

Neonatal Birth Weight Variations between Inland and Littoral Croatia

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ABSTRACT

The aim of the study was to assess neonatal birth weight (BW) differences between inland and littoral Croatia, to identify BW groups with most pronounced differences, and possible variations in the rate of BW ≥4000 g between Šibenik area and the rest of littoral (counties with access to the Adriatic Sea) and inland Croatia. The study included data on 99.42% of 200,740 live births recorded in 37 Croatian maternity hospitals during the 2001–2005 period. Distribution of 500-g BW groups was analyzed irrespective of neonatal sex and gestational age. Differences were found between the inland and littoral parts of Croatia according to distribution of the BW groups of <2500 g (5.4% vs. 4.4%), 2500–3999 g (84% vs. 80.2%) and ≥4000 g (10.6% vs. 15.4%) ($\chi^2=882$; $p<0.001$). The highest rate of BW ≥4000 g was recorded in Šibenik-Knin County (5-year mean 18.32%) and was greater throughout the littoral as compared with inland Croatia (5-year mean 14.99% vs. 9.58%). A shift towards higher BW groups recorded throughout littoral as compared with inland Croatia supports the hypothesis on variation in anthropologic characteristics in the respective populations to be pronounced as early as at birth. Study results confirmed fetal macrosomia not to be exclusively characteristic of Šibenik-Knin County, since the rate of neonatal BW ≥4000 g was significantly higher in the entire littoral as compared with inland Croatia.

Key words: birth weight, growth, child development, infant, child, Croatia

Introduction

Birth weight is a resultant of individual and reciprocal hereditary influences and numerous environmental factors, and represents one of the basic anthropometric characteristics of the population observed. In the majority of newborns, birth weight ranges from 2500 to 3999 g¹. Birth weight data are of major relevance for both the individual and the community, providing an insight into the efficiency of prenatal and maternal care², and valuable information for timely screening of high risk neonates^{3,4}. Due attention is paid to low birth weight and excessive birth weight newborns, not only because of their specific neonatal morbidity and mortality⁵, but also for their susceptibility to cardiovascular and metabolic diseases later in life^{6,7}.

In most countries, the rate of neonatal low birth weight is 5%–8%⁸. The rate of neonatal birth weight ≥4000 g in normal pregnant women (fetal macrosomia)

ranges from 3.4%⁹ to 14.5%¹⁰ in different settings and ethnic groups. Results of studies previously conducted in Croatia point to the presence of fetal macrosomia in some towns on the Adriatic coast, e.g., 20.3% in Šibenik¹¹ and 17% in Trogir¹².

The aim of the present study was to assess the existence of neonatal birth weight variation between the inland and littoral parts of Croatia and to identify the neonatal birth weight groups with most pronounced differences. Another aim was to determine whether Šibenik area differed from the rest of littoral and inland Croatia according to the rate of neonatal birth weight ≥4000 g.

The study hypothesis was that the Mediterranean area differs from the inland parts of Croatia according to the population anthropologic characteristics, which can be recorded as early as at birth by analysis of neonatal birth weight.

Subjects and Methods

During the 2001–2005 period, a total of 200,740 live births were recorded in 37 Croatian maternity hospitals. The study included 99.42% (N=199,570) of total live births recorded during the 5-year period because birth weight was unknown in 1170 (0.58%) newborns. Data on neonatal birth weight were obtained from the routine health statistics survey (individual delivery reporting) performed by the National Institute of Public Health in line with the National Program of Statistical Surveys¹³.

Birth weight is the neonate's weight measured within the first hour of life¹⁴. Birth weight variations between inland and littoral Croatia were analyzed according to 500 g weight groups irrespective of gestational age and neonate sex. Based on the neonatal birth weight, newborns were further divided into three main groups: low birth weight (<2500 g), birth weight 2500–4000 g, and excessive birth weight \geq 4000 g¹⁵. In addition, the mean 5-year rate of neonatal birth weight \geq 4000 g was analyzed in Šibenik-Knin County and in all other counties from littoral and inland Croatia.

Data on inland Croatia included newborns from the following counties: Krapina-Zagorje, Sisak-Moslavina, Karlovac, Varaždin, Koprivnica-Križevci, Bjelovar-Bilogora, Virovitica-Podravina, Požega-Slavonia, Brod-Posavina, Osijek-Baranya, Vukovar-Srijem, Međimurje, City of Zagreb, and Zagreb County. Data on littoral Croatia included newborns from the counties with access to the Adriatic (Mediterranean) Sea: Primorje-Gorski kotar, Lika-

-Senj, Zadar, Split-Dalmatia, Istria, Dubrovnik-Neretva, and Šibenik-Knin.

During the 2001–2005 period, 63,930 children were born in littoral areas and 135,640 in inland areas of Croatia. The 5-year period of observation offered the possibility of predicting the birth weight pattern in the two different geographic areas. The influence of war and post-war poor socioeconomic conditions on neonatal birth weight should have been less pronounced in 2000 than in the 1991–2000 period burdened by massive population migration that considerably reflected on the neonatal birth weight variation in the population of Croatia¹⁶.

Statistics

Results were expressed as absolute and relative frequencies. Differences in neonatal birth weight groups between the two geographic areas were assessed by χ^2 -test. Statistical significance was set at $p < 0.05$.

Results

During the 5-year study period, a mean of 82.8% (n=165,250) of newborns with birth weight 2500–3999 g, 12.15% (n=24,246) with birth weight >4000 g and 5.05% (n=10,074) with birth weight <2500 g were recorded in Croatia as a whole. Statistically significant differences were found between the inland and littoral parts of Croatia according to distribution of the neonatal birth weight groups of <2500 g (5.4% vs. 4.4%), 2500–3999 g (84% vs. 80.2%) and >4000 g (10.6% vs. 15.4%) ($\chi^2=882$;

TABLE 1
DISTRIBUTION OF NEWBORNS (%) ACCORDING TO 500-GRAMME BIRTH WEIGHT GROUPS IN LITTORAL AND INLAND CROATIA DURING THE 2001-2005 PERIOD

Year	Neonatal birth weight groups (gramme)										n	$(\chi^2)p$
	500–999	1000–1499	1500–1999	2000–2499	2500–2999	3000–3499	3500–3999	4000–4499	4500–4999	5000–5499		
2001												(619)
Littoral	0.3	0.4	0.8	2.5	11.4	34.0	35.4	12.5	2.4	0.2	12.191	<0.001
Inland	0.2	0.4	1.1	3.7	16.1	38.6	30.2	8.4	1.2	0.1	25.808	
2002												(108)
Littoral	0.3	0.4	1.1	3.0	11.3	33.7	34.5	13.2	2.1	0.3	12.576	<0.001
Inland	0.2	0.5	1.1	4.1	15.2	38.1	30.7	8.8	1.2	0.1	27.060	
2003												(354)
Littoral	0.3	0.3	0.9	3.0	11.8	34.0	34.5	13.1	2.0	0.2	12.526	<0.001
Inland	0.2	0.5	1.0	3.6	15.6	38.2	30.1	9.4	1.2	0.1	26.623	
2004												(348)
Littoral	0.3	0.4	0.9	2.7	11.2	33.3	35.2	13.6	2.1	0.2	13.172	<0.001
Inland	0.3	0.5	1.0	3.4	14.5	37.9	31.3	9.7	1.3	0.1	27.294	
2005												(313)
Littoral	0.3	0.4	0.7	2.7	12.0	33.0	35.8	12.7	2.3	0.2	13.465	<0.001
Inland	0.2	0.5	1.0	3.3	14.7	37.4	31.6	9.7	1.3	0.1	28.855	

Littoral=parts of Croatia with access to the Adriatic Sea (synonyms: southern Croatia, Mediterranean parts of Croatia)

Inland=landlocked parts of Croatia (synonym: inland Croatia)

p=level of significance

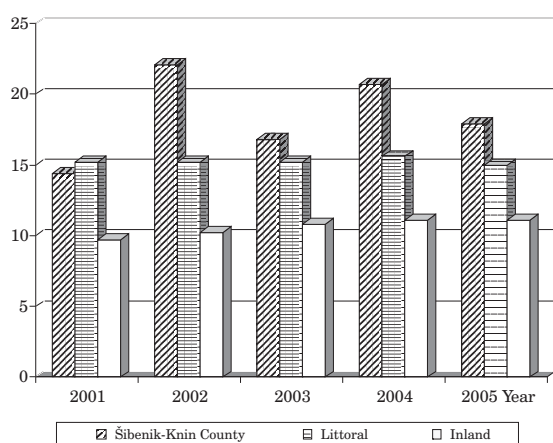


Fig. 1. The rate of neonatal birth weight ≥ 4000 gramme in Šibenik-Knin county versus other littoral and inland regions of Croatia during the 2001–2005 period.

$p < 0.001$). The distribution of 500 g groups showed steady and uniform differences throughout the study period (Table 1). The proportion of neonatal birth weight

3000–3499 g was highest in inland parts (5-year mean 38.4%), and of 3500–3999 g in littoral parts (5-year mean 35.08%) of Croatia. The rate of neonatal birth weight 4000–4499 was higher in littoral *versus* inland Croatia (5-year mean 13.02% *vs.* 9.2%), the same pattern being recorded for the 4500–4999 g and ≥ 5000 g birth weight (5-year mean 2.18% *vs.* 1.24% and 0.22% *vs.* 0.1%, respectively). The rate of neonatal birth weight 1500–1999 g and 2000–2499 g was greater in inland as compared with littoral parts of Croatia (5-year mean 1.04% *vs.* 0.84% and 3.62% *vs.* 2.78%, respectively). The difference was especially pronounced in the 2500–2999 g birth weight group, with a 5-year mean of 15.22% in inland and 11.54% in littoral Croatia.

The highest rate of neonatal birth weight > 4000 g was recorded in Šibenik-Knin County (5-year mean 18.32%) (Table 2). During the 5-year study period, the number of newborns with birth weight exceeding 4000 g recorded in this county was significantly greater in comparison with other littoral and inland Croatian counties (Figure 1). Also, the proportion of newborns with birth weight ≥ 4000 g was higher in littoral parts than in inland parts of Croatia (5-year mean 14.99% *vs.* 9.58%).

TABLE 2
MEAN 5-YEAR RATES OF NEONATAL BIRTH WEIGHT < 2500 GRAMME, 2500–3999 GRAMME AND ≥ 4000 GRAMME IN INLAND AND LITTORAL COUNTRIES OF CROATIA DURING THE 2001–2005 PERIOD

	Birth weight groups (gramme)							
	500–2499		2500–3999		≥ 4000		Total	
	n	%	n	%	n	%	n	%
Inland counties								
Krapina-Zagorje	224	5.01	3885	86.89	362	8.10	4471	2.24
Sisak-Moslavina	199	3.97	4416	88.11	397	7.92	5012	2.51
Karlovac	237	4.34	4705	86.22	515	9.44	5457	2.73
Varaždin	444	5.40	7118	86.63	655	7.97	8217	4.12
Koprivnica-Križevci	245	4.39	4829	86.43	513	9.18	5587	2.80
Bjelovar-Bilogora	226	5.91	3222	84.26	376	9.83	3824	1.92
Virovitica-Podravina	206	5.06	3520	86.53	342	8.41	4068	2.04
Požega-Slavonia	240	3.79	5459	86.14	638	10.07	6337	3.18
Brod-Posavina	313	3.56	7489	85.09	999	11.35	8801	4.41
Osijek-Baranya	1023	6.61	12930	83.49	1533	9.90	15486	7.76
Vukovar-Srijem	312	3.51	7541	84.82	1038	11.67	8891	4.46
Međimurje	295	4.93	5176	86.48	514	8.59	5985	3.00
City of Zagreb and Zagreb County	3327	6.22	43688	81.65	6489	12.13	53504	26.81
Littoral counties								
Primorje-Gorski kotar	663	5.02	10819	81.89	1729	13.09	13211	6.62
Lika-Senj	49	3.60	1146	84.14	167	12.26	1362	0.68
Zadar	360	4.58	6431	81.87	1064	13.55	7855	3.94
Split-Dalmatia	1179	4.72	19550	78.24	4257	17.04	24986	12.52
Istria	266	4.07	5307	81.11	970	14.83	6543	3.28
Dubrovnik-Neretva	168	2.94	4635	81.17	907	15.88	5710	2.86
Šibenik-Knin	98	2.30	3384	79.38	781	18.32	4263	2.14
Total Croatia	10074	5.05	165250	82.80	24246	12.15	199570	100.00

Discussion

Study results revealed significant variations between the littoral and inland parts of Croatia according to neonatal birth weight distribution. The overall birth weight distribution according to 500-g groups showed a right shift towards higher weight groups, whereas a left shift towards lower weight groups was recorded in the inland regions of Croatia. Differences were especially pronounced in >3500 g and <3000 g birth weight groups.

Growth is dependent on hereditary and environmental factors and their interactions. The values of birth weight may be analyzed as part of the process of aging, considering the complexity of mechanisms such as genetic and environmental factors involved in its regulation¹⁷. The identification of genes that regulate human height would greatly enhance our understanding of human growth¹⁸. Epidemiological studies have shown that genetic factors account for 38%–80% of birth weight variance¹⁹. The value of birth weight may be the result of some nucleotide polymorphisms as in other anthropometric traits^{20,21}. Environmental factors may relate to maternal pregnancy physiology and longer-term maternal phenotype, while genetic factors may relate to ethnicity, body size, or specific polymorphisms, and their influence may be mediated by multigenerational effects counterbalanced by within-lifetime plasticity²².

However, the present study was primarily focused on the anthropologic aspect of the birth weight variations observed. This systematic analysis of the neonatal birth weight distribution in the inland and littoral regions of Croatia was undertaken in continuation to the previously published results of local birth weight studies conducted in Šibenik¹¹, Zagreb²³ and Split²⁴, and in some other Mediterranean countries^{25,26}. According to Miletić et al., ethnically predetermined anthropometric characteristics of parents, especially mothers, have an impact on the birth weight of their newborns²⁷. Increases in maternal anthropometry, reduced cigarette smoking, and changes in socio demographic factors have led to an increase in the weight of infants born at or after term²⁸. Significant variations in anthropometric characteristics were found between the population of Morocco and native Catalanian population²⁵. Birth weight and birth length were found to show independent positive correlation with height and BMI²⁹. Prebeg demonstrated the children aged 7–10 years from the northern (inland) parts of Croatia to be by 5–6 cm shorter than their peers from Dalmatia³⁰. These results and the presented neonatal birth weight shift towards higher birth weight groups in the entire littoral region as compared with the inland parts of Croatia support the hypothesis on differences in anthropologic characteristics between the two populations. Differences in the neonatal birth weight distribution between the littoral and inland regions of Croatia may be underlain by different interactions of hereditary features related to parents and socioeconomic factors from their environment. Neonatal birth weight is greatly influenced by the parental ethnicity and anthropometric characteristics²⁷. According to Martin et al., maternal

body height during her childhood is significantly associated with her child's neonatal birth weight³¹. Johnston et al. demonstrated strong familial trends in birth size with a significant correlation between parental birth weight and birth weight in index cases¹⁹. A British nationwide study with follow-up of three generations suggested a potentially significant intergenerational association with neonatal birth weight³¹. Wilcox et al. explain the impact of paternal body height on his child's birth weight by the inherited potential of skeletal development³². The higher rate of greater neonatal body weight recorded not only in Šibenik area but also all over the littoral region of Croatia may be favored by the presence of favorable environmental factors in the area, along with ethnically predisposed parental, in particular maternal anthropometric characteristics²⁷. Coastal areas and the City of Zagreb had a significantly lower prevalence of unhealthy dietary habits³³. Since good socioeconomic conditions are associated with proper diet and good medical care of pregnant women, they are important for appropriate growth of infants, and thereby for appropriate birth weight of live born babies³⁴. In addition, the traditional diet of the population, and hence of pregnant women, in combination with culturally less common cigarette smoking and drinking of spirited beverages in the course of pregnancy could have a favorable effect on the delivery of children belonging to heavier weight groups³⁵.

According to the Croatian Society of Perinatal Medicine recommendation, newborns with the expected birth weight of <1800 g predicted by prenatal monitoring should be delivered at maternity wards with intensive neonatal care units³⁶. The value of these units was in part confirmed by the present study results. However, it should be noted that the proportion of low birth weight newborns was higher in inland regional hospitals as compared with littoral regional hospitals (City of Zagreb and Zagreb County 6.22%, Osijek-Baranya County 6.61% vs. Primorje-Gorski kotar County 5.02% and Split-Dalmatia County 4.72%). The lowest proportion of neonatal birth weight <2500 g was recorded in Šibenik-Knin County (2.3%), where fetal macrosomia was most common (18.32%).

Neonatal birth weight is influenced by hereditary factors, maternal nutritional and health status before and during pregnancy, parity, and neonatal sex, which should be taken in consideration on epidemiological and especially clinical analysis of neonatal birth weight.

The present study suffered from some limitations related to the centralized method of data collection from maternity wards, where systematic data on pregnancy pathology, multiple pregnancies, parity, gestational age, newborn sex, and parental anthropometric and social characteristics were incomplete until 2005. These data are needed for clinical but not necessarily for anthropologic interpretation of the neonatal birth weight. In this study we could not analyze the impact of environmental pollution on birth weight, but there is a difference in the existing industrial facilities between inland and littoral Croatia with greater burden in the inland

part. Recent epidemiological studies addressed environmental chemicals such as polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans and polychlorinated biphenyls in regard to genetic susceptibility and birth weight³⁷. The environmental-genetic impact on birth weight in different parts of Croatia remain to be investigated in future studies.

Conclusion

Our study results support the hypothesis on differences in anthropometric characteristics between the populations of inland and littoral regions of Croatia,

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which are pronounced as early as at birth. In littoral Croatia, the rate of high neonatal birth weight significantly exceeds the rate recorded in inland Croatia. In addition, our study results revealed fetal macrosomia not to be a phenomenon exclusively confined to Šibenik-Knin County; the more so, the rate of neonatal birth weight >4000 g was significantly higher throughout the other littoral regions as compared with inland Croatia. The results obtained point to the need of additional studies of anthropologic and ethnic variations in the populations observed, also including socioeconomic variables, respective lifestyle and other environmental factors, in order to identify the factors contributing most to differences between the two geographically different regions of Croatia.

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VARIJABILNOST PORODNIH MASA IZMEĐU PRIOBALNOG I KONTINENTALNOG DIJELA HRVATSKE

SAŽETAK

Ciljevi studije su utvrditi razlike vrijednosti porodne mase (BW) između priobalnog i kontinentalnog dijela Hrvatske, utvrditi u kojim su težinskim skupinama razlike najizrazitije, analizirati razliku u se Šibensko-kninska županija u odnosu na ostali priobalni i kontinentalni dio Hrvatske po udjelu BW ≥ 4000 grama. Istraživanjem je obuhvaćeno 99,42% od ukupno 200,740 novorođenih u 37 hrvatskih rodilišta u razdoblju od 2001 do 2005. godine. Raspodjela BW u kontinentalnom i priobalnom dijelu Hrvatske (županije s izlazom na Jadransko more) analizirane su u 500 gramskim težinskim skupinama, neovisno o gestacijskoj dobi i spolu novorođenčeta. Kontinentalni i priobalni dio razlikuje

se po raspodjeli BW<2500 grama (5,4% naprema 4,4%), 2500-3999 grama (84% naprema 80,2%) i ≥4000 (10,6% naprema 15,4%) ($\chi^2=882$; $p<0,001$). Najveća učestalost BW≥4000 grama je u Šibensko-kninskoj županiji (petogodišnji prosjek 18,32%), ali je njihov udio veći i u preostalom priobalju u odnosu na kontinentalni dio Hrvatske (petogodišnji prosjek 14,99% naprema 9,58%). Pomak vrijednosti BW prema većim težinskim skupinama u cijelom priobalnom u odnosu prema kontinentalnom dijelu Hrvatske podupiru tezu o razlikama antropoloških obilježja tih populacija izraženih već po rođenju. Rezultati potvrđuju da »fetalna makrosomija» nije isključivi fenomen šibensko-kninske županije već je i u preostalom priobalnom u odnosu na kontinentalni dio Hrvatske veći udio BW≥4000 grama.