Micronutrient Deficiencies during the Weaning Period and the First Years of Life

Editors
J. M. Pettifor, Johannesburg, South Africa
S. Zlotkin, Toronto, Canada
Contents

VII  Preface

IX   Foreword

XI  Contributors

1  Role for Micronutrient Interactions in the Epidemiology of Micronutrient Deficiencies: Interactions of Iron, Iodine and Vitamin A
Hurrell, R.F.; Hess, S.Y. (Zurich)

21  The Epidemiology of Vitamin D and Calcium Deficiency
Pettifor, J.M. (Johannesburg)

37  Epidemiology of Micronutrient Deficiencies in Developing and Developed Countries, Specifically Zinc, Copper, Selenium and Iodine
Castillo-Duran, C.; Ruz, M. (Santiago)

53  Stable Isotope Methods in Micronutrient Research
Abrams, S.A. (Houston, Tex.)

67  Interactions between Micronutrients: Synergies and Antagonisms
Lönnerdal, B. (Davis, Calif.)

83  Influence of Food Intake, Composition and Bioavailability on Micronutrient Deficiencies of Infants during the Weaning Period and the First Year of Life
Gibson, R.S. (Dunedin); Hotz, C. (Cuemavaca); Perlas, L.A. (Metro Manila)
<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>Micronutrient Malnutrition and Poverty</td>
<td>Bloem, M.W.; de Pee, S. (Singapore)</td>
</tr>
<tr>
<td>119</td>
<td>Impact of Micronutrient Deficiencies on Behavior and Development</td>
<td>Lozoff, B. (Ann Arbor, Mich.); Black, M.M. (Baltimore, Md.)</td>
</tr>
<tr>
<td>137</td>
<td>Impact of Micronutrient Deficiencies on Immune Function</td>
<td>Semba, R.D. (Baltimore, Md.)</td>
</tr>
<tr>
<td>153</td>
<td>Impact of Micronutrient Deficiencies on Bone Growth and Mineralization</td>
<td>Specker, B. (Brookings, S. Dak.)</td>
</tr>
<tr>
<td>173</td>
<td>Impact of Infections on Micronutrient Deficiencies in Developing Countries</td>
<td>Bhutta, Z.A. (Karachi)</td>
</tr>
<tr>
<td>187</td>
<td>The Economic Impact of Micronutrient Deficiencies</td>
<td>Horton, S. (Toronto, Ont.)</td>
</tr>
<tr>
<td>203</td>
<td>Practical Considerations for Improving Micronutrient Status in the First Two Years of Life</td>
<td>Parvanta, I.; Knowles, J. (Atlanta, Ga.)</td>
</tr>
<tr>
<td>213</td>
<td>Specific Strategies to Address Micronutrient Deficiencies in the Young Child: Targeted Fortification</td>
<td>Neufeld, L.M. (Morelos); Ramakrishnan, U. (Atlanta, Ga.)</td>
</tr>
<tr>
<td>233</td>
<td>Specific Strategies to Address Micronutrient Deficiencies in the Young Child: Supplementation and Home Fortification</td>
<td>Zlotkin, S.; Tondeur, M. (Toronto, Ont.)</td>
</tr>
<tr>
<td>249</td>
<td>Crystal Ball Gazing: Micronutrients for All by 2015</td>
<td>Mannar, M.G.V. (Ottawa, Ont.)</td>
</tr>
<tr>
<td>263</td>
<td>Conclusions</td>
<td></td>
</tr>
<tr>
<td>269</td>
<td>Subject Index</td>
<td></td>
</tr>
</tbody>
</table>
Preface

In economically advanced countries, mineral and vitamin deficiencies have virtually been eliminated over the past 50 years through a combination of national legislation mandating the fortification of some staple foods and voluntary fortification of foods typically sold in grocery stores. The iodization of salt is perhaps the best example of mandated fortification, while ready-to-eat breakfast cereals are a typical example of the voluntary fortification of a commonly eaten food. Historically, the problem of anemia in children largely disappeared in North America and Western Europe only after the introduction and social marketing of highly fortified foods targeted to children. Although pockets of infants and children remain at risk, including infants born prematurely, those living in poverty, new immigrants and some aboriginal groups, generally the eradication of micronutrient deficiencies in the West is recognized as a successful public health accomplishment. The same cannot be said for most developing countries. In developing countries, fortified infant cereals are often unavailable or beyond the reach of financially impoverished communities, and recommendations to use formula are inappropriate, since it competes with breast-feeding.

Iron deficiency is the most common preventable nutritional deficiency in the world despite global goals for its reduction. In the developing world it is estimated that more than 50% of children less than 4 years of age are anemic primarily due to a diet inadequate in bioavailable iron. In some African and South Asian countries, the prevalence of iron-deficiency anemia is as high as 80% of young children. Among the many risk factors that contribute to iron-deficiency anemia in children are low birth weight, early cord clamping, maternal anemia, high rates of infectious disease including malaria, *Helicobacter pylori*, and helminth infections, poverty, poor access to iron-rich foods, and other nutritional deficiencies which impede the incorporation of iron into hemoglobin.

The present volume reviews current knowledge of micronutrient deficiencies during the critical weaning period and first years of life, and follows on a highly successful workshop held a year previously, which looked at micronutrient deficiencies in the first months of life. The workshop provided a
logical chronology of the issues and challenges associated with micronutrient deficiencies during this critical later phase of infant and toddler development. To understand the extent of the problem, the first speakers explored the epidemiology of micronutrient deficiencies including state-of-the-art discussions on the use of stable isotopic methods to investigate factors affecting the absorption and interactions of micronutrients. Following directly on the epidemiology was a session on the various etiological factors which predispose ‘at risk’ populations of infants and young children to micronutrient deficiencies. The Workshop was updated on the more traditional factors like food composition and infectious diseases that would be expected to influence micronutrient status, but in addition, socio- and geopolitical factors like poverty, globalization, and natural disasters were also considered in a thoughtful presentation and panel discussion. In the third session, the health and economic implications of micronutrient deficiencies were considered. Presenters, who are world experts in the field, emphasized the cognitive, intellectual, and social-emotional impairments that may not be reversible in children under 2 years of age with iron-deficiency anemia compared to those without iron deficiency anemia. These children have reduced learning capacity and school achievement and as adults decreased wages and work capacity. Although most in attendance were aware of the health implications of micronutrient deficiencies, it was less well known that its burden results in a reduction of 4.5% of GDP through reduced learning and ultimately poorer paying jobs.

The final session was devoted to a wide-ranging discussion on strategies for the prevention of micronutrient deficiencies. Despite the widely acknowledged lack of success of current public health interventions to prevent micronutrient deficiencies, the presentations and discussion were markedly upbeat and positive. Speakers emphasized that through a combination of food diversification, general supplementation, targeted fortification and ‘home fortification’ the problem could be addressed. By developing partnerships between the private and public sector and through the initiatives of governments and non-governmental organizations, the prevention of micronutrient deficiencies was deemed by the Workshop to be a real possibility.

What distinguishes the Nestlé Workshops from others is the format of short presentations followed by long discussions. This thoughtful format allows the speakers and audience to actively interact for more than the usual 5 minutes of questions. As the reader will come to understand, the inclusion of the questions, cross-discussion and debate during the question period is a highlight of the Workshop. Thus the proceedings do more than present state-of-the-art information, they provide a thoughtful and hopefully useful discourse on this important topic.

J.M. Pettifor and S. Zlotkin
For this 54th Nestlé Pediatric Nutrition Workshop, which took place in October 2003 in Sao Paulo, the topic ‘Micronutrient Deficiencies during the Weaning Period and the First Years of Life’ was chosen as a follow-up to the 52nd workshop on ‘Micronutrient Deficiencies in the First Months of Life’.

We were interested in the epidemiology of micronutrient deficiencies and the interactions between the various micronutrients, the appropriate methods in micronutrient research, the influence of food intake and bioavailability on micronutrient deficiencies, the relation between micronutrient malnutrition and poverty, the effect of micronutrient deficiencies on behavior and development, immune functions as well as on bone growth and mineralization, the influence of infections on micronutrient deficiencies in developing countries, the economic impact of micronutrient deficiencies, and finally strategies for the prevention of micronutrient deficiencies in the young child. In order to answer these questions we sought the knowledge of various experts to clarify the pathogenesis of micronutrient deficiencies in the young child and to develop preventive strategies.

I would like to thank the two chairmen, Prof. John Pettifor and Prof. Stanley Zlotkin, who are well-known experts in this field, for putting the program together and inviting as speakers the opinion leaders in the field of micronutrients in health and various disease conditions. Pediatricians invited from 14 countries contributed to the discussions that are published in this book. Mr. João Oliveira and his team from Nestlé Brazil provided all logistical support, so that participants gained an appreciation of the Brazilian hospitality. Dr. Denis Barclay from the Nestlé Research Center in Lausanne, Switzerland, was responsible for the scientific coordination. His cooperation with the chairpersons was essential for the success of this workshop.

Prof. Wolf Endres, MD
Vice-President
Nestec Ltd., Lausanne, Switzerland