Factors associated with birth weight in Sweden: the study of men born in 1913

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Abstract

Study objective – To analyse factors associated with birth weight and to evaluate the validity of obstetrical data.

Design – Obstetrical data were retrieved for singleton men born in 1913 and living in Gothenburg, Sweden in 1963. Information on birth weight, maternal age, marital status, parity, social class, proteinuria, gestational age, and place of birth (home or hospital) was obtained from these birth records.

Setting – Sweden.

Participants – Fifty year old men living in Gothenburg, Sweden, in 1963.

Main results – Obstetrical records were obtained for 524 men (65%). Place of birth, gestational age, maternal age, parity, proteinuria, and marital status were all significantly correlated to birth weight. In multivariate analyses, place of birth, gestational age, parity, and proteinuria influenced birth weight. There was a substantial difference in mean birth weight between hospital deliveries (3352 g) and home deliveries (3817 g), which could be explained only partly by sociodemographic variables. Birth weight increased with parity and gestational age in home delivered babies as well as those delivered in a hospital.

Conclusions – The validity of obstetrical records from 1913 was good. The place of birth (home or hospital) is strongly associated with birth weight and may be a confounding factor in studies of the implications of birth weight for future risk of disease or death.

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During the past decade Barker *et al* have published a number of investigations supporting the hypothesis that factors related to pregnancy have long term effects on the fetus which later may affect the risks for cardiovascular and malignant diseases. Low birth weight and a low weight increase during the first year have repeatedly been shown to be associated with increased risk of diseases later in life, especially cardiovascular disease.¹⁻⁴ However, this hypothesis has been questioned by others.^{5,6} Low birth weight is more common in the lower social classes, and it may be the effect of social class during a lifetime that predisposes to later diseases.^{7,8} There may thus be potential confounding bias in these types of analyses.

In this report a number of factors possibly associated with birth weight, and the validity

of data from obstetrical records, are presented for a cohort of men sampled from the general population of the city of Gothenburg, Sweden.

Study population and method

The study population is a cohort of Swedish men born in 1913 who have been followed up since 1963. The cohort has been described in detail elsewhere.⁹ In 1963, a systematic sample consisting of men born in 1913 on a day divisible by three (that is, the third, sixth, ninth day and so on of each month) and living in the city of Gothenburg at the age of 50 was drawn. Altogether 973 men fulfilled these criteria and were invited to participate in the study; 855 (88%) agreed to participate and were examined in 1963. The cohort has been re-examined five times (1967, 1973, 1980, 1988, and 1993) since then.

Forty four foreign-born men were excluded from this report since it was considered that it would be impossible to find their obstetrical records. For the remaining 811 men, information was retrieved by searching 200 national and local archives. Obstetrical data were obtained for 524 births (65%). After the exclusion of 12 twins from the obstetrical records obtained, 512 singleton births remained for analysis.

Data were obtained from two types of obstetrical records – case records from hospital deliveries and midwives' record books from home deliveries. In this way, information on maternal age, marital status, parity, birth weight, gestational age, and medical status of the mother and child during delivery was obtained. In addition, the urbanisation level of the birth parish and information on occupational status of the parents were derived from the birth registries or from the ministerial books or the catechetical examination books of the birth parishes.

Maternal age was defined as age at delivery. Parity was defined as number of previous births, including stillbirths, and was for this report dichotomised into those with no previous births and those with at least one previous birth. Gestational age was estimated from the mother's last menstrual period. Proteinuria was measured as no proteinuria, trace of protein, or definite proteinuria; for this report the latter two groups were pooled into a proteinuria group. The birth parishes were divided into urban or rural according to the official classification of urbanisation level in 1910.¹⁰ Information about social class was based primarily on the occupation of the child's father. If the parents were not married or not betrothed, the mother's occupation was used. Occupational status was then grouped ac-

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Table 1 Characteristics of those whose obstetric data were retrieved compared with those whose data were not retrieved

	Total no	Obstetric records retrieved				Obstetric records not retrieved				p value
		No	(%)	Mean	(SD)	No	(%)	Mean	(SD)	
1913										
Urbanisation level	811									<0.0001
Urban	382	324	(85)			58	(15)			
Rural	429	200	(47)			229	(53)			
Social class	787									<0.05
I	26	17	(65)			9	(35)			
II	126	90	(71)			36	(29)			
III	70	35	(50)			35	(50)			
IV	212	147	(69)			65	(31)			
V	353	227	(64)			126	(36)			
1963										
Social class	811									NS
I	79	49	(62)			30	(38)			
II	332	227	(68)			105	(32)			
IV	342	207	(61)			135	(39)			
V	58	41	(71)			17	(29)			
Smoking habits	811									NS
Never smoked	196	120	(61)			76	(39)			
Ex-smokers	158	109	(69)			49	(31)			
Smoking <14 g/d	424	272	(64)			152	(36)			
Smoking ≥ 15 g/d	33	23	(70)			10	(30)			
Yearly income (SEK)	783	513		17 064	(10 705)	279		17 190	(10 173)	NS
Blood pressure										
Systolic	811	524		138.8	(20.8)	287		137.0	(20.3)	NS
Diastolic	811	524		91.7	(13.5)	287		90.7	(12.1)	NS
Cholesterol (mg/100 ml)	811	524		247.4	(42.1)	287		246.9	(44.1)	NS
Triglyceride (mg/100 ml)	811	524		1.25	(0.69)	287		1.23	(0.73)	NS
Body mass index	808	522		24.7	(3.3)	286		24.8	(2.8)	NS
Total	811	524	(65)			287	(35)			

NS = not significant.

cording to a classification especially developed for this period of time.^{11,12} It has five main groups: (I) high white collar workers; (II) low white collar workers, including master artisans and craftsmen, shop workers, and foremen; (III) farmers and tenant farmers; (IV) skilled blue collar workers, including craftsmen and

artisans below the rank of masters; and (V) unskilled blue collar workers from urban or rural areas.

Obstetrical records were more often untraced in rural birth parishes than urban birth parishes (table 1). Moreover, among social class groups, farmers (social class III) had the highest rates of untraced obstetrical records. If the farmers' level was excluded there was no difference in the fathers' social status in 1913 between those whose records were found and those not found. In 1963, when the men in the cohort were 50 years old, there were no significant differences at all between the groups regarding social class, yearly income, and the traditional risk factors for cardiovascular diseases such as smoking habits, blood pressure, cholesterol, triglycerides, and body mass index.

Table 2 Mean (SD) birth weights according to maternal sociodemographic characteristics, proteinuria, gestational age, and place of birth

	No	(%)	Birth weight	
			Mean	(SD)
Maternal age (y)	21	(4)	3540	(803)
15–19	104	(22)	3582	(652)
20–24	127	(27)	3699	(534)
25–29	106	(22)	3851	(598)
30–34	83	(17)	3693	(613)
40–49	32	(7)	3913	(501)
Missing	5	(1)	3742	(799)
Marital status				
Married	401	(84)	3760	(606)
Unmarried	68	(14)	3473	(601)
Missing	9	(2)	3512	(263)
Parity at delivery				
No children	123	(26)	3405	(574)
≥ 1 child	336	(70)	3820	(590)
Missing	19	(4)	3848	(485)
Social class				
I	14	(3)	3631	(778)
II	82	(17)	3683	(570)
III	32	(7)	3809	(579)
IV	134	(28)	3712	(635)
V	209	(44)	3708	(595)
Missing	7	(2)	4026	(816)
Proteinuria				
No	387	(81)	3732	(617)
Yes	61	(13)	3542	(569)
Missing	30	(6)	3841	(534)
Urbanisation level				
Urban	295	(62)	3710	(616)
Rural	183	(38)	3720	(599)
Place of birth				
Home deliveries	372	(78)	3817	(592)
Hospital deliveries	106	(22)	3352	(528)
Missing	0			
Gestational age (quartiles)				
≥ 273 (1)	110	(23)	3448	(636)
274–288 (2–3)	229	(48)	3776	(555)
> 288 (4)	94	(20)	3877	(515)
Missing	45	(9)	3710	(780)
Total	478	(100)	3714	(609)

STATISTICAL ANALYSIS

Summary statistics were computed using standard methods. The univariate analyses were conducted with *JMMP* software release 3.02.¹³ Other data analyses were conducted with *SAS* software release 6.07.¹⁴

For the correlation analyses, Spearman's non-parametric correlation coefficients were computed. Multivariate analyses were performed with the multiple logistic or linear regression technique. The isotonic regression technique was used to construct the regression surface of figure 2. All tests were two tailed. Probability values less than 0.05 were regarded as statistically significant. Very small p values were denoted <0.0001.

Results

The mean maternal age at delivery (SD) was 29.5 (6.3) years. Only 4% of the mothers were teenagers and 24% were 35 years old or older

Table 3 Correlation matrix of variables possibly correlated to birth weight. *r* = correlation coefficient and *p* = the corresponding *p* value

		Birth weight	Maternal age	Marital status	Parity	Social class	Proteinuria	Gestational age	Urban level
Maternal age	<i>r</i>	0.137							
	<i>p</i>	0.0028							
Marital status (married = 1; unmarried = 2)	<i>r</i>	-0.160	-0.386						
	<i>p</i>	0.0005	0.0001						
Parity (no children = 0; ≥ 1 = 1)	<i>r</i>	0.301	0.454	-0.263					
	<i>p</i>	0.0001	0.0001	0.0001					
Social class (I-V)	<i>r</i>	0.009	-0.100	0.157	0.020				
	<i>p</i>	0.8523	0.0255	0.0005	0.6694				
Proteinuria (no = 0; yes = 1)	<i>r</i>	-0.111	-0.016	0.008	0.001	0.104			
	<i>p</i>	0.0184	0.7234	0.8658	0.9833	0.0247			
Gestational age	<i>r</i>	0.255	0.068	-0.133	0.079	-0.036	0.007		
	<i>p</i>	0.0001	0.1518	0.0048	0.1022	0.4504	0.8856		
Urbanisation level (urban = 1; rural = 2)	<i>r</i>	0.040	0.024	-0.118	0.007	-0.016	0.032	-0.047	
	<i>p</i>	0.3819	0.5912	0.0078	0.8756	0.7156	0.4841	0.3160	
Place of birth (home = 1; hospital = 2)	<i>r</i>	-0.324	-0.253	0.397	-0.262	0.116	0.090	-0.100	-0.231
	<i>p</i>	0.0001	0.0001	0.0001	0.0001	0.0090	0.0519	0.0323	0.0001

(table 2). Eighty four per cent of the mothers were married and 14% were single. Twenty six per cent gave birth for the first time. Nearly three out of four were from social classes III or IV. Thirteen per cent had proteinuria or traces of proteinuria. Sixty two per cent were born in urban parishes and 38% in rural ones. Seventy eight per cent were delivered at home and 22% in a hospital. The mean (SD) gestational age at delivery was 280 (15) days. Mean birth weight was 3714 (609) g.

Mean birth weight increased with maternal age up to the age group 30 to 34 years. Compared with infants of unmarried mothers, infants whose mothers were married had higher birth weights. Mean birth weights were higher among offspring of parous women than of nulliparous women, increased with gestational age, and decreased with the presence of proteinuria. The mean birth weight of infants delivered at

home exceeded the mean birth weight of infants delivered in hospital by 465 g. There was no difference in the mean birth weights of babies born in urban and rural parishes. No obvious association between social class and mean birth weight was found.

In table 3 a correlation matrix of variables possibly correlated to birth weight is shown. Maternal age, marital status, parity, proteinuria, gestational age, and place of birth were all significantly correlated to birth weight, whereas social class and the urbanisation level were not. Maternal sociodemographic characteristics such as age, marital status, parity, and social class were all significantly correlated to place of birth, and so was the urban/rural level. Compared with mothers delivered at home, mothers delivered in a hospital tended to be younger and were more often from lower social classes, unmarried and nulliparous.

The birth weight distribution of home and hospital deliveries is illustrated in figure 1. Compared with hospital deliveries, the birth weight distribution of home deliveries was shifted to the right. Most of the children with low birth weights were born in a hospital and nearly all of the children with heavy weights were born at home.

To see if the weight difference could be due to measurement bias, an analysis of the accuracy of birth weight notations was done. The various levels of notational exactness are indicated in table 4. In all hospital deliveries, birth weights were noted in grams, while in home deliveries several levels of exactness were used. When home delivery birth weights noted in grams were used, the difference in birth weight between infants born at home and in hospital remained (409 g). In addition, home delivery birth weights with a more imprecise notation were consistently higher than birth weights in hospital deliveries.

To see if the variables that were related to birth weight in univariate analyses were independently correlated to birth weight, a multiple regression analysis was performed (table 5). Place of birth, gestational age, parity, and proteinuria remained significantly and independently correlated to birth weight, whereas maternal age and marital status were not.

The combined impact of the variables place of birth, parity, and gestational age on birth

Figure 1 Distribution of birth weight (g) for hospital and home delivered babies in the study of men born in 1913, Sweden.

Table 4 Birth weights in hospital and home deliveries in relation to the exactness of notation

	Hospital deliveries		Home deliveries	
	Birth weight	No	Birth weight	No
Birth weight in g	3352	106	3761	127
Birth weight in kg with one decimal			3785	68
Birth weight in quarter kg			3866	69
Birth weight in kg			3870	92
Other birth weight notations			3888	16
Missing information		5		29

Table 5 Stepwise multiple regression analyses with birth weight (g) as the dependent variable.

	Regression coefficient	Partial (%)	In the model (%)	p value
Place of birth	-332.79	10.58	10.58	<0.0001
Gestational age	10.06	6.70	17.27	<0.0001
Parity	263.41	3.71	20.98	<0.0001
Proteinuria	-164.35	0.86	21.85	<0.05
Maternal age				NS
Marital status				NS
Total model			21.97	

NS = not significant

Figure 2 Birth weight in relation to place of birth, parity, and gestational age in the study of men born in 1913, Sweden.

weight is shown in figure 2. The smallest babies were those who were born in a hospital, who were their mothers' first child, and whose gestational period was estimated to be 272 days or less (2975 g). At the opposite extreme were babies born at home, whose mothers had given birth before, and whose gestational age was estimated to be more than 288 days (3986 g).

Discussion

Birth weight has been described as a biological marker for complex processes during the uterine period. It may be influenced by socio-demographic factors or nutritional intake before or during pregnancy, which may result in lasting effects on health later in life.^{4,15-17} Birth weight analyses may therefore contribute to our understanding of the natural history of these conditions.

However, before amalgamating the obstetrical data with our cohort data from 1963-93 for testing the programming idea,¹ it is important to test the quality and representativeness of the obstetrical data obtained.

The analysis of table 1 showed that those for whom the obstetrical data could be retrieved (65%) did not differ from those with untraced obstetrical records in any way that would give us reason to believe that the results might be

biased, since urbanisation level and social class were not significantly correlated to birth weight (table 3).

Obstetrical records from 1913 proved to be of good validity. Factors well known to influence birth weight in modern studies also influenced birth weight in the present investigation. For example, the increase in birth weight with gestational age is very similar to that reported in studies using more recent data.^{18,19} The birth weight decrease related to proteinuria has also been confirmed in other studies.^{20,21} The mean birth weight difference between infants with parous and nulliparous mothers was of a larger magnitude than obtained in investigations using data from more recent deliveries.^{22,23} However, although of less magnitude, the parity related increase in birth weight continues after the second birth.²⁴ Compared with the present, mean parity was generally higher in Sweden 80 years ago, which may be one explanation for the relatively high birth weight difference obtained in infants with parous and nulliparous mothers.

The high mean birth weight (3714 g) was obtained from a cohort of survivors of men at 50 years and cannot be compared with the mean birth weight of newborns. Boys have higher birth weight than girls and the mean birth weight was probably also influenced by the loss of those who died before 50 years of age.

The birth weight difference between children born inside and outside hospital was surprisingly large, although it was reduced when the influence of other factors was taken into account. In spite of the fact that birth weight measurements were more imprecise among home deliveries, the data in table 4 indicate that the birthweight difference is unlikely to be due to measurement diversities.

Recall bias or other notational errors may also have influenced the differences in birth weight between hospital and home deliveries. The midwives' record books, used in home deliveries, were altered from 1912 and were the same all over Sweden. The midwife received the book from the general practitioner (GP). When it was full, or the midwife moved, it was to be returned to the GP. On the first pages of each book it was pointed out that she must note all requested information from all deliveries immediately. The new book was therefore easy to use and conveniently sized to fit into the pocket of the midwife's apron. These circumstances have most certainly contributed to the validity of the obstetrical data.

Another possible explanation for the birth weight differences might be a difference in midwifery competence between those working in a hospital and those working in the community. However, all midwives were required to have formal education. In Sweden, the dramatic decline in maternal mortality in the late 19th century has primarily been attributed to the modern training of midwives and the introduction of antisepsis.²⁵ A Swedish law in 1913 stipulated that there was to be at least one midwife in each parish, which was the smallest administrative unit. One of the two schools in Sweden for training midwives was

located in Gothenburg. All hospital births in this area took place in the hospital to which the school was affiliated. Thus, the improved quality of midwifery education also influenced the quality of home deliveries. The midwives were supervised by the local GP. The supervision was documented in specially kept conduct books, which are still available. From the notes in these books, it is possible to evaluate the skills and performance of individual midwives at the time. The GPs seemed to be generally satisfied with the midwives.

A fourth possible explanation for the differences in birth weight between hospital and home deliveries could be selective retrieval of birth records. The hospital records were filed in a uniform manner and were therefore relatively easy to find. Records from home deliveries, on the other hand, are stored in many different types of archives and some records have been lost, especially in the countryside. This has led to better retrieval of birth data from urban parishes ($p < 0.0001$). But when the midwives record books from home deliveries had been well archived, the drop outs were few. Most of the records not found were from areas where the whole archives were lost. As the mean birth weight for both urban and rural parishes was equal, selective retrieval of birth records is unlikely to have influenced the differences in birth weight between hospital and home deliveries.

The hospital-home birth weight difference is also found in English studies. In studies from Hertfordshire, England, including mostly home deliveries from 1911–30, the mean birth weights were around 3600 g for those who were alive at 20 years of age, compared with 3817 g in our study.^{215 26} In Sheffield, England, in a study that included only hospital deliveries from 1907–24, the mean birth weight for survivors was 3311 g (compared with 3352 g in our study).²⁷ Thus, in these English studies the birth weight difference between home and hospital deliveries was 290 g, which is less than the birth weight difference obtained in the present study (465 g).

The cause of the hospital-home birth weight difference, which remained after controlling for possible confounding factors, is unclear. It may reflect differences in socioeconomic or demographic factors other than those controlled for in the present study. In the English studies, as well as in the present one, the better off women were more often delivered at home.¹⁷ According to the Public Health Committee of Gothenburg in 1916, women could be delivered inside a hospital free of charge while those delivered at home often, if possible, payed some part of the midwifery commitment – this involved checking up the mothers and the newborns sometimes during the following three weeks.

An ideal study design for investigating the importance of birth weight for future health would be a population based cohort study in which the cohort is followed from birth to death with repeated examinations.^{5 28} No such study exists, but one is in the course of preparation. This is even more necessary since it has been

suggested that a redeeming factor, perhaps a conventional risk factor, adds to the effect caused by low birthweight instability.^{1 3 29}

In conclusion, there are reasons to believe that the obstetrical data from 1913 are reasonably valid, that there are no obvious selection biases, and that the hospital-home birthweight difference seems to be real.

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