Malnutrition, Long-Term Health and the Effect of Nutritional Recovery

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Abstract

It is estimated that over 51 million people in Brazil live in slums, areas where a high prevalence of malnutrition is also found. In general, the population of ‘slum dwellers’ is growing at a faster rate than urban populations. This condition is associated with poor sanitation, unhealthy food habits, low birthweight, and stunting. Stunting is of particular concern as longitudinal and cross-sectional studies of stunted adolescents have shown a high susceptibility to gain central fat, lower fat oxidation, and lower resting and postprandial energy expenditure. In addition, higher blood pressure, higher plasma uric acid and impaired flow-mediated vascular dilation were all associated with a higher level of hypertension in low birthweight and stunted children. In particular, stunted boys and girls also showed lower insulin production by pancreatic β cells. All these factors are linked with a higher risk of chronic diseases later in life. Among stunted adults, alterations in plasma lipids, glucose and insulin have also been reported. However, adequate nutritional recovery with linear catch-up growth, after treatment in nutritional rehabilitation centers, can moderate the alterations in body composition, bone density and insulin production.

Health, Nutrition and Life Conditions

It has become clear that, for a real understanding of diseases and their etiology, the influence of the anthropological aspects, the psychological dynamism and the social context on the regulation of body metabolism must be considered. A reasonable amount of scientific findings offer ever more examples of an integrated approach to studying medical problems, such as studies
on the effects of happiness on the overall health of elderly people. For example, a study of catholic nuns in the United States concluded that writings with a positive emotional content at 22 years of age were associated with health and longevity at 60 years of age [1]. Thus, one may ask, as far as physiology is concerned, what goes on in a person who considers him or herself happy? There are strong relationships between that kind of statement, life expectancy and the frequency and intensity of chronic diseases, such as cardiovascular, inflammatory and self-immune ones [2]. Such studies identified an inversely correlate biological marker of that happiness declaration: cortisol, the stress hormone. The higher its levels in the saliva when the person wakes up, the greater the stress level and the worse the life quality in the long-term. The quality of a human life depends on what he feels and on the meaning he gives to things, both of which are associated with physiological status.

These same mechanisms are activated when a person receives insufficient nutrition in quantitative terms or inadequate nutrition in qualitative terms (when there is a lack of necessary nutrients, such as good quality of protein, vitamins and minerals), mainly early in life. In this case, the nervous system seems to permanently program itself to conserve energy as fat and to reduce growth to guarantee survival in adverse conditions. One of the essential hormones for fat conservation that is released during stress, such as periods of undernutrition, is cortisol, aptly named a stress hormone. The vicious cycle of inadequate food intake and infectious diseases stimulate the release of cortisol, a factor that plays a very important role in the association of malnutrition with chronic diseases in the adult phase [3, 4].

Malnutrition is responsible for over 50% of childhood mortality worldwide and is associated with many other diseases of children under 5 years of age [5]. Worldwide, as well as in Brazil, the prevailing type of malnutrition is stunting, an indicator not only of poor nutrition but also of poverty, as environmental factors are more significant than genetics in determining a person's adult height [6]. The causes for stunting range from poor maternal diet, intrauterine growth restriction secondary to placental insufficiency, not breastfeeding until the child is 6 months old, late introduction of complementary foods, inadequate quantity and quality of complementary foods, nutrient absorption impaired by infections and intestinal parasitic diseases [7].

In Brazil, approximately 52 million people live in slums [8], areas with an annual growth rate greater than urban areas. For example, in São Paulo, the growth rate of slums was estimated at 2.97% in 2000, while that of the city was 0.78% [9]. According to data from the municipality of São Paulo, there are over 2,000 slums with the greatest concentration in the southern zone of the city (1,107) [9]. Data on malnourished children under treatment at a center for recovery from malnutrition in São Paulo (CREN) located in that zone [10] found that over 70% of the children were born with low or insufficient weight. CREN is a center that offers treatment to children from the slums who are reported to have mild to severe malnutrition. Pediatricians, nutritionists, social workers
and psychologists participate in the treatment. The pediatrician monitors the clinical status, laboratory findings and anthropometric progress of each child. The nutritionist follows the child’s diet and corrects the problems identified during treatment. Laboratory tests (blood and stools) are done each semester and the children also receive Fe and vitamin (A, B, C and D) supplements in prophylactic doses. The children are either treated in an outpatient clinic or in a day-hospital. The children treated in the day-hospital are more severely malnourished. Data from CREN show that, among the moderately malnourished children under treatment, about 80% had at least one infectious episode in the previous month, and among the severely malnourished ones, that prevalence rose to about 90%. The difference in the severity of malnutrition referred mainly to the rate of infections. Besides, 60% of them had parasites. Another very common occurrence was anemia, verified in 62% of the children [11].

With regard to infections, it is important to note that most acute infections are often not life-threatening for a healthy child, but can jeopardize not only weight gain but also linear growth in a malnourished child. This observation is confirmed by the work at CREN where the recovering children stay all day (from 7.30 a.m. to 17.30 p.m.), eat 5 balanced meals/day, receive adequate treatment for the infections, and where both they and their families have the necessary medical and psychological care. Yet despite these interventions, normal childhood infections, such as otitis media, pharyngitis or the flu, have been found to retard normal growth. One can only speculate that if they were at home with no access to these interventions they would most certainly suffer more serious growth retardation and slip down the growth charts toward being severely stunted (fig. 1).

**What Are the Long-Term Consequences of Malnutrition?**

One important consequence of chronic malnutrition is that the body programs itself to store energy. We have previously shown that children who have been malnourished and who have not recovered in terms of height present a greater fasting respiratory quotient than those who have never been malnourished [12]. This means that the organism is physiologically prone to accumulate body fat, especially truncal fat [13]. Therefore, the child will grow less, have a lower fat-free mass, impaired bone growth, and will tend to use more excess energy ingested for fat accumulation [14]. Such findings are also associated with a greater susceptibility to accumulate body fat when the malnourished children consume a diet richer in fats [15].

By comparing the rate of weight gain of stunted adolescent girls to a control group, a longitudinal study showed that the malnourished girls presented faster weight gain, at the expense of a reduction in resting energy expenditure. That reduction in energy expenditure to gain weight was associated with an increase in body fat, mainly in the waist region where fat accumula-
tion is most dangerous since it is closely related to chronic diseases such as diabetes and cardiovascular diseases in the adult life [16].

In a recent study comparing stunted adolescents to controls with normal height, we observed a reduction in insulin production by the β-pancreas cells (HOMA-β) and, as a response to this deficiency, a greater insulin sensitivity (HOMA-S). These alterations may lead to pancreatic failure and to a greater risk of diabetes in adult life (fig. 2) [17].

Our studies also showed higher diastolic blood pressure levels in boys and girls living in slums, which indicated greater risk of hypertension and cardiovascular diseases in adult life [18]. Further studies have shown that malnourished children with low birthweight have vascular alterations (a reduction of the vessel elasticity) and higher plasma uric acid, which might be the cause of the alterations observed in blood pressure and the pancreas (fig. 3) [19].

Combining all that information (fig. 4), we can then say that insufficient consumption during growth causes a stress in the organism, leading to an increase in the cortisol-to-insulin ratio. As is well known, malnutrition and/or hunger are powerful stimulators of stress and can prompt an increased secretion of cortisol and its catabolic action to direct energy as glucose to brain. In addition, energy restriction reduces the anabolic action of insulin-dependent tissue synthesis, resulting in wasting. This hormonal balance leads to a reduction in key hormones responsible for growth, such as insulin-like growth factor-1 (IGF-1) [20]. The high cortisol-to-insulin ratio and low IGF-1 also reduce the gain of muscle mass and linear growth, as well as increasing the waist-to-
hip ratio and reducing body fat oxidation. If a child in that condition starts to ingest a ‘modern’ diet and presents physical inactivity due to urban living conditions, an excessive fat gain will take place, which can result in an association between stunting, obesity, hypertension and diabetes.

In fact, a study of individuals living in slums of Maceió, Brazil, showed an association between stunting and diabetes in the adult population [21]. Table 1 shows the biochemical profiles of overweight/obese women and men of short and average stature. In comparison to women of average stature, short women presented statistically higher levels of glycosylated hemoglobin, total and LDL cholesterol, insulin, HOMA-IR (an indication of insulin resistance) and HOMA-%β (β-cell function), whereas their HDL cholesterol levels were significant lower, as well as the T₃ levels. Among men higher levels of glycosylated hemoglobin, insulin, HOMA-IR and HOMA-%β, were found, indicating a risk of diabetes.

**What Happens after Nutritional Recovery?**

When a child has received appropriate treatment for malnutrition at a day-hospital, their chances of full recovery of weight and maintenance of normal growth rate are high [11]. In fact, at CREN, children recover height faster than weight [11] and we have observed a recovery of height-for-age of about 1
standard deviations among the most severely malnourished per year. Another important finding is that children with low weight at birth often recover better than those with normal weight at birth. Thus, it appears as though the human organism is potentially prepared to recover what was lost in the beginning of life, especially among intrauterine growth-restricted children who receive adequate treatment during the first years of life [11].

Recently, when studying children who recovered from malnutrition and were discharged from CREN, we observed normal body composition unlike what is found in malnourished children who were never treated and who remained stunted throughout their childhood and until their adolescence, as described previously. Among the recovered girls, the lean mass and body fat mass were similar to that observed in the control group (children with no history of weight or height deficits; table 2). Among the boys, body composition was normal, even though their values were lower in comparison to those of the control group. Similar findings have also been reported with respect to bone mineral density as outlined in figure 5 [10].

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**Fig. 3.** Children with normal (opens symbols) and low (solid symbols) birthweight. Correlations between birthweight and uric acid ($a; r = -0.498, p > 0.001$), systolic blood pressure ($b; r = -0.320, p = 0.004$), and flow-mediated dilation ($c; r = 0.427, p < 0.001$). Reprinted with permission from Hypertension [19].
Recently, we studied how glucose metabolism and insulin levels changed in children who received adequate treatment at nutritional rehabilitation centers and showed linear catch-up growth. The results of the recovered group, consisting of children who were treated in their early years of life (0–6 years),

Fig. 4. Association between short stature, obesity, hypertension and diabetes.

Table 1. Biochemical profile of overweight/obese women and men of short and average stature

<table>
<thead>
<tr>
<th>Stature</th>
<th>Women</th>
<th></th>
<th></th>
<th>Men</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stature</td>
<td>short</td>
<td>normal</td>
<td>p</td>
<td>short</td>
<td>normal</td>
<td>p</td>
</tr>
<tr>
<td>Glucose, mmol/l</td>
<td>04.76</td>
<td>04.68</td>
<td>0.16</td>
<td>05.04</td>
<td>05.00</td>
<td>0.72</td>
</tr>
<tr>
<td>Glucosylated hemoglobin, %</td>
<td>07.70</td>
<td>07.34</td>
<td>0.02*</td>
<td>07.96</td>
<td>07.72</td>
<td>0.03*</td>
</tr>
<tr>
<td>Cholesterol, mg/dl</td>
<td>186.0</td>
<td>166.2</td>
<td>0.03*</td>
<td>187.8</td>
<td>191.2</td>
<td>0.22</td>
</tr>
<tr>
<td>LDL, mg/dl</td>
<td>116.0</td>
<td>103.2</td>
<td>0.02*</td>
<td>114.6</td>
<td>112.8</td>
<td>0.12</td>
</tr>
<tr>
<td>HDL, mg/dl</td>
<td>044.0</td>
<td>048.3</td>
<td>0.05*</td>
<td>044.1</td>
<td>043.6</td>
<td>0.61</td>
</tr>
<tr>
<td>Total cholesterol/HDL, mg/dl</td>
<td>04.23</td>
<td>03.44</td>
<td>0.02*</td>
<td>04.25</td>
<td>04.38</td>
<td>0.25</td>
</tr>
<tr>
<td>T3, ng/ml</td>
<td>01.22</td>
<td>01.48</td>
<td>0.04*</td>
<td>01.49</td>
<td>01.41</td>
<td>0.57</td>
</tr>
<tr>
<td>Insulin, µg/ml</td>
<td>11.34</td>
<td>09.26</td>
<td>0.02*</td>
<td>09.72</td>
<td>08.58</td>
<td>0.05*</td>
</tr>
<tr>
<td>HOMA-IR</td>
<td>02.39</td>
<td>01.93</td>
<td>0.01*</td>
<td>02.17</td>
<td>01.91</td>
<td>0.04*</td>
</tr>
<tr>
<td>HOMA-β%</td>
<td>180.0</td>
<td>156.9</td>
<td>0.002*</td>
<td>126.2</td>
<td>114.4</td>
<td>0.03*</td>
</tr>
</tbody>
</table>

Data obtained from a very low income population in Maceió, Alagoas, northeastern Brazil.
Table 2. Body composition of control, outpatient, and day-hospital groups of girls and boys at follow-up, including only prepubertal children

<table>
<thead>
<tr>
<th></th>
<th>Girls</th>
<th></th>
<th>Boys</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>control (n = 15)</td>
<td>outpatient (n = 12)</td>
<td>day-hospital (n = 18)</td>
<td>p value</td>
</tr>
<tr>
<td>Body fat, kg</td>
<td>6.9±2.6</td>
<td>3.8±0.9ª</td>
<td>4.0±1.0ª</td>
<td>0.006</td>
</tr>
<tr>
<td>Body fat, %</td>
<td>26.4±4.5ª</td>
<td>19.9±3.4ª</td>
<td>19.8±2.8ª</td>
<td>0.016</td>
</tr>
<tr>
<td>Lean mass/height, g/cm</td>
<td>145±13</td>
<td>130±10</td>
<td>131±14</td>
<td>0.112</td>
</tr>
<tr>
<td>Fat-free mass, kg</td>
<td>18.7±3.2</td>
<td>15.3±1.8</td>
<td>16.1±2.5</td>
<td>0.104</td>
</tr>
<tr>
<td>Fat-free mass index, kg/m²</td>
<td>12.5±0.3</td>
<td>11.9±0.7</td>
<td>11.8±1.1</td>
<td>0.259</td>
</tr>
<tr>
<td></td>
<td>6.2±2.2ª</td>
<td>3.9±1.4ª</td>
<td>3.6±0.7ª</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>20.5±5.0ª</td>
<td>17.7±3.4ª</td>
<td>15.4±2.4ª</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>173±18ª</td>
<td>146±26ª</td>
<td>151±17ª</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>23.8±4.4ª</td>
<td>18.4±5.3ª</td>
<td>19.9±3.2ª</td>
<td>0.012</td>
</tr>
<tr>
<td></td>
<td>13.9±0.7ª</td>
<td>12.7±1.3ª</td>
<td>12.8±0.9ª</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Values are means ± SD. Means in a row without a common superscript differ: p < 0.05. Reprinted with permission from the Journal of Nutrition [10].
showed insulin and insulin-sensitivity values similar to the control group (well-fed) [22]. Thus, what was once considered to be a metabolic alteration now appears to be reversible under favorable dietary and medical conditions.

These findings can be explained by the treatment offered at CREN, which consists of a balanced diet with protein of high biological value, nutrition education, and medication for parasites, infections and anemia. Parents and chil-
dren receive nutrition education, which is an important source of information on what should be consumed in terms of food in order to recover nutritionally and develop healthier life habits. This education is very important for the slum population who live in poor urban areas, tend to consume cheap industrialized or out-of-home prepared food, and face a high level of unemployment or irregular jobs leading to lower physical activity.

**Conclusion**

We have presented data suggesting that children who experience energy restriction early in life may be metabolically programmed to deposit more fat, under specific conditions, and suffer from a number of metabolic pathologies. However, we also presented data suggesting that undernourished children exposed to proper dietary and medical environments can reverse these pathologies and return to normal growth trajectories. These findings, taken together, show that nutritionally recovered children foster a normalization of body composition, bone density and insulin metabolism and, therefore, reduce the risk of chronic diseases in adulthood.

**References**

Long-Term Effect of Malnutrition and Nutrition Recovery


Discussion

Dr. Yajnik: Your studies have shown that stunting is associated with bad metabolic outcomes. It is impressive that they did quite well after treatment. It seems you improved other things, but not blood pressure. At what age did you supplement them? When did you study them again? Was there any relationship to their early life experiences?

Dr. Sawaya: We treat these children, not only with supplementation, until they recover their stature. The most severe ones are treated in hospital and the less severe ones are treated as outpatients. They receive education, medication, but not food, and they receive treatment between 0 and 6 years. I did not show the data, but the only difference between the children less than 2 and more than 2 years of age is the speed with which they recover. Children recover from malnutrition also during puberty. Obviously it depends on the mother, the parents, and the life situation of the children. Treatment should not only include the child, but the whole family. Not only should food be given but also nutritional education. In our experience nutritional education works so well that the children take the good habits home to their families and they start teaching their parents that they want to sit at the table, they want to have vegetables, they want to eat fruits, and they want to eat at a certain time of the day.

Dr. Yajnik: Is there a window of opportunity? What do you think is the ideal time to intervene?

Dr. Sawaya: If they are treated before 2 years of age, they recover much faster in the features I showed. I am not sure about hypertension.

Dr. Yajnik: What was the age during the repeat study?

Dr. Sawaya: It depends on the age of the child because in general they stay in this treatment for 2 years until they recover. When they have caught up and their stature has normalized, they are discharged. We studied the children 3–6 years after they left the center. So the age at the repeat study was 8, 9, 10 years and even up to puberty.
Dr. Shetty: I just want to confirm that the classical thinking is that stunting is not reversed beyond 2 years of age. It is very interesting that you show that in fact stunting can be reversed even after 2 years of age. To my knowledge there are studies with micronutrient supplements showing that stunting can be reversed to some extent. Have you measured cortisol, insulin and IGF in the children who recovered? Are you changing the environment such that the endocrine response at that time has changed?

Dr. Sawaya: I personally believe that cortisol is a key issue. When I think about cortisol, I am not thinking about hunger, famine or whatever, I am thinking about stress, all kinds of stress. It is false to separate the stress of these children because living in a slum with a high score of depression is by itself a stressful condition, and we definitely measured higher cortisol levels. The cortisol levels decreased but I did not measure it in these children. Especially abdominal fat has normalized; they didn’t have the accumulation of abdominal fat that is so typical with high cortisol.

Dr. Popkin: First I want to disagree. We have had a lot of population studies in the last 4–5 years showing catch-up growth in South Africa, the Philippines and elsewhere. Rolland-Cachera et al. [1] did a number of studies in France on children and hypothesized that increased protein intake would be associated with reduced adiposity. Now your research is leading to the protein side, because you seem to show that the stunted children who got the higher protein diet were the ones who reduced their risk of obesity. Or am I reading your results wrong?

Dr. Sawaya: No, not exactly. We give them good nutritional education, and during treatment they receive supplementation of vitamins, especially iron. We also treat the diseases related to malnutrition, all infections, parasites, etc., the whole treatment. I think the most important finding is that the good food education we give them is retained. We also found that protein intake was significantly higher compared to control slum dwellers, and the protein intake was of good quality because they are taught to avoid processed food and to eat natural foods, and therefore decrease the cost of the feeding.

Dr. Ravussin: What is the likelihood of misclassification because height is one of the most heritable traits? Do you adjust the height or the percentile height of the child for the parents, or at least the mothers when the fathers are missing?

Dr. Sawaya: About genetic background, yes we do measure the height of the mothers and they are low. But in a population with this standard of living I don’t believe at all that stunting is not due to nutritional deficits over generations. I do know that if the bodies of these children are given the opportunity to catch up in height, then they do reach the normal range. So the body or the brain sees that the genetic potential is not there, and if the opportunity is there they catch up, for example the results with the supplements. If food is given they eat more, they don’t control the daily food intake as the non-stunted control children do. If we measure IGF1, for me this is the most important thing, it is below the normal range. So these children are stunted because they have lower IGF1 levels, below the normal range.

Dr. Ravussin: My second question is more about energy metabolism in these children. You showed, at least in adult women, that there was a very low T3, and a low metabolic rate. There was also no difference in food or energy intake. First of all, do you trust the food intake measurements? In small numbers I would not trust them myself. Can you account for the low metabolic rate; does it account for the weight gain that is seen during this catch-up period?

Dr. Sawaya: Yes, I believe that a lower energy expenditure is causing the actual data in adolescents; we don’t have data in adults. What we saw in these stunted adolescents, mainly girls, over the 36-month follow-up period was a lower energy expenditure associated with higher weight gain over time. So in the adult population I am implying that these lower T3 levels are also related to lower energy expenditure.
Dr. Ajayi: I just want to link up the earlier lecture to this one with regard to income and malnutrition. I believe that it is purely coincidental that income does not lead to malnutrition, because if a person has the ability to buy food and eat it, it does not mean they have the knowledge of what to buy and what to eat. I think this is reflected in this particular presentation as well, because it is only when a person has the knowledge, the understanding of what to use, even when it is not expensive, that they actually come out of the cycle of malnutrition. This is also true for people with high incomes because having a high income does not necessarily mean that they do not have malnutrition or are not malnourished. It is just coincidental, a person buys something, it happens to be good food and it is eaten, not because they have the knowledge of what to buy, what to eat, and how to prepare and how to consume it. We must not forget to look at education; educating those who have the resources as well as educating those who do not have the resources. When people have a sound understanding and know what to apply, then the right results will be obtained.

Dr. Ganapathy: There are a lot of articles on changing urban lifestyle and the metabolic syndrome [2–4]. You showed us your work on the metabolic syndrome: low growth hormone, lean body mass, low muscle mass, adiposity, insulin resistance, along with a rather low T3 for that age. Do you feel that you should have evaluated the TSH status? During rehabilitation was there a change in the environment of the slum child? Was is it only rehabilitation that brought the child back to normal? Did you ever think of endocrine disruptors in that slum area?

Dr. Sawaya: Yes, the condition of the family in general changes. What does not change, because it requires a big change, is the place where they live. To be able to move from a slum to a house, to be able to pay a rent is a big step upwards in terms of income, and that is difficult, at least in our environment. But if you think about the life within the family, yes, it has improved. We have data about the stability of jobs, the ability to shop and to choose the proper food. The comparison between the nutritional education given to these families and the drop in the obesity rate among very rich Brazilian women is due to the return to the natural staple Brazilian diet. So if cheaper food is supplied, at least in Brazil, by avoiding processed foods that are more expensive, good nutritional education and good nutritional outcome can be achieved, even if the person lives in a slum.

Dr. Ganapathy: Was there a change in the environment? I just want to know whether they were institutionalized, hospitalized, or something of that sort.

Dr. Sawaya: It is a daycare center. We don’t take the children out of their families. If they need hospitalization we send them to the hospital, but this is for a few days or a few weeks, due to other infections like pneumonia.

Dr. Ganapathy: So they were not hospitalized, only receiving nutritional rehabilitation. What about TSH?

Dr. Sawaya: We have not measured TSH here.

Dr. Ganapathy: When there is stunting and obesity, it is prudent to think of an endocrine cause such as hypothyroidism.

Dr. Sawaya: You are a pediatrician, so I understand your concern. In our situation it is so obvious that these people don’t have enough money to buy food, and it is so obvious that the whole family is short due to nutritional problems. When there is a high prevalence of stunting as in this situation, we are talking about 20% of the slum population, hormonal problems are something that we don’t think of as the first cause of stunting, so we have not measured TSH.

Dr. Shetty: I just want to follow-up on the role of cortisol. In the West Indies they conducted studies during stress in children and showed that the cortisol responses were much higher in stunted as compared to non-stunted children [5]. I believe this
is a very simple noninvasive method, looking at stress and its relationship to salivary cortisol and may be worth looking at in your subjects.

**Dr. Wharton:** The other thing that they did in Jamaica was to get the children to play much more. You mentioned psychological input to the mother but you did not mention anything about psychological input into the children or play. Did you do that as well in the daycare?

**Dr. Sawaya:** It is very important for the children to be in a positive environment. Very often they are not in a positive environment at home, and so the day hospital treatment for the most severely affected children with the most severe problems in their family is very important. In our center the social workers say that when they see that the mother is well-dressed and happy, the growth curve of the child is better. So a very positive environment for these children is definitely very important.

**Dr. Shahkhalili:** In your control group the energy intake is still not adequate. Thus you are comparing stunted children with undernourished but non-stunting children, is that true?

**Dr. Sawaya:** You are correct; I am comparing slum-dwelling children. The controls had lower IGF1, higher blood pressure; so they are not healthy either, they are slum children. So I am comparing control non-stunted slum children with stunted slum children.

**Dr. Shahkhalili:** You demonstrated the health and growth improvements in your treated group, except for the kidney problem. Do you know if your study group suffered from IUGR which has an irreversible impact on kidney development?

**Dr. Sawaya:** This is a good question; I don’t know and would like to study this more. As far as I know, the number of nephrons in the kidney is mainly set up prenatally. 73% of our children have low or insufficient birthweight, and that is why I think it starts before birth and continues after birth, it is a continuing problem. I would like to see what happens after puberty for example.

**References**