239
35–39 / 20–24	1.158	0.959	1.399
40–44 / 20–24	1.173	0.774	1.779
20–24	**1**		
Father's age			
–19 / 20–24	0.852	0.705	1.030
25–29 / 20–24	1.021	0.938	1.111
30–34 / 20–24	0.959	0.856	1.075
35–39 / 20–24	1.053	0.908	1.222
40–44 / 20–24	1.173	0.948	1.451
20–24	**1**		
Birth order			
1 / 2	1.017	0.942	1.098
3 / 2	1.060	0.954	1.177
4+ / 2	1.060	0.916	1.227
2	**1**		

	Pr > ChiSq
MATURITY	**<.0001**
SEX	**<.0001**
MOTHER'S EDUCATION	0.909
FATHER'S EDUCATION	0.516
MOTHER'S AGE	0.508
FATHER'S AGE	0.159
BIRTH ORDER	0.702

** alpha = 0.01   * *alpha = 0.05*   1 = reference category

other*) birthweight > 2499 and gestation < 37 or birthweight < 2500 and gestation > 37

Table 4b. Neonatal mortality when mother's and father's education and age are interrelated (Binary logistic regression: Main effect model with education and age coded as combinations)

Response variable neonatal death/live birth
4399 neonatal deaths / 600892 live births
Marital births in the Czech Republic (1986–1990 birth cohorts) where mother's and father's age is 15–44 years

Odds Ratio Estimates (Point Estimates)

Mother's education	**Father's education** Basic	Vocational	Secondary	University
Basic	0.890	1.105	1.034	1.555
Vocational	***1.259****	1.035	0.986	1.037
Secondary	1.075	1.024	1.033	1.208
University	1.078	1.293	1.056	**1**

Mother's age	**Father's age** –19	20–24	25–29	30–34	35–39	40–44
–19	0.863	1.071	1.058	1.213	0.563	
20–24	0.920	**1**	1.008	0.858	1.125	1.261
25–29	0.923	0.906	1.050	1.077	1.018	1.319
30–34	1.865	0.981	***1.302****	0.954	1.130	1.327
35–39		1.684	1.122	1.113	1.238	1.195
40–44			1.328	0.532	1.168	1.422

Odds Ratio Estimates for remaining single factors in the model

Effect	Point Estimate	95% Wald Confidence Limits	
Maturity			
Birthweight & Gestation < 2500 & < 37 / >= 2500 & >= 37	**80.450 ****	74.971	86.329
Birthweight & Gestation other*) / >= 2500 & >= 37	**11.226 ****	10.121	12.453
Birthweight & Gestation >= 2500 & >= 37		**1**	
Sex			
Boys / Girls	**1.495 ****	1.403	1.592
Girls	**1**		
Birth order			
1 / 2	1.014	0.940	1.095
3 / 2	1.063	0.957	1.181
4+ / 2	1.080	0.932	1.250
2	**1**		

	Pr > ChiSq
MATURITY	**<.0001**
SEX	**<.0001**
BIRTH ORDER	0.615
MOTHER'S and FATHER'S EDUCATION	0.109
MOTHER'S and FATHER'S AGE	0.747

** alpha = 0.01   * *alpha = 0.05*   1 = reference category

Table 5a. Postneonatal mortality – adjusted risks (Binary Logistic Regression: Main Effects)

Response variable postneonatal death / survival the first year

1973 postneonatal deaths / 594570 survival the first year

Marital births in the Czech Republic (1986–1990 birth cohorts) where mother 's and father's age is 15–44 years

Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Limits	
Maturity			
Birthweight & Gestation < 2500 & < 37 / >= 2500 & >= 37	**6.934** **	6.095	7.888
Birthweight & Gestation other*) / >= 2500 & >= 37	**3.727** **	3.225	4.308
Birthweight & Gestation >= 2500 & >= 37	1		
Sex			
Boys / Girls	**1.293** **	1.181	1.416
Girls	1		
Mother's education			
Basic / University	**1.443** **	1.134	1.836
Vocational / University	0.985	0.787	1.232
Secondary / University	0.833	0.673	1.030
University	1		
Father's education			
Basic / University	*1.270* *	1.008	1.602
Vocational / University	1.099	0.907	1.332
Secondary / University	0.939	0.771	1.144
University	1		
Mother's age			
–19 / 20–24	1.046	0.895	1.223
25–29 / 20–24	**0.818** **	0.718	0.932
30–34 / 20–24	**0.678** **	0.557	0.825
35–39 / 20–24	*0.713* *	0.530	0.958
40–44 / 20–24	0.594	0.272	1.295
20–24	1		
Father's age			
–19 / 20–24	1.098	0.846	1.424
25–29 / 20–24	0.937	0.830	1.058
30–34 / 20–24	0.951	0.811	1.116
35–39 / 20–24	0.923	0.739	1.152
40–44 / 20–24	0.952	0.677	1.338
20–24	1		
Birth order			
1 / 2	**0.748** **	0.667	0.839
3 / 2	**1.410** **	1.223	1.626
4+ / 2	**1.481** **	1.201	1.827
2	1		
	Pr > ChiSq		
MATURITY	**<.0001**		
SEX	**<.0001**		
MOTHER'S EDUCATION	**<.0001**		
FATHER'S EDUCATION	**0.0081**		
MOTHER'S AGE	**0.0026**		
FATHER'S AGE	0.8578		
BIRTH ORDER	**<.0001**		

** alpha = 0.01   * *0.05 = alpha*   1 = reference category

other*) birthweight > 2499 and gestation < 37 or birthweight < 2500 and gestation > 37

Table 5b. Postneonatal mortality when mother's and father's education and age are interrelated (Binary logistic regression: Main effect model with education and age coded as combinations)

Response variable postneonatal death / survival the first year
1973 postneonatal deaths / 594570 survival the first year
Marital births in the Czech Republic (1986–1990 birth cohorts) where mother's and father's age is 15–44 years

Odds Ratio Estimates (Point Estimates)

Mother's education	**Father's education** Basic	Vocational	Secondary	University
Basic	**1.806 ****	**1.764 ****	1.132	1.968
Vocational	*1.428 **	1.133	0.920	1.016
Secondary	1.260	0.914	0.848	0.900
University	1.672	0.973	1.150	**1**

Mother's age	**Father's age** –19	20–24	25–29	30–34	35–39	40–44
–19	1.060	1.009	0.912	*2.195 **	0.655	**6.914 ****
20–24	1.190	**1**	0.884	0.952	0.960	0.715
25–29	1.118	*0.665 **	**0.778 ****	**0.728 ****	0.752	0.948
30–34	4.172	0.625	0.750	**0.626 ****	**0.521 ****	0.760
35–39		0.676	0.704	*0.511 **	0.765	*0.511 **
40–44			1.106	1.242	0.593	0.288

Odds Ratio Estimates for remaining single factors in the model

Effect	Point Estimate	95% Wald Confidence Limits	
Maturity			
Birthweight & Gestation < 2500 & < 37 / >= 2500 & >= 37	**6.934 ****	6.094	7.889
Birthweight & Gestation other*) / >= 2500 & >= 37	**3.728 ****	3.226	4.310
Birthweight & Gestation >= 2500 & >= 37		**1**	
Sex			
Boys / Girls	**1.295 ****	1.183	1.418
Girls	**1**		
Birth order			
1 / 2	**0.745 ****	0.664	0.835
3 / 2	**1.418 ****	1.230	1.635
4+ / 2	**1.507 ****	1.221	1.860
2	**1**		

	Pr > ChiSq
MATURITY	**<.0001**
SEX	**<.0001**
BIRTH ORDER	**<.0001**
MOTHER'S and FATHER'S EDUCATION	**<.0001**
MOTHER'S and FATHER'S AGE	**0.0031**

** 0.01 = alpha   ** 0.05 = alpha*   1 = reference category

The increased risk of postneonatal death is also observed for higher birth orders and is the lowest for the first child *(Table 5a)*. The differences are highly statistically significant. Because the negative effect of higher birth order appears mainly in the postneonatal period and has no impact during late fetal age and the neonatal period, the result implies that birth order primarily has a social meaning in Czech settings – unlike the traditional biological interpretations of many authors (Cramer 1987; Kiely et al. 1986). In a society with one of the highest rates of women's participation in the labor force, having more than two children may be a heavy burden for a family, especially when the parents are young. The postneonatal mortality profile by mother's age based on adjusted risks is rather unexpected in that it reflects a decrease for age groups 25–29 and 30–34. Higher survival for infants born to older mothers may denote a more stable family situation, particularly regarding housing. Father's age is not statistically significant.

5. Conclusion

The role of investigated factors differs in the various infant ages (late fetal, neonatal, and postneonatal) and also changes when adjusted and unadjusted indicators are compared. During the late fetal period the maturity of a child is a key predictor but the role of maternal and paternal age is also pertinent. Mother's education is relatively significant. Neonatal mortality depends primarily on birth weight/duration of gestation and child sex that was somewhat unimportant in the late fetal period. Social determinants, minimally apparent in the late fetal age and insignificant during the neonatal period, clearly emerge during the postneonatal period. From the second month of child life, besides parents' education, birth order appears to be very influential. Higher birth order worsens child survival. Therefore, the impact of birth order, mainly apparent in the postneonatal period, can be considered to be as a social condition, as is the educational factor. Unlike the late fetal age, where parents' age was significant and birth order not, an inverse pattern emerges during the postneonatal age. Comparing maternal and paternal characteristics acting alone or in combination leads to the same conclusions. In addition, the observed patterns become even more obvious when the factors are combined. The association between the risk of having a premature child and parents' age is the only exception showing the opposite gradient. While the risk of bearing a premature child is higher when the mother is older, an inverse relationship is observed for the age of the father. In addition, a combination of ages of both parents confirms the peculiar pattern. These findings call for additional research. Although many research activities on fetal-infant mortality have been oriented toward maternal characteristics, it seems that the father is also relevant for a child's future destiny.

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MAJÍ CHARAKTERISTIKY MATKY A OTCE STEJNÝ VÝZNAM PŘI POSUZOVÁNÍ RIZIKA MRTVOROZENOSTI A KOJENECKÉ ÚMRTNOSTI?

Résumé

Míra kojenecké úmrtnosti bývá považována za významný indikátor sociální vyspělosti dané země i za citlivý ukazatel společenských nerovností uvnitř dané populace. Vyšší intenzita kojenecké úmrtnosti obvykle souvisí s určitou mírou sociální deprivace. Ukazatele mrtvorozenosti i kojenecké úmrtnosti se liší např. podle rodinného stavu matky/otce nebo podle jejich vzdělání. Další skupinou proměnných, které se dávají do souvislosti s rizikem úmrtí kojenců nebo mrtvorozeností, jsou biologické faktory, za které jsou považovány věk rodičů a pořadí narozeného dítěte. Všechny výše uvedené proměnné ovlivňují porodní hmotnost a délku těhotenství, tj. ukazatele, které nejvýznamnějším způsobem determinují přežívání plodů a novorozenců. V předložené studii byly reprodukční ztráty prenatálního a kojeneckého období studovány na souboru dětí narozených v manželství, rodičům ve věku 15–44 let, v období 1986–1990. Analýza vycházela z anonymizovaných individuálních záznamů o narozených v letech 1986–1990, které byly spojeny se záznamy o zemřelých do jednoho roku v České republice. Soubor obsahoval 600 892 vět o živě narozených, které byly spojeny s 6322 záznamy o zemřelých do jednoho roku. Navíc bylo připojeno 2357 vět o mrtvě narozených. Metodou binární logistické regrese byly analyzovány asociace mezi mrtvorozeností, resp. neonatální úmrtností, resp. postneonatální úmrtností a faktory: vzdělání matky a otce, věk matky a otce, pořadí a pohlaví dítěte a zralost dítěte (kombinace porodní hmotnosti a délky těhotenství). Dopad studovaných faktorů na úmrtnost se liší v závislosti na věku dítěte. Zralost dítěte je vždy výrazným prediktorem jeho dalšího přežívání. Ve třetím trimestru těhotenství k tomu přistupuje věk rodičů, a to zejména matky. Riziko mrtvorozenosti není odlišné pro chlapce a dívky, ale je signifikantně vyšší pro první pořadí. Také nižší vzdělání matky vede k častějšímu porodu mrtvého plodu. V novorozeneckém období (0–27 dnů) je mimo zralosti jediným rizikovým faktorem pohlaví, vyšší úmrtnost pro chlapce. V ponovorozeneckém období (28–364 dnů) ztrácejí biologické faktory na významu a důležitým vysvětlujícím činitelem je vzdělání rodičů; čím nižší vzdělání, tím vyšší úmrtnost. Věk matky i otce a pořadí dítěte mají inverzní dopad v porovnání s prenatálním obdobím. V postneonatálním období se totiž s narůstajícím věkem rodičů riziko úmrtí snižuje a ve vyšším pořadí zvyšuje. Pořadí má tak spíše sociální interpretaci. Vzorce chování/typy rizik, které jsou signifikantní pro faktory, individuálně se ještě zesilují v případě kombinace vzdělání rodičů, resp. věku rodičů.