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Social Variations in Infant Growth Performance in Severodvinsk, Northwest Russia: Community-based Cohort Study

Andrej M. Grjibovski[1,2], Lars O. Bygren[1,3], Agneta Yngve[1], Michael Sjöström[1]

[1]Unit for Preventive Nutrition, Department of Biosciences at NOVUM, Karolinska Institute, Huddinge, Sweden; [2]Institute of Hygiene and Medical Ecology, Northern State Medical University, Arkhangelsk, Russian Federation; and [3]Social Medicine, Department of Community Medicine and Rehabilitation, Umea University, Umea, Sweden

Aim. To examine infant growth characteristics and their socio-demographic determinants in Severodvinsk, northwest Russia.

Methods. Length-for-age, weight-for-age, and weight-for-length Z-scores of 1,067 infants born in 1999-2000 in Severodvinsk were calculated on the basis of the data on the length and weight obtained from the medical files. Multiple linear regression was used to estimate independent effects of maternal age, education, occupation, marital status, weight, parity, sex of the baby, and breastfeeding duration on infant growth.

Results. At the age of 12 months, 1.1% of the infants were stunted, 1.1% underweight, and 0.5% wasted in comparison with the Centers for Disease Control and Prevention 2000 reference population. The mean Z-scores for length-for-age, weight-for-age, and weight-for-length were 0.48 ± 0.93, 0.38 ± 1.04, and 0.65 ± 1.03, respectively. Mean weight-for-length Z-scores considerably increased from birth to 12 months, while length-for-age Z-score remained largely unchanged. In regression analysis, length-for-age Z-scores were lower by 0.43 ($p = 0.028$) and by 0.30 ($p < 0.001$) in infants born to mothers with basic and unknown education, respectively. Positive trends between linear growth and maternal age ($p = 0.027$) and education ($p = 0.024$) were observed. No social variations in weight-for-length Z-scores were found.

Conclusion. Prevalence of stunting, underweight, and wasting were lower than previously reported from Russia, which may reflect good overall socio-economic conditions in the town. Social variations in linear growth indicate the existence of inequalities in infant health, which may further increase with age.

Key words: *growth; infant; Russia; socioeconomic factors*

Infancy is the period of postnatal life when growth rates and nutritional demands are the highest (1). Even small changes in nutritional or health status are reflected in the changes in infant growth pattern. Impaired growth in this period is associated with increased risk of morbidity and mortality (2). Delayed consequences of growth failure in infancy may include lasting deficits in growth (3), poor cognitive development (4), cardiovascular diseases (5), and reduced work capacity (6). On the other hand, excessive weight gain during infancy is associated with increased risks of obesity in childhood (7) and young adulthood (8).

Anthropometric characteristics are the main criteria used to assess the adequacy of infant growth (2). The most often used parameters are length-for-age, weight-for-age, and weight-for-length. Low length-for-age (stunting) reflects a failure to reach linear growth potential as a result of long-term cumulative inadequacies of nutrition and general health. Low weight-for-length (wasting) is often associated with acute malnutrition and/or severe illness. Low weight-for-age reflects both indicators. In addition to evaluating health and nutritional status, growth assessment of infants and children provides good indirect measurement of social well-being of a population. This is particularly relevant for transitional economies due to the problems with measuring the actual income or the consumption in these countries (9).

Although children have similar growth potential in infancy and early childhood, there is a wide variation in infant growth characteristics among and within countries (10). A substantial part of this variation can be attributed to socio-economic determinants (11). Moreover, social, demographic, and economic factors are more important than genetic attributes in producing deviations from the international reference values of child growth (12). Thus, studying social variations in early child growth is of increased public health concern in populations with high or increasing levels of social inequalities.

Rapid transition to a market economy in Eastern Europe, followed by major societal changes, provides a unique opportunity for studying social determinants of health. Considerable social variations in infant size at birth have been observed in the Czech Republic (13), Estonia (14), and Lithuania (15) during the time of transition. Even greater social disparities in birthweight have been found in Russia (16), reflecting Russia's levels of inequalities, which are the highest in Europe (17). The peak of the Russian economic crisis occurred in August 1998, and since then some positive trends in the national economy have been registered: the annual growth of gross domestic product was 6.4% in 1999 and 10.0% in 2000; however, life expectancy decreased from 67.0 years in 1998 to 65.3 years in 2000, infant mortality rates remained unchanged, and the population continued to decrease (17).

The latest available data on infant growth available on the national level are from 1995 and show that 28.6% of infants were stunted, 8.8% were wasted, and 3.7% were underweight (10). Thus, infant growth patterns and their determinants in transitional Russia, especially after the economic trends have reversed, remain largely unknown.

This study aims to assess infant growth and its socio-demographic determinants in an urban Russian setting.

Subjects and Methods

Setting

The study was performed in Severodvinsk, a town in northwest Russia, with a population of 238,800 in 1998. The population is homogenous: Russians account for more than 93%. The main industry is shipbuilding.

Data Collection

From 1 January to 31 December 1999, most (>99%) pregnant women in Severodvinsk were enrolled in a cohort and followed through the delivery. This cohort had a total of 1,399 singleton live births (16). We attempted to trace all of the infants from this cohort who were alive and residing in Severodvinsk at 12 months of age. The information on maternal socio-demographic characteristics and infant data at birth was collected from the prenatal care centers and municipal maternity home and classified as described elsewhere (16). Data on infant weight and length at 12 months of age were obtained from the medical records at the pediatric policlinics. According to the local regulations, district pediatricians perform all measurements on the Tuesday or Thursday nearest to the infant's birthday. Length is measured in a recumbent position, using wooden infantometers, to the nearest 0.5 cm and weight is measured to the nearest 50 g, using regularly calibrated mechanical scales. Because breastfed infants grow differently from formula-fed infants (2), data on the duration of breastfeeding were obtained from the infant's records and classified in three groups: less than 3 months, 3-5 months, and 6 or more months. Because the records in Russia do not contain information on the exclusivity of breastfeeding, the term breastfeeding here refers to any breastfeeding, irrespective of complementary foods.

Data Presentation

The characteristics of attained growth were calculated by comparing an individual infant to a reference population and expressed as Z-scores. Length-for-age, weight-for-age, and weight-for-length Z-scores at birth and at 12 months of age were calculated using the Centers for Disease Control and Prevention 2000 reference population (18) and Nut Stat module in Epi Info-6 software (19). Infants with length-for-age, weight-for-length, and weight-for-age Z-scores below -2.0 were termed stunted, wasted, and underweight, respectively. Infants with weight-for-length Z-scores above 2.0 were classified as overweight. Mean Z-scores were used for all analyses. Using mean Z-scores is advantageous in describing the nutritional status on a population level compared to using subsets of individuals below set cut-offs. Using mean Z-scores gives higher statistical power for a given sample and since Z-scores are normally distributed, they allow the use of parametric statistics (2).

Infants with birthweight below the 10th percentile for gestational age were classified as small-for-gestational-age (SGA). We applied race-, sex-, and parity-specific standards calculated by Zhang and Bowes for the entire US population (20). The delivery was classified as preterm if it occurred before the 37th completed week of gestation, measured from the last menstrual period.

Data Analysis

Mean values between two continuous variables were compared using t-tests. Differences between nominal variables were assessed by chi-square tests. Paired t-tests were used to compare mean values of the estimates at birth and at 12 months of age. The effects of maternal socio-demographic factors on growth characteristics at 12 months of age were quantified by multiple linear regression with and without adjustment for potential confounders. The variables were maternal age, education, occupation, marital status, pre-pregnancy weight, parity, duration of breastfeeding, sex of the baby, relevant Z-scores at birth, as well as preterm and birth-weight-for-gestational-age status. Trends across maternal age, education (excluding unknown education), maternal weight, and duration of breastfeeding were studied by introducing these categories as continuous independent variables in multiple models. What is believed to be the most favorable group was selected to be the reference group for each variable. Given that social variations in birth weight in this cohort had been previously described (16), regression analyses were applied only to the infant characteristics at 12 months of age. All analyses were performed using SPSS software version 4 (SPSS Inc., Chicago, IL, USA).

Results

Infant Anthropometric Characteristics

A total of 1,386 infants from this cohort survived the first year. Anthropometric data at 12 months of age were available for 1,067 (77%) of them (Table 1). Compared with the reference population with the mean of 0 and SD of 1, Russian infants were taller, although lighter and thinner at birth. At 12 months of age, they remained taller, but also became heavier in relation to their age and length than infants in the reference population. This made body proportions more

Table 1. Infant characteristics (mean ± standard deviation) at birth and at 12 months (563 boys and 504 girls)

	At birth			At 12 months		
Characteristic	boys	girls	p*	boys	girls	p*
Length (cm)	51.40 ± 2.32	50.81 ± 2.07	<0.001	76.82 ± 2.78	75.39 ± 2.66	<0.001
Weight (kg)	3.45 ± 0.52	3.32 ± 0.46	<0.001	10.73 ± 1.18	10.10 ± 1.20	<0.001
Length-for-age Z-score	0.54 ± 0.88	0.56 ± 0.84	0.741	0.41 ± 0.93	0.56 ± 0.93	0.006
Weight-for-age Z-score	-0.10 ± 0.93	-0.13 ± 0.93	0.580	0.29 ± 0.99	0.48 ± 1.09	0.003
Weight-for-length Z-score	-0.73 ± 0.79	-0.72 ± 0.71	0.780	0.73 ± 1.03	0.57 ± 1.03	0.008

*Student's t-test.

harmonic than they were at birth. Mean length-for-age Z-scores decreased from birth to 12 months of age by 0.13 in boys (p = 0.002), but remained unchanged in girls. All other characteristics increased in both sexes from birth to 12 months of age (p < 0.001 for all tests). The most remarkable increase occurred in weight-for-length Z-scores in both boys (1.46) and girls (1.29). Proportions of stunted (1.1%), underweight (1.1%), and wasted (0.5%) infants in Severodvinsk were much lower than previously reported in Russia (10). The prevalence of wasting decreased by 10 times during the first year of life, and almost 10% of infants became overweight at 12 months of age (Table 2). Infant anthropometric data are summarized in Table 3. Even infants born to mothers from the least favorable social groups were not smaller at 1 year than infants in the reference population.

Table 2. Infants (No., %) below and above reference cut-off points at birth and at 12 months

	Z scores for cut-off points for					
	length-for-age		weight-for-age		weight-for-length	
Measurement	≤2.0	>2.0	≤2.0	>2.0	≤2.0	>2.0
At birth:						
boys	6 (1.1)	17 (3.0)	12 (2.1)	11 (2.0)	33 (5.9)	0
girls	6 (1.1)	16 (3.2)	14 (2.8)	6 (1.2)	20 (4.0)	0
both sexes	12 (1.1)	33 (3.1)	26 (2.4)	17 (1.6)	53 (5.0)	0
At 12 months:						
boys	10 (1.8)	21 (3.7)	7 (1.2)	20 (3.6)	1 (0.2)	61 (10.8)
girls	2 (0.4)	27 (5.4)	5 (1.0)	42 (8.3)	4 (0.8)	44 (8.7)
both sexes	12 (1.1)	48 (4.5)	12 (1.1)	62 (5.8)	5 (0.5)	105 (9.8)

Non-responder Analysis

Infants who were lost during the follow-up (n = 319) had lower length-for-age (0.41 ± 0.92 vs 0.55 ± 0.86, p = 0.015) and weight-for-age (-0.26 ± 0.97 vs -0.11 ± 0.93, p = 0.015), but not weight-for-length (-0.73 ± 0.75 vs -0.73 ± 0.75, p = 0.943) Z-scores at birth. This group had higher proportion of preterm (8.2% vs 4.9%, p = 0.026), but not small-for-gestational-age (11.7% vs 9.8%, p = 0.332) infants. Mothers of these babies were less educated (chi-square = 12.79, df = 4, p = 0.012). This difference was attributed to the higher proportion of mothers with basic education in infants lost during the follow-up (6.6% vs 2.7%, p = 0.001). No significant differences between the groups were found in relation to other baseline characteristics. The main reason for follow up losses was the failure to trace the infants because of moving and unavailability of the medical documentation at the time of data collection.

Crude Analyses

Compared to the reference groups, lower length-for-age Z-scores were found in infants born to teenage mothers, women with basic, secondary, vocational, and unknown levels of education, unemployed, and

Table 3. Infants' anthropometric characteristics at 12 months by maternal socio-demographic characteristics and infants' characteristics at birth

		Z-scores (mean ± standard deviation) for		
Characteristic	No. (%)	length-for-age	weight-for-age	weight-for-length
Maternal age (years):				
15-19	104 (9.7)	0.15 ± 1.05	0.10 ± 1.11	0.57 ± 1.00
20-29	781 (73.2)	0.51 ± 0.89	0.40 ± 1.03	0.65 ± 1.03
30 +	182 (17.1)	0.56 ± 1.00	0.47 ± 1.05	0.73 ± 1.06
Education:				
basic	29 (2.7)	-0.07 ± 1.36	0.03 ± 1.20	0.71 ± 0.87
secondary	262 (24.6)	0.44 ± 0.92	0.30 ± 1.02	0.57 ± 0.98
vocational	290 (27.2)	0.49 ± 0.86	0.49 ± 0.99	0.78 ± 1.03
university*	265 (24.8)	0.70 ± 0.85	0.56 ± 1.05	0.69 ± 1.07
unknown	221 (20.7)	0.33 ± 1.00	0.19 ± 1.06	0.53 ± 1.05
Occupation:				
unemployed[†]	348 (32.6)	0.39 ± 0.95	0.28 ± 1.06	0.59 ± 1.02
blue collar	174 (16.3)	0.50 ± 0.96	0.35 ± 1.09	0.61 ± 1.05
skilled blue collar	117 (11.0)	0.48 ± 0.79	0.55 ± 0.93	0.87 ± 1.01
students	62 (5.8)	0.42 ± 0.99	0.32 ± 1.19	0.62 ± 1.15
white collar	366 (34.3)	0.57 ± 0.94	0.45 ± 1.01	0.68 ± 1.02
Marital status:				
unmarried	365 (34.2)	0.40 ± 0.98	0.37 ± 1.07	0.70 ± 1.04
married	702 (65.8)	0.52 ± 0.90	0.39 ± 1.03	0.63 ± 1.03
Maternal weight:				
underweight	57 (5.3)	0.40 ± 0.87	0.18 ± 1.18	0.45 ± 1.21
normal	960 (90.0)	0.47 ± 0.94	0.37 ± 1.03	0.66 ± 1.01
overweight	50 (4.7)	0.70 ± 0.87	0.80 ± 1.11	1.03 ± 1.14
Parity:				
1	701 (65.7)	0.43 ± 0.97	0.41 ± 1.05	0.66 ± 1.05
2 +	366 (34.3)	0.51 ± 0.91	0.32 ± 1.02	0.63 ± 1.00
Breastfeeding duration[‡] (months):				
< 3	266 (25.0)	0.55 ± 0.97	0.49 ± 1.02	0.75 ± 0.96
3-5	293 (27.5)	0.49 ± 0.94	0.35 ± 1.05	0.58 ± 1.05
6 +	506 (47.5)	0.44 ± 0.91	0.34 ± 1.05	0.64 ± 1.06
Preterm infant:				
yes	52 (4.9)	0.52 ± 0.93	-0.13 ± 1.24	-0.13 ± 1.34
no	1,015 (95.1)	0.66 ± 1.04	0.40 ± 1.02	0.51 ± 0.90
Small-for-gestational-age infant:[§]				
yes	104 (9.8)	0.30 ± 1.05	-0.32 ± 1.06	-0.19 ± 0.96
no	955 (90.2)	0.69 ± 1.02	0.47 ± 1.01	0.55 ± 0.90

*At least 3 years of university studies.
[†]Including housewives.
[‡]Data on breastfeeding were missing for 2 cases.
[§]Birth-weight-for-gestational-age status could not be assessed for 8 infants born after 42 completed weeks of gestation.

unmarried women (Table 4). Weight-for-age Z-scores were lower in infants born to teenagers, women with basic, secondary, and unknown education, and unemployed women. Disparities in infant linear growth by maternal education increased during the first year of life, whereas the variations in weight-for-age Z-scores remained unchanged (Fig. 1). No social variations were observed in weight-for-length Z-scores. Both weight-for-age and weight-for-length Z-scores were higher in babies of overweight mothers.

Preterm infants had lower length-for-age and weight-for-age Z-scores, but not weight-for-length Z-scores at 12 months of age in comparison with term infants. Small-for-gestational-age infants were shorter, lighter, and thinner at 12 months than their counterparts who had a birth weight expected for their gestational age.

Adjusted Analyses

Social factors significantly associated with lower length-for-age Z-scores at 12 months of age were maternal age below 20 years, maternal basic and unknown levels of education (Table 4). First-born infants and infants who were breastfed for less than 3 months were significantly taller than those in the reference groups independent of other factors. Infant length-for-age Z-scores at 12 months increased with increasing maternal age ($p = 0.027$) and level of education ($p = 0.024$) and decreased with increasing duration of breastfeeding ($p < 0.001$).

Weight-for-age Z-scores were lower for infants born to teenage mothers and women with unknown education (Table 4). First-born babies, infants of overweight mothers, and infants who were breastfed for less than 3 months were significantly heavier than infants in the reference groups. Positive trends were revealed for weight-for-age Z-scores by maternal age ($p = 0.044$) and weight ($p = 0.012$), whereas a negative trend was observed between weight-for-age Z-scores and duration of breastfeeding ($p = 0.004$).

Weight-for-length Z-scores were significantly higher for babies of overweight mothers. Positive

Table 4. Results of multiple linear regression of length-for-age, weight-for-age, and weight-for-length Z-scores by maternal characteristics

	Differences in Z-scores for											
	length-for-age				weight-for-age				weight-for-length			
Characteristic	crude	p	adjusted*	p	crude	p	adjusted*	p	crude	p	adjusted*	p
Maternal age (years):												
15-19	-0.35	<0.001	-0.22	0.048	-0.30	0.006	-0.22	0.079	-0.08	0.471	-0.09	0.497
20-29[†]												
30+	0.05	0.510	0.10	0.192	0.07	0.408	0.11	0.220	0.09	0.321	0.09	0.378
Education:												
basic	-0.77	<0.001	-0.43	0.028	-0.53	0.009	-0.21	0.354	0.02	0.913	0.12	0.628
secondary	-0.27	<0.001	-0.17	0.080	-0.26	0.004	-0.15	0.180	-0.11	0.212	-0.11	0.359
vocational	-0.21	0.007	-0.09	0.287	-0.07	0.422	-0.01	0.946	0.09	0.286	0.06	0.533
university[†]												
unknown	-0.38	<0.001	-0.30	<0.001	-0.37	<0.001	-0.28	0.006	-0.15	0.103	-0.13	0.221
Occupation:												
unemployed	-0.17	0.015	0.08	0.295	-0.18	0.022	0.05	0.541	-0.09	0.249	-0.02	0.872
blue collar	-0.06	0.469	0.08	0.451	-0.10	0.281	0.06	0.574	-0.06	0.501	0.02	0.845
skilled blue collar	-0.09	0.363	-0.07	0.484	0.10	0.375	0.07	0.553	0.19	0.076	0.11	0.373
students	-0.15	0.245	-0.03	0.822	-0.13	0.362	-0.05	0.779	-0.06	0.691	-0.03	0.842
white collar[†]												
Marital status:												
unmarried	-0.13	0.033	-0.08	0.145	-0.02	0.731	0.04	0.950	0.08	0.254	0.08	0.276
married[†]												
Maternal weight:												
underweight	-0.07	0.562	0.02	0.879	-0.20	0.165	-0.07	0.597	-0.20	0.163	-0.17	0.241
normal[†]												
overweight	0.23	0.091	0.20	0.097	0.43	0.004	0.42	0.003	0.39	0.010	0.35	0.019
Parity:												
1	0.09	0.158	0.25	<0.001	0.10	0.160	0.27	<0.001	0.03	0.653	0.08	0.300
2+[†]												
Breastfeeding (months):												
<3	0.11	0.125	0.22	<0.001	0.15	0.061	0.22	0.003	0.11	0.145	0.14	0.083
3-5	0.06	0.424	0.10	0.124	0.01	0.880	0.04	0.542	-0.06	0.463	-0.03	0.667
6+[†]												
Sex of the baby:												
boy	-0.16	0.006	-0.14	0.007	-0.19	0.003	-0.20	0.001	0.17	0.008	0.16	0.012
girl[†]												
Preterm infant:												
yes	-0.64	<0.001	0.07	0.606	-0.53	<0.001	0.02	0.907	-0.14	0.373	-0.03	0.868
no[†]												
Small-for gestatational age infant:												
yes	-0.74	<0.001	-0.30	0.002	-0.78	<0.001	-0.31	0.009	-0.39	<0.001	-0.41	<0.001
no[†]												
Z-score at birth[‡]	0.41	<0.001	0.37	<0.001	0.36	<0.001	0.31	<0.001	0.02	0.598	0.00	0.935

*Adjusted for variables in the table.
[†]Reference group.
[‡]Length-for-age Z-scores at 12 moths were adjusted for length-for-age Z-scores at birth; weight-for-age Z-scores at 12 months were adjusted for weight-for-age Z-scores at birth; and weight-for-length Z-scores at 12 months were adjusted for weight-for-length Z-scores at birth.

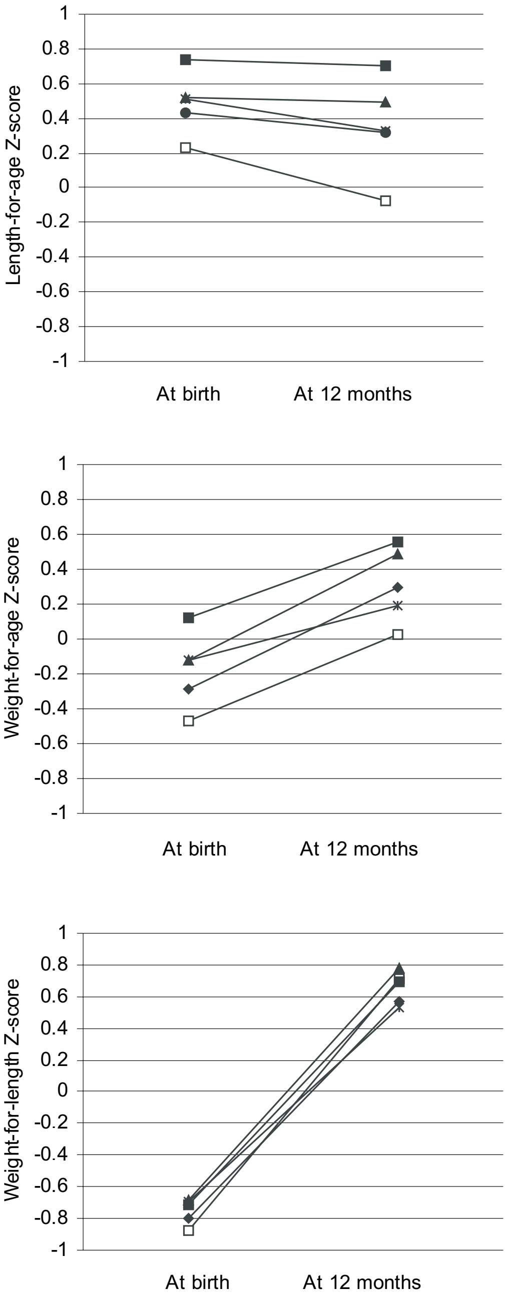

Figure 1. Z-scores at birth and at 12 months by maternal education. Open square – basic; diamond – secondary; triangle – vocational; closed square – university; asterisk – unknown.

trend between maternal weight and infant weight-for-length Z-scores was also found (p = 0.012).

Boys had lower length-for-age and weight-for-age Z-scores, but they had higher weight-for-length Z-scores than girls independent of potential confounders.

Small-for-gestational-age infants remained shorter, lighter, and thinner than infants which had birth weight expected for their gestational age, at 12 months of age independently of other studied factors, whereas no differences in anthropometric characteristics were found between preterm and term infants in multivariable analysis.

Discussion

To our knowledge, this is the first community-based cohort study on infant growth in an urban area in Russia after the beginning of economic improvements. Contrary to what might be anticipated bearing in mind the latest national data (10), the proportions of stunted (1.1%), underweight (1.1%), and wasted (0.5%) infants were very low and the mean Z-scores for all studied characteristics were higher than in the reference population. This indicates that most infants were well-nourished and proportionally developed at 12 months of age. Weight-for-age data in the study reflect length-for-age data which is typical for communities without significant wasting. Although the studied characteristics are only proxy indicators of infant health and nutrition, their use is justified due to the high sensitivity of infant growth to nutritional alterations in a population (21). Low stunting rates and low wasting rates indicate good overall socio-economic conditions and the absence of food crisis in the town (2). Northwestern regions of Russia are relatively wealthy and have the lowest infant mortality rates. Our findings are not surprising given that Russia is comprised of diverse regions with vastly different stages of development and large urban-rural differences. Only 0.7% of infants aged 0.50-0.99 years were underweight in the three large cities of Moscow, St. Petersburg, and Ekaterinburg whereas 3.9%, 5.4%, and 14.2% of infants from the same age group were stunted, underweight, and wasted, respectively in Ingushetia (10).

A decrease in linear growth observed in infants born to women with low education and independent associations between social factors and length-for-age Z-scores should raise concern with respect to social inequalities in infant health. The most important factors implicated in reducing growth velocity are nutritional deficiencies, recurrent infections, and sub-optimal caregiver feeding practices. Observed social variations in infant linear growth, but not in ponderal growth (as expressed in weight-for-length Z-scores), suggest that the differences in infant nutrition across social strata are of a long-term character and refer to the quality of the nutrition rather than to its quantity. Nutrient density, feeding frequency, viscosity, variety, and flavor of complementary foods are determinants of micronutrient intake (22). Even in the absence of general undernutrition, mild long-standing deficiencies in micronutrients, such as zinc, phosphorus, and some others, lead to progressive stunting (22). Better-educated women in our sample may have more knowledge and resources to provide their infants with better foods, use health care facilities more often and more effectively, and have better mother-infant interaction. These speculations are supported by our previous findings that low educated mothers from this cohort were more likely to start prenatal care late, smoke, report psychosocial stress during pregnancy, have an unemployed partner, live in substandard housing, and have an unplanned pregnancy (23). In the subsequent years observed social variations in linear growth during infancy may create even greater differences in the health status of children in this cohort given that linear growth faltering may continue up to the third year of life (2).

Infants born to primiparous women were lighter and thinner at birth (16), but taller and heavier at 12 months of age. Their excessive postnatal growth may be explained by the fact that growth restricted infants have lower leptin levels that lead to increased appetite and rapid growth in adequate postnatal conditions (24). However, resource deficit in families with more than one child may also be proposed as an explanation given that many women postpone childbirth due to economic reasons: birth rates in the town decreased from 15.3‰ in 1989 to 6.6‰ in 1999.

Breastfeeding duration was negatively associated with length-for-age and weight-for-age Z-scores at 12 months of age; this agrees with most previous studies (2) whereas no association with ponderal growth is an unexpected finding. Kramer et al (25) recently showed in a randomized controlled trial that exclusive and prolonged breastfeeding may accelerate weight and length gain during early infancy with no subsequent growth deficit at 12 months of age. Infant growth may be more sensitive to timing of introduction of supplementary foods and their quality than to the duration of breastfeeding *per se*. Early introduced solids compete with breast milk as a primary source of nutrients and energy resulting in progressive decrease in linear growth accompanied by rapid increase in ponderal growth during the first months and declining afterwards (26). We do not have data on infant feeding in this cohort, although early introduction of supplementary foods has been traditionally common in Russia (27), which may explain considerable increase in weight-for-length scores from birth to 12 months without changes in average length-for-age Z-scores in the full sample.

Babies of overweight mothers had higher weight-for-age and weight-for-length Z-scores. However, this study cannot distinguish whether these associations are due to genetic predisposition or due to different feeding practices in overweight mothers.

Rapid weight gain during infancy confers increased risk of adult obesity (28). Overweight during infancy persists through preschool years and is more pronounced among low birth weight children than normal or high birth weight children (29). Therefore, our findings on increase in average weight-for-length Z-scores from birth to 12 months by 1.46 in boys and 1.29 in girls with unchanged (in girls) or even slightly decreased (in boys) length-for-age Z-scores, may have long-lasting health implications in this cohort.

Some methodological aspects should be considered. The measurements were taken often, but not always exactly on the infant's birthday, and it is more likely that they were taken 1-2 days after the birthday than 1-2 days before it (Dr TB. Suhova, personal communication). Thus, the characteristics might be slightly overestimated. We think that this bias is non-differential in relation to maternal socio-demographic characteristics. The overall quality of the data seems sufficient: there were no outliers in estimated Z-scores based on flexible exclusion rates recommended by the World Health Organization, and the standard deviations of the mean Z-scores for all three measurements were close to 1.0 or lower, indicating that the data were of high quality (2). The validity of the Russian medical documentation was proved adequate for epidemiological studies in reproductive health (30) which supports the validity of our estimates in relation to maternal factors and birth characteristics. Infants who were lost during follow-up (23% of those who survived the first year) were shorter and lighter at birth, and they were more likely to have mothers with lower education. Given that birth characteristics were positively associated with attained length-for-age and weight-for-age Z-scores at 12 months and that maternal education was positively associated with linear growth, our findings regarding length-for-age and weight-for-age but not weight-for-length Z-scores at 1 year are likely to be overestimated. However, because the number of mothers with basic education is only 3.6% in the total sample (16) and the differences in Z-scores at birth are small, this overestimation does not influence the general conclusions.

In summary, the proportions of stunted, underweight, and wasted infants in Severodvinsk at 1 year of age are low and comparable with those from other European countries (10). However, we do not recommend generalizing our findings to other areas of Russia, bearing in mind large differences between the regions. Infant growth characteristics are probably less favorable in rural areas. Social variations in linear growth by maternal age and educational attainment should raise concern with respect to inequalities in infant health, which may further increase with age. Moreover, social variations are likely to be larger in big cities. This cohort needs to be followed up further to explore whether rapid weight gain experienced by our relatively thin at birth infants confers increased risk of obesity and other health conditions in childhood.

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Correspondence to:
Andrej Grjibovski
Unit for Preventive Nutrition
Department of Biosciences at Novum
Karolinska Institutet
14157 Huddinge, Sweden
andrej.grjibovski@prevnut.ki.se