PREDICTIVE FACTORS IN DETERMINATION OF NEWBORN WEIGHT

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Recent observations that there is a secular variation in newborn weight and length call for their continuous assessment, as well as evaluating factors that influence them. The influence of maternal age, weight and height, as well as the number of previous deliveries, abortions and the number of cigarettes smoked per day on newborn weight and length was examined. Data were collected from 181 healthy pregnant women from Zagreb, Croatia, who delivered healthy newborns in term. Multiple regression, correlation coefficients and variance analysis were performed to assess the significance of tested variables on observed fetal features. Maternal age has no significant influence on birth weight, even though mothers younger than 20 and older than 30 tend to have lighter children. Both the numbers of previous deliveries and abortions showed no significant correlation to newborn weight. The number of cigarettes smoked per day during pregnancy and maternal pre-pregnancy weight were found to have significant correlation to newborn weight and length. Maternal height correlated significantly with newborn weight and length, but when multiple regression was performed, controlling for other parameters, no significant influence on newborn weight was found. These results indicate that smoking cessation and im-provement in maternal nutritional status (expressed as body weight) are the two modifiable factors that play a significant role in the reduction of low birth weight children, and thus the reduction of perinatal mortality.

INTRODUCTION

Recent researches indicate that there are secular variations in newborn weight and length (Wohlfahrt et al., 1998; Chike-Obi et al., 1996; Wright et al., 1993). Such time-related changes in newborn weight and length impose the need of continuous monitoring and assessing factors that influence these two newborn features in various populations, since reduced newborn weight for certain population's standards is the major factor of perinatal mortality.

Fetal growth is influenced by many factors. Maternal weight and height (that can be expressed as body mass index) as well as parity and the sex of a child are considered major determinators of newborn weight in normal pregnancies. Maternal age can also influence newborn weight, but this is mostly the case in juvenile pregnancies, and less is seen in mothers over 35 years of age (Drazancic et al., 1994).

Reduced birth weight can be a result of environmental, maternal, uteroplacental and fetal factors. An important environmental factor often found worldwide is maternal nutrition, either insufficient or excessive. Hyperglycemia, which results either from increased food intake or decreased insulin activity, causes fetal hypertrophy, whereas hypoglycemia has the opposite effect (Drazancic et al., 1994). The most important maternal factors that are associated with low newborn weight are weight and height (which can be expressed as body mass index), but also maternal age and parity (Drazancic et al., 1994; Lippi et al., 1989). The number of abortions is the factor that is interestingly associated with very low birth weight (Levkoff et al., 1982), but not with low birth weight (Levkoff et al., 1982; Fedrick and Adelstein, 1978).

Cigarette smoking decreases newborn weight by decreasing oxygenation of maternal blood and inducing vasoconstriction (Drazancic et al., 1994; Resnik et al., 1979). It is important to notice that an increase in maternal age and parity potentiate the risk of low birth weight in mothers who smoke (Spinillo et al., 1995). It is well known that smoking in pregnancy influences intrauterine growth and causes growth retardation. Children born to mothers who smoke are significantly lighter, and therefore have higher morbidity and mortality than children born to non-smoking mothers. Also, there is a correlation between the number of smoked cigarettes per day and the loss of newborn weight (Maruoka et al., 1998).

Socioeconomic status is also an important factor for delivering children with low birth weight, since it can modify the factors mentioned above. Prenatal care, which includes surveillance, diagnosis and treatment of the possible complications of pregnancy plays a significant role in lowering the number of newborns with low birth weight and thus lowers perinatal mortality (Drazancic et al., 1994). This is, again, more evident and has greater impact in the population of smoking pregnant women (Spinillo et al., 1995). Preventing pre-term deliveries, naturally, reduces the risk of the delivery of a hypothrophic newborn (Lippi et al., 1989). Maternal employment and low social class are further social factors that contribute to low birth weight (Levkoff et al., 1982); however, in the areas where there are efforts to remove the negative effects of these factors, this may not always be the case (Amin et al., 1993).

SUBJECTS AND METHODS

A group of 181 healthy pregnant women from Zagreb, Croatia, was examined to evaluate influence of maternal age, parity, pre-pregnancy weight, number of abortions, height and cigarette smoking on newborn weight and length, as well as to determine interrelation between these features. Only women resident in Zagreb, Croatia were included in the study to avoid potentially confusing cofounders that may emerge from differences in urban and rural populations.

Included were pregnant women who controlled their pregnancy in the Clinic. All subjects met following criteria: ab-sence of risk factors in their reproductive anamnesis, no oral contraceptives used 6 months prior to conception, neither should there have been any reasons for hospitalization, medication or reduction diet during pregnancy. Also, no signs of toxemia were allowed. All women gave vaginal birth to healthy newborns, after 38-41 weeks of gestation. Newborns had Apgar scores 7 or more in the first, and 10 in the fifth minute. All pregnancies studied were singleton. Women were chosen at random.

Maternal height was measured and the age was obtained from the admission records. Number of previous deliveries, abortions, body weight before pregnancy and the number of cigarettes smoked per day were taken from auto-anamnesis. Newborns were weighed and their length measured immediately after delivery. Maternal weight was expressed in kilograms (kg), whereas newborn weight was expressed in grams (gr.). Both maternal height and newborn length were expressed in centimeters (cm).

Women were grouped into four groups according to their age (Table 1) to test differences in observed features according to maternal age. Data were analyzed using multiple regression, correlation coefficients and one-way variance analysis. Value of p bellow 0.05 was taken to identify significance.

➲ TABLE 1
Variance analysis for pre-pregnancy weight, newborn weight and length according to maternal age

Age (years)	N	PPW (kg)		BW (grams)		BL (cm)	
		Mean	SD	Mean	SD	Mean	SD
≤19	14	58.857	3.820	3374.3	381.146	50.071	0.997
20-24	67	60.731	4.950	3533.4	338.636	50.612	0.953
25-29	76	61.124	6.157	3561.1	316.222	50.697	1.132
30-39	24	62.750	7.685	3380.4	381.809	50.000	1.383
F		1.431		2.599		3.398	
DF		3,177		3,177		3,177	
p		0.2325		0.0538		0.0191	

N = number of women in each group, PPW = maternal weight before conception, BW = newborn weight, BL = newborn length.

RESULTS

There were 14 newborns weighing between 2 560 and 2 999 grams. 74 newborns weighed between 3 000 and 3 499 grams and 82 weighed between 3 500 and 3 999. Eleven newborns weighed between 4 000 and 4 499 grams. Newborn length was between 48 and 53 cm; 95 were girls and 86 were boys.

Six variables in the model explained 35% of the infant weight variability and 27.2% of the infant height variability. Also, variables used in this research explained the most variability for the body length of male infants (r^2=43.57%) and the least variability for body length of female infants (r^2=23.72%).

Multiple regression showed that maternal age had no significant influence on newborn weight (p=0.920) and length (p=0.717). It's impact on newborn weight and length was also insignificant if viewed separately for male and female infants (p>0.05). No significant difference was found in newborn weight among four groups of mothers according to their age (F=2.599, DF=3,177, p=0.0538), even though it was evident that mothers younger than 20 and older than 30 years tend to have lighter children. However, the difference in newborn length between these groups was found to be significant (F=3.398, DF=3,177, p=0.0191), indicating that mothers younger than 20 and older than 30 also have shorter children (Table 1).

The number of previous deliveries showed to have no significant influence on either newborn weight or length (p>0.05). The same was found for male and female children when viewed separately. Also, variance analysis showed no difference in newborn weight (F=1.039, DF=2,178, p=0.356) and length (F=2.515, DF=2,178, p=0.084) among the three groups of mothers according to the number of previous deliveries.

There was no significant impact of the number of abortions on the weight of a child (multiple regression, p=0. 838). This impact was also insignificant among groups according to the gender of a child (p=0.414 for females and p=0.154 for males). The number of abortions also insignificantly determined newborn length (p=0.789).

Pre-pregnancy weight was found to have significant influence on newborn weight (p<0. 001) and length (p=0.003). Variance analysis showed no significant difference in maternal weight before pregnancy among groups according to their age (F=1.431, DF=3,177, p=0.235) (Table 1). If viewed separately, for male and female children, mothers who delivered male children had similar bodyweight before conception in four age groups (F=0.458, DF=3,82, p=0.712). In contrast, the average weight of women who were 35 years of age or older (N=4) was 71.3 kg. This can explain why the correlation coefficient between maternal age and pre-pregnancy weight was 0.214 (p<0.05)

for all women, and 0.105 ($p>0.05$) for women who gave birth to male newborns.

Correlation between maternal pre-pregnancy weight and the number of previous deliveries was 0.214 ($p<0.05$). Also, this correlation was significant for mothers of female children ($r=0.363$, $p<0.05$) and insignificant for mothers of male children ($r=0.028$, $p>0.05$).

The number of cigarettes smoked per day had a strong negative influence on both newborn weight and newborn length. Regression coefficient of -23.3394 ($p=0.000$) was found for the impact of smoking on child's bodyweight, and -0.0670 ($p=0.000$) for the influence of smoking on child's length. The influence of maternal smoking in pregnancy was greater on boys' weight (coeff=-27.2996, $p<0.001$) and length (coeff=-0.0964, $p<0.001$) than on girls' weight and length (coeff=-19.6387 for weight and coeff=-0.0426 for length, $p<0.05$).

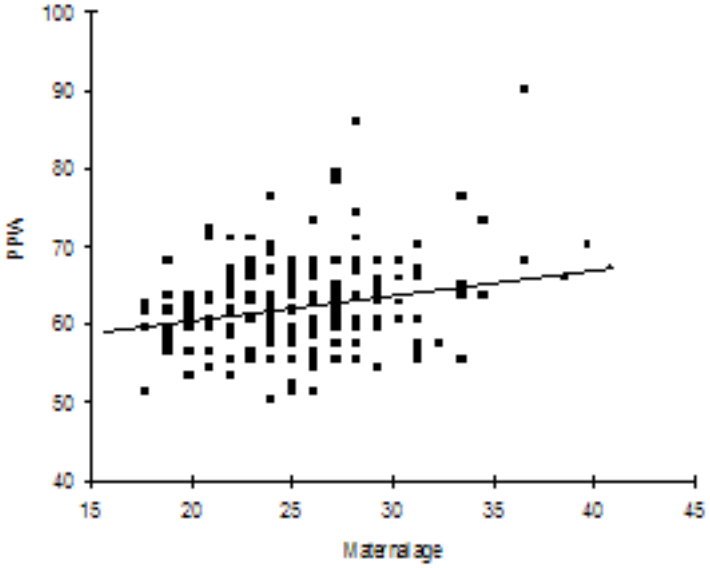
Smoking correlated significantly to the number of previous deliveries ($r=0.249$, $p<0.05$) and insignificantly to the number of abortions in women's anamneses ($r=0.059$, $p>0.05$). There was no significant difference in the number of cigarettes smoked per day among five groups according to maternal age ($F=1.048$, $DF=4,176$, $p=0.3839$).

No significant influence of maternal height on newborn weight ($p=0.597$) and length ($p=0.602$) was found using multiple regression when controlled for other variables in the system.

DISCUSION

Our results show that maternal age has no influence on newborn weight in the population of mothers between 18 and 39 years of age. This is in accordance with the findings of other authors since only age under 16 years is associated with lower birth weight, as well as the age of 35 or more (Drazancic et al., 1994). Sadenwasser et al. also found no correlation between maternal age and newborn weight in the group of 7 715 infants (Sedenwasser and Adomssent, 1986). Still, as can be seen in Table 1, in our study group, newborn weight was lower in mothers younger than 20 and older than 30 years of age, even though this difference was not significant. This may be due to four women older than 34 whose pre-pregnancy body weight was 71.3 kg and who all delivered female children with the average newborn weight of 3 652. 5 gr. Such results, therefore, require further research. However, maternal age did have a statistically significant influence on newborn length. Newborns who were born to mothers younger than 20 had about 6-7 mm shorter birth length than those of mothers between 20 and 30 years of age. The same was observed in the group of mothers older than 30 years, whose children were also 6-7 mm short-

er (Table 1). This research also showed that older mothers have greater pre-pregnancy weight, which is the better predictor of newborn weight (Figure 1).



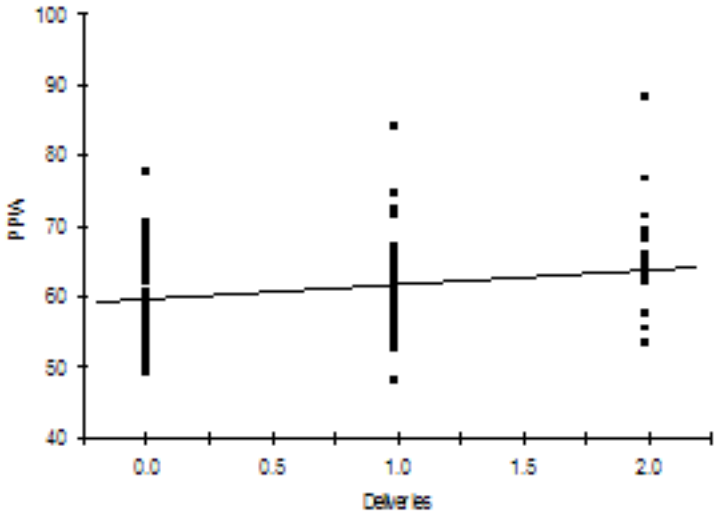
➲ FIGURE 1
Linear regression showing the increase in maternal pre-pregnancy weight (PPW) with maternal age

Children of primiparous women in our research had similar birth weight to the children of women with one or two previous deliveries (Table 2). These findings are quite opposite to what can be found in literature. Drazancic et al. (1994) found that the second child is about 200 grams heavier than the first one. Similar results were obtained by Seidman et al. (1988). Parazzini et al. (1991) examined centile curves on 1,200,000 births in Italy in the period of 1984-1985 and found that the value of the 50th centile was about 5% higher in women with three or more deliveries, when compared to women who had no previous deliveries. The same author observed that birth weight centiles were higher in older women, but that effect was smaller with a tendency of disappearance in gestations that lasted 36 weeks or more. A possible explanation for our results may be that the number of previous deliveries correlated significantly with the number of smoked cigarettes and pre-pregnancy weight, which may influence the results. Also, the theory of desensitization (Warburton and Nylor, 1971), claiming that the effect of parity on newborn weight is lost if children do not have the same father, may be the explanation. Our results indicate that maternal pre-pregnancy weight increases after each delivery, thus we believe it is maternal weight rather than parity that influences newborn weight (Figure 2). It is necessary, therefore, to perform further research, with special attention towards acquiring anamnestic data about children's fathers.

➲ TABLE 2
Variance analysis for newborn weight and length according to previous deliveries

		BW (grams)		BL (cm)	
PD	N	Mean	SD	Mean	SD
0	105	3527.1	344.478	50.6	1.067
1	54	3524.1	351.775	50.5	1.128
2	22	3413.6	313.195	50.0	1.253
F	1.039	2.515			
DF	2, 178	2, 178			
P	0.356	0.084			

PD = number of previous deliveries, N = number of women in each group, BW = newborn weight, BL = newborn length.



➲ FIGURE 2
Linear regression line showing the increase in maternal pre-pregnancy weight (PPW) with the number of previous deliveries

There are no consistent reports of on effect of previous abortions on newborn weight. There are observations that the history of abortions increased the risk of delivering infants weighing under 1500 grams, and that induced abortions were responsible for 9% of very low birth weight infants (Lumley, 1986). On the other hand, Mandelson et al. reported that the number of previous induced abortions had no effect on birth weight in the group of 6541 white women (Mandelson et al., 1992), and that the children of mothers with four or more induced abortions had similar risk of low birth weight to those of mothers with one or two abortions. The WHO Task Force on Sequelae of Abortion (1979) claims that effects of spontaneous abortions are the same to those of induced abortions. Bracken et al. found that two induced abortions did not increase the risk of low birth weight, and neither had influence on mean birth weight (Bracken et al., 1986). Authors suggest that this may be due to the fact that the abortion of the

first pregnancy prevents a decrease in low birth weight and an increase in mean birth weight in the second pregnancy. Levkoff et al. (1982) stated that abortion is the risk factor for very low but not for low birth weight. Since there were no children with birth weight under 2500 grams in our research, we can only say that in our research the number of abortions did not influence newborn weight of children. No conclusions about the influence of abortions on LBW (low birth weight) and VLBW (very low birth weight) infants can be drawn. We found no statistically significant difference in either newborn weight or newborn length among four groups of women according to the number of abortions, even though women with three previous abortions tend to have 212.6 grams lighter and 0. 6 cm shorter children (Table 3).

➲ TABLE 3
Variance analysis for newborn weight and length according to the number of abortions

		BW (grams)		BL (cm)	
AB	N	Mean	SD	Mean	SD
0	84	3532.6	372.8	50.6	1.2
1	59	3469.2	312.6	50.4	0.9
2	34	3560.3	273.2	50.6	1.0
3	4	3320.0	623.6	50.0	2.4
F	1.050	0.697			
DF	3, 177	3, 177			
p	0.3719	0.5548			

AB = number of previous abortions, N = number of women in each group, BW = newborn weight, BL = newborn length.

One should not overlook an interesting finding by Tan et al. (1990) who reported that first born children were 73.5 grams heavier if their mothers had induced abortions in anamnesis. If mothers had spontaneous abortions, first born children were 119.4 grams heavier. It is important, however, to analyze these findings with respect to maternal age. From our results (Table 1) it is evident that younger mothers have lighter children. It is obvious that if such juvenile mothers abort their first pregnancy, they are more likely to give the first birth when they are older and, thereby, heavier. With greater prepregnancy weight, newborn weight increases (Table 4).

Maternal pre-pregnancy weight significantly influenced newborn weight in our sample. This correlation is well known. Abrams and Laros (1986) found that body weight before pregnancy, expressed as body mass index, had significant influence on newborn weight, even more evident that the one of pregnancy weight gain (for obese women). Winikoff and Debrovner (1981) observed that different maternal variables influ-

ence the weight of a child. In mothers with low body weight for height the most significant factor was pregnancy weight gain. In mothers with intermediate weight for height it was the pre-pregnancy weight that influenced newborn weight. However, in mothers with high weight for height the outcome was best explained with maternal height.

A.	Coefficient	P value	Std Error	-95%	95%	t
Constant	2254,4	0,0001	569,60	1130,20	3378,60	3,958
Number of deliveries	-15,58	0,715	42,62	-99,70	68,53	-0,366
Number of abortions	-6,024	0,838	29,39	-64,03	51,98	-0,205
Maternal height	2,020	0,597	3,81	-5,51	9,55	0,530
Pre-pregnancy weight	17,69	<0,00005	4,28	9,25	26,13	4,138
Number of cigarettes smoked per day	-23,34	<0,00001	3,60	-30,44	-16,24	-6,489
Maternal age	-0,752	0,920	7,429	-15,42	13,91	-0,101
Source	SS	SS%	MS	F	F Signif	df
Regression	7,422e06	35	1,237e06	15,62	2,643e-14	6
Residual	1,378e07	65	79210,2			174
Total	2,120e07	100				180

B. Summary		
	|R|	0,592
	R^2	0,350
	R^2 adjusted	0,328
	Standard Error	281,44
	# Points	181
	Press	14886083,57
	R^2 for Prediction	0,298
	Durbin-Watson d	1,946
	First Order Autocorrelation	0,024
	Collinearity	0,260
	Coefficient of Variation	8,013

TABLE 4
Multiple linear regression for newborn weight (results of multiple regression for newborn weight as dependent variable on the sample of 181 women)

Voigt et al. (1989) examined connections between maternal age, parity, weight and height and their influence on birth weight. Both maternal weight and height were found to have considerable influence on birth weight, so that children born to equally tall mothers were heavier if maternal weight was greater. Furthermore, they found that maternal age, parity and weight were interconnected. Older mothers, naturally, had more deliveries. Also, women with previous deliveries were heavier than primiparous women at the same age. Average yearly increase in maternal weight was 401 grams. Thus, maternal weight indirectly contains a portion of information about both maternal age and parity. In addition, they consider maternal weight and height to be relatively equivalent factors influencing newborn weight. Our results also show that maternal parity and age both increase maternal weight which is, we consider, the mechanism of their influence on newborn weight.

Rossner and Ohlin (1990) reported that an increase in body weight was the most important factor in predicting birth weight, just before initial maternal weight. In women with body mass index above 24 kg/m2 newborn weight did not increase significantly with maternal weight.

Our findings that maternal height has no influence on newborn weight and length may be the result of it's high correlation with pre-pregnancy weight ($r=0.443$, $p<0.05$) which has a great influence on both newborn weight and length. Witter and Luke (1991) compared birth weight between two groups of mothers, according to their height. They found that the children born to mothers who were shorter were significantly lighter and shorter than children born to mothers who were taller. Also, children born to shorter women had their birth weight and birth length symmetrically reduced, so that there was no difference between infants' ponderal indexes between these two groups.

It is estimated that 20-40% of women smokes worldwide (Jaksic, 1989). Regardless the decrease of male-smokers, the number of female smokers is showing increase (Prebeg et al., 1993; Sturz, 1993). The fact that women are "catching up" with men has profound negative influence on newborn weight, and therefore, on public health. Smoking in pregnancy is the major cause of intrauterine growth retardation. The growth retardation is caused by hypoxemia in maternal and fetal blood and by vasoconstriction. Mothers who smoke give birth to children who are significantly lighter, thus having greater morbidity and mortality rates than children born to mothers who have never smoked. Correlation between the number of smoked cigarettes per day and the loss of newborn weight is strong and well-proven (Maruoka et al., 1998). Our results show that cigarette smoking is the most influential factor in predicting newborn weight among all other variables included in the model (Table 4). The reduction of birth weight and birth length was obvious, and present in both infant genders. This harmful effect can, however, be avoided. Most women start smoking because of curiosity, and the maintaining of this habit is severely influenced by commercials (Starcevic, 1998). Advertising cigarette smoking as an acceptable behavior, during the vulnerable period of secondary socialization, has increased the chance of being accepted by an adolescent. This habit will then be hardly given up.

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Faktori predviđanja u određivanju težine novorođenčadi

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Novija zapažanja da postoje sekularna odstupanja u težini i duljini novorođenčadi zahtijevaju stalnu provjeru, kao i vrijednosti koje na njih utječu.Stoga se ispitivao utjecaj majčine dobi, težine i visine, kao i broj prijašnjih poroda, abortusa te broj popušenih cigareta na dan, na težinu i duljinu novorođene djece.Podaci su prikupljani od 181 zdrave trudnice iz Zagreba, Hrvatske, koje su rodile zdravu novorođenčad u terminu.Izvedene su regresijska analiza, korelacija koeficijenata i analiza varijance kako bi se utvrdila značajnost provjeravanih varijabli na opažanim karakteristikama fetusa.Majčina dob ne utječe značajno na težinu novorođenog djeteta, premda su majke mlađe od dvadeset godina i starije od 30 sklone rađanju djece s manjom porođajnom težinom.Broj prijašnjih poroda kao i prekida trudnoće nije značajno povezan s težinom novorođenčeta. Međutim, broj dnevno popušenih cigareta tijekom trudnoće te težina majki prije trudnoće bile su značajno korelirane s težinom i duljinom novorođenog djeteta.Visina majki također je bila značajno povezana s težinom i duljinom djeteta, ali nakon regresijske analize, kontrolom ostalih parametara, nije zamijećen značajan utjecaj na djetetovu težinu.Ovi nalazi pokazuju da su prestanak pušenja i poboljšanje majčine prehrane (izražene u tjelesnoj težini) dva modificirajuća faktora koji imaju važnu ulogu u smanjivanju broja djece s niskom porođajnom tjelesnom težinom te tako smanjuju i perinatalni mortalitet.

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PREDICTIVE FACTORS...

Prädiktoren zur Gewichtsbestimmung bei Neugeborenen

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Jüngsten Beobachtungen zufolge gibt es unter Neugeborenen außerordentlich große Schwankungen in Körpergewicht und Größe. Dies wie auch die Umstände, die dazu führen, erfordern eine ständige Kontrolle. Die vorliegende Untersuchung galt daher den Auswirkungen, die das Alter der Mutter, deren Körpergewicht und Größe, die Zahl der früheren Geburten und Abtreibungen, die Zahl der pro Tag gerauchten Zigaretten auf das Körpergewicht und die Größe von Neugeborenen haben. Die ermittelten Angaben stammen von 181 Schwangeren aus Zagreb, Kroatien, die innerhalb des Geburtstermins gesunde Babys zur Welt brachten. Es wurden eine Regressionsanalyse, eine Koeffizienten-Korrelation und eine Varianzanalyse angewandt, um die Auswirkung der geprüften Variablen auf die an den Föten beobachteten Charakteristiken zu untersuchen. Das Gewicht des Neugeborenen wird nur unwesentlich durch das Alter der Mutter beeinflußt, auch wenn Frauen unter 20 sowie Frauen über 30 Jahren dazu neigen, Kinder mit geringerem Körpergewicht zu gebären. Ebensowenig steht die Zahl früherer Geburten und Schwangerschaftsabbrüche in einem wesentlichen Zusammenhang mit dem Körpergewicht des Neugeborenen. Dafür erwies sich jedoch, daß die tägliche Zahl der während der Schwangerschaft gerauchten Zigaretten sowie das Körpergewicht der Mutter vor der Schwangerschaft in wesentlichem Bezug zu Körpergewicht und Größe des Neugeborenen stehen. Dasselbe gilt für die Körpergröße der Mutter, doch konnte – nach angewandter Regressionsanalyse und einer Kontrolle der übrigen Parameter – kein ausschlaggebender Einfluß auf das Körpergewicht des Säuglings nachgewiesen werden. Diese Angaben zeigen, daß die Einstellung des Rauchens und eine verbesserte Ernährungsweise der Mutter (ausgedrückt im Körpergewicht) zwei modifizierende Faktoren darstellen, die nachhaltig dazu beitragen können, die Zahl der untergewichtigen Neugeborenen und somit das Ausmaß der Säuglingssterblichkeit einzudämmen.