PHYSICAL GROWTH DURING THE FIRST YEAR OF LIFE OF INFANTS
A LONGITUDINAL STUDY IN ONE RURAL AND ONE URBAN AREA OF HANOI, VIETNAM

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ABSTRACT

Background: Infant growth can influence the future health in childhood and later in life. Assessing growth is common in pediatric care all over the world, both at the population and individual level. There is a lack of birth weight and longitudinal growth studies using larger groups of children and comparing urban and rural communities in Vietnam. This paper aims to describe and compare the birth weight distributions and physical growth (weight and length) of children from birth to 12 months in one rural and one urban area of Hanoi Vietnam.

Methods: Totally 1,466 children, born from 1st March, 2009 to June 2010, were followed monthly from birth to 12 months of age with respect to weight and length in two Health and Demographic Surveillance Sites; one in a rural area and one in an urban area of Hanoi, Vietnam. In all, 14,199 measurements of weight and length were made. Birth weight was recorded separately. Growth descriptions were obtained using Fractional Polynomial models. Standard statistical methods were used otherwise.

Results: Generally, urban infants have higher birth weight and gain weight faster than rural infants. The mean birth weight for urban boys and girls were 3,298 grams and 3,203 grams as compared to 3,105 grams and 3,057 grams for rural children. The differences of attained infant weight between urban and rural increased with increasing age. At 90 days, the urban boys were estimated to be 4.1% heavier than the rural. This ratio increased to 7.2% at 360 days. The corresponding numbers for girls were 3.4 % and 10.5 %. The differences for length were comparatively smaller, but increased during the first year of life.

Conclusion: Birth weight was lower and growth slower in the rural area. Further studies can show possible associations with factors that can be targeted for intervention in the two studied areas or in other settings where the results can be considered applicable.
BACKGROUND

Growth of children is influenced by maternal, environmental, genetic and hormonal factors. Nutrition is assumed to be the one of the most important factors for the growth of infants [1]. Some causes of growth failure in children are underlying chronic illnesses, inadequate nutrition or other problems in child well-being [2]. Slow intrauterine and infant growth can influence the weight gain in childhood and later in life increase the risk for diseases like coronary heart disease, type 2 diabetes and hypertension [3]. Assessing growth, both at population and individual level, is common in pediatric care all over the world. At population level, growth assessment of children means estimating prevalence of undernourishment, overweight and identification of different groups in need of intervention [4]. Differences in birth weight and growth of children between urban and rural areas have been reported in some studies [5-8]. Inequality of family income, general living conditions, average number of children in families and nutrition have been pointed out as the main explanations for such differences [6, 7].

At the individual level, children are followed over time. Growth of the single child is compared to a growth chart, which is a diagram showing standard weight for age, length or height for age, weight for height and other anthropometric measures as functions of child age. The graphic description most often includes mean with standard deviations, as functions of child age, or in the case of weight, of length or height. This follow-up is used to evaluate deviations of the growth in individual children which could be early signs of ill-health.

From the Doi Moi reforms starting in 1986 until present, there has been a dramatic improvement in economic conditions in Vietnam; income per capita has increased from $130 to $900 from the early 1990s until 2008. Absolute poverty has been reduced from 58 percent of the population in 1993 to 13 percent in 2008 [9]. The prevalence of underweight of children has decreased from 45% in 1990 to 26.6% in 2004. The rate of reduction of
malnutrition was higher in urban areas than in rural areas [10]. The percentage of low birth weight in Vietnam was estimated to be higher in rural areas (5.9%) than in urban areas (3.9%) in 2002 [11]. Over the last decades, a few longitudinal studies of rather small groups were conducted to follow the growth of children born in delivery clinics or maternal hospitals [12-14]. Generally, however, there is a lack of knowledge about birth weight and growth of larger groups of children as well as comparisons between urban and rural communities of Vietnam.

The aim of this study is to describe and compare the birth weight distributions and physical growth (weight and length) of children from birth to 12 months in one rural and one urban area of Hanoi, Vietnam.

**METHODS**

**Study sites.**

The study was conducted in two Health and Demographic Surveillance Sites (HDSS), one urban and one rural, in Hanoi, the capital of Vietnam. Dongda is an urban district in central Hanoi with about 352,000 inhabitants. Three communes with 37,000 persons in 10,500 households, strategically selected to have different economic levels, were defined as the DodaLab HDSS in 2007 [15]. Bavi is a rural district, also within Hanoi with 250,000 persons. A random sample of 11,100 households and 51,000 persons, called FilaBavi HDSS, has been followed since 1999 [16]. Thus the research designs in terms of selecting households do differ between the two areas. This, however, is not likely to seriously affect the results of the study.

Household surveys were undertaken in both sites during late 2007 and 2008 as well as during 2009 to obtain information about demographic conditions, education, occupation and economic conditions of persons and households. In both sites, all households are routinely visited every three months to record vital events, birth, death, migration and pregnancies.
Study design and subjects in the follow-up of child growth

The parents of all children reported to have been born alive from 1st March, 2009 to 30th June, 2010, 540 in DodaLab and 926 in FilaBavi, were invited to enroll their child in the study. Children with congenital and malformation diseases (two in DodaLab and six in FilaBavi) were excluded. About 1% (totally 15 children, 12 in DodaLab) of the mothers did not give consent and the child was not enrolled.

Altogether 12 children were born as twin and were not used in the present analysis. Low birth weight infants (below 2,500g) were included in the analysis, since their growth potential was considered as normal [17]. The measurements made on later out-migrated (61 from DodaLab and 27 from FilaBavi) or children who died (altogether five, four of them in DodaLab) have been used in the analysis.

Totally 1,466 children were used to analyze growth during the first year of life. The 540 DodaLab children provided 4,964 measurements each of weight and length. In FilaBavi 926 children contributed with 9,235 measurements. Totally 14,199 measurements were analyzed, that is 9.7 measurements per child.

Measurements and data collection

Birth weight information was provided by the mothers, who reported the measurement made at the hospital or commune health centers immediately after birth. For less than 1% of the children birth weight information was not obtained. The information about birth weight has been analyzed separately from the subsequent measurements of growth.

Given the mother’s consent, children were registered for the study and scheduled for measurement of weight and length every month from one month after birth to the age of 12 months. The percentages of scheduled measurements actually done were 65% for DodaLab and 77% for FilaBavi. The frequency of missed measurements increased with the age of the
infant. The percentage of children actually followed to at least 11 months was 80% in DodaLab and 90% in FilaBavi.

Standardized equipment for measuring the child recommended from Hanoi Medical University was used. A number of commune health centre staff members in DodaLab were trained specifically to measure children. In FilaBavi, a number of the permanent interviewers were trained to measure children. The principle of measurement was that the same field worker should assess a child at each visit using the same equipment. Weight was measured to the nearest 10 gram with the child in light clothes using a portable infant scale. Length was measured to the nearest centimetre in horizontal position using a length board. Two person worked together in order to have valid and reliable measurements [12].

**Statistical analysis**

Several methods have been suggested for statistical description and analysis of growth data [18]. The ambition for the present work was to use a simple approach, still theoretically and scientifically defendable. The statistical description has two major objectives, the estimation of mean and variation of attained growth and growth velocity by urban or rural context as well as child sex. Several models for smoothing curves were tried. The finally selected were Fractional Polynomial Models [19] which provided good fit with reasonably simple forms. The study of residuals in the weight model (not for length) suggested that a logarithmic transformation should improve normality. The models presented therefore are Fractional Polynomials of degree 3 with relative residuals assumed to be normally distributed with constant variance, in the case of weight after logarithmic transformation. Subgroup specific fitted Fractional Polynomials were used to describe the growth by area and sex.

Statistical significance for birth weight differences was assessed using linear regression with site and sex as independent variables. Differences in growth between the sites and child sex for birth weight and length were assessed using two-level, mixed effect models applied to the
residuals from the overall fitted Fractional Polynomials. Traditional statistical tests and confidence intervals were used to describe other random variation.

The growth velocity as a function of age was estimated empirically as an approximation of the first derivative of the subgroup specific estimated growth curves and was also considered as differences over a longer period.

The software used for all analysis was STATA version 11. In the analysis we used only singleton children. To identify preterm birth we needed the dates of last menstruation of the mothers. The dates that could be obtained were considered to be uncertain. Using it, we would exclude some ‘‘premature’’ children with minor influence on the results. Thus no distinction of term or preterm children was made.

**Ethical consideration**

Approval of the project was obtained from the Scientific and Ethical Committee of Hanoi Medical University, Hanoi Health Bureau and Dongda district authorities. The proposal was approved by the Ministry of Health and permission for the study was given after the baseline survey. All mothers of infants were informed about the purpose of the studies and their right to decline participation or withdraw. Consent for participation was given by all mothers of the included infants.

**RESULTS**

**Birth weight**

Wide and highly statistically significant differences in mean birth weight were found between the urban and rural areas (Table 1). The estimated difference in boys was 193 g and in girls 146 g. The mean birth weight of the urban girls was actually significantly higher than of the rural boys (all p-values <1%). The distribution of the mother reported birth weights was reasonably symmetric.
Infant growth

The estimated growth curves differed statistically significantly between the sites for both sexes (Figure 1). The mean attained weight was generally higher in the urban area than in the rural and, as seen in the graph, increased in absolute term with increasing age. The p-values from the two-level analysis of residuals were smaller than 0.001 both for the area and the child sex comparison. The same tendencies and p-values were seen for the mean attained length (Figure 2).

Estimated attained weight (grams) and limits for plus and minus two standard deviations at 90, 180, 270 and 360 days of age differed between the two sites (Table 2). Urban girls were almost 0.5 kg heavier than rural boys at one year of age. The asymmetry of the limits is due to the residual skewness. The estimated attained length (cm) and limits for plus and minus two standard deviations at 90, 180, 270 and 360 days of age also differed between the two sites (Table 3). The residual distributions for length were symmetrical and thus also the standard deviation limits.

The differences of infant growth in weight between urban and rural increased with increasing age. At 90 days, the urban boys were estimated to be 4.1% heavier than the rural boys. This ratio increased to 7.2% at 360 days. The corresponding numbers for girls were 3.4% and 10.5%.

Estimated weight growth velocity and length growth velocity at 90, 180, 270 and 360 days decreased throughout the first year of life in both sites (Table 4). The differences of growth velocity between the rural and urban infants increased over age. This was particularly evident for the weight differences at all ages.

Table 4 shows also the averaged growth velocity from 90 to 360 days together with 95% confidence interval. The rural area estimates are significantly lower than the urban for weight
(p-value <5%). For length, rural girls grow significantly slower than the other groups (p-value <5%).

DISCUSSION

The main findings of the study are differences in birth weight as well as the subsequent growth between the urban and rural areas, in accordance with results from previous studies [6, 7, 20]. Differences in growth of infants between urban and rural areas have been described in Peru in 1980. The height for age and weight for age fell more rapidly in rural than in urban infants for both sexes [20]. New studies in China published in 2008 and 2011, also show that urban infants grow faster than rural infants [6, 7]. The average weight and height for infants of both sexes in rural and urban areas increased during the past 20 years [6].

Socioeconomic conditions, nutrition of mothers during pregnancy, antenatal care, and increased mother’s weight gain during pregnancy have been seen to be associated to the birth weight of the child [21-24]. Economic resources in Vietnam are larger in urban areas [15, 16], which can lead to better nutrition for mothers and increased fetal weight gain. A study in 1996 found that 94% of all farming women had insufficient food intake, compared to 40% for non-farmer women [25]. This situation has improved, but there can still be considerable differences in food intake between farming women and non-farming women in Vietnam. The prevalence of anemia in women was higher in a rural area than in an urban area in India [26]. In Vietnam, no results on the prevalence of anemia in urban areas are available but a study in 2005 reported that the prevalence among pregnant women in one rural area was as high as 43.2% [27]. The rural mothers of the children in the present study attended antenatal care later, had fewer visits and much less of specific medical services than in the urban [15]. Differences in antenatal care could be one factor behind the differences found in infant growth and will be studied in a forthcoming analysis.
Several conditions and factors have been shown to be associated to poor growth of infants. Nutrition is the most important [1, 28]. Some studies explain the difference in growth of children between rural and urban areas with differences in family income and with general living conditions being better in urban areas. Fewer children in the urban families might lead to better nutrition of each child [6, 7]. In Vietnam, the total fertility rate in the rural areas was higher than in the urban area [29] but the income per capita in urban areas was higher than in the rural [15, 16], which might contribute to a better nutritional situation for infants in urban areas. The differences in weight gain between rural and urban infants found in this study are established at an early age. An important factor may be differences in breastfeeding patterns, especially the duration of exclusive breastfeeding. A study in Belarus in 2002 showed that the weight and length of infants with exclusive breastfeeding is higher than in those without exclusive breastfeeding during the first few months of age [30]. The breastfeeding pattern differs between urban and rural areas in different ways in different countries. In Tanzania, initiation of breast feeding during the first hour after birth was more common in the urban area than in the rural area and the mean duration of exclusive breast feeding was longer than in the rural area [31]. In China, a study found that the women who started exclusive breastfeeding before discharge from hospital comprised 38% in the urban and 61% in the rural areas. This study also concluded that a consequence can be differences of time to start supplement food and type of supplement food for infants between urban and rural area [32]. Results on breastfeeding for the children in this study as related to growth will be published in a forthcoming article.

Infants in the urban area are likely to have easier access to child health care than rural infants. Some barriers to access child health care in rural areas in Vietnam, like distance and long travel times, do exist. Financial, sociocultural, language, ethnicity are other possible barriers together with lack of knowledge, awareness and inequalities in quality of health care [33].
The differences between the two sites with respect to infant length were comparatively smaller at low ages, but increased in absolute terms during infancy. The results of our study are in agreement with results of studies from China where urban children were taller than rural children at all ages from one to 12 months of age [6, 7]. One study found that the difference of growth in length of children between rural and urban areas becomes statistically significant only after six months and especially after 2 years of age [6].

Different standards for child growth have been published by various institutions and international organisations. Most recently, the World Health Organization (WHO) launched growth standards in 2006. These were constructed to show child growth under ideal conditions [34]. A study in Vietnam that assessed the growth of children by using the new WHO child growth standards as reference showed that deficient growth of infant is widespread in Vietnam [14]. Another study in an urban area of Hanoi found that the growth of Vietnamese infants was also lagging behind the earlier used National Centre for Health Statistic reference population [13]. The present results for urban boys and girls reached levels similar to the WHO child growth standards whereas the growth levels of rural infants were lower, indicating that genetic factors do not necessarily explain deviations in growth at a population level in Vietnamese infants.

Compared to results of a study in urban Hanoi in the 1990’s, the birth weight and growth of infants in the present study are higher for both sites [13], indicating that the birth weight and growth of infants in both rural and urban areas of Hanoi have improved. There is, however, still a gap between the rural area and the urban area suggesting differences in child health care and nutrition.

One limitation of the study is the short follow-up time. One year is not enough to study if differences tend to decrease or increase as the children get older. The ambition for continued research shall be to continue follow-up to at least 5 years to see if the rural children catch up
with urban children or if the gaps are further widened. Certain unavoidable differences between the study designs, data collection and administrative procedures might be seen as limitations. For example the two cadres of interviewers have different employment conditions. But many studies would have these problems. The situation that there are unequal sample sizes in the two areas is not optimal for the comparison. As p-values depend on sample sizes, they cannot be compared between the two areas.

The research was conducted in two sites within the capital of Vietnam. These areas are generally considered to have rather good socioeconomic conditions compared to the rest of country. Even so, the birth weights and growth of infants are higher in the urban area than in the rural area. This suggests that differences are likely to occur also in other, comparatively poorer, settings in Vietnam.

CONCLUSION

Mean birth weight and weight growth of infants were different between the investigated areas in Vietnam. The birth weight was lower and the growth considerably slower in the rural area, for boys as well as for girls. The corresponding differences in length growth of the infants were more modest but increased with age during the first year of life. The differences can be due to several underlying factors that further analysis of the present data will explore. There is also a need for further studies in other parts of Vietnam.

COMPETING INTERESTS

The authors declare that our findings have not been influenced by our personal or financial relationship with other person or other organization

AUTHORS’ CONTRIBUTIONS

NTH led and supervised the fieldwork and data management. She also drafted and completed this paper. BE assisted in the research design as well as in the statistical analyses, interpretation of results and revising the manuscript. HA, NTL, NTKC, MP and GB were
involved in the design of the study, supervised the study and revised the manuscript. All authors have read and approved the final manuscript.

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REFERENCES


Figure 1- Estimated mean curves for attained weight as functions of age by sex of the child
Figure 2- Estimated mean curves for attained length as functions of age by sex of the child
Table 1- Mean birth weight (grams), standard deviation and proportion of low birth weight for all children

<table>
<thead>
<tr>
<th></th>
<th>Urban boys</th>
<th>Urban girls</th>
<th>Rural boys</th>
<th>Rural girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean birth weight and 95% CI</td>
<td>3298</td>
<td>3203</td>
<td>3105</td>
<td>3057</td>
</tr>
<tr>
<td>(grams)</td>
<td>(3263, 3422)</td>
<td>(3148, 3259)</td>
<td>(3071, 3139)</td>
<td>(3017, 3097)</td>
</tr>
<tr>
<td>SD (grams)</td>
<td>450</td>
<td>435</td>
<td>390</td>
<td>408</td>
</tr>
<tr>
<td>Proportion LBW (%)</td>
<td>2.3</td>
<td>4.2</td>
<td>4.1</td>
<td>4.9</td>
</tr>
<tr>
<td>Number of children</td>
<td>300</td>
<td>237</td>
<td>513</td>
<td>409</td>
</tr>
</tbody>
</table>

SD = standard deviation

CI = confidence interval
Table 2- Attained weight (grams) and limits for plus and minus two standard deviations at selected ages

<table>
<thead>
<tr>
<th>Age</th>
<th>Urban area Mean (±2 SD)</th>
<th>Rural area Mean (±2 SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys Girls</td>
<td>Boys Girls</td>
</tr>
<tr>
<td>90</td>
<td>6432 (5176,7992) 5999 (4703,7652)</td>
<td>6166 (4970,8562) 5794 (4646,7112)</td>
</tr>
<tr>
<td>180</td>
<td>8037 (6468,9986) 7541 (5912,8517)</td>
<td>7688 (6198,9490) 7156 (5783,8851)</td>
</tr>
<tr>
<td>270</td>
<td>9066 (7296,11264) 8618 (6757,9734)</td>
<td>8521 (6870,10568) 7982 (6451,9874)</td>
</tr>
<tr>
<td>360</td>
<td>9894 (7963,12294) 9644 (7561,12301)</td>
<td>9173 (7395,11377) 8624 (6970,10668)</td>
</tr>
</tbody>
</table>
**Table 3**: Attained length (cm) and limits for plus and minus two standard deviations at selected ages

<table>
<thead>
<tr>
<th>Age (days)</th>
<th>Urban area</th>
<th>Rural area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
<td>Girls</td>
</tr>
<tr>
<td></td>
<td>Mean ±2 SD</td>
<td>Mean ±2 SD</td>
</tr>
<tr>
<td>90</td>
<td>60.3 (54.6,66.0)</td>
<td>59.1 (53.4,64.8)</td>
</tr>
<tr>
<td>180</td>
<td>66.5 (60.2,72.9)</td>
<td>65.1 (58.9,71.3)</td>
</tr>
<tr>
<td>270</td>
<td>71.5 (64.7,78.3)</td>
<td>70.1 (63.4,76.8)</td>
</tr>
<tr>
<td>360</td>
<td>76.0 (68.8,83.2)</td>
<td>75.0 (67.8,82.2)</td>
</tr>
<tr>
<td>Age</td>
<td>Boys</td>
<td>Girls</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>90 days</td>
<td>24.0</td>
<td>20.9</td>
</tr>
<tr>
<td>180 days</td>
<td>14.1</td>
<td>13.8</td>
</tr>
<tr>
<td>270 days</td>
<td>10.0</td>
<td>11.5</td>
</tr>
<tr>
<td>360 days</td>
<td>7.7</td>
<td>10.3</td>
</tr>
<tr>
<td>Averages velocity from 90 to 360 days with 95% CI</td>
<td>12.8 (12.2, 13.4)</td>
<td>13.5 (12.7, 14.3)</td>
</tr>
</tbody>
</table>
Figure 1- Estimated mean curves for attained weight as functions of age by sex of the child
Figure 2- Estimated mean curves for attained length as functions of age by sex of the child