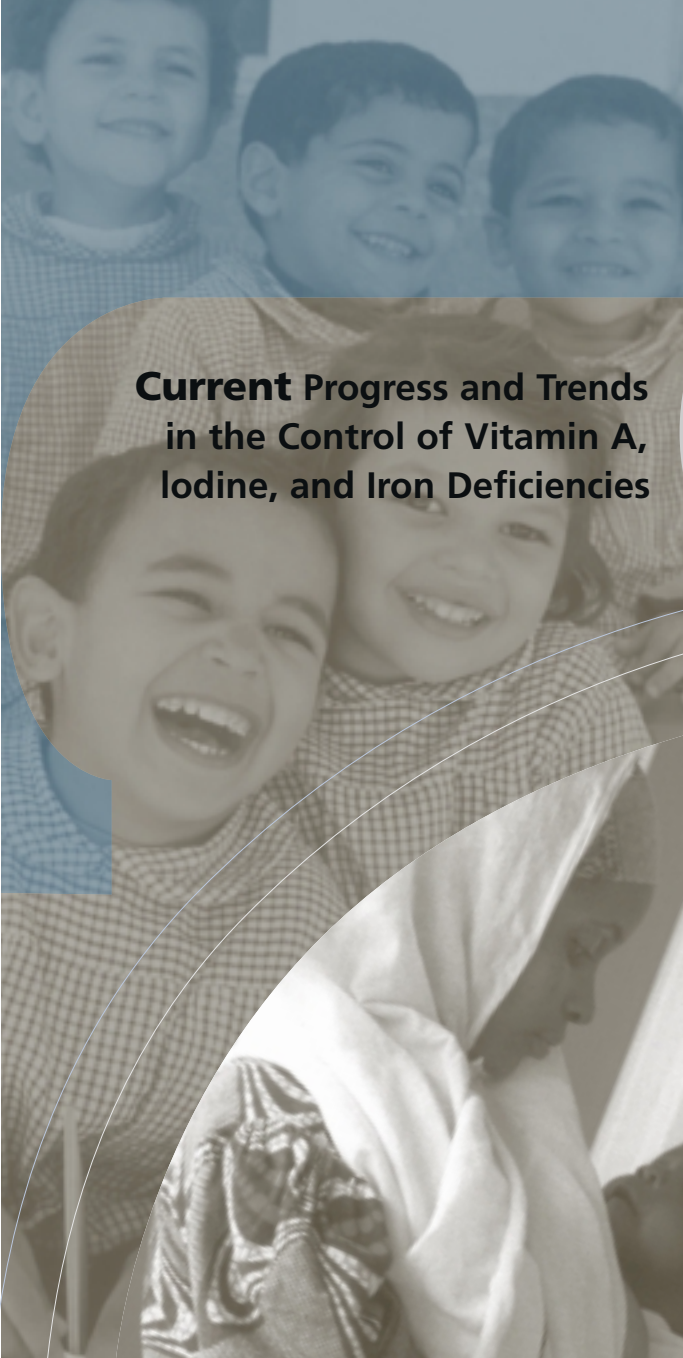




The Micronutrient Report



**Current Progress and Trends
in the Control of Vitamin A,
Iodine, and Iron Deficiencies**



John. B. Mason
Mahshid Lotfi
Nita Dalmiya
Kavita Sethuraman and Megan Deitchler

The Micronutrient Report

Current Progress and Trends in the Control of Vitamin A, Iodine, and Iron Deficiencies

Micronutrient deficiencies are a significant cause of malnutrition and associated ill health throughout the world. This is particularly true in the developing world, where nearly 20% of the population suffers from iodine deficiency, about 25% of children have subclinical vitamin A deficiency, and more than 40% of women are anaemic. Micronutrient deficiencies also lead to impaired growth and cognitive development, birth defects, cretinism, and blindness, as well as decreased school and work performance and poor general health.

The Micronutrient Report summarizes current data on the prevalence of vitamin A, iodine, and iron deficiencies and reports on the implementation and progress of programs to battle these deficiencies in developing countries. Prepared by the Department of International Health at Tulane University, the Micronutrient Initiative, and UNICEF, this report is the first in what will be an ongoing series on the state of micronutrient nutrition and the battle against micronutrient deficiency. It sets a reference point by which priorities for program content and coverage can be better informed and a baseline from which progress in deficiency prevention can be measured. Part 1 summarizes prevalence trends for deficiencies of vitamin A, iodine, and iron; part 2 describes the status of current programs aimed at preventing or reducing micronutrient deficiencies. The report is illustrated with numerous statistical tables, figures, and maps.

John B. Mason is a professor in the Department of International Health and Development at Tulane University (USA). From 1986 to 1996, he was Technical Secretary of the United Nations Coordinating Committee on Nutrition based at the World Health Organization in Geneva. He is also past Director of the Cornell Nutritional Surveillance Program. **Mahshid Lotfi** is Senior Program Specialist for the Micronutrient Initiative, where she monitors and helps to develop international health, nutrition, and development programs in Asia, Africa, and Latin America. She holds a doctorate in physiological nutrition from the University of London (UK). **Nita Dalmiya** works for the Nutrition Division in the United Nations Children's Fund (UNICEF) in New York. **Kavita Sethuraman** is currently completing doctoral research at the Centre for International Child Health, University College, London, UK. She has worked for the United Nations Coordinating Committee on Nutrition and as a community-based nutritionist in the inner city of Boston and in the South Pacific. **Megan Deitchler** currently works at Tulane University as program coordinator for a multicentre micronutrient project. She holds a master's degree in public health from Tulane University.

L'Initiative
micronutriments



The Micronutrient
Initiative

ISBN 1-894217-18-7



9 781894 217187

The Micronutrient Report

Current Progress and Trends in the Control of
Vitamin A, Iodine, and Iron Deficiencies

The Micronutrient Report

Current Progress and Trends in the Control of
Vitamin A, Iodine, and Iron Deficiencies

John. B. Mason

Department of International Health and Development, Tulane University School of Public Health and Tropical Medicine, New Orleans, LA, USA

Mahshid Lotfi

Micronutrient Initiative, Ottawa, ON, Canada

Nita Dalmiya

Nutrition Section, United Nations Children's Fund, NY, USA

Kavita Sethuraman and Megan Deitchler

with

Scott Geibel, Kari Gillenwater, Amy Gilman, Karen Mason, and Nancy Mock

Department of International Health and Development, Tulane University School of Public Health and Tropical Medicine, New Orleans, LA, USA



L'Initiative
micronutriments



The Micronutrient
Initiative



Published by the Micronutrient Initiative
PO Box 8500, Ottawa, ON, Canada K1G 3H9
<http://www.micronutrient.org>

© International Development Research Centre 2001

National Library of Canada cataloguing in publication data

Main entry under title :

The micronutrient report : current progress and trends in the control of vitamin A, iron, and iodine deficiencies

Includes bibliographical references.

Co-published by Micronutrient Initiative.

ISBN 1-894217-18-7

1. Vitamin A deficiency — Developing countries.
2. Iron deficiency anemia — Developing countries.
3. Iodine deficiency diseases — Developing countries.
4. Regional medical programs — Developing countries.

I. Mason, John B.

II. Micronutrient Initiative (Association)

III. International Development Research Centre (Canada)

RA645.V56M52 2001

615'.328

C2001-980031-2

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, or otherwise, without the prior permission of the International Development Research Centre. A microfiche edition is available. IDRC Books endeavours to produce environmentally friendly publications. All paper used is recycled as well as recyclable. All inks and coatings are vegetable-based products.

One or more photos in this publication were selected from Photoshare, the online database of the Media/Materials Clearinghouse at the JHU/Population Information Program at www.jhuccp.org/mmc. Cover photos, clockwise from top: Mohsen Allan (93-28), Mohsen Allan (93-20), Liz Gilbert, courtesy of the David and Lucille Packard Foundation (2355-14).

Published in association with the
International Development Research Centre
PO Box 8500, Ottawa, ON, Canada
<http://www.idrc.ca>



Contents

Foreword	ix
Acknowledgments	xi
Executive Summary	xiii
Part I. Trends in Prevalences	1
1. Introduction — What Are We Trying To Find Out?	1
2. Data and Analytical Methods	3
Measurement and Indicators	3
Data Sources for Population Assessments	6
Issues in Aggregating Data, Making Comparisons, and Assessing Trends	7
Samples	8
Cutoff Values	10
Biological Groups	11
Seasonality	12
Aggregation of Data to Standard Time	13
Estimation of Trends	18
3. Results: Trends in Reducing Micronutrient Deficiencies	21
Recent Trends in Prevalence of Vitamin A Deficiency	21
Recent Trends in Prevalence of Iodine Deficiency Disorders	23
Recent Trends in Prevalence of Anemia	26
Levels of Vitamin A, Iodine, and Iron Deficiencies	30
Overlaps and Multiple Deficiencies	36
4. Conclusions	39
Part II. Program Implementation in the 1990s	41
1. Introduction	41
2. Types of Programs	42
3. Methods, Data Sources, and Treatment of Data	44
General Principles of Data Treatment	45
Vitamin A	45
Iodine	47
Iron	48
Multiple Micronutrient Programs	48

4. Results: Progress in Micronutrient Deficiency Control Programs	49
Control of Vitamin A Deficiency	49
Control of Iodine Deficiency Disorders	56
Control of Iron Deficiency	60
Addressing Multiple Deficiencies	62
5. Conclusions	67
References	69
Appendix 1. Prevalence of clinical signs of vitamin A deficiency in preschool children	76
Appendix 2. Prevalence of subclinical vitamin A deficiency	77
Appendix 3. Prevalence of iodine deficiency disorders	78
Appendix 4. Prevalence of anemia in pregnant women 15–49 years of age	80
Appendix 5. Prevalence of anemia in nonpregnant women 15–49 years of age	82
Appendix 6. Prevalence of underweight for 1995	84
Appendix 7. Prevalence of underweight in 1995 and most recent survey years	86
Appendix 8. Status of micronutrient supplementation policies and fortification legislation	88
Appendix 9. Procurement of vitamin A capsules in relation to need for children 6–12 and 12–59 months of age	95
Appendix 10. Countries with national immunization days (NIDs), micronutrient (M-NUT) days, Extended Programs for Immunization (EPIs) coupled with vitamin A capsule distribution, or policies for postpartum supplementation, 1998	102
Appendix 11. Households consuming adequately iodized salt	106
Appendix 12. Reported program coverage for iron supplementation during pregnancy, 1996	108
Appendix 13. Estimated adequacy of supply and reported program coverage for vitamin A, iodine (through iodized salt), and iron	110

Tables

1. Indicators of micronutrient deficiencies as established by WHO	4
2. Estimates of clinical and subclinical prevalences of vitamin A deficiency in relation to multiplication factors (WHO 1995).	9
3. Summary of five surveys of subclinical vitamin A deficiency reported in WHO (1995)	9
4. Prevalence of anemia (hemoglobin < 120 g/L) in nonpregnant women 15–49 years of age	29
5. Prevalence of anemia (hemoglobin < 110 g/L) in pregnant women 15–49 years of age	29
6. Prevalence and number of preschool children affected by clinical vitamin A deficiency, 1985–1995	31

7. Prevalence and number of preschool children affected by subclinical vitamin A deficiency, 1995	32
8. Prevalence and number of people (all ages) with goitre (visible + palpable) in 1990 and 1998	34
9. Prevalence and number of women (15–59 years of age) affected by anemia in 1995	35
10. Prevalence of nutritional problems and implied overlap of deficiencies in preschool children	38
11. Preferred initial approaches to prevention and control of vitamin A, iodine, and iron deficiencies in populations at different levels of micronutrient malnutrition	43
12. Numbers of countries with micronutrient supplementation policies and fortification legislation	50
13. Regional procurement of vitamin A capsules in relation to need	52
14. Countries with priority for external provision of vitamin A supplements	53
15. Distribution of vitamin A capsules in relation to national immunization days (NIDs), micronutrient (M-NUT) days, Expanded Programs for Immunization (EPIs), and postpartum supplementation policies	55
16. Percentage of mothers receiving high-dose vitamin A capsules within 4–8 weeks after delivery in countries reporting presence of a program	56
17. Commodities being used for fortification with vitamin A in operational country programs	57
18. Households consuming adequately iodized salt, 1995–1998	57
19. Regional procurement of iron supplements in relation to need	61
20. Commodities being used for fortification with iron	63
21. Regional procurement in relation to need for vitamin A, iodine, and iron	66

Figures

1. Prevalence of subclinical vitamin A deficiency in Southeast Asia	15
2. Trends in clinical vitamin A deficiency	19
3. Clinical vitamin A deficiency in preschool children	21
4. Subclinical vitamin A deficiency in preschool children	22
5. Trends in iodine deficiency disorders for nine countries	24
6. Prevalence of iodine deficiency disorders in school-age children	26
7. Prevalence of anemia among nonpregnant women 15–49 years of age	27
8. Prevalence of anemia among pregnant women 15–49 years of age	28
9. Estimated prevalence of clinical vitamin A deficiency among preschool children in 1985 and 1995	32
10. Estimated prevalence of subclinical vitamin A deficiency among preschool children in 1995	33
11. Estimated numbers of preschool children affected by subclinical vitamin A deficiency in 1995	33
12. Prevalence of anemia among women 15–49 years of age in 1995	35

13. Summary of regional prevalences of underweight, subclinical vitamin A deficiency, iodine deficiency disorders, and anemia among preschool children in 1995	37
14. Reported program coverage with high-dose vitamin A capsules for preschool children in 1998 and estimated adequacy of external capsule supply	53
15. Prevalence of subclinical vitamin A deficiency and reported coverage of vitamin A supplementation programs in 1998	54
16. Households receiving adequately iodized salt for the period 1995–1998.	58
17. Prevalence of iodine deficiency disorders and percentage of households receiving adequately iodized salt	59
18. Reported program coverage with iron supplementation for pregnant women in 1996 and estimated adequacy of external supply	62
19. Prevalence of anemia among pregnant women and reported coverage of iron supplementation programs	64
20. Percentage of countries reporting high program coverage for vitamin A supplementation, iodine fortification, and iron supplementation	65

Foreword

Micronutrient deficiencies are a significant cause of malnutrition and associated ill health among populations in developing countries. Deficiencies in vitamin A, iodine, and iron are known to be especially prevalent and are associated with a range of mild (and often reversible) to severe (and often irreversible) effects. At the subclinical level of micronutrient deficiency, poor general health and decreased school and work performance are likely to result, and mortality risk increases. Known clinical outcomes of micronutrient deficiencies include impaired growth and cognitive development, poor birth outcomes, anaemia, cretinism, and blindness.

Global prevalences of micronutrient deficiencies are remarkably high. In the developing world, more than 40% of women are anaemic, nearly 20% of the population suffers from iodine deficiency disorders (IDDs), and about 25% of children have subclinical vitamin A deficiency. The level of clinical vitamin A deficiency is now falling quite rapidly (MI et al. 1998). The prevalence of IDDs must also be falling in regions where the salt is iodized, but as yet the data are too scarce to verify this. For anaemia, however, there is no evidence of improvement.

To understand the full extent of the problem, a reliable assessment of deficiency prevalence and proper monitoring and evaluation of micronutrient programs are required. To respond to this need, the Department of International Health at Tulane University, the Micronutrient Initiative, and the United Nations Children's Fund (UNICEF) have cooperated in the preparation of this report. The report summarizes current data on the prevalence of vitamin A, iodine, and iron deficiencies and reports on the implementation and progress of programs to battle these deficiencies in developing countries. Each of the hundreds of different data points assembled and analyzed herein represent substantial data-collection efforts by many people, all over the world. *The Micronutrient Report* is presented in two parts: (1) a summary of prevalence trends for deficiencies of vitamin A, iodine, and iron; (2) a description of the status of current programs aimed at preventing or reducing micronutrient deficiencies.

It is hoped that this report helps both to establish a reference point by which priorities for program content and coverage can be better informed and a baseline from which progress in deficiency prevention can be measured. The baseline estimates, given here and to come in the

future, will provide for updated trend estimates in future reports. The report aims to give guidance on appropriate methods for future assessment of trends in deficiencies and interventions. It also identifies specific gaps in existing data — anaemia prevalences at the national level for instance — that need to be addressed. National surveys need to be carried out regularly, with attention to comparability through time and between countries. Proper evaluations will not only help to better assess the progress of programs but will also help to inform the most cost-effective and sustainable means of preventing micronutrient deficiencies.

Tulane University, the Micronutrient Initiative, and UNICEF are pleased to report the great increase in the extent of micronutrient policies and programs, especially vitamin A supplementation and salt iodization. Many countries have implemented large-scale programs to reduce vitamin A and iodine deficiencies. Accelerated decreases in the prevalence of micronutrient deficiencies could rapidly result from further program expansion.

The time is right to act more widely still on micronutrient deficiencies. Although encouraging progress is already evident, much more remains to be achieved. Low-cost interventions are already available, and research for additional solutions is advancing. More resources could be mobilized toward the effort, and more effective programs could be implemented on a larger scale. Control of micronutrient deficiencies, notably IDD and vitamin A deficiency, is set to become a major public health and nutrition success story, in the league of

smallpox eradication. We hope that this report — intended to be the first of a regular series, in print and available online with regular updates — will provide useful information for expanding and supporting these efforts.

M. G. Venkatesh Mannar

Executive Director
The Micronutrient Initiative
Ottawa, Canada

Werner Schultink

Senior Advisor, Micronutrients
UNICEF
New York, USA

Robert Magnani

Acting Chair
Department of International Health
and Development
School of Public Health and
Tropical Medicine
Tulane University
New Orleans, USA

Acknowledgments

This report results from a great deal of data compilation and analysis by many people. The epidemiological data originated from hundreds of surveys, usually analyzed in the countries concerned, and then summarized and compiled through international bodies such as the World Health Organization, the United Nations University, the International Council on the Control of Iodine Deficiency Disorders (mostly through the University of Virginia), and the United States Agency for International Development and its contracting institutions such as Opportunities for Micronutrient Intervention, the International Vitamin A Consultative Group, the International Nutritional Anemia Consultative Group, and others. Program data came both from responses to questionnaires by country offices of the United Nations Children’s Fund (UNICEF) and from demographic and health surveys (Macro International), multiple indicator cluster surveys, and local surveys. Both earlier and more recent compilations of information on policies, legislation, and programs in the MN-Net — a system of online databases maintained by the Micronutrient Initiative (MI), which was itself updated as part of this

work — all contributed. Some of the material on vitamin A was previously published in *Progress in Controlling Vitamin A Deficiency* (MI et al. 1998). Our thanks are due to the many people who have worked at the different stages to measure indicators, accumulate data, and analyze and summarize the information.

We are grateful for comments from Jean-Pierre Habicht, Fernando Viteri, and François Delange, who reviewed Part I of the report, and UNICEF, MI, and Tulane University staff who checked the voluminous data in Part II.

At UNICEF, Roger Shrimpton and Werner Schultink provided support and help in many ways. At the MI, Venkatesh Mannar showed patience and gave encouragement. Many thanks to these and others at their institutions.

Our particular thanks are due to staff in the UNICEF country offices for completing the questionnaires and to Tulane University students — some of whom are coauthors — and others who contributed in various ways: Roxanne Johnson, Pam Opdyke, Nate Smith, and Erica Wetzler.

We gratefully acknowledge financial support from the MI to the Department of International Health and Development, Tulane University School of Public Health and Tropical Medicine, to enable this work to be undertaken.

John B. Mason, PhD

Mahshid Lotfi, PhD

Executive Summary

Micronutrient deficiencies affect nearly half of humanity. In this report, we summarize the extent of and trends in deficiencies of vitamin A, iodine, and iron (in part I) and progress in programs for their control (in part II). The main purpose is to establish a baseline from which to set priorities for program interventions and for conducting research and development to accelerate progress.

A view of trends through time is needed to assess progress: it makes a lot of difference whether matters are getting better or worse, how fast the changes are occurring, and whom they affect. Part I of this document describes micronutrient deficiencies and their trends, and Part II presents information on program implementation. Where the trends show improvements, the issues include how to sustain the interventions and generate permanent solutions — achieving full coverage, with adequate monitoring and quality control. Where there are no real trends of improvement, steps are needed to find and implement effective, large-scale programs suited to conditions in poor countries.

Overlap between deficiencies and interactions between nutrients have so far received relatively scant attention in large-scale programs. However, supplementation and fortification with multiple micronutrients may make more sense both biologically and operationally and should result in enhanced health benefits. Viewing the information in a more integrated way is thus the logical next step, rather than perpetuating the boundaries between deficiencies, which exist mostly for recent historical reasons. We can also learn from comparing and contrasting experiences with collection, analysis, and interpretation of data concerning different deficiencies, which in turn should lead to more effective and integrated surveillance in the future. In this document, underweight in children is also included for comparative purposes, in part because it is the most widely available indicator of general malnutrition.

Recent trends in prevalences of clinical vitamin A deficiency, assessed by comparing results of repeated national surveys (available from eight countries), have shown improvements.

Furthermore, comparisons of regional estimates of the prevalence of clinical vitamin A deficiency for 1985 and 1995 indicate an overall trend of strong improvement. The global prevalence of clinical vitamin A deficiency for 1995 is probably best estimated as 1.2% in preschool children (a value based on reported prevalences that have not been reduced according to assumptions related to survey coverage, such as the World Health Organization [WHO] multiplication factor; the global prevalence would be 0.6% if this factor were used — see Table 2). For subclinical vitamin A deficiency, defined as serum retinol level of less than 0.7 $\mu\text{mol/L}$, the trend is less clear because of the scarcity of data; however, calculations based on subclinical results, which are almost always obtained from surveys conducted independently of assessments of clinical vitamin A deficiency, support the idea that a significant improvement is under way. On a global basis, it is estimated that 75–140 million preschoolers are affected by subclinical vitamin A deficiency, with the upper limit of this range thought to be more likely. The highest prevalences of both clinical and subclinical vitamin A deficiency occur in South Asia and sub-Saharan Africa, where 30% to 40% of preschool children are at heightened risk of ill health and death because of this deficiency and which is home to 100 million of the 140 million people worldwide who are affected by subclinical vitamin A deficiency.

By the late 1990s, about half of the countries in the developing world had adopted national policies for addressing vitamin A deficiency, including two-thirds of countries in East Asia and the Pacific region and one-third of those in the Middle East and northern Africa. In most cases, distribution of high-dose vitamin A capsules was an important part of the policy. Over the period 1993–1998 over 100 million capsules, on average, were distributed annually, and high levels of coverage were achieved in many countries in the mid-1990s. Operationally, it is useful to identify countries with high prevalence of vitamin A deficiency and low coverage of the population through supplementation programs, which would be possible priorities for program development, as well as countries with significant prevalence of deficiency and high coverage through supplementation programs, but low ability to procure the supplement. Some of these countries (those without domestic sources of vitamin A capsules) might have priority for external provision of the supplement. Such considerations argue that priority for program development should go to Burundi, Chad, India, Malawi, and Pakistan, and that the question of increasing the external supply of capsules to Bangladesh and the Philippines should be explored. These analyses should be updated as programs change.

Thirty-nine countries reported distribution of vitamin A supplements during national immunization days or in conjunction with other mass immunization campaigns. In the African countries, this was by far the commonest method, and several countries distributed supplements in this way although they had no national policy on supplementation. Vitamin A supplementation is also being integrated into routine visits to mother and child health clinics and is occurring through community-based nutrition programs. These methods reportedly lead to high coverage rates for children. Moreover, 44 countries reported adoption of policies for supplementation of all mothers with a high-dose vitamin A capsule within 8 weeks after childbirth.

Fewer than half of the roughly 50 countries that have a national policy for addressing vitamin A deficiency also have legislation governing fortification of foods with this micronutrient. In Latin America and the Caribbean, supplementation is not a common approach, and more reliance is placed on fortification. Sugar and margarine are the commodities most often fortified in developing countries (usually when legislation is in place, except for sub-Saharan Africa); maize flour, vegetable oil, rice, and dairy products are also used. Research and pilot projects are under way in several other countries.

Overall, a judicious conclusion is that vitamin A deficiency is extensive and serious, but that there is an underlying trend of improvement, which could be accelerated by large-scale programs.

The prevalence of iodine deficiency disorders, assessed as visible plus palpable goitre, is about 20% to 30% in Africa and the eastern Mediterranean region (including Pakistan); estimates for Southeast Asia are lower. The total number of people affected in these countries was estimated at nearly 600 million in 1998, out of a total of 740 million people thought to be affected by goitre worldwide. About 80 national surveys of goitre have been carried out since 1970, but only for 8 countries were repeat surveys that were likely to be comparable identified. For two additional countries (Cameroon and Peru) progress was tracked by a sentinel site monitoring system.

It appears that rapid improvement occurs when adequately iodized salt, with wide population coverage, is introduced. This outcome is expected, given the long-established effectiveness of salt iodization. What is uncertain is the trend before widespread programs were implemented. [In most of the countries for which repeat data are available, some extent of iodine-deficiency control had been undertaken.] Thus, a pattern of improvement has been observed in Ethiopia, Indonesia,

Viet Nam, and Zambia. About 68% of households are now getting adequately iodized salt, and three-quarters of the countries in the developing world have legislation in place for iodization of salt. Nearly 90% of households in Latin America and the Caribbean are using adequately iodized salt. The corresponding figures are 65% to 75% for Asia, 50% to 74% for sub-Saharan Africa, and about 50% for the Near East and northern Africa. The lowest coverage with adequately iodized salt occurs in the former Soviet Union. Countries that should have priority for assistance might be those with significant prevalences of goitre (e.g., more than 10%) and low percentages of households using adequately iodized salt (e.g., less than 30%) — examples are Burkina Faso, Ethiopia, Ghana, Mauritania, and the Philippines.

A comparison of the estimates for 1990 and 1998 indicates little change in the prevalence of iodine deficiency disorders over this period. When the results from nationally representative surveys are pooled by groups of countries and periods (1980–1989, 1990–1999), the averages indicate no overall improvement and indeed possible deterioration. This apparent increase, reported by the WHO, may reflect increased effort to identify the deficiency in recent years and should probably not be taken as evidence for general deterioration. It does, however, support the idea that significant improvement occurs only when effective salt iodization programs are in place. It also stresses the

lack of representative data that would allow a better assessment of trends.

Improving quality control for the iodine content of salt is now a key issue. Lack of quality control is one major reason that access to iodized salt is not even higher than it is. The other reason is that distribution and marketing of iodized salt still has not reached more remote areas, which is a particular problem in countries where there are large numbers of small, traditional producers.

No repeated, comparable survey results at the national or subnational level could be found for iron deficiency, which is usually assessed as anemia. Thus, direct comparisons for determining trends are not possible. This situation is serious now but will become worse if two deliberate efforts are not begun soon: first, to select existing survey results and ensure that repeat surveys generating comparable data are undertaken, and second, where such surveys do not exist, to begin establishing a baseline from which trends can be estimated in the future. The data compiled for this report showed too great a variation to allow any meaningful conclusions. The results for nonpregnant women, representing about 90% of the female population, are more likely than pregnant women to be representative of the overall population. Prevalences have been calculated for 1995, and they are similar to the averages for the period 1975–1997 since there is little apparent change over time. These values show that Asian countries have the highest

prevalences of anemia among both nonpregnant and pregnant women, about 60%. For developing countries as a group, the average prevalences are 42% and 56% for nonpregnant and pregnant women, respectively, and an estimated 1.14 billion nonpregnant women and 96 million pregnant women are anemic.

The variation among regions tends to be higher for pregnant women than for nonpregnant women, which confirms a wider range of anemia prevalences among subgroups of the population. Despite this variation, a consistent pattern of higher prevalence among pregnant than among nonpregnant women is evident across all regions, and the numbers of women affected are increasing. An exception is in South Asia, perhaps because prevalences have already peaked in this region. The data vary enormously, although they have been carefully examined for possible errors. It is reasonable to state conservatively that there has been no detectable change in any region. But a stronger assertion may be valid: there is no improvement in rates of anemia for most women in developing countries.

Pregnant women are the most common target group for iron supplementation programs, and it is mainly for this group that data on program coverage are available. For the 39 countries reporting on coverage, the range is wide; some countries reported up to 100% coverage (e.g., Cuba and Nicaragua), whereas others, such as Tunisia, reported very

low coverage (10%). These figures are somewhat difficult to interpret, as they refer only to women registered in programs and do not estimate adherence to the required regimen of frequent supplementation throughout pregnancy. Furthermore, not many countries reported supplementation programs, and, for those that did, the programs bore little relation to need. Although program coverage needs to be expanded, there is a sense that countries may be waiting for better methods to be identified and demonstrated.

Data from the United Nations Children's Fund (UNICEF) on procurement of iron tablets are less informative than data for vitamin A capsules, because a higher proportion of iron supplements are obtained from suppliers other than UNICEF. Nonetheless, the supply of iron tablets may be much lower than the need; only 3% of the need for pregnant women is currently being met by UNICEF. Even if the supply in relation to need were calculated on the basis of weekly supplementation, this supply would still be less than 20% of the need for pregnant women. Because supply problems have been considered a major constraint, improvement of the low level of external supply could be a step toward greater program effectiveness.

Fortification of foods with iron is of great potential importance, and fortification of wheat is being widely adopted; this is especially relevant where wheat is the staple food. Solutions to the technical problems that remain for

fortifying rice would represent a major breakthrough in controlling iron deficiency, and such solutions can be anticipated in the foreseeable future. Meanwhile, a number of other commodities are being tried at both experimental and large scales — premixes to be added to rice and commercially processed foods (e.g., in Thailand), salt in India and elsewhere (which presents separate technical challenges, particularly if iodized salt is used), and sugar.

The prevalence of multiple (two or more) deficiencies is estimated at between 10% and 25% among preschool children. Such estimates are valuable for providing some idea of the extent of the problem and stressing that tackling one micronutrient at a time may lead to only limited success in controlling the effects of micronutrient deficiencies. Twenty-eight countries have policies for addressing all three of the deficiencies that currently have priority (vitamin A, iodine, and iron). Although these policies have not yet been translated into integrated approaches (such as multiple supplementation and fortification), these countries could provide valuable opportunities now for multiple micronutrient supplementation and fortification interventions.

In summary, iodization of salt is the most extensive micronutrient intervention at present. Coverage through vitamin A supplementation is 60% or more in about 30 countries, half of these in Asia and sub-Saharan Africa; in Latin America more reliance is put on fortification with vitamin A than supplementation. Iron supplementation is lagging: only 20 countries report more than 60%

coverage of pregnant women, and this figure is likely a considerable overestimate of actual supplementation, given the known logistic and adherence problems for iron tablets.

Control of micronutrient deficiencies has gathered much momentum in the past 10 years. The trends are undoubtedly positive for iodine and vitamin A. For iodine, the improvement is due to iodized salt. For vitamin A, there is a positive underlying trend that must be accelerated by continuing and expanding programs of supplementation and fortification (which must overlap, not substitute for, one another until it is safe to do so). Research on controlling iron deficiency is urgently needed, mainly to find effective fortification methods. Multiple micronutrient interventions should increase in importance. The current momentum must be sustained and reinforced. With this momentum, the goals of eliminating or greatly controlling these deficiencies can be achieved in the foreseeable future.

1. Trends in Prevalences

1. INTRODUCTION — WHAT ARE WE TRYING TO FIND OUT?

The extent of micronutrient deficiencies is well known. The World Health Organization (WHO) estimates that anemia affects about 2 billion people in the world (WHO 1997), or about one-third of the population, women suffering the most. Judging by the extent of goitre, the usual sign of iodine deficiency, about 13% of the population or 740 million people are disadvantaged through lack of this nutrient, of which only minute amounts are needed (WHO 1999). Vitamin A deficiency, while less common clinically, is present in subclinical form — increasing risks of ill health and death — in at least

one-quarter of children in developing countries (WHO 1995; MI et al. 1998). Moreover, these problems certainly overlap and interact, so many people must have multiple deficiencies.

Such estimates of prevalences and numbers of people affected, summarized by groups of countries and over ranges of time, are periodically issued by the United Nations (UN) system. Comprehensive regional estimates of deficiencies of vitamin A, iodine, and iron were released in 1992 (ACC/SCN 1992, chapter 3) and updated in 1996 (ACC/SCN 1997). National and

subnational estimates are available on the Micronutrient Initiative (MI) Web site (MI 1999), which is now updated to 1999.

Although keeping information up to date is important, its assembly and interpretation as a basis for policy and program decisions are crucial. Without these steps, we are “flying blind.” Two aspects are particularly useful. First, an internally consistent review of the extent and severity of deficiencies, for all affected countries at a defined point in time, is needed to determine priorities for resource allocations. Second, a review of trends in deficiencies through time, at a reasonable level of disaggregation, is needed to assess progress: it makes a lot of difference whether matters are getting better or worse, how fast the changes are occurring, and who is affected. Evaluation research is needed to determine whether positive changes can be ascribed to intervention, although this may require collection of specific new data rather than interpretation of existing cross-country data.

The consequences of single micronutrient deficiencies and the best means of controlling them are adequately established as a basis for advocacy and for effective control of the deficiencies. For example, the US Institute of Medicine has recently issued a definitive publication covering the three major known deficiencies (Howson et al. 1998b), and the MI, individual micronutrient groups such as International Vitamin A Consultative

Group, and UN agencies have all provided guidance on specific nutrients. Overlap between deficiencies, and their interactions, have so far not received as much attention, and an attempt is made to do so later in the current report.

The most obvious deficiencies are the easiest to tackle, and those more difficult to observe tend also to be the most difficult to prevent. This pattern extends to the quantitative demonstration of the consequences of deficiency and to monitoring. Thus, vitamin A deficiency is known to cause blindness and its prevention demonstrably protects sight, as well as substantially reducing death in children (and probably mothers) in areas of deficiency. Moreover, prevention can be readily achieved through an infrequent supplement, whose distribution can be monitored in a straightforward manner. Similarly, iodine deficiency has visibly distressing results, such as cretinism, which is easily prevented, at least in principle, by iodized salt, and the use of iodized salt can also be simply tracked. Conversely, iron deficiency anemia is less readily observed and less easily prevented. General malnutrition, assessed by growth failure, often goes unrecognized but is the largest single risk factor in the global burden of disease (Murray and Lopez 1997). It can be improved through community-based programs, but these are much more complex than those aimed at micronutrient deficiencies.

Comparative data on nutrient deficiencies and progress in controlling them must therefore also redress these

perceptual imbalances, between obvious and more easily tackled problems and their opposites. As will be seen, this applies notably to iron deficiency. It is very likely that other deficiencies are important but not systematically assessed and that they interact with the better-recognized ones. The control of micronutrient deficiencies no longer focuses on one deficiency at a time, and multiple micronutrient supplementation and fortification may make more sense both biologically and operationally.

Viewing the available information in a more integrated way is thus the logical next step, rather than perpetuating the borders between deficiencies, which exist mostly for recent historical reasons. In this report, underweight in children is included for comparative purposes, in part because it is the most widely available indicator of malnutrition. We can learn also from the experiences with data collection, analysis, and interpretation by comparing and contrasting the deficiencies, which in turn should lead to more effective and integrated surveillance in the future. Moreover (as will be seen), time should be taken to obtain baseline data designed

to be comparable over time — without such data now (and it is scarce in many areas), it will not be possible to assess changes in the future, nor to implement fully effective interventions now.

The overall aim of this report is to summarize trends and levels of deficiencies to determine priorities for program interventions and development, including research. Thus, where there are established trends in eliminating deficiency, sustaining the interventions and moving to more permanent solutions may be the issues. At the same time, fostering full coverage of those affected (or, for iodine, fostering universal coverage) becomes a priority, along with good monitoring and quality control. Where there are no real trends of improvement, steps are needed to find effective programs suited to the services and structural conditions of poor countries and to find innovative ways to implement such programs on a large scale. The results in this part of the report describe the deficiencies and their current trends. Part II of the report presents information on program implementation, to guide policy for program development.

2. DATA AND ANALYTICAL METHODS

Measurement and Indicators

The indicators of micronutrient malnutrition for vitamin A, iodine, and iron, as established by WHO and associated bodies, are summarized in Table 1 (WHO 1994, 1996; WHO,

UNICEF, UNU 1997; Howson et al. 1998b). Clinical indicators are common to all three. Subclinical (biochemical) measurement is also important, especially for vitamin A (for which deficiency appears as low serum levels of retinol).

Table 1. Indicators of micronutrient deficiencies as established by WHO.

Degree of deficiency	Indicator of deficiency		
	Vitamin A	Iodine	Iron
Clinical	Xerophthalmia Night blindness (XN) in children 24–71 months of age Bitot's spots (X1B) Sum (XN+X1B) used here	Goitre Grade 1 = palpable but not visible Grade 2 = visible when the neck is in a normal position Sum (grades 1 + 2) used here	Anemia Hb < 120 g/L in nonpregnant women >15 years of age Hb < 110 g/L in pregnant women of any age Hb < 130 g/L in men >15 years of age* Hb < 110 g/L in children 6–60 months of age Hb < 115 g/L in children 5–11 years of age* Hb < 120 g/L in children 12–14 years of age*
Subclinical	Retinol level In serum, <0.7 µmol/L In breast milk,* <1.05 µmol/L	Urinary iodine* Median value (for population group) <100 µg/L TSH (neonates)* Level >5 mU/L	Serum ferritin*

WHO = World Health Organization, Hb = hemoglobin, TSH = thyroid-stimulating hormone.

Sources: Howson et al. (1998a, Table 2-1); for vitamin A, WHO (1996); for iodine, WHO (1994); for iron, WHO, UNICEF, UNU (1997).

*Indicator not used for this report.

The characteristics of measurement and data differ for the various deficiencies and their control methods. The basic measures of vitamin A deficiency and iodine deficiency disorders have historically been clinical signs: xerophthalmia and goitre, respectively.

The eye changes referred to as xerophthalmia are relatively rare, with a prevalence of about 1% in preschool children in affected areas. Therefore, large sample sizes are needed for accurate estimates. This matters most for assessing the significance of changes over time; the certainty with which differences between groups (usually defined by administrative or geographic areas) are known is usually less important.

In contrast, the prevalence of goitre is higher, so smaller samples may be needed; however, the assessment methods can change over time and are sensitive to the level of training of enumerators. For instance, in four surveys in Bangladesh, the reported total prevalence of goitre was 29% in 1962–1964, 14% in 1975, 11% in 1981–1982, and 47% in 1993 (condition visible in 9%) (Yusuf et al. 1993). The apparent sharp jump in 1993 (a much higher estimate than in similar countries, and one that occurred **after** control measures had been initiated) seems to indicate that these results are not fully comparable, perhaps in part because of differences in training to recognize goitre that is palpable but not visible.

Anemia is widely used as a measure of iron deficiency. Several complicating factors must be borne in mind, both in terms of the relation between anemia and iron deficiency and in terms of other causes of anemia. Iron deficiency is estimated to be twice as prevalent as anemia, where malaria is not endemic (Viteri 1998). Strictly speaking, the population can be divided into four groups — anemic and iron deficient, anemic for reasons other than iron deficiency (see below), iron-deficient and not anemic, and neither anemic nor iron-deficient (see also ACC/SCN 1992, p. 43). Anemia is usually considered a measure of iron deficiency, because prevalences of anemia not related to iron deficiency anemia (notably that caused by malaria) and nonanemic iron deficiency may roughly balance, but this relationship has not been verified for a range of countries. Malaria is the main confounder, but anemias due to other nutrient deficiencies and other causes of iron deficiency — especially intestinal parasites (hookworm and whipworm) — also complicate the estimates. Nutritional deficiencies that cause anemia are notably those of folic acid, vitamin B₁₂, and vitamin A. Lack of vitamin C also contributes, by inhibiting iron absorption; other inhibitors include dietary tannins (in tea) and phytates (in cereals).

Other measures of micronutrient deficiencies depend on biochemical assay of blood, serum, or urine. Serum level of retinol is becoming a widely used

measure of vitamin A deficiency and is discussed later. Urinary iodine measures are sometimes available on a population basis. For anemia, hemoglobin concentrations in the blood constitute the basic measure; other indicators (such as ferritin and transferrin in the serum) are rarely measured on a population-wide basis and do not contribute to the overall picture.

The most widely available measure of general malnutrition is underweight children. This measure is also useful in this context, in part because it summarizes malnutrition. Child weight probably responds to some extent to micronutrient deficiencies in the mother or the child or both. Reference to general malnutrition, measured by the prevalence of child underweight, rather than protein-energy malnutrition, is based on the realization that child growth deficits can be due to micronutrient effects, both in utero and during early childhood. This principle applies to mild deficiencies of “type II” nutrients and more severe cases of “type I” nutrient deficiencies (Golden 1994, 1995), type I referring to micronutrients with specific signs of clinical deficiency (vitamin A, iodine, and iron are all of this type) and type II referring to those without specific clinical signs, for which growth failure is a first response to deficiency (protein and zinc are examples). Thus, prevalence of underweight is included in some of the results used here. Although stunting is a better measure of cumulative malnutrition, prevalence of underweight is more widely available. Because it is

strongly associated with stunting, underweight is a good proxy indicator of this condition and hence of cumulative malnutrition in most populations.

In sum, the following four groups of indicators are used in this report:

- ◆ vitamin A deficiency: as the clinical indicator, prevalence of eye changes (night blindness or Bitot's spots) in preschool children (<5 years of age); as the subclinical indicator, prevalence of serum retinol <0.7 $\mu\text{mol/L}$ in preschool children;
- ◆ iodine deficiency disorder: total goitre rate, the prevalence of goitre (both palpable only and visible) in school-age children (5–15 years of age) or in the total population;
- ◆ anemia: prevalence of hemoglobin (Hb) level <120 g/L in nonpregnant women 15–49 years of age; data on pregnant women of the same age with Hb <110 g/L are also used;
- ◆ general malnutrition: underweight in children 6–59 months of age, defined as body weight more than two standard deviations below mean weight for age, according to National Center for Health Statistics (NCHS) and WHO standards (WHO 1983).

Data Sources for Population Assessments

The most useful data for the present purposes derive from nationally representative surveys. Although such surveys are common for anthropometry (e.g., demographic and health surveys, surveys by the United Nations Children's

Fund [UNICEF], and multiple indicator cluster surveys), they are less widely available for micronutrient deficiencies. For iron, most results derive from clinic or small-scale survey data on anemia in pregnant women, and their representativeness is unknown. A smaller set of results is available for nonpregnant women; these are more often from surveys intended to assess population prevalences and therefore are probably more reliable for this purpose, even though they have fewer data points. For clinical vitamin A deficiency and for iodine deficiency disorders, the surveys have generally been aimed at population assessment of areas within countries, rather than at a national level; this survey characteristic has led to some difficulties in comparison and aggregation.

Compilations of survey results are published periodically by WHO: for vitamin A deficiency, WHO (1995); for iodine deficiency disorders, from the International Council on the Control of Iodine Deficiency Disorders (ICCIDD), WHO, and UNICEF, as WHO (1993, 1999); and for iron, WHO (1992, 1997). Recently, these results and others identified from the literature and from the MN-Net have been recompiled and are now available on the World Wide Web through the updated MN-Net (MI 1999). These data are used here. The data on vitamin A deficiency were published earlier as MI et al. (1998), and a few new results have been added. The iron data were reported in Mason, Sethuraman, Mason, et al. (1998). The iodine deficiency data are available at the

Web sites of ICCIDD (ICCIDD 2000) and the MI (MI 1999). An earlier compilation was given in Mason, Sethuraman, Gilman, et al. (1998). Results from these sources were also included in the databases and are listed in Appendixes 1 to 5.

Issues in Aggregating Data, Making Comparisons, and Assessing Trends

Single estimates of prevalences are of limited meaning until they are compared either with norms or with other estimates. Cutoff values and interpretation of prevalences below these levels are suggested, usually by WHO. For example, a prevalence of night blindness of more than 1% among preschool children and a prevalence of low serum retinol ($<0.7 \mu\text{mol/L}$) of more than 10% have been suggested as defining public health problems related to vitamin A deficiency (WHO 1996); these are examples of using normative values for interpretation. Available data must be checked and sometimes transformed for comparison with such norms, which also raises the issue of the population to which the original data refer or of which these data are taken as representative.

Further meaning comes from comparing estimates between different groups, usually countries or regions, to indicate priorities for resource allocation, for instance. Often the most useful comparisons are those through time, to assess progress. Such comparisons

necessitate ensuring that the estimates are in fact comparable and thus can also be aggregated, usually for groups of countries (regions), or compared validly over time to give an assessment of trends. Assessing the validity of such comparisons and aggregations to generate self-consistent sets of data is the most time-consuming feature of assembling and interpreting these data.

Results were obtained from summarized reports, in which the variances and confidence intervals of the estimates were not systematically given (nor were the sample sizes always similar). These problems preclude reassembling the data for meta-analysis. It should be stressed therefore that the sample numbers given refer to numbers of survey results — i.e., the prevalence estimates for a country-year — each of which is derived from many individual measurements (often in the thousands). Thus, although the significance of differences cannot be realistically tested, it is certainly greater than that reported from treating (unavoidably) each survey result as one case. For example, the 35 data points on clinical vitamin A deficiency represent many thousands of measurements, and if we could directly compare any two of these (say) as two surveys, we could estimate the significance of the difference; just comparing two summary data points can give only the size of the difference, not whether it is likely to be due to chance. Nonetheless, the significances estimated are likely to be highly conservative because of this constraint.

Such comparisons can refer to different activities (vitamin A vs iodine, for instance), to different countries, or to groups of countries. The grouping into regions is mainly a summarization process for the first case — comparing problems within a region — but aims to draw attention to regions of greatest need in the second — such as the very high levels of anemia among Asian women.

Valid assessment of trends in practice has more rigorous requirements than comparisons of data across countries for one point in time. For example, ranking countries, or areas within countries, by prevalence usually shows quite large differences — a rule of thumb is that at least a doubling of prevalence is generally seen between better- and worse-off areas — and hence a minimum difference of 5 percentage points is often adequate. However, in a trend analysis, changes of less than 1 percentage point per year (for underweight children about 0.5 percentage points per year is average) may be of interest; thus, more certainty about smaller differences is needed for assessment of trends.

The main factors to be considered in comparing two or more results are samples (design, size, and multiplication factors), cutoff points (and standards), biological groups, seasonality, date of estimate, and standardized time for aggregation, population weights, and assessment of trends. These factors will be discussed first, and then methods of aggregation and trend estimation will be described.

Samples

Samples were designed to be representative (i.e., deliberately selected in population surveys, usually as multistage cluster designs) or were taken from people attending clinics or schools, a self-selected and thus usually biased sample of the overall population. Although in the latter case it is difficult to relate data to population estimates when the clinical data are scarce (e.g., xerophthalmia and anemia), sometimes these samples give results that are judged (by those compiling and publishing the data) to be at least better than nothing. For example, the major compilations of data on vitamin A deficiency and anemia by WHO (1992, 1997) listed results from both types of sources, and attempts were made to aggregate after selection. Here, except for anemia, the aim has been to include only results that are based on some attempt at representative sampling. Another issue is the size of the sample, which affects the confidence intervals around the estimates (although these are generally unknown). Many samples reported are very small; here a minimum of 100 was used for inclusion. For example, the 35 results listed in Appendix 1 for clinical vitamin A deficiency include 13 national surveys, the rest covering subnational areas. The data given in Appendixes 1 and 2 for vitamin A deficiency are those used here for aggregation.

An approach used by WHO for the vitamin A deficiency data, to address the question of how to use samples of

below-national coverage has been to introduce a “multiplication factor” (WHO 1995, p. 16). This factor ranges from 0.25 for samples aimed to be representative of 20% to 30% of the population, through 0.40 for 30% to 60% representation and 0.60 for 60% to 75% representation, to 0.75 for national samples; why the last factor is not 1.0 is not explained. The premise appears to be that subnational surveys focus on areas of higher prevalence, so to extrapolate the prevalences to the national population would lead to an overestimate. In fact, the results do not bear this out: if this assumption were true, we might expect higher prevalences in the more localized surveys, but the

mean values of clinical and subclinical prevalences by coverage (as judged by the multiplication factor) are not higher at lower coverage, but are as presented in Table 2 (if anything, they are higher in the high-coverage surveys).

Another empirical approach is to examine the observed distributions of prevalences of low serum retinol by subnational geographic area, to determine the extent of concentration of the deficiency. Some surveys allow this, including the recent Sri Lanka survey (Government of Sri Lanka 1997). Five such surveys are presented in the disaggregated tables in WHO (1995). The results are shown in Table 3.

Table 2. Estimates of clinical and subclinical prevalences of vitamin A deficiency in relation to multiplication factors (WHO 1995).

Multiplication factor	Population coverage* (%)	Reported mean prevalence of deficiency (%) and no. of surveys	
		Clinical	Subclinical
0.25	20–30	2.00 (2)	30.3 (8)
0.40	30–60	1.23 (7)	26.2 (17)
0.60	60–75	1.65 (13)	47.6 (8)
0.75	National	2.46 (13)	30.5 (9)
Average		1.89 (35)	32.0 (42)

*Percentage of population covered by sample.

Table 3. Summary of five surveys of subclinical vitamin A deficiency reported in WHO (1995).

Country	Scope	Year	Areas	Prevalence of subjects with serum retinol <0.7 µmol/L (%)	
				Raw data for areas	Mean*
Brazil	Possibly national	1972	5 regions	11.4, 22.7, 26.3, 26.3, 27.4	25.3
Ecuador	National	1993	4 regions	9.6, 14.8, 17.7, 18.1	16.2
Ethiopia	National	1980–1991	4 ecozones	55.6, 62.3, 69.2, 77.8	59.6
Indonesia	Subnational	1991	5 provinces	32.7, 58.0, 68.8, 69.3, 86.6	64.7
Sri Lanka	National	1996	7 provinces	22.3, 24.3, 35.0, 42.5, 46.3, 51.3, 57.3	36.3

*For Brazil, Ecuador, and Indonesia, data were weighted by sample size for calculation of the mean. For Ethiopia and Sri Lanka, the means was taken as already reported in WHO (1995).

Unless there was an unfortunate choice of region in a subnational survey, there would be only about a doubling of prevalence between better- and worse-off areas, and even if the worse-off area were selected for survey, it would never need to be multiplied by a factor of even 0.6 to bring it to the mean, given that the ratio of mean to highest prevalence in these five cases ranged from 0.63 to 0.92 (average 0.79).

To summarize, there are four reasons to believe that the prevalences of at least subclinical deficiency should not be adjusted down by this factor. First, we now expect subclinical vitamin A deficiency to be widely spread in the population. Second, if anything, higher-coverage surveys (>60%, which would imply a multiplication factor ≥ 0.6) have higher prevalences than lower-coverage ones. Third, the distribution now observed of low prevalences of below-normal serum retinol does not show extensive clustering. Fourth, recent results (such as those in Government of Sri Lanka [1997]) are higher than would be predicted on the basis of the multiplication factor. The values of the multiplication factor greatly influence the adjusted prevalences, largely arbitrarily, and although they probably ensure that the resulting estimates are not overestimated, they in fact substantially determine the comparisons between countries and through time. In the data presented here, results aggregated by region are calculated both with and without the multiplication factor. The multiplication factor is not

used for deficiencies other than that of vitamin A, so the issue does not arise for iodine or iron.

Cutoff Values

The standard cutoff levels for determining prevalences were given earlier, and the question here is the approach to be taken when different cutoffs were given in the survey reports. This applies most often to hemoglobin, for which a variety of cutoffs have been used. No method of adjustment was available, and prevalences with cutoffs different from the standard 120 g/L for nonpregnant women and 110 g/L for pregnant women were not used for aggregation or trend assessment. For serum retinol, a few reports (e.g., Government of Sri Lanka 1997) used micrograms per decilitre as the unit of measurement; however, 20 $\mu\text{g}/\text{dL}$ is equivalent to 0.7 $\mu\text{mol}/\text{L}$, so these units caused no problem.

Analogous problems occurred with the prevalence estimates based on clinical signs, specifically xerophthalmia and (to a lesser extent) goitre. Most of the prevalence data for clinical vitamin A deficiency combined night blindness (known as XN) with eye changes, mainly Bitot's spots (known as X1B). WHO (1995) used the prevalence of "total xerophthalmia" as an aggregation of various clinical signs, depending on how they were reported (often the sum of night blindness and Bitot's spots). Because these two signs have the highest prevalences, omitting the prevalences of other signs presents a relatively minor

source of error. The sum of the prevalences of night blindness and Bitot's spots is thus the most feasible standard indicator. When both are reported, the prevalence of Bitot's spots usually ranges from one-half the prevalence of night blindness to the same as the prevalence of night blindness. Thus, when only one or the other was known, the sum of prevalences was estimated conservatively (using the lower end of the range), as follows: when the prevalence of night blindness was unknown, it was assumed to be equal to the prevalence of Bitot's spots, and the sum was twice that of Bitot's spots; when the prevalence of Bitot's spots was unknown, it was assumed to be equal to half the prevalence of night blindness, and the sum was 1.5 times that of night blindness.

For goitre, the indicator is clearly defined as palpable plus visible goitre. Although the classification of different degrees of goitre has changed over the past decade, the resulting summary indicator of "total goitre rate" has remained the same (WHO 1993, 1994). The important source of uncertainty is therefore the measurement itself, as discussed earlier.

For child anthropometry, the cutoff of two standard deviations below the mean weight for age by NCHS standards is now the norm; earlier surveys used other cutoffs (usually <80% weight for age, almost the same as two standard deviations below the mean) and sometimes different standards (local

or "Harvard" [Jelliffe 1966]). The data used here had already been standardized to two standard deviations below the mean according to NCHS standards, as given in ACC/SCN (1993, p. 94).

Biological Groups

The biological groups assessed (in terms of age, sex, and pregnancy status) are reasonably well standardized for the three deficiencies.

Preschool children are the reference group for vitamin A deficiency (and underweight), usually defined as up to 60 months of age, but with variation more common at younger ages, starting at 0, 3, 6, or sometimes even up to 24 months (see Appendixes 1 and 2). The prevalence of both clinical vitamin A deficiency and low serum retinol change with age (which can be seen, for example, by inspection of results by age band [WHO 1995, pp. 69–95]). What is needed are sets of data with prevalence by age group for different regions. If consistent, such data might allow adjustments to be made to more exactly standardized age bands; however, suitable data have not been found. The error introduced by varying age-group definitions has thus been ignored; it is certainly a source of "noise" (random error) in the data, but there is no evidence that different age-group definitions are systematically associated with specific countries or survey dates, so this is unlikely to introduce bias into the calculations (and any error is certainly less than the errors introduced by the multiplication

factors.) For underweight data, the estimates were already been adjusted to the standard age range of 6–60 months (ACC/SCN 1993, p. 95).

For goitre, the data were taken from results assembled by WHO, ICCIDD, and UNICEF, as reported by UNICEF (1998), and the biological group was defined as children 6–11 years of age. Methods for adjusting results to this age group when the original estimates covered a different age group are not given here, but generally the prevalences are not greatly affected by age, so such variation is probably not a major source of error. Other issues for this age group, such as accounting for children who do not attend school (where samples would be obtained), ensuring correct sample representation for more remote schools (where the prevalences of goitre are likely higher), and standardizing diagnostic methods between enumerators, are likely to be more important but cannot be easily assessed retrospectively.

For anemia, hemoglobin data are reported for a wide variety of biological groups, including children, adolescents, women of reproductive age (various definitions), and pregnancy status. The database for this study was combined with that set up for the *Second Report on the World Nutrition Situation* (described under “Women’s Nutritional Status Indicators,” ACC/SCN 1993, p. 114). New results were compiled from WHO (1992, 1997), MN-Net (MI 1999), UNICEF (N. Dalmiya, personal communication, 1998), and a

computerized literature search. In fact, many reports give results for several different groups as well as aggregated values. In setting up the database, each case was defined as a separate group, so each report could generate several cases; this allowed comparisons and aggregation (but produced a complex data file). Overall, the database contained 562 cases, which were then separated into the two main files (for pregnant and nonpregnant women 15–49 years old). Rules were set up to guide selection to approximate this definition of groups and the intended indicators (<110 and <120 g/L Hb, respectively). The age groups used here were intended to represent reproductive age; where feasible, groups within a report were aggregated to give typically 15–49 years, which is thus used as the definition. When pregnancy status was not defined, nonpregnant status was assumed.

Seasonality

Seasonality has a significant effect on prevalences of underweight children in many environments, which can lead to differences of as much as 10 percentage points or more between the high and low values throughout the year (ACC/SCN 1989). As a result, attempts are sometimes made to time repeat national surveys at the same season and to prefer slower-reacting measures, notably stunting. Similar seasonal data are not available for micronutrient deficiencies, but substantial variation is likely. Seasonality may well be a source of considerable error in the estimates,

but cannot be assessed, let alone corrected for, with the data presently available. Again, this factor probably contributes noise, not systematic error. Seasonality is of particular concern in interpreting changes through time between two or more individual national estimates, where the effect will not be averaged out. This factor should be carefully considered if a more organized effort is to be made to monitor trends in micronutrient deficiencies.

Aggregation of Data to Standard Time

Aggregating data to a standard time is one of the more difficult methodological problems. Its importance depends both on whether rapid change is occurring and on the intended uses of the results. When the aim is to give a general picture of size and relative distribution of deficiencies by groups of countries, estimating these data by averaging over a range of years may be adequate, if the resulting estimate is treated with caution. This is the standard method used by WHO for anemia (e.g., WHO 1992). However, when we want to validly compare countries at one point in time, especially if there are several indicators, we need to go further. In addition, estimates of numbers of people affected have to be anchored at one point in time, because population numbers change from year to year.

The challenge can be envisaged by considering a country–year matrix, within which the columns represent years and the rows represent countries and where each survey result is inserted

in the appropriate cell. Most of the cells will be blank, and indeed many rows will have no data at all (because the countries in question have not carried out a survey). To derive an average value for groups of countries (regions), even for a range of years, some assumptions are needed about the prevalences for the countries for which data are missing. Often these prevalences are set, at least implicitly, to the average for the other countries in the group. In other words, the values for the countries in each region for which data are available are averaged, and this value is taken as the average for the whole region. The issue that arises when a range of years is used is whether to use the population data for the year of the survey or for the midpoint of the range of years or even for the latest year in the range. Usually the population numbers (and weights) are applied for a given year; sometimes, this is the last year of the range, and occasionally the prevalences by region are then reported as if they apply to this last year (e.g., WHO 1997). Although they are perhaps somewhat unclear, such results usually give a picture of the problem that is appropriate for general advocacy. The main problems that arise for more accurate reporting are in presenting country-level data, for example by mapping, and in estimating trends.

Country-level data, whether mapped or presented in other forms, imply that the indicators are comparable between countries, which means that they should refer to the same year (unless the

indicators are changing particularly slowly, which should be determined). The date on the map or table must be clearly stated. Thus, some assumptions are needed to bring the data points scattered through the country–year matrix to one point in time (one column). This requires some form of interpolation, of which the simplest is to assume no change in the indicator throughout the period. This gives an unbiased estimate of the average, if there really is no change. However, when there is an underlying trend (usually of improvement), and the interpolation is made toward the latter part of the period, then the assumption of no change will yield an overestimate of the actual prevalence and, moreover, may distort the relative prevalences between groups of countries.

Determining changes through time is important for both analytical and policy purposes. There is no escaping the need for repeated estimates on the same or a very similar population. For clinical vitamin A deficiency and iodine deficiency disorders, almost enough pairs of data points exist to draw conclusions on changes through time (see Figs. 2 and 5, discussed later), and these strongly indicate a trend of improvement. For anemia there are virtually no pairs of data points allowing an assessment of trend, and the same applies to serum retinol. In the case of underweight, many measures through time have been determined, and long-term trends can be confidently estimated on this basis, but this was not so in the

1980s, when indirect methods (subsequently confirmed by survey data) were also used (ACC/SCN 1987, 1993).

Further investigation using less direct methods for estimating anemia and subclinical vitamin A deficiency (serum retinol) are thus necessary if we want to have an idea of trends. The data can be visualized as scatter plots (as shown in Figs. 3 and 4 and discussed later). The serum retinol results for Southeast Asia illustrate the problem (Fig. 1). It is evident that the average value depends on which countries are included; for example, averaging for the 1980s and the 1990s gives similar prevalences (28% and 31%), but the countries included in these two estimates are different — for example, Indonesia, with a high reported prevalence, appears only once, in 1991. This effect is less important if there are more data points, as the plot for the complete data set for serum retinol shows (Fig. 3, discussed later). Here, there are indications of an improving trend, such that averaging across a wide time range could be misleading. Fitting a regression line to such disparate data points is not very satisfactory, but is better than simply determining an overall average. Applied to the anemia data (see Results section) fitting a line also allows averaging through time, especially as most countries appear several times in this larger data set.

FIG1 » Prevalence of subclinical vitamin A deficiency, defined as serum retinol level below 0.7 µmol/L, in Southeast Asia (MI et al. 1998).



A second method of deriving consistent data for one point in time and filling in gaps for countries with no data is to interpolate on the basis of relationships with other data that are available for every country and year. Only a limited number of types of data are available every year for every country, specifically gross domestic product or gross national product, food supply (e.g., energy, as determined from food balance sheets), and demographic data, notably mortality rates (especially infant mortality rate, which itself is derived from infrequent data obtained by indirect methods). The prevalence of underweight has been interpolated using regression models in this way (ACC/SCN 1993).

For clinical vitamin A deficiency, associations of these variables with data on the vitamin A supply (from food balance sheet calculations [FAO 1997]) and with underweight were investigated

by regression, as were interactions between the variables, using the data shown in Appendix 1. The strongest relationship was with infant mortality rate (IMR) and underweight prevalences; the latter were derived in previous work from 174 country data points, interpolating as described in ACC/SCN (1993, 1996). The final equation was $\ln(1/p - 1) = 7.23 - 0.0216(\text{IMR}) - 0.0131(\text{underweight prevalence})$ (where p = prevalence, as a proportion from 0 to 1; $R^2 = 0.82$, $n = 35$; year was not significant). Substituting in this equation gave values for each country for 1985 and 1995, which with child population numbers (UN 1997) gave estimates of the prevalences and numbers affected by region for these years. These clinical estimates included use of the multiplication factor, for consistency with WHO values. The average relationship for the clinical data between the estimates with and without

the multiplication factor is 1.26, so the results (shown in Table 6, discussed later) could be multiplied by 1.26 to give the equivalent estimates without this adjustment. A similar approach was taken to interpolating low serum retinol values, using the data shown in Appendix 2. In this case, as might be expected, the best model was with clinical vitamin A deficiency (with both clinical and subclinical prevalences as logarithms). The derived values of clinical vitamin A deficiency were thus transformed further to give estimates of the prevalence of low serum retinol ($<0.7 \mu\text{mol/L}$), using the following equation: $\ln(\text{prevalence of low serum retinol}) = 3.019 + 0.555 \ln(\text{estimated clinical prevalence})$ ($R^2 = 0.44$, $n = 42$). Further details of these methods are given in MI et al. (1998).

This approach generated a set of prevalence estimates for clinical and subclinical vitamin A deficiency for each country for 1985 and 1995. These estimates were multiplied by the child population to determine the numbers affected. To aggregate by region, these numbers were summed and divided by the total child population for the region, to give numbers affected and population-weighted mean prevalences.

For the prevalence of iodine deficiency disorders (goitre), the database used here was compiled from data in WHO (1993), MN-Net (generally updated to mid-1998) (MI 1999), and a current literature search (Appendix 3). Nationally representative estimates

were available for 81 countries in total. Averages were calculated for groups of countries and for two periods, 1980–1989 and 1990–1999 (see Fig. 6, discussed later). Where more than one estimate existed for a country within these periods (e.g., Thailand), these values were averaged to obtain one country–period value. Overall, there were 62 estimates applying to Asia, Africa and the Middle East, and Latin America and the Caribbean. Most of the survey results were for school-age children, but no correction was made for those reported for the general population, as the extent of the difference in prevalence between these age groups is thought to be relatively small (WHO 1993, p. 49). The urinary iodine data were insufficient to be used for trend analysis. The goitre data used below, accumulated from WHO (1993), MN-Net (MI 1999), and literature searching, are very similar to those used in WHO (1999), and the WHO (1999) calculations of regional levels were directly extracted.

For anemia, the problem was different again. Each case was defined as a group or subgroup by year, country, area (e.g., district), and pregnancy status. If only the year of publication was given, the survey year was estimated by subtracting 5 years from this date, the average period for studies in which both survey and publication dates were known. Sample size generally had to be at least 100 for inclusion. If the data were from a national survey, sample sizes were assumed to be greater than 100.

Surveys from a few countries of years that were underrepresented were retained, regardless of sample size. A total of 562 acceptable cases were included. Of these the sample size was under 100 for 56 (10%), and sample size was missing for 124 (22%). Cutoffs were hemoglobin level 120 and 110 g/L for nonpregnant and pregnant women, respectively (for some samples, the cutoff values differed slightly, but only by 5 g/L). Only a few studies did not report cutoff values, and in these cases prevalences have been estimated by WHO (1992). Pregnancy status was known in all but two cases. In 40 cases (7%) the sample included both pregnant and nonpregnant women. These data were included in the nonpregnant group, and a cutoff of 120 g/L was used. The age range varied but was usually 15–49 years; in some cases, the range was narrower. The pregnant group represented a younger sample of women on average than the nonpregnant group. Age differences in relation to prevalence of iron deficiency anemia could not be studied in this analysis; however, this limitation should be considered in comparisons of pregnant and nonpregnant groups. All age groups under 15 years were omitted.

Through this procedure 148 new cases were added to the 1992 database (ACC/SCN 1993, p. 114). Of the new cases, more referred to pregnant than to nonpregnant women. Several were newly identified results from the 1980s rather than more recent results. Most cases were not national in coverage. Some countries

had clumps of results in particular years (e.g., 34 data points for India in 1984; 8 data points for South Africa in 1978). To reduce the influence of this clustering and of scatter in general, the data were aggregated such that each country–year had only one data point (the mean). This resulted in a file with 269 points, 122 for nonpregnant women and 147 for pregnant women. (The sample sizes by region are shown in later tables, where the *n* values refer to numbers of country–years; the data points in the figures also represent the average for a country–year.)

Aggregations were done within region, by pregnancy status. For these, no population weights were used (the same approach as in ACC/SCN [1992, chapter 4]). This was based in part on the view that because most of the estimates covered subnational areas (some of which were very small, such as one clinic), it made little sense to weight a survey according to the population of the whole country (e.g., Bali vs Indonesia). Thus, within regions each survey was taken as a sample of the region. In an analysis such as this, a single case (i.e., country–year) can greatly influence the mean for that region–year. Small samples from well-off areas may thus give much lower values for prevalences of iron deficiency anemia than the country as a whole. For example, a study in one region of Algeria (Biskra) showed 10% prevalence for one subgroup and 87% for another. Fortunately, these within-country differences were not usually so marked;

however, moderate differences were common and for this reason alone trends should be viewed with some caution. A more valid comparison is between regions, as these averaged results are less influenced by unusual cases.

Trends by region were estimated by fitting a regression line to the available data from 1970 through 1995. Considering the variability of iron deficiency anemia, it was decided that the best analytical procedure to test regional and trend differences was analysis of variance (ANOVA). Data were grouped by year, as follows: 1970–1980, 1981–1985, 1986–1990, and 1991–1998. Type III sums of squares analysis (used in an unbalanced design) was selected in testing regional differences, while controlling for trends over time, and vice versa. Regional estimates were calculated for 1995, from the regression results by region. These results are reported later.

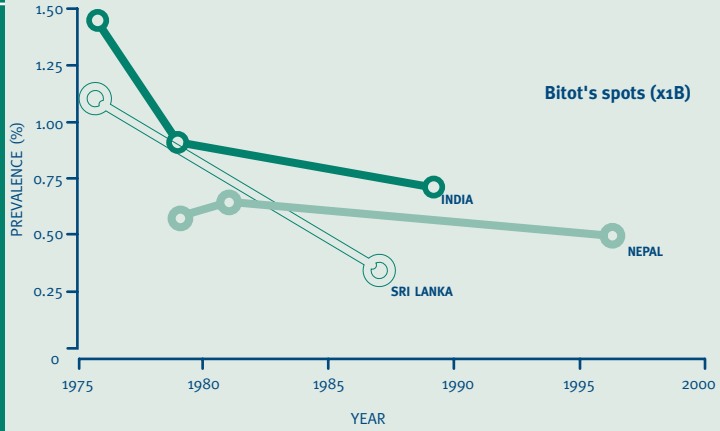
Underweight prevalences are used here to a limited extent. They are included in the regional estimates in Table 10, where the extent of those with multiple deficiencies includes underweight prevalences. These data are the same as used in ACC/SCN (1996). The same underweight prevalence estimates are included in the calculation of vitamin A deficiency prevalences, as described earlier. The calculation uses the same approach as described in ACC/SCN (1993, pp. 95–100). The country-level underweight prevalence results for 1995 are given in Appendix 6, together with the equation used for the calculation.

Estimation of Trends

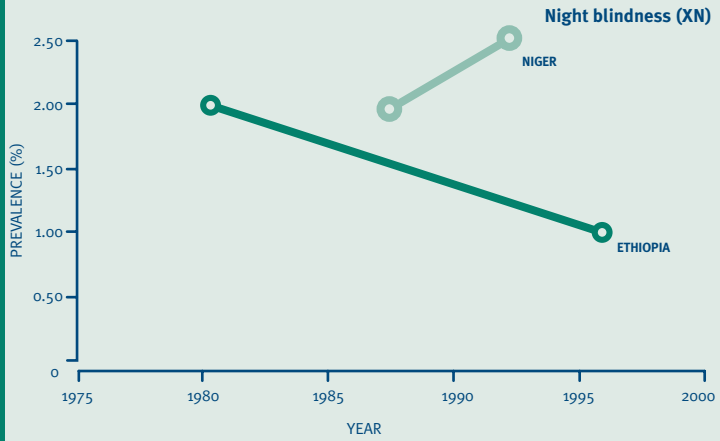
Trends were estimated by different methods, depending on the data available and their characteristics. In principle, the most important method is to assess change at the national level between two comparable surveys carried out several years apart. Given the uncertainties of individual comparisons, the pattern of change thus seen is important: if most pairs of comparable surveys show the same direction of change at comparable rates, we can have reasonable confidence that the underlying trend is real. This approach is feasible for clinical vitamin A deficiency results and for goitre rates. As mentioned earlier, the method of assessment is now well established for underweight prevalences, for which 57 pairs of survey results from 42 countries, from 1980 on, were reported in 1996 (ACC/SCN 1996). For vitamin A deficiency the corresponding values are 10 pairs of results from 8 countries and for iodine deficiency disorder, 11 pairs from 6 countries. Although it was not possible to check the comparability in terms of sample design and assessment methods, the consistent pattern of results to some extent compensates for these drawbacks and the small number of replicates. For estimates of trends in clinical vitamin A deficiency, it was necessary to match results by the specific clinical signs recorded, of which the most consistently available in pairs of surveys was Bitot's spots (Fig. 2). In contrast, the combination of Bitot's spots and night blindness was chosen as the standard

2A

FIG2 >> Trends in clinical vitamin A deficiency, defined as Bitot's spots and night blindness, as determined from national surveys in various years. All data in this figure are reported survey values; the WHO multiplication factor has not been used.

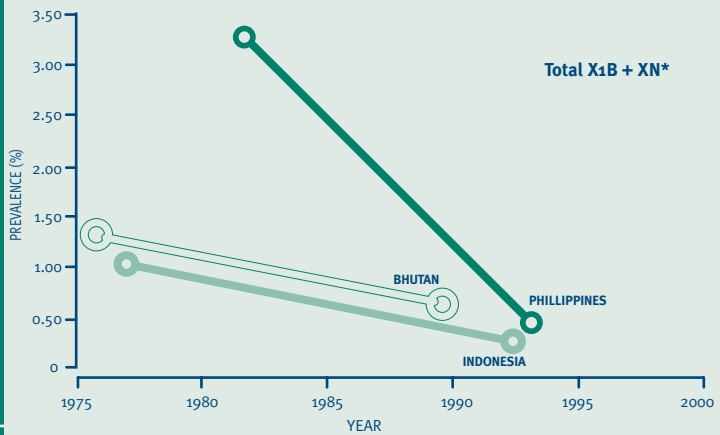


2B



2C

* Except Indonesia:
X1B only.



indicator for the database presented in Appendix 1 (in line with WHO's practice [WHO 1995, pp. 69–83]). For iodine, nationally representative survey results for eight countries could be compared; in addition, there were two cases from sentinel site surveillance (shown later, in Fig. 5). For anemia there are no comparable representative surveys, so this method could not be applied.

A second, less satisfactory, approach is to examine apparent trends by fitting a line to the scatter of data points through time. This method is vulnerable to extreme country–year values appearing at the beginning or end of the time period by chance, as illustrated earlier for subclinical vitamin A deficiency in Asia. Fitting a regression line to a time series of points from different countries is associated with the same type of problems as taking regional averages of national results for two time periods (e.g., as for goitre [WHO 1999, Table 5]) — the expectation is that there is no association of types of country (by underlying prevalence) with time, and with enough cases the appearance of a country in one group only will not be misleading; this can be checked by examining the scatter plots, which except for the case of Southeast Asia in Fig. 1 (introduced to illustrate this point) do not appear to be affected by outliers.

For the global data and for regional groupings for which there are 20 or more country–year data points there is a pattern, the consistency of which may be meaningful; at a minimum, for anemia, it seems reasonable to conclude (see below) that there is no strong trend. This method also facilitates making estimates of prevalences at a single point in time for comparison with other indicators, by taking the value of the fitted line at the reference year.

Third, where regional prevalences are estimated at two points in time (1985 and 1995 for vitamin A deficiency here), comparing the estimates gives a further indication of probable trend. This is more credible if the variable for “year” is not significant in the regression, a situation that implies that sources of change have been captured in the independent variables, as was the case for the models used here. Again, the pattern is important: for vitamin A deficiency, the trends estimated by comparing the 1985 and 1995 data are very similar to those observed in the 12 pairs of country–year data points that could be compared.

These methods were applied to the databases described here, yielding the results presented in the next section.

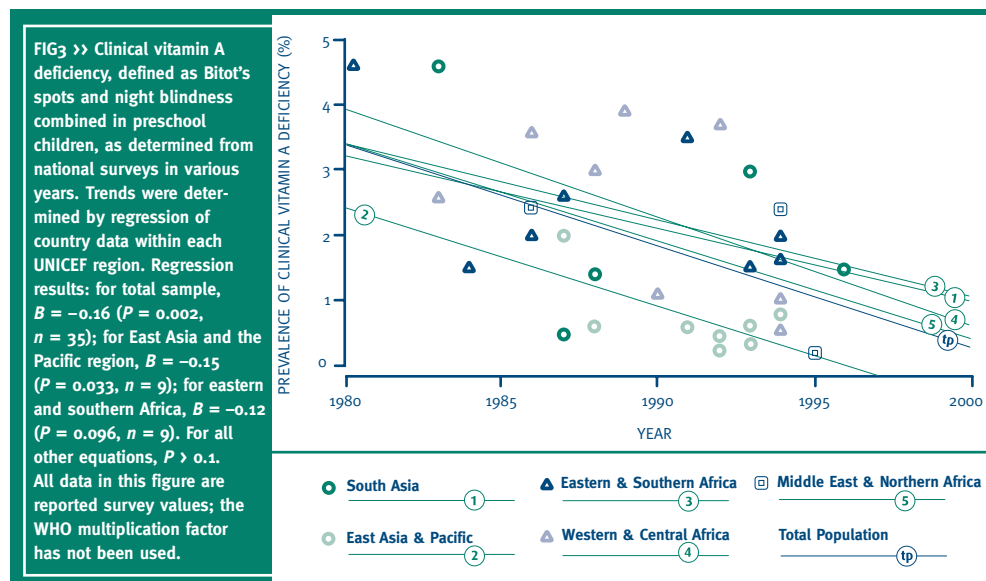
3. RESULTS: TRENDS IN REDUCING MICRONUTRIENT DEFICIENCIES

Recent Trends in Prevalence of Vitamin A Deficiency

Trends in the prevalence of clinical vitamin A deficiency (mainly Bitot's spots) were assessed by comparing repeat national survey results, when these were available. Such data were identified for eight countries, with 10 pairs of estimates (Fig. 2). Except in Niger and Nepal, a pattern of improvement is evident. The average rate of decrease in Bitot's spots is about 0.5 percentage points per 10 years in this small sample of results.

The total sample of prevalence estimates for clinical vitamin A deficiency (night blindness + Bitot's spots) is plotted

against year in Fig. 3. The regression line fitted to the full sample ($n = 35$) is significant and indicates an estimated rate of improvement of 1.5 percentage points per 10 years. If the prevalence of Bitot's spots is about half that of night blindness (as is often the case), Bitot's spots would contribute a third of the total ($XN + X1B$), so the rate here of 1.5 percentage points per 10 years is in line with 0.5 percentage points per 10 years for Bitot's spots as determined from individual pairs of data points. The fitted lines are significant for East Asia and the Pacific region and for eastern and southern Africa (see caption for Fig. 2), but not for the other regions.



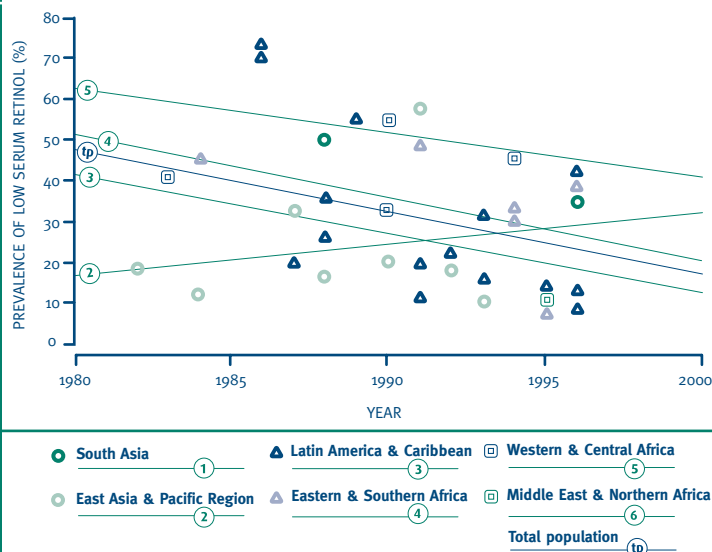
As will be seen later (Table 6), comparing the prevalence estimates for clinical vitamin A deficiency (as indicated by night blindness and Bitot's spots) by region for 1985 and 1995 also indicates a strongly improving overall trend (0.4–0.9 percentage points per 10 years). This includes the multiplication factor, so would be lower than other estimates that do not use the multiplication factor, but it generally supports the conclusion that an important general improvement has been occurring in clinical vitamin A deficiency.

For subclinical vitamin A deficiency assessed by serum retinol levels $<0.7 \mu\text{mol/L}$ the picture is less clear. Only four countries, all in Latin America (Colombia, Costa Rica, El Salvador, and Guatemala) have repeated surveys, and although these surveys indicate some improvement in this region, they are not

much to go on. The plot of all the available individual data points against time is shown in Fig. 4. The overall regression line is significant, and the reduction averages 15 percentage points per 10 years. The fit for eastern and southern Africa is also significant, but the others are not, and differences between regions should not be regarded as having been demonstrated here. As discussed earlier, such analyses are also vulnerable to the effects of high-prevalence countries (for example, Indonesia for East Asia and the Pacific region).

Furthermore, because of the lack of data on subclinical vitamin A deficiency and the need to use the relation with clinical vitamin A deficiency to estimate regional levels, the subclinical results by region are given only for 1995. Thus a comparison of regional estimates for 1985 and 1995 is not available.

FIG4 » Subclinical vitamin A deficiency, defined as serum retinol level $<0.7 \mu\text{mol/L}$ in preschool children, as determined from national surveys in various years. Trends were determined by regression of country data within some regions (as defined by UNICEF). Regression results: for total sample, $B=-1.54$ ($P=0.02$, $n=41$); for eastern and southern Africa, $B=-1.57$ ($P=0.07$, $n=9$). For all other equations, $P>0.1$. Average prevalences (total sample): for 1980–1989, 40.3% ($n=16$); for 1990–1996, 27.1% ($n=25$) ($P=0.02$).



A judicious conclusion may be that the subclinical vitamin A deficiency results, which are almost always taken from surveys conducted independently of clinical assessments, support the idea that a significant and broad improvement is under way.

Recent Trends in Prevalence of Iodine Deficiency Disorders

Goitre has existed for centuries, and it might be expected that in the absence of interventions, prevalences would remain fairly static. In countries where the food systems are still localized and the foods are not highly processed, there is no particular reason to expect improvement, unlike the situation with vitamin A deficiency, where socioeconomic progress may lead to reductions. About 80 national surveys of goitre have been carried out since 1970 (see Appendix 3). Only in eight countries were repeated surveys, likely to be comparable, identified. In two additional cases (Cameroon and Peru) progress was tracked by a sentinel site monitoring system.

It appears that a rapid improvement occurs when salt iodization is effectively introduced, as illustrated in Figs. 5A and 5B. This improvement is expected, given the long-established effectiveness of salt iodization (Hetzel 1988), and the success stories (such as that of Bolivia [Fig. 5A]) are well understood (e.g., Stanbury 1998). What is uncertain is the trend that occurs before a widespread program is in place. In most of the countries for which repeat data are available (Figs. 5C and 5D),

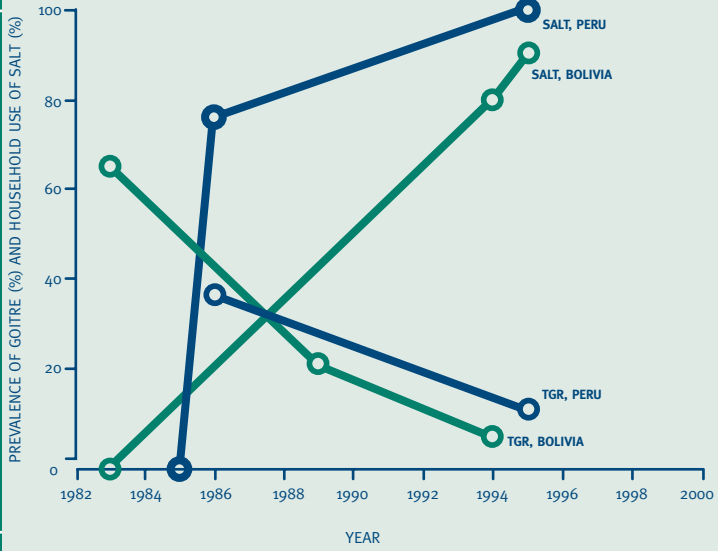
some degree of iodine deficiency control has been undertaken, if generally less extensive than in the countries shown in Figs. 5A and 5B. Thus a pattern of improvement of about 1 percentage point per year has been observed in Ethiopia, Indonesia, and Zambia.

Two contrasting results are shown in Fig. 5D. In Guatemala, salt iodization was started nationally in the 1950s, and the prevalence of goitre was estimated at 11% in 1979; in the 1980s the program declined with the political crisis, and the goitre rate increased to 20% in 1987 (Stanbury 1998). The data from Bangladesh probably reflect a different story (as noted in the section on methods): the 1993 survey was larger and more organized than earlier ones, and in particular much more attention was paid to training field staff to recognize goitre (Yusuf et al. 1993). The result is likely to be a more comprehensive assessment, but one that may well not be comparable with previous results. The situation in Bangladesh is thus probably not deteriorating as seriously as Fig. 5D implies (and deficiency control programs have been operating for some time), but the level may indeed be one of the highest seen.

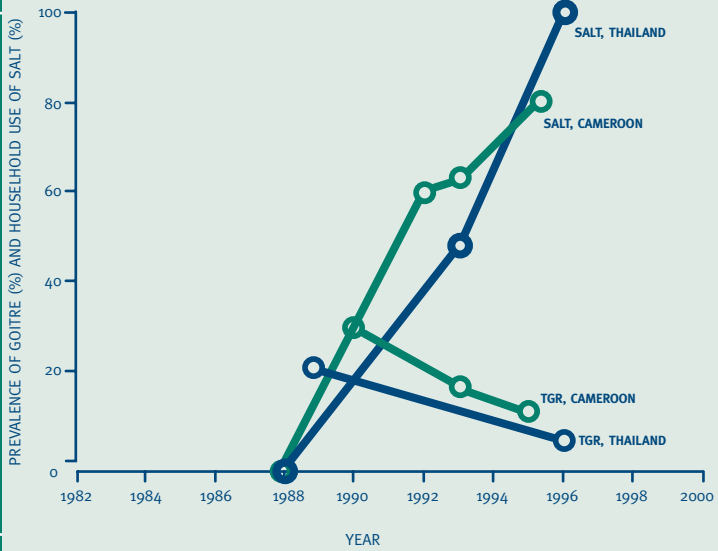
When the results from nationally representative surveys are pooled by groups of countries and periods (1980–1989 and 1990–1999), the averages indicate no overall improvement, and indeed may show deterioration (Fig. 6). In fact, the number of estimates is small (62 in

5A

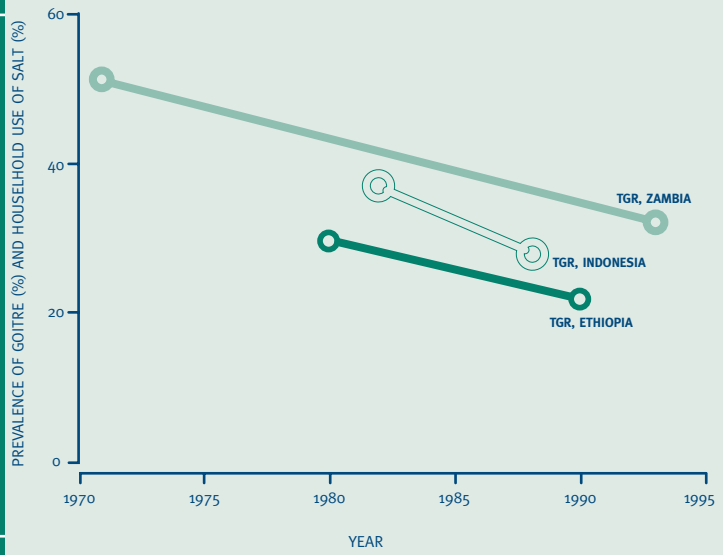
FIG5 >> Trends in iodine deficiency disorders, as determined from surveys of total goitre rate (TGR) in various years for nine countries. These trends are related to household use of iodized salt for four countries.



5B



5C



5D



total for the three country groups), and the differences through time are not significant. This apparent increase was reported by WHO (1999, p. 17), as shown here in Table 7, and is discussed later in the current report in that context. The apparent increase may reflect increased effort to identify the deficiency in recent years. It should probably not be taken as evidence of general deterioration, but it does support the idea that there is only an important improvement when effective salt iodization programs are in place. These findings also emphasize the lack of representative data that would allow a better assessment of trends.

In sum, there is just enough evidence to infer that iodine deficiency disorders as measured by goitre remain at high levels until effective control programs,

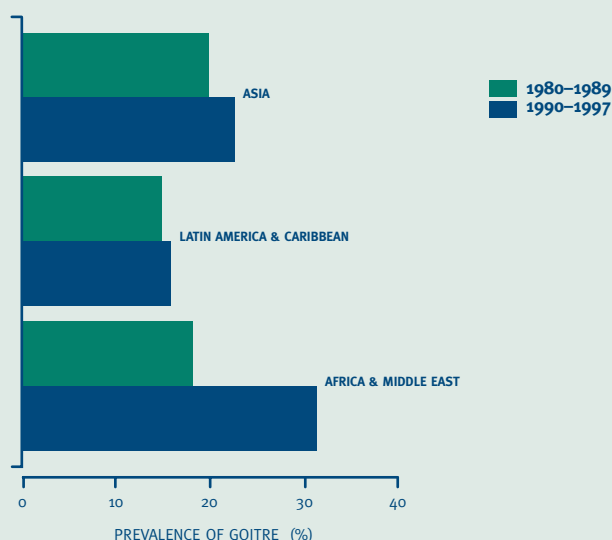
primarily with iodized salt, are in place. The underlying trend is probably fairly unimportant compared with the rapid and widespread reduction that can be achieved with iodine fortification.

Recent Trends in Prevalence of Anemia

Iron deficiency and anemia are not synonymous (as discussed in section 2, "Data and Analytical Methods"), but the prevalence of anemia is by far the commonest indicator used to monitor iron deficiency, and if the distinction is kept in mind, misleading conclusions can be avoided.

No repeated, comparable surveys of anemia, at national or subnational levels, could be identified. Thus we do not have available the first line of

FIG6 >> Prevalence of iodine deficiency disorders, defined as goitre (both visible and palpable) in school-age children, as determined from averages of national survey data. Regions are as defined by UNICEF (1998, p. 122). When more than one estimate was available for a given period for one country (e.g., Thailand), the values were averaged. Sample sizes: Asia, for 1980–1989, $n=8$, and for 1990–1997, $n=10$; Latin America and the Caribbean, 1980–1989, $n=7$, and for 1990–1997, $n=9$; Africa and the Middle East, for 1980–1989, $n=9$, and for 1990–1997, $n=19$.



analysis for determining trends. This is a serious lack now, but will become worse if two deliberate efforts are not made soon: first, to select existing survey results from the past and ensure that repeat surveys conducted in future can be compared with the existing results; and second, where such surveys do not exist, to begin to establish a baseline from which trends can be estimated in the future.

The data compiled were separated into two groups (pregnant and nonpregnant women, 15–49 years of age) and aggregated to give no more than one estimate for each group per country–year. The large degree of variation in the data is apparent for both nonpregnant (Fig. 7) and pregnant (Fig. 8) women. Indeed, any real trend would have to be substantial if it were to

emerge through the noise in the data. Can we derive useful conclusions from these results?

Mean prevalences of anemia by region can be estimated (Tables 4 and 5). It is likely that the estimates for nonpregnant women tend to come from survey data, whereas estimates of anemia for pregnant women usually derive from those attending antenatal clinics. The results for nonpregnant women are thus more likely to be representative of the overall population. This may relate to the seemingly more stable trends in the data for nonpregnant women. The nonpregnant group also represents about 90% of the female population. The relative levels of anemia by region in nonpregnant women can be seen in Table 4 and Fig. 7 (fitted lines). South Asia has the highest average prevalence of

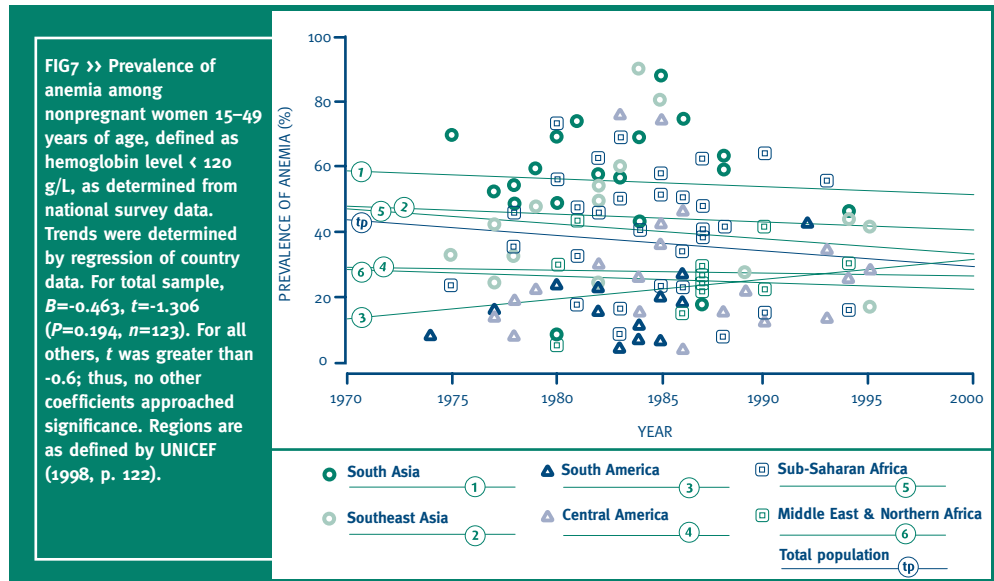
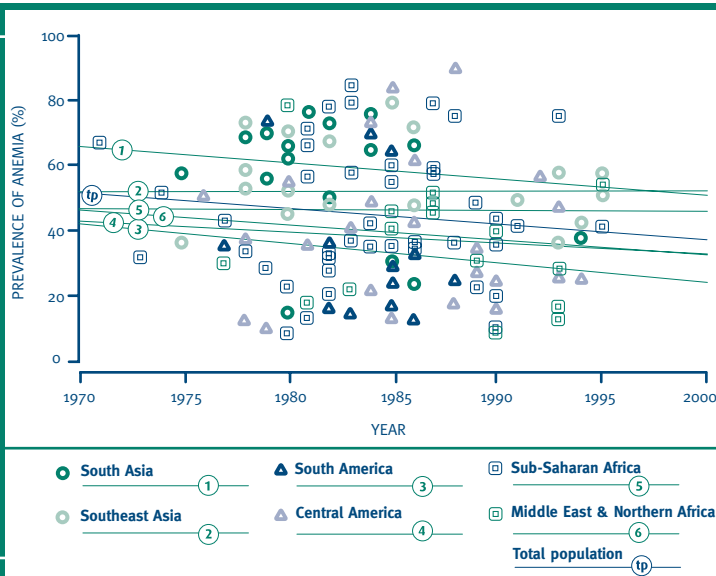


FIG8 » Prevalence of anemia among pregnant women 15–49 years of age, defined as hemoglobin level < 110 g/L, as determined from national survey data. Trends were determined by regression of country data. For total sample, $B = -0.449$, $t = -1.444$ ($P = 0.151$, $n = 150$). For all others, no coefficients approached significance. Regions are as defined by UNICEF (1998, p. 122).



anemia, at about 58%; the prevalence is 46% in Southeast Asia. The prevalence in Sub-Saharan Africa is about 40%, and the Near East and northern Africa and Central and South America have prevalences between 20% and 30%. Comparison tests (ANOVA) between regions show that the situation in South Asia is significantly worse than that in all other regions, except Southeast Asia.

Regression results showed no significant trends in any region. The coefficients of the lines shown in Fig. 7 are not significant in any region, nor is the overall average for all regions. There is enormous variation, but the data have been very carefully examined for likely errors. It is certainly true to state conservatively that there has been no detectable change, but a stronger assertion may be valid: there really is

no improvement in anemia for most women in developing countries.

The estimates for pregnant women are shown in Table 5 and Fig. 8. The prevalences in South Asia are again significantly worse than in other regions, except Southeast Asia and sub-Saharan Africa. The variation by region tends to be higher among the pregnant women, which confirms a wider spread in anemia prevalences between subgroups and perhaps more questionable reliability. Despite this variation, a consistent trend of higher prevalences among pregnant women than among nonpregnant women is evident across all regions — the exception being South Asia, perhaps because prevalences have already peaked in this region. No significant trends were found for pregnant women.

Table 4. Prevalence of anemia (hemoglobin <120 g/L) in nonpregnant women 15–49 years of age.

Region*	Prevalence of anemia (%)			
	Sample size (country-years)	Average for 1975–1997	Estimate for 1995	Trend† (percentage points/year)
South Asia	19	56.0‡	53.4	–0.21
Southeast Asia	18	44.7	42.5	–0.23
Middle America and Caribbean	25	28.3	27.6	–0.07
South America	14	22.8	25.0	+0.15
Sub-Saharan Africa	32	40.8	36.0	–0.45
Near East and northern Africa	14	25.4	24.3	–0.18
China	4	23.2	—	—
Pacific islands	3	33.6	—	—

Dash = information not available.

*Regions as defined by ACC/SCN (1992, p. 5).

†Trends calculated by regression (as in Fig. 7). None of the trends were significant. Trend for all data: $B = -0.56$, $n = 129$, $P = 0.11$.

‡South Asia significantly higher than Near East and northern Africa and the American regions ($P < 0.05$).

Table 5. Prevalence of anemia (hemoglobin <110 g/L) in pregnant women 15–49 years of age.

Region*	Prevalence of anemia (%)			
	Sample size (country-years)	Average for 1975–1997	Estimate for 1995	Trend† (percentage points/year)
South Asia	18	59.7‡	53.9	–0.48
Southeast Asia	23	52.1	52.7	+0.01
Middle America and Caribbean	26	38.0	34.8	–0.33
South America	18	34.0	27.2	–0.60
Sub-Saharan Africa	43	46.4	48.5	+0.21
Near East and northern Africa	19	37.7	34.1	–0.50
China	6	30.3	—	—
Pacific Islands	2	20.8	—	—

Dash = information not available.

*Regions as defined by ACC/SCN (1992, p. 5).

†Trends calculated by regression (as in Fig. 8). None of the trends were significant. Trend for all data: $B = -0.32$, $n = 155$, $P = 0.32$.

‡South Asia significantly higher than Near East and northern Africa and the American regions ($P < 0.05$).

The slopes of the lines in Figs. 7 and 8 are compiled in Tables 4 and 5 as the changes in percentage points per year. As mentioned earlier, the estimates for nonpregnant women are probably more reliable. A slope of –0.5 percentage points/year — the highest seen — implies that a prevalence of 40% (e.g., as in sub-Saharan Africa) would be reduced to the level of 10% that seems to be typical of industrialized countries over a 60-year period — plausible but far too

slow to simply let happen if there were effective interventions to accelerate progress. Most regions are hardly improving at all by this indicator, and South Asia may be deteriorating. Because trends through time are probably small compared with the overall prevalences, the year at which prevalences are considered is not crucial, in contrast to other indicators of malnutrition (where they change more rapidly). For presentation purposes, the prevalences

have been calculated for 1995, as given in Tables 4 and 5. This is the value of the plotted regression line in Figs. 7 and 8, for 1995. These are broadly in line with the 1975–1997 averages, since there is little apparent trend, and thus with those given by WHO (1997, Table 8). They show that the Asian countries have the highest prevalences among both pregnant and nonpregnant women. Prevalences during pregnancy usually appear higher (in four of the six regions) although less pronounced when estimated in this way than those shown in Table 5 (means by region). It should be remembered that the cutoffs are different for pregnant and nonpregnant women, and therefore prevalences are not necessarily directly comparable between these two groups.

In terms of the numbers of people affected by anemia, data from WHO (1992, 1997) imply that some 419 million pregnant and nonpregnant women (about 44% of the developing world population) were affected in 1988 and that this value rose to 532 million in 1995. The present results would generally support this estimate (for 1995), as discussed in the next section and shown in Table 9.

In sum, progress in reducing the prevalence of anemia is hardly detectable, and numbers affected are increasing. Earlier estimates of deterioration in South Asia and sub-Saharan Africa remain plausible, but cannot be taken further as insufficient new data (after 1987) are available;

however, significant improvement does not appear to be occurring in these regions or, indeed, elsewhere. Further analysis seems merited, both to compare raw data from surveys in specific countries, and to combine data in more meaningful ways, taking account of sample size and other information, to better understand recent trends and their determinants.

Levels of Vitamin A, Iodine, and Iron Deficiencies

As discussed previously, vitamin A deficiency is declining substantially, which means that data should not be averaged over time. For clinical vitamin A deficiency (indicated by night blindness and Bitot's spots), the model described in section 2 ("Data and Analytical Methods") was therefore used to predict prevalences for 1985 and 1995 for countries with and without survey results from the period 1980–1997. These results, weighted by population numbers and aggregated according to regions, are shown in both Table 6 and Fig. 9. The values incorporate the WHO multiplication factor and are therefore probably conservative estimates. The numbers of people affected (Table 6) are similar to numbers reported by WHO (1995), for which 1994 population data were used and prevalences (not corrected for trend) were averaged from 1980 onward. The total number of preschool children affected by clinical vitamin A deficiency in 1995 is estimated at 3.3 million, equivalent to a prevalence of 0.63%.

The comparable WHO value (WHO 1995) was 2.8 million children.

Table 6 includes some alternative estimates. Yet however the values are calculated, the trend of improvement appears. The numbers of children affected as of the mid-1990s might range from 3.3 to 6 million, with a possible prevalence range of 0.6% to 1.4%. The values in Table 6 are used here as a point of reference for 1985 and 1995, in recognition that they are probably conservative estimates. Prevalences of clinical vitamin A deficiency by region for 1985 and 1995 are displayed in Fig. 9.

As described earlier, the multiplication factor is probably incorrect. In this case, the basic value for global prevalence of clinical vitamin A deficiency in 1995 is probably best estimated as 1.2% in preschool children.

Estimates of subclinical vitamin A deficiency for 1995, as prevalences of low serum retinol level ($<0.7 \mu\text{mol/L}$) and numbers affected, are shown in Table 7 and Fig. 10. Two values are given, one with and the other without the multiplication factor. The upper value probably more closely approximates reality (see Methods section in MI et al. [1998]). The numbers affected are shown in Fig. 11. The highest prevalences of both clinical and subclinical vitamin A deficiency were observed in south Asia and sub-Saharan Africa, where 30% to 40% of preschool children are at heightened risk of ill health and death. WHO (1994) suggested that in populations in which more than 20% of the children have serum retinol levels less than $0.7 \mu\text{mol/L}$, vitamin A deficiency should be regarded as a severe public health problem; this criterion applies to the populations of these regions.

Table 6. Prevalence and number of preschool children affected by clinical vitamin A deficiency,* 1985–1995.

Region†	Prevalence (%)		No. affected (millions)		Change in prevalence (percentage points/decade)
	1985	1995	1985	1995	1985–1995
South Asia	1.79	0.95	2.67	1.58	-0.84
East Asia and Pacific	0.43	0.25	0.66	0.40	-0.18
Latin America and Caribbean	0.35	0.24	0.17	0.12	-0.11
Eastern and southern Africa	1.80	1.06	0.69	0.53	-0.74
Western and central Africa	1.40	0.87	0.53	0.45	-0.53
Middle East and northern Africa	0.63	0.27	0.24	0.12	-0.36
Total‡	1.06	0.63	5.00	3.30	-0.43

Source: MI et al. (1998).

Note: The values in this table were computed with the WHO multiplication factor.

*Defined as xerophthalmia (night blindness and Bitot's spots).

†Regions as defined by United Nations Children's Fund (UNICEF).

‡Alternative calculations of total prevalence values for all developing regions are possible. Method 1—averaging the available survey results within time periods, with and without the applicable WHO multiplication factor (MF) (WHO 1995), yields the following: for 1980–1989, with MF, prevalence = 1.65%, without MF, prevalence = 2.45% ($n = 16$); for 1990–1996, with MF, prevalence = 0.79%, without MF, prevalence = 1.41% ($n = 19$) ($P = 0.013$). Method 2—using the model estimates without MF, values for 1995 are as follows: prevalence = 1.15% and no. affected = 6.0 million. The WHO MF is used as a way of allowing for how well the sample reflects the population; see Table 2.

FIG9 » Estimated prevalence of clinical vitamin A deficiency among preschool children in 1985 and 1995. Values in this figure incorporate the WHO multiplication factors. The data are presented in Table 6. Regions are as defined by UNICEF (1998, p. 122).

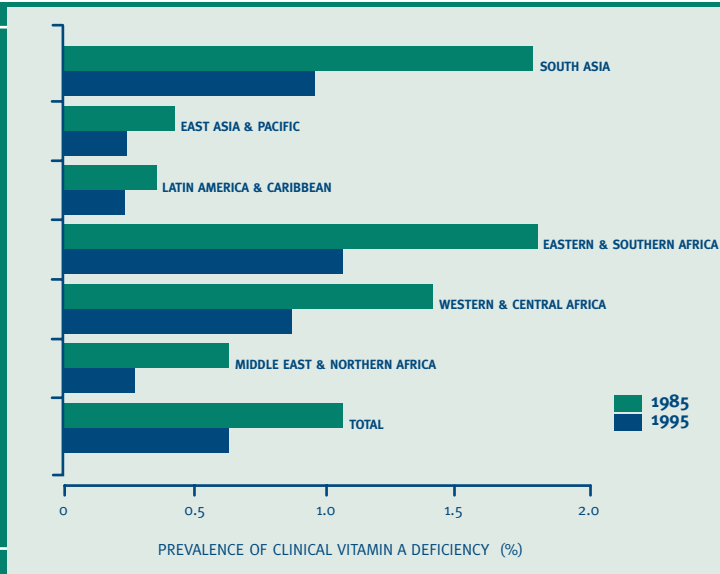


Table 7. Prevalence and number of preschool children affected by subclinical vitamin A deficiency,* 1995.

Region†	Prevalence (%)		No. affected (millions)	
	With WHO	Without WHO	With WHO	Without WHO
	MF	MF	MF	MF
South Asia	19.2	35.6	32.3	59.5
East Asia and Pacific	9.1	18.2	14.8	29.6
Latin America and Caribbean	9.0	19.6	4.7	10.2
Eastern and southern Africa	20.0	37.1	10.0	18.6
Western and central Africa	18.1	33.5	9.4	17.4
Middle East and northern Africa	9.8	9.8	4.2	4.2
Overall	14.6	26.5	75.4	139.5

WHO MF = World Health Organization multiplication factor (used as a way of allowing for how well the sample reflects the population; see Table 2).

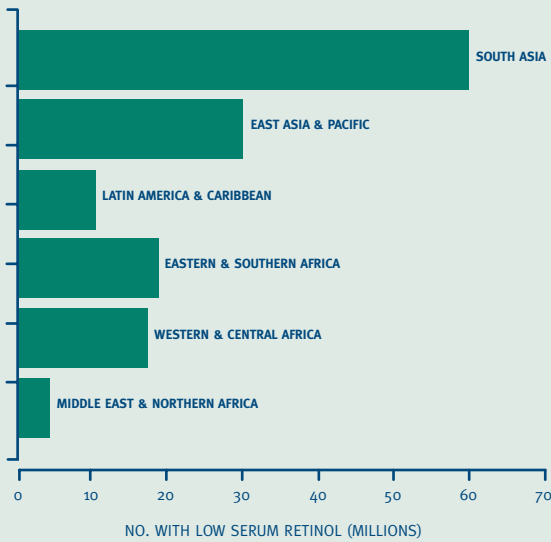
*Defined as serum retinol $<0.7 \mu\text{mol/L}$.

†Regions as defined by UNICEF.

FIG10 >> Estimated prevalence of subclinical vitamin A deficiency, defined as serum retinol level < 0.7 μmol/L, among preschool children in 1995. Regions are as defined by UNICEF (1998, p. 122).



FIG11 >> Estimated numbers of preschool children affected by subclinical vitamin A deficiency, defined as serum retinol level < 0.7 μmol/L, in 1995. Regions are as defined by UNICEF (1998, p. 122).



Of the global total of 140 million children affected by vitamin A deficiency, nearly 100 million live in south Asia or sub-Saharan Africa.

Prevalences and numbers affected by iodine deficiency, assessed as visible plus palpable goitre, were recently reported by WHO (1999), and the results for regions of developing countries (excluding Latin America and the Caribbean) are shown in Table 8. In Africa and the eastern Mediterranean region (including Pakistan), the prevalences are about 20% to 30%; estimates for Southeast Asia are lower. The total number affected in these countries is estimated as nearly 600 million in 1998, of the 740 million thought to be affected by goitre worldwide (WHO 1999, Table 3). Comparing the estimates for 1990 and 1998 indicates little change in overall prevalence over this period (WHO 1999, Table 5; Table 8 in the current document).

Iron deficiency is indicated by anemia, and the prevalence data summarized by

WHO (1997) for the period 1980–1996 may be taken as the reference. No significant trend is seen in any region, so averaging across several years should not introduce bias. The population numbers were standardized to 1995 by WHO (1997). The data for pregnant and nonpregnant women 15–59 years of age extracted from WHO (1997) are given in Table 9 and Fig. 12. Southeast Asia and the eastern Mediterranean region are thought to have the highest prevalences, around 60%. The higher value of 79.6% for pregnant women in Southeast Asia depends on how prevalence is calculated for India (see below). For developing countries as a whole, the average prevalences are 42% to 56% for nonpregnant and pregnant women, respectively, and an estimated 1.14 billion nonpregnant women and 96 million pregnant women are anemic.

The anemia data in Table 9 are for regions defined by WHO and thus cannot be readily compared with the regional definitions used here, which correspond to those of UNICEF. The

Table 8. Prevalence and number of people (all ages) with goitre (visible + palpable) in 1990 and 1998.

Region*†	1990		1998	
	Prevalence (%)	No. affected (millions)	Prevalence (%)	No. affected (millions)
Southeast Asia	13.0	176	12	172
Western Pacific	9.0	141	8	124
Africa	15.6	86	20	124
Eastern Mediterranean	22.9	93	32	152
Overall	12.5	496	13.6	572

Sources: for 1990, WHO (1993, Table 2A); for 1998, WHO (1999, Table 5).

*Regions as defined by WHO.

†Americas not included because industrialized (Canada and United States) and non-industrialized (Latin America and the Caribbean) regions could not be distinguished in these data. Data here can be compared with data for Africa, Asia, Latin America, and the Caribbean, shown in Fig. 6.

prevalences for 1995 calculated from our database and presented in Tables 4 and 5 can be used for comparison with other estimates by region. The main differences between the WHO estimates and those in Tables 4 and 5 are for pregnant women in the WHO region “Southeast Asia” (prevalence 79.6%; see Table 9), which is essentially

equivalent to the UNICEF region “South Asia” (prevalence 59.7%; see Table 5). The difference depends mainly on the prevalence estimated for India. From the database used here, the values ranged from 66% to 90%, and the median of eight values was 72%. The median value for Bangladesh was 62% and for Pakistan 51%. On this basis, although

Table 9. Prevalence and number of women (15–59 years of age) affected by anemia in 1995.

Region*	Pregnant women†		Nonpregnant women‡	
	Prevalence (%)	No. affected (millions)	Prevalence (%)	No. affected (millions)
Southeast Asia	79.6	22 227	57.0	192 746
Western Pacific (non-industrialized)	38.5	9 384	33.8	144 558
Americas (non-industrialized)	39.0	3 838	30.0	40 546
Africa	46.9	9 586	36.6	48 194
Eastern Mediterranean	63.9	8 807	49.0	51 389
Overall	55.8	53 842	42.0	477 433

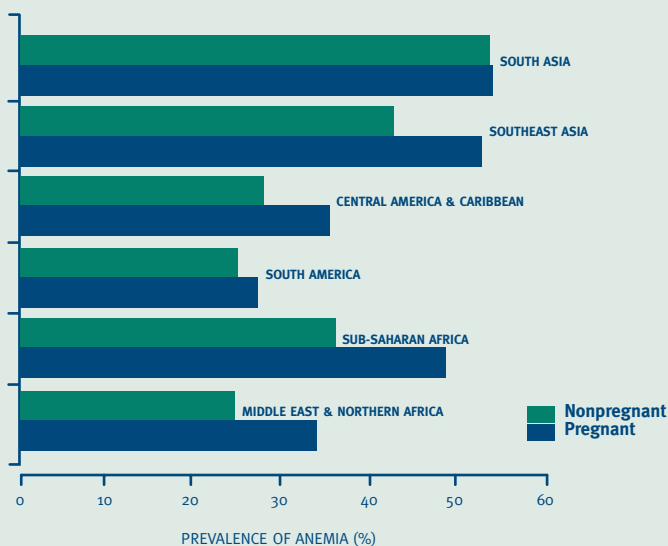
Source: WHO (1997, Table 8).

*Regions as defined by WHO.

†For pregnant women, anemia defined as hemoglobin level <110 g/L.

‡For nonpregnant women, anemia defined as hemoglobin level <120 g/L.

FIG12 >> Prevalence of anemia among women 15–49 years of age in 1995; definition of anemia for pregnant women is hemoglobin < 110 g/L and for nonpregnant women, hemoglobin < 120 g/L. Regions are as defined by UNICEF (1998, p. 122).



the prevalence of 79.6% seems relatively high, the prevalence of 59% might be low. In any case, this analysis gives some idea of the range of uncertainty, and either way the prevalence is very high.

For comparing prevalences of different deficiencies and examining possible overlaps, the age group most commonly used is preschool children. The anemia estimates for this group have been taken directly from WHO (1997), although certain assumptions have been made so that definitions of the various regions are essentially equivalent.

Overlaps and Multiple Deficiencies

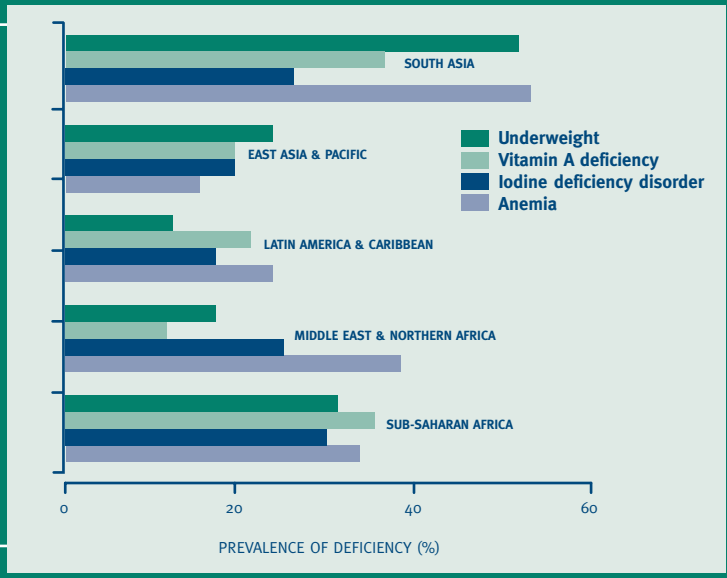
Prevalences of the different deficiencies, summarized in Fig. 13, are generally highest in South Asian and lowest in East Asia and the Pacific region. The extent of multiple deficiencies can be approximated from these data by making some assumptions about how individual deficiencies overlap in the preschool population. We can make some reasonable estimates of the highest and lowest prevalences likely for two or more deficiencies in the same children. A high estimate would assume that the worst-off children were the same for several deficiencies — that the poorest, for example, tended to suffer from the combination of deficiencies. For example, if it is assumed that the prevalence of vitamin A deficiency is 25% and that of anemia is 40%, then the 25% of children with vitamin A deficiency are assumed to represent a subset of those with anemia. In this

situation, all of the children with vitamin A deficiency would be anemic, and the prevalence of those with both vitamin A deficiency and anemia would be 25%. This estimate of the prevalence of dual deficiency is probably high. An alternative assumption is that there is no correlation between various deficiencies and that (in this example) the prevalence of vitamin A deficiency in the anemic population is the same as in the overall population, 25%. Thus the proportion of those with both anemia and vitamin A deficiency would be 25% of the 40% with anemia or 10% of the total population. Therefore, the likely prevalence of two or more deficiencies could be set as 10% to 25%. Although this range is wide, it has a certain value in giving some idea of the extent of the problem.

The actual overlap can be gauged from a few studies and probably lies somewhere between these bounds (W. Schultink, UNICEF, personal communication, 1999). For example, some results from Indonesia showed higher levels of low serum retinol level in anemic preschool children (Merzenich et al. 1994), whereas for others the prevalence was similar to that in the overall population (Angeles-Agdeppa et al. 1997; Thu et al. 1999).

Results based on these calculations are presented in Table 10. The overall range of prevalences for preschool children with two or more deficiencies is estimated at 13% to 27%, and about 100 million children are affected.

FIG13 >> Summary of regional prevalences of underweight, subclinical vitamin A deficiency, iodine deficiency disorders, and anemia among preschool children in 1995. Data are presented in Table 10. Regions are as defined by UNICEF (1998, p. 122).



Many deficiencies are known to interact. For our purposes, the most important interactions are those for which a single nutrient intervention will be ineffective in reducing the effects of the deficiency because another nutrient is lacking. Such problems can occur at different levels, for example absorption from the gut or metabolic pathways. Anemia is a good example. Many nutrients are involved in anemia (see, for example, Viteri 1998), which has various causes, many but not all of which involve dietary iron supply. Reduction of anemia (through effects on absorption, metabolism, probably gene expression, and other processes) can depend on concurrent provision of other nutrients, such as vitamin C, folate, or vitamin A (for example, see Schultink and Gross 1997). Similarly, most nutrient deficiencies affect the immune system,

and all such deficiencies may need to be corrected before full immune competence can be restored.

The calculations performed here (Table 10) show clearly that we can expect only limited success in controlling the effects of micronutrient deficiencies by tackling one micronutrient at a time. For example, in theory, reducing the most prevalent deficiency (bearing in mind that cutoff values are somewhat arbitrary) might reduce the prevalence of dual deficiency to that where the next most scarce nutrient becomes limiting — from 35.6% to 27.4% in South Asia, for example.

This analysis argues for a multifaceted approach incorporating supplement— and fortification with several micronutrients, supported where

Table 10. Prevalence of nutritional problems and implied overlap of deficiencies in preschool children.

Region	Underweight* (1995)			Vitamin A deficiency† (subclinical, 1995)			Iodine deficiency‡ (1985–1996)			Anemia§ (1975–1997)			With two or more nutritional deficiencies		
	Prev- alence (%)	No. affected (millions)	Prev- alence (%)	No. affected (millions)	Prev- alence (%)	No. affected (millions)	Prev- alence (%)	No. affected (millions)	Prev- alence (%)	No. affected (millions)	Prev- alence (%)	No. affected (millions)	Prev- alence (%)	No. affected (millions)	
South Asia	5.2	87.4	35.6	59.5	25.3	42.5	52.7	93.8	27.4	35.6	46.1	59.8			
East Asia and Pacific	2.3	39.3	18.2	29.6	18.0	31.1	14.1	20.0	4.2	18.2	8.2	31.1			
Latin America and Caribbean	1.1	6.2	19.6	10.2	15.6	8.8	22.9	13.0	4.5	19.6	2.5	11.1			
Sub-Saharan Africa	3.0	30.9	35.3	36.0	29.2	30.1	33.1	34.1	11.7	33.1	12.1	36.3			
Middle East and northern Africa	1.6	7.4	9.8	4.2	24.0	11.1	38.3	17.7	9.2	24.0	4.3	7.4			
Overall	3.1	171.2	26	139.5	2.3	123.6	3.5	178.6	13	27	73.2	145.7			

*Values are based on ACC/SCN (1996), calculated for regions from country estimates.

†Prevalence of subclinical vitamin A deficiency as given in MI et al. (1998). For sub-Saharan Africa, values for eastern and southern Africa and western and central Africa were weighted and collapsed into a single value (for eastern and southern Africa, prevalence was 37.1%, and 18.6 million were affected; for western and central Africa, prevalence was 33.5%, and 17.4 million were affected).

‡Prevalences calculated from nationally representative data in MN-Net (MI 1999) and other sources (see Appendix 3), as used for Fig. 6, by averaging all data points by region. These results were for school-age children and have not been adjusted for age, but differences from preschool children are relatively minor (WHO 1993, p. 49).

§Data from WHO (1997, Table 8). Some approximations were used for regional aggregation, as follows: South Asia is the approximation for the WHO region called "Southeast Asia"; Middle East and northern Africa approximates WHO region called "Eastern Mediterranean"; East Asia and Pacific region is approximated by WHO region called "western Pacific, non-industrialized"; and Latin America and the Caribbean approximates WHO region called "Americas, non-industrialized."

||Lower value assumes no correlation between multiple deficiencies, such that in the highest-prevalence group, the prevalence of the second-highest deficiency in the overall preschool population is applied (i.e., the two highest prevalences are multiplied); the higher figure assumes complete overlap between multiple deficiencies, so that all subjects in the second-highest prevalence group are taken as having the deficiency represented by the highest prevalence (i.e., this equals the second highest prevalence). These two estimates are likely to bound the actual prevalence. Underweight is considered a deficiency here, for example protein-energy malnutrition or protein-energy deficiency.

feasible with increased micronutrient intake from the diet. Such an approach not only makes sense in operational terms — if a supplement is to be given (especially daily or weekly), it ought to

contain all that is needed — but may actually be imperative biologically.

4. CONCLUSIONS

Vitamin A deficiency is decreasing rapidly, and clinical forms are likely to become rare in the near future. Subclinical deficiency, however, which carries substantial risk of death, is at a high level among children in poor countries, and its control would repay continued vigorous efforts.

In contrast, there is little evidence of improvement in anemia levels, which both reflects iron deficiency and is caused by it. This deficiency affects particularly women and their infants and is the most common deficiency today — half a billion women are anemic worldwide. No highly effective control measure is available, but a combination of approaches including attention to associated deficiencies (e.g., vitamin A and folate) can bring relief.

Iodine deficiency disorders certainly respond rapidly to iodized salt programs, but without such programs, the disorders appear to persist at levels associated with risk of developmental problems. The expansion of control measures, mainly iodized salt, if they can be monitored

and sustained, may lead to major success in human nutrition.

Overlaps and interactions between micronutrients (anemia is a clear example) are likely widespread, probably affecting about 20% of preschool children, and half of the children with any deficiency may have multiple deficiencies. This situation argues strongly for a multifaceted approach, notably supplementation and fortification with multiple micronutrients, for both operational and biological reasons.

There is a serious scarcity of data for making these assessments. In particular, few comparable, representative national surveys have been conducted through time. Priority should be given to repeating such surveys to allow better assessment of current progress. In addition, first-time surveys are needed in many countries (especially for anemia but also for other deficiencies) to generate baseline data, so that we can determine in the future whether efforts have had any effect.

Finally, there is no doubt that many people are affected by deficiencies of many other nutrients, and assessment methods are not yet adequate to identify these deficiencies. Zinc is an obvious example. Rickets, possibly caused by a complex of factors, is still widely observed. Other deficiencies, such as that of selenium, may both be important themselves and interact with others (such as iodine deficiency in the case of selenium deficiency). Many vitamins and minerals are probably limiting during catch-up growth in children, which constitutes much of the growth of children in poor environments. In terms of understanding these deficiencies on a worldwide basis, the surface is only now being scratched, and an increase in attention to these problems holds great promise for improvements in human health and development.

2.

Program Implementation in the 1990s

1. INTRODUCTION

Over the past two decades there has been a major increase in the global attention and commitment to the control and elimination of micronutrient malnutrition. Results of the research conducted during the 1980s have expanded our understanding of the adverse consequences of these deficiencies, which are much more extensive than previously assumed in a large number of developing countries. Several key international meetings held in 1990s, including the World Summit for Children in 1990, the 1991 Montreal meeting entitled “Ending Hidden Hunger,” and the 1992

International Conference on Nutrition, raised awareness and stimulated worldwide actions to address micronutrient malnutrition. Many countries developed plans of action to specifically control and eliminate deficiencies of vitamin A, iodine, and iron in their populations for health, intellectual development, and economic gains. These plans, together with availability and leverage of substantial external and internal resources, led to an increasing number of affected countries initiating actions to control micronutrient deficiencies.

Part II of this report reviews progress in planning and implementing programs to control micronutrient deficiencies and indicates, where feasible, the evolution of such programs in recent years. Of course, data collection progressed in conjunction with the control programs, so assessing current status of programs

is easier than assessing trends. Because countries are at various stages of situation analysis, policy development, program implementation, and program evaluation, the main aim of this section is to provide information that will be useful to policy and decision making at global, regional, and national levels.

2. TYPES OF PROGRAMS

The major strategies to correct micronutrient deficiencies are supplementation, dietary diversification or modification, and fortification.

- ▶ **Supplementation** is a medical approach to treating and preventing micronutrient malnutrition and involves administration of capsules, tablets, syrups, and other preparations of the required micronutrient. Supplementation is the method of choice when the deficiency is severe and life threatening or when access to regular intake of micronutrients is limited and there is high likelihood of severe deficiency episodes.
- ▶ **Dietary diversification or modification** aims to correct dietary behaviours that lead to micronutrient deficiencies and to ensure that deficient populations have access to foods rich in micronutrients.
- ▶ **Fortification** is the addition of micronutrients to foods that are regularly consumed and as such it can deliver micronutrients to a large population through the daily diet.

On the basis of experiences to date, a mix of strategies seems most likely to result in sustained enhancement of health benefits, particularly when combined with health measures. According to the Institute of Medicine (Howson et al. 1998a), the preferred approach is related to the extent of the problem at the population level (see Table 11). The long-term goal of intervention should be to shift emphasis away from supplementation toward a combination of food fortification (through universal salt iodization or fortification of flour with iron, for example) and dietary diversification, where appropriate and feasible. In other words, as populations move along the continuum of risk from a position of higher to one of lower risk, the relevant mix of interventions should favour those involving food intake and should be modeled after that presented in Table 11.

The high-priority interventions are targeted supplementation for iron and vitamin A and universal fortification for vitamin A, iodine, and iron. The following sections summarize programs

Table 11. Preferred initial approaches* to prevention and control of vitamin A, iodine, and iron deficiencies in populations at different levels† of micronutrient malnutrition.

Approach	Level IV		Level III		Level II		Level I	
	Iodine	Vit A	Vit A	Iron	Iodine	Vit A	Vit A	Iron
Supplementation								
Targeted to vulnerable groups	++++	+++		+++			+	++
Universal	-	+		++			-	-
Fortification								
Targeted foods	-	-		-			-	-
Universal	+++	++		+			++	+++
Food-based approaches								
Nutrition education	+	+++		++			++++	++++
Food products	na	++		+			-	-
Food-to-food fortification‡	-	+++		+++			-	-
Public health control measures								
Immunization	-	++++		++++			++++	++++
Parasite control	-	++		+++			-	-
HW/S	-	++		+++			-	-
DD/ARI	-	++		+++			-	-
Personal sanitation and hygiene	-	++++		++++			++++	++++

na = not applicable, HW/S = healthy water and public sanitation; DD/ARI = control of diarrheal diseases and acute respiratory infections.

Adapted, with permission, from Howson et al. (1998, p. 8).

*++++, = very strong emphasis, +++ = strong emphasis, ++ = moderate emphasis, + = light emphasis, - = no emphasis.

†Level IV = severe micronutrient malnutrition, level III = moderate-to-severe micronutrient malnutrition, level II = mild, widespread micronutrient malnutrition, level I = mild, clustered micronutrient malnutrition.

‡Mixing of staple foodstuffs (e.g., mango with guava) at the household level to enrich nutrient content.

planned or implemented in these areas. Multiple micronutrient fortification and supplementation have only recently emerged as potentially important

interventions, so there are fewer data to report on these approaches. Similarly, public health measures are not examined in detail here.

3. METHODS, DATA SOURCES, AND TREATMENT OF DATA

The first source of much of the data used for this report is the Micronutrient Network (MN-Net) (MI 1999). The sources of data for MN-Net are the databases developed and maintained by the ICCIDD, WHO, and UNICEF, as well as information obtained from ad hoc inquiries through international agencies and literature searches. The iodine data were compiled by ICCIDD and are also available through MN-Net. At the time MN-Net was developed, no database on programs for controlling iron deficiency had been compiled in the required format, so the MI developed the appropriate database itself, using information available from various sources. MN-Net incorporates information obtained through questionnaires sent to all UNICEF field offices as well as other sources available in 1995. UNICEF carried out surveys in 1997 for iron, and in 1997 and 1998 for vitamin A.

The information in MN-Net was updated in 1999, with data on vitamin A and iron from the UNICEF field surveys and a further literature search, as outlined in MI et al. (1998) for vitamin A. Also in 1999, MN-Net was restructured, and the results and

tables presented in this document reflect much of the current structure of MN-Net.

Data on policy and legislation (Table 12) are based on information contained in MN-Net (MI 1999) and WHO (1999) and on results obtained by the Asia Development Bank (ADB) and UNICEF (Mason et al. 2000). Table 12 includes MN-Net data for vitamin A, mostly derived from a 1998 UNICEF field survey, originally presented in MI et al. (1998). MN-Net information on national iron supplementation policies comes mainly from a 1997 UNICEF field survey. MN-Net data on iodine legislation was provided by ICCIDD (2000), as well as WHO (1999). Information on micronutrient policy and legislation for countries in Southeast Asia also incorporates results obtained by ADB and UNICEF (Mason et al. 2000).

Information on procurement of vitamin A capsules and iron–folate tablets (donated by Canada and shipped by UNICEF) was provided from official records of the MI and UNICEF.

General Principles of Data Treatment

One problem in assembling the data and deriving the various averages and estimates of adequacy (expressed as percentage of need met) is the incompleteness of data by country and year. The following principles were therefore applied.

- ◆ With respect to program data, countries that have never reported program coverage were treated as missing and were not included in denominators. For countries reporting for some years and not others, the years without reports were treated as missing, and regional coverage was expressed as a median value (e.g., column I in Table 13 and column H in Table 19) excluding the iodine data.
- ◆ With respect to procurement data, countries with no recorded procurement were given a zero value for estimation of the regional averages (e.g., column F in Table 13 and column E in Table 19). The regional average was not used in estimating the adequacy of supply, in part because of this manipulation. Comparisons of supply with estimated need for one year (i.e., vitamin A capsules in 1998, iron in 1996) included only countries with some level of procurement reported.
- ◆ With respect to policy and legislation data, the regional values for each indicator represent only countries that have already adopted the particular policy or legislation.

Thus, in compiling the data, countries for which information on supplementation policy or fortification legislation was unavailable and those with policy or legislation in the planning stages, in draft form, or pending were given a value of zero (and have a “no” entry in Appendix 8). Information on current status of policy and legislation in these countries appears in footnotes to Appendix 8.

Vitamin A

Appendix 9 (columns A and D) presents total procurement of 100 000 IU and 200 000 IU vitamin A capsules by various countries in 1998. The procurement data were provided by the UNICEF Copenhagen Supply Division and represent shipments of vitamin A capsules (donated by the Canadian International Development Agency) from Copenhagen to UNICEF field offices in 1998. The total number of capsules procured by a country does not include any capsule supply purchased with national funds (either government or nongovernmental organization) or obtained through local production. These procurement data are aggregated by UNICEF region in Table 13, which also includes regional vitamin A procurement for 1993–1996; these data were also provided by the UNICEF Copenhagen Supply Division and are shown here as given in MI et al. (1998). For determining the annual average for regional procurement for the five years presented in Table 13, any country with no procurement was given a zero value.

Therefore, for determining the annual average, the denominator is 5 years, regardless of the countries and years for which no data are available.

To assess the potential range of coverage with vitamin A capsules, the estimated adequacy of the capsule supply was calculated separately for the age categories 6–12 months and 12–59 months. The potential coverage values for various countries are presented in Appendix 9 (columns C and G). The estimated adequacy of capsule supply for the two age groups was derived from the total number of capsules received and represents the potential percentage of children who received the recommended age-specific dose of vitamin A. The values were calculated on the basis of 1996 population figures and policy recommendations made by WHO, UNICEF, IVACG (1997). That document recommends one 100 000-IU capsule per year for children 6–12 months of age, two 200 000-IU capsules per year for children 12–59 months of age, and one 200 000-IU capsule for postpartum women.

Given the recommended supplementation dose and frequency of administration and the available age-specific population data, the estimated annual need for each age group was calculated (Appendix 9, columns B and E). Column F shows the estimated annual capsule need for postpartum women. Estimated annual capsule need is presented here only for countries and

capsule dosages for which 1998 procurement data were reported. Because children 6–12 months of age need only one 100 000-IU capsule annually, computation of the estimated adequacy of capsule supply is straightforward (division of the total number of 100 000-IU capsules procured in 1998 by the total estimated need for this age group in that year, i.e., [column A ÷ column B] x 100 = column C in Appendix 9). Computation of the estimated adequacy of capsule supply for children 12–59 months of age was more complicated. Division of the number of 200 000-IU capsules received by the estimated capsule need will overestimate potential capsule coverage, because postpartum women also receive 200 000-IU capsules, although the proportion of capsules received by the country that are used for this group is unknown. To account for postpartum supplementation, equal coverage for postpartum women and children 12–59 months of age was assumed. The values in column G of Appendix 9 were calculated as follows: ([no. of capsules received in 1998] ÷ [estimated annual need for children 12–59 months + estimated annual need for postpartum women]) x 100, i.e. (column D ÷ [column E + column F]) x 100 = column G in Appendix 9.

In computing the percentage of estimated need met in each country (Appendix 9, columns C and G) and in each region (Table 13, column H), only the estimated annual need for countries with reported procurement data were

included. Lack of procurement data is thus counted as missing data, rather than as zero values for the region. Although counting lack of procurement data as missing data has an obvious effect only on the interpretation of columns C and G in Appendix 9, this approach should also be considered carefully when interpreting the regional values in Table 13. Proper interpretation of the aggregated estimate of supply adequacy requires consideration also of the effect of countries with a capsule supply greater than 100% of need (e.g., Mongolia, Myanmar, Honduras, and Nicaragua; see Appendix 9, column G). Moreover, in comparing potential and reported program coverage for vitamin A in Tables 13 (columns H and I) and 21 (columns C and D), it should be remembered that the values are not directly comparable. The estimated adequacy of annual capsule supply represents the potential coverage for children 12–59 months of age for 1 year, whereas the values for reported coverage were obtained from UNICEF country field offices in response to a specific inquiry concerning the proportion of children 6–59 months who received at least one vitamin A dose in the previous 6 months.

Table 15 shows the number of countries in each region that distribute vitamin A capsules in conjunction with national immunization days, micronutrient days, or extended immunizations programs, or through postpartum supplementation policies. Many of the countries with national immunization days did not

respond when asked whether these events were combined with distribution of vitamin A capsules. They were recorded as having given no response (Table 15). In addition, many countries received vitamin A capsules through UNICEF but did not distribute them through the mechanisms described above.

Iodine

The data on households consuming adequately iodized salt are the same as those given in UNICEF (2000) and were provided directly by UNICEF (T. Wardlaw, N. Levin, and N. Dalmiya, 1999). As far as possible, data on the production of iodized salt have been excluded, and only data on household consumption are included. The definition of adequately iodized salt is salt with at least 15 ppm iodine, usually determined by means of testing kits used in household surveys. Most data points for reporting countries fall within the period 1995–1998; however, for 23 countries, information on the date of survey was not available or the data were collected before 1995 (Table 18 and Appendix 11). Country-level data on household consumption of iodized salt are presented Appendix 11, and regional population-weighted averages of household consumption of iodized salt are presented in Table 18. These regional values cover only countries that reported consumption of iodized salt. Population data from UNICEF (1998) were used in weighting countries that reported consumption data.

Iron

Procurement information for iron tablets presented in Table 19, columns A–E, comes from the UNICEF Copenhagen Supply Division and incorporates country-level data for both iron folate and ferrous sulfate tablets. The procurement data for iron have also been used to assess the estimated potential coverage of the tablet supply received by the countries in question. The adequacy of the 1996 iron tablet supply is estimated for each country in Appendix 13 (column E). The values represent the annual potential percentage of pregnancies covered (for countries with recorded 1996 procurement data), assuming a need for 300 iron tablets over a 40-week term pregnancy, according to the following formula:

$$\left(\frac{[\text{no. of iron tablets procured in 1996}] \div [\text{no. of births in 1996} \times 300\text{-tablet need per pregnancy}]}{100} \right)$$

The estimated adequacy of the supply of iron tablets was also calculated on a regional basis (Table 19, column G). The annual number of births in the region (Table 19, column F) was determined from country-level data (UNICEF 1998) and represents the sum of births in countries with recorded 1996 procurement data for iron tablets. Appendix 12 presents the reported program coverage in 1996 for individual countries. These data were compiled from the results of a 1997 UNICEF field survey to country offices. In most regions, data for reported coverage of

iron programs is missing for more than half of the countries. Regional program coverage values in Table 19 (column I) are therefore given as the minimum and maximum values, rather than as a weighted average with a large proportion of the regional population excluded. The median value for each region is also given in Table 19 (column H) to facilitate interpretation.

Table 19 (column E) shows the annual regional average procurement of iron tablets for the period 1993–1996. As stated above, countries for which there were no procurement data were assigned a zero value, rather than treating data as missing for computation of the regional averages. The denominator for calculating average iron procurement was therefore 4 years for all countries in each region, regardless of the countries and years for which no procurement data were listed.

Multiple Micronutrient Programs

For determining the number of countries with a policy on vitamin A supplementation (Table 12, column B), only countries that had adopted a universal policy for addressing vitamin A deficiency were included. Countries that were counted as having a national policy for iron (Table 12, column E) include those for which supplementation is provided to pregnant women either universally, on the basis of hemoglobin level, or on the basis of a clinical assessment. Where the supplementation policy adopted is not universal, the basis for supplementation is presented in

Appendix 8. The number of countries in each region considered to have national vitamin A policy, iodine legislation, and iron policy (Table 12, column G) is the sum of the countries for which the criteria of columns B, D, and E are all met. For countries in Central and Eastern Europe and for newly independent states, information is available only on iron supplementation and iodine legislation; therefore, to avoid large amounts of missing data, these countries were excluded from Table 12. Available policy and legislation data for this group of countries are compiled at the country level in Appendix 8.

The methods of computing regional procurement and estimating the adequacy of the supply of vitamin A capsules (Table 21) were described in the methods section for vitamin A. The methods of calculating annual average procurement and estimating

adequacy of tablet supply for iron can be found in the preceding section on iron. The sources for reports of program coverage for vitamin A and iron and for consumption of iodized salt consist of UNICEF field surveys of country offices (for iron in 1997 and for vitamin A in 1998) and UNICEF (2000) for iodized salt, with additional information provided through UNICEF staff (T. Wardlaw, N. Levin, and N. Dalmiya, personal communication, 1999). For each region, individual country data on program coverage for vitamin A and iron and consumption of iodized salt were classified as low, medium, or high (low, <10%; medium, 10% to 60%; high, >60%), and the number of countries in each category is presented in Table 21). The numbers of countries not reporting coverage data are also shown. Regional data are reported in this way because a large number of countries did not report coverage data.

4. RESULTS: PROGRESS IN MICRONUTRIENT DEFICIENCY CONTROL PROGRAMS

Control of Vitamin A Deficiency

By the late 1990s, about half of the countries in the developing world had adopted national policies for addressing vitamin A deficiency (see Table 12). Regional program coverage ranged from two-thirds of the countries in East Asia and the Pacific region, to one-third of countries in the Middle East and northern Africa. In most countries, distribution of high-dose vitamin A

capsules was an important part of the policy. Most countries implementing vitamin A supplementation programs have adopted the policy recommended by WHO, UNICEF, IVACG (1997), which specifies that children 6–12 months of age should receive a 100 000-IU dose and children older than 12 months of age should be given a 200 000-IU dose every 4 to 6 months.

Table 12. Numbers of countries with micronutrient supplementation policies and fortification legislation.

UNICEF region	No. of countries with policy or legislation*						
	Total no. of countries Col. A	Vitamin A		Iodine	Iron		Multiple policies (no. and % of countries) Col. G
		National policy (1996–1998) Col. B	Legislation for fortification (1996–1998) Col. C	Legislation for iodizing salt (1998–1999) Col. D	National policy for supplementation (1996–1998) Col. E	Legislation for fortification (1996–1998) Col. F	
South Asia	7	4	1	4	5	0	3 (43)
East Asia and Pacific	12	8	4	9	7	0	6 (50)
Latin America and Caribbean	21	12	12	18	11	10	6 (29)
Eastern and southern Africa	20	8	0	15	9	0	3 (15)
Western and central Africa	21	11	0	15	12	1	7 (33)
Middle East and northern Africa	18	6	0	13	5	0	3 (17)
Total	99	49	17	74	49	11	28 (28)F

Sources: MI (1999), WHO (1999), and Mason et al. (2000). See Appendix 8 for complete data set.

Note: For countries in central and eastern Europe and newly independent states, information is available only on iron supplementation and iodine legislation. Of the 27 countries in the region, 10 have a national iron supplementation policy and 18 have legislation concerning iodization of salt (see Appendix 8).

*Countries for which no information was available concerning policies or legislation for micronutrients were presumed not to have already adopted a micronutrient policy or legislation and were given a value of zero for the respective indicator.

Many countries distributing high-dose vitamin A supplements procure the capsules through UNICEF's Supply Division in Copenhagen. Other countries, including China, India, and Indonesia, procure supplements locally or regionally. Consolidated purchasing by UNICEF results in low costs. A single 200 000-IU capsule purchased through the UNICEF Supply Division costs US\$0.02. The total number of vitamin A capsules procured from UNICEF for 1993–1996 and 1998 is shown in Table 13. A rapid increase in procurement after 1993 is evident. On average, over 100 million vitamin A capsules were provided in 1993–1998. In 1998, for example, over 153 million vitamin A capsules were sent to 52 different countries (see Appendix 9 for individual country data), a value that can be used to determine the adequacy of coverage for young children on the assumption of two capsules per year (see Methods section of MI et al. [1998]). This quantity of capsules would be sufficient to supply an estimated 38% of the children in the countries that received capsules (Table 13) but only 10% of all children in developing countries.

Coverage through vitamin A supplementation programs can also be assessed from the reports obtained from country offices (Appendix 9, column H). Because only a limited number of countries report levels of coverage and because the estimates (presented as percentages) vary widely, the best regional description of coverage is

the median value (Table 13, column I). In the 52 countries reporting supplementation programs, the median coverage was over 80%, except in Latin America and the Caribbean. (There are several reasons why the values for available supply and reported program coverage differ, one of which is that supply stocks are carried over; for example the reported coverage data for South Asia do not match the supply data because of carryover of capsule stocks from previous years' supplies in Bangladesh).

The regional estimates of access to vitamin A capsules, in terms of reported program coverage and adequacy of supply, for the 52 countries reporting such data, are displayed in Fig. 14. These data generally support the conclusion that high levels of capsule distribution were achieved in many countries in the mid-1990s.

The estimated prevalences of low serum retinol (see part I) can be compared visually with reported vitamin A program coverage by categorizing and mapping these two factors (Fig. 15). Some correspondence between reported coverage and extent of the deficiency is evident, for example, in sub-Saharan Africa. Operationally, it could be useful to identify countries with high prevalence of vitamin A deficiency and low coverage, which might be given priority for program development, as well as countries with significant prevalence of deficiency and high program coverage, but low levels of

Table 13. Regional procurement of vitamin A capsules in relation to need.
No. of vitamin A capsules procured (millions)*

UNICEF region	1993	1994	1995	1996	1998	Annual average	Need† (millions	Estimated	Median reported
	Col. A	Col. B	Col. C	Col. D	Col. E	Col. F	of capsules)	adequacy of supply‡ (%)	coverages§ (%) and no. of countries
	Col. A	Col. B	Col. C	Col. D	Col. E	Col. F	Col. G	Col. H	Col. I
South Asia	5.36	46.50	48.06	2.40	6.73	21.81	62.73	9.1	87 (5)
East Asia and Pacific	3.95	13.70	12.64	26.00	31.31	17.52	36.32	66.6	80 (8)
Latin America and Caribbean	8.90	26.80	25.56	4.30	23.32	17.78	62.05	30.0	60 (9)
Eastern and southern Africa	14.13	51.40	38.95	11.80	31.08	29.47	33.85	67.8	83 (13)
Western and central Africa	3.92	6.02	9.40	5.15	36.33	12.16	73.15	36.2	90 (11)
Middle East and northern Africa	8.68	17.40	0.32	17.40	24.73	13.71	21.32	57.6	85 (6)
Total	44.94	161.82	134.93	67.05	153.50	112.45	289.42	38.1	80 (5.2)

Sources: MI et al. (1998), UNICEF Copenhagen Supply Division (data for 1998), UNICEF field survey of country offices undertaken in 1998.

*Numbers of vitamin A capsules procured for 1993–1996 do not include data for Gambia or Swaziland. Total number of vitamin A capsules procured for 1998 is the sum of 100 000-IU capsules and 200 000-IU capsules for each region (sum of columns A and D in Appendix 9). Total numbers of capsules procured in each year do not include capsules purchased with national funds (either government or nongovernmental organizations) or obtained through local production. For calculation of annual average procurement (for 1993–1996 and 1998), absence of procurement data was counted as zero rather than as missing data. The annual average procurement for a region does not necessarily represent procurement data for the same countries over the 5-year period.

†For children 12–59 months of age. Based on 200 000-IU capsules, for countries with reported capsule procurement for 1998 (Appendix 9, column E) and using country population data for those countries.

‡For children 12–59 months of age in countries receiving UNICEF capsules. Estimated adequacy of capsule supply is based on policy recommending provision of one 200 000-IU capsule to postpartum women and two 200 000-IU capsules annually to children 12–59 months of age. The calculation assumes equal distribution of 200 000-IU capsules between these two population groups. Some countries have greater than 100% potential coverage of children for 1998 (see Appendix 9). Potential vitamin A coverage of South Asian children is low in part because procurement data for India were not available.

§For children 6–59 months of age who received at least one supplement in the previous 6 months, as reported for 1998.

procurement, because any of these without domestic sources of vitamin A supplements might be given priority for external provision. Table 14 shows examples of countries in these two groups (based on MI et al. [1998], p. 32; Appendix 9 in the current document).

Such results argue that priority be given to program development in Burundi, Chad, India, Malawi, and Pakistan, as well as to exploring whether the external supply of capsules to Bangladesh and the Philippines should be increased. These analyses could then be updated as programs change.

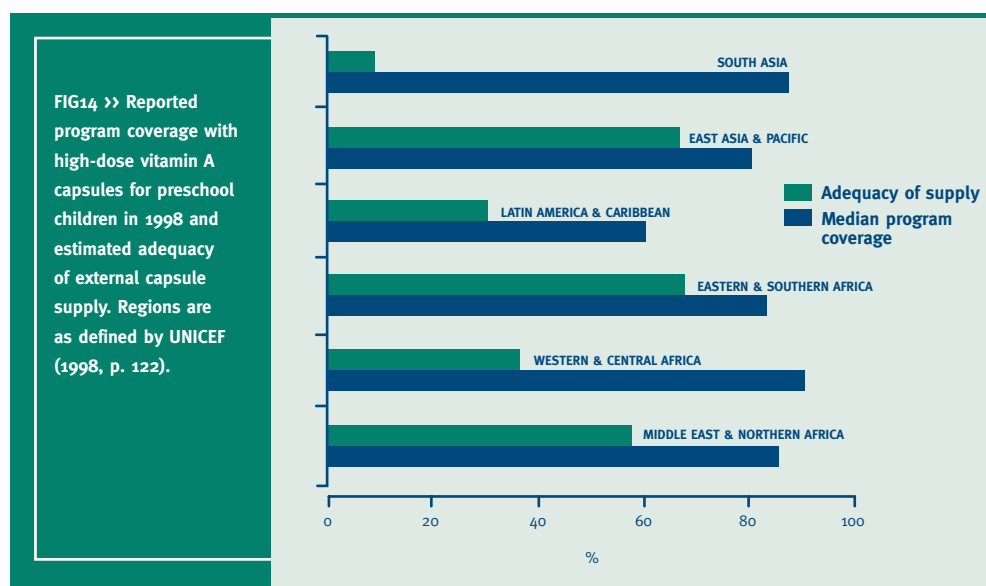


Table 14. Countries with priority for external provision of vitamin A supplements.

Country	Prevalence of low serum retinol (%)	Reported program coverage (% of population)	Procurement (% of need)
High prevalence of deficiency, low coverage			
Chad	24	0	37
Pakistan	18	1	1
Burundi	20	15	85
India	18	25	—
Malawi	31	34	90
High prevalence, high program coverage, low procurement			
Bangladesh	26	95	3
Philippines	10	80	3

Dash = information not available.

Source: MI et al. (1998, Annex 4).

In 39 countries, vitamin A supplements are distributed during national immunization days or in conjunction with other mass immunization campaigns (Table 15). In the African countries, this was by far the commonest method; in fact, several countries used this form of distribution even though they did not have a national policy for addressing vitamin A deficiency. More generally, vitamin A supplementation is being integrated into routine visits to mother and child health clinics and through community-based nutrition improvement programs. High coverage for children is reported from these methods, as discussed below.

In 1997 WHO, UNICEF, and IVACG (1997) recommended that, in countries with vitamin A deficiency, all mothers should receive a high-dose vitamin A capsule within 8 weeks of giving birth. Such supplementation maintains adequate concentrations of vitamin A in breast milk until the child is up to 6 months of age (Stoltzfus et al. 1992). As of 1998, 44 countries had adopted a policy for postpartum supplementation (Appendix 10), and 19 had reported on the estimated coverage (Table 16). The median coverage was 30%.

Table 15. Distribution of vitamin A capsules in relation to national immunization days (NIDs), micronutrient (M-NUT) days, Expanded Programs for Immunization (EPIs), and postpartum supplementation policies.

	Total no. of countries	NIDs, M-NUT days, or EPI with capsule distribution	No. of countries				
			NIDs without capsule distribution			Policy for postpartum supplementation	
			Answered "No"	No response	No NIDs	Yes	No response
UNICEF region							
South Asia	7	1	0	6	0	4	3
East Asia and Pacific	12	4	0	2	6	6	6
Latin America and Caribbean	21	0	0	0	21	9	12
Eastern and southern Africa	20	13	2	2	3	9	11
Western and central Africa	21	15	0	4	2	12	9
Middle East and northern Africa	18	6	4	0	8	4	14
Central and eastern Europe, newly independent states	27	0	0	12	15	0	27
Total	126	39	6	26	55	45	81

Source: UNICEF field survey of country offices, undertaken in 1998. See Appendix 10 for complete data set.

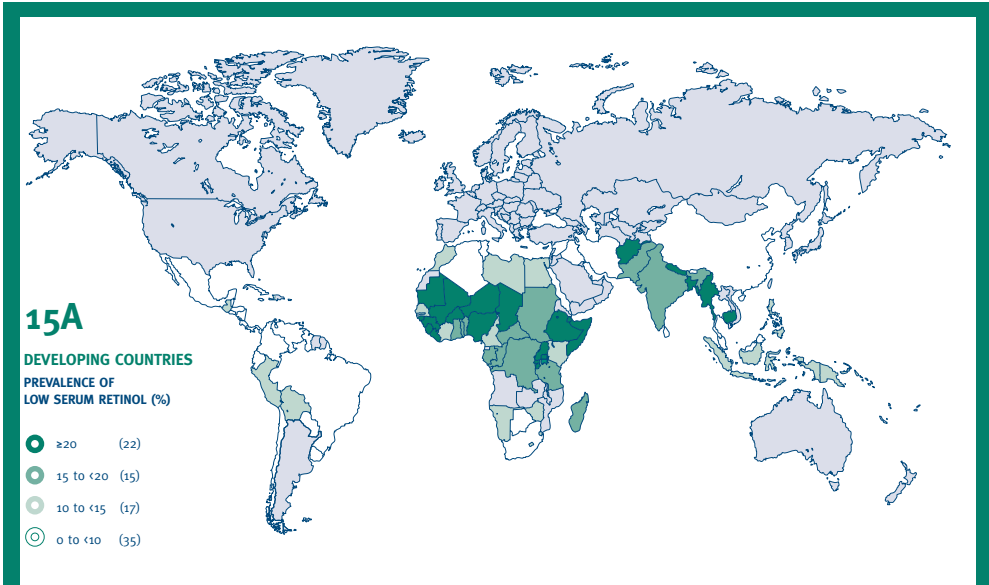


FIG15 >> Prevalence of subclinical vitamin A deficiency, as defined by serum retinol <math><70\ \mu\text{mol/L}</math> (A), and reported coverage of vitamin A supplementation programs in 1998 (B). Values in parentheses in the legend represent the total number of countries. Regions are as defined by UNICEF (1998, p. 122).



Table 16. Percentage of mothers receiving high-dose vitamin A capsules* within 4–8 weeks after delivery in countries reporting presence of a program.

Country	% of mothers receiving capsule	Country	% of mothers receiving capsule
Nigeria	90	Burkina Faso	30
Bhutan	80	Philippines	30
Iraq	64	Bolivia	26
Honduras	53	Ethiopia	15
Viet Nam	53	Madagascar	13
El Salvador	40	Guatemala	10
Indonesia	40	India	10
Malawi	39	Somalia	10
Panama	37	Zambia	10
		Haiti	5

Source: UNICEF field survey of country offices, undertaken in 1998.

*Usually 300 000 IU.

Fewer than half of the 49 countries with a national policy for addressing vitamin A deficiency (for 1996–1998) also had legislation governing vitamin A fortification of foods (Table 12 and Appendix 8). In fact, in Latin America and the Caribbean, vitamin A supplementation is not a common approach, and more reliance is placed on fortification. The commodities most often fortified in developing countries are shown in Table 17: sugar and margarine are the most common, with maize flour, vegetable oil, rice, and dairy products also being used. Research and pilot projects are under way in a number of additional countries.

Control of Iodine Deficiency Disorders

Three-quarters of the countries in the developing world now have legislation in place for iodizing salt (Table 12, Appendix 8). Most of the countries have adopted this legislation in the past 10–15 years. Thanks to the fact that

large-scale surveys — such as multiple indicator cluster surveys and demographic and health surveys — now include direct estimates of the iodization level of salt in sampled households, the extent to which households are consuming adequately iodized salt can be directly assessed. National results are presented in Appendix 11, and regional averages are given in Table 18. Two-thirds of households (68%) are now estimated to be getting adequately iodized salt (defined in most cases as at least 15 ppm of iodine). This estimate refers to the average for the countries reporting data, which accounts for almost all countries except those in Central and Eastern Europe and newly independent states, as indicated in the last column of Table 18.

Nearly 90% of households in Latin America and the Caribbean are consuming adequately iodized salt; the range is about 65% to about 75% for countries in the Asian regions, about 50% to about 74% in sub-Saharan

Table 17. Commodities being used for fortification with vitamin A in operational country programs

Developing countries with fortification programs in place*			
Commodity	No. of developing countries exploring fortification	Primary program	Secondary program
Sugar	20	El Salvador, Guatemala, Honduras, Nicaragua, Zambia (<i>n</i> = 5)	Chile, Viet Nam† (<i>n</i> = 2)
Margarine	14	Malaysia, Peru, the Philippines, Sri Lanka, Brazil (<i>n</i> = 5)‡	Ecuador, El Salvador, Guatemala, Honduras, India, Mexico, Panama, Singapore, Zimbabwe (<i>n</i> = 9)
Maize flour	5	Colombia, Zimbabwe (<i>n</i> = 2)	Venezuela (<i>n</i> = 1)
Rice	3	Burkina Faso, Lesotho, Singapore§ (<i>n</i> = 3)	None
Oil	6	Bolivia, China, Tanzania (<i>n</i> = 3)	None
Milk, dairy products	5	India (on regional basis), Thailand (condensed milk) (<i>n</i> = 2)	China (<i>n</i> = 1)
Dried mango	2	Haiti, Senegal (<i>n</i> = 2)	
Noodles	2	None	Indonesia, Thailand (<i>n</i> = 2)
Wheat flour	3	Nonell	None

*In data compiled for MN-Net (MI 1999), fortified commodities are defined as "primary" and "secondary." These terms refer to the scale of implementation, secondary methods often being at the experimental stage.

†Viet Nam is exploring the feasibility of a program.

‡Margarine is also fortified with vitamin A in European and North American countries.

§Rice is also fortified with vitamin A in Hungary and Japan.

||Indonesia and Namibia report plans to do so.

Table 18. Households consuming adequately iodized salt,* 1995–1998.

UNICEF region	No. of countries in region	Households consuming iodized salt (average %) [†]	No. of countries reporting
	Col. A	Col. B	Col. C
South Asia	7	65.1	6
East Asia and Pacific	12	75.3	9
Latin America and the Caribbean	21	88.6	19
Eastern and southern Africa	20	51.6	19
Western and central Africa	21	73.6	16
Middle East and northern Africa	18	48.9	12
Central and eastern Europe and newly independent states	27	28.2	10
Total	126	67.8	91

Sources: UNICEF (2000).

*Adequate iodization defined as ≥15 ppm iodine.

†Average calculated on the basis of the reporting countries only. Regional average is weighted according to 1996 population data for countries reporting household consumption data. Data points for all reporting countries are for years within the period 1995–1998, with the exception of the following 23 countries: Argentina, Costa Rica, Cuba, Ecuador, Eritrea, Ghana, Guatemala, India, Korea DPR, Mauritania, South Africa, Venezuela, and Zimbabwe (date not available); Haiti (data for 1989); Russian Federation (data for 1992); Burundi, Gambia, and Libya (data for 1993); Botswana, Macedonia, Tajikistan, Uzbekistan, and Yugoslavia (data for 1994).

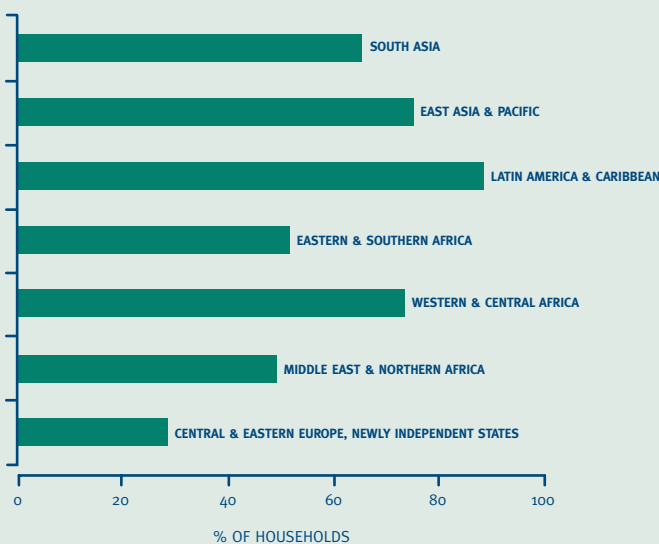
Africa; and about 50% in the Middle East and northern Africa. The lowest coverage with adequately iodized salt occurs in the former Soviet bloc (data on iodized salt are more available than data on program coverage for iron and vitamin A and are therefore included here for this group of countries [Fig. 16]). Even though the average for most regions is high (Table 18), Appendix 11 shows that a number of countries still lag, for example, Cambodia and Pakistan in Asia, several countries in western and central Africa, and a few in the Middle East and northern Africa.

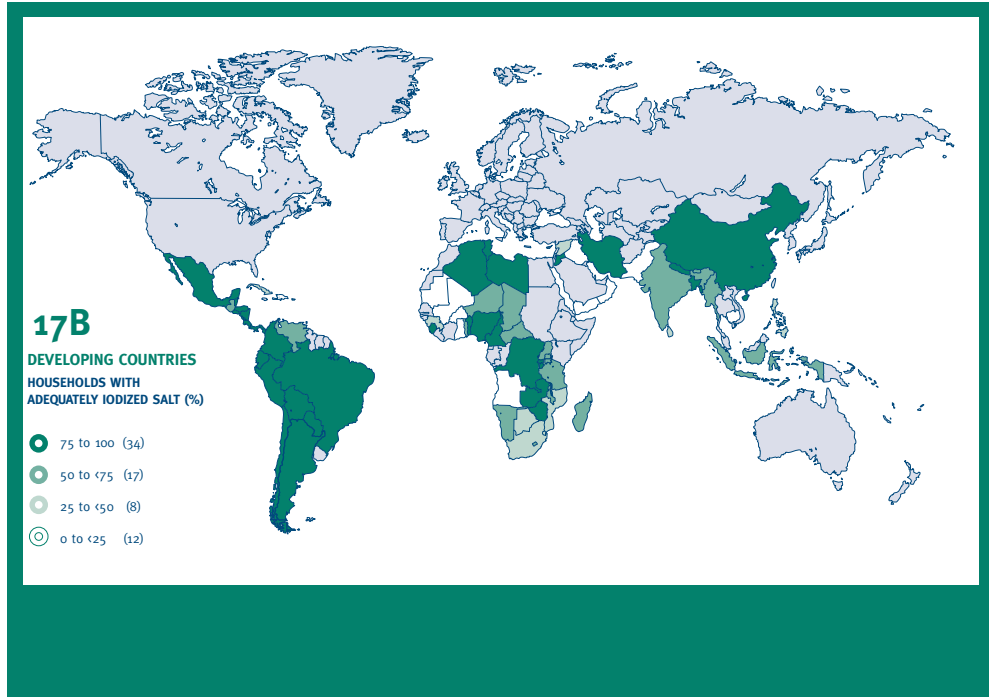
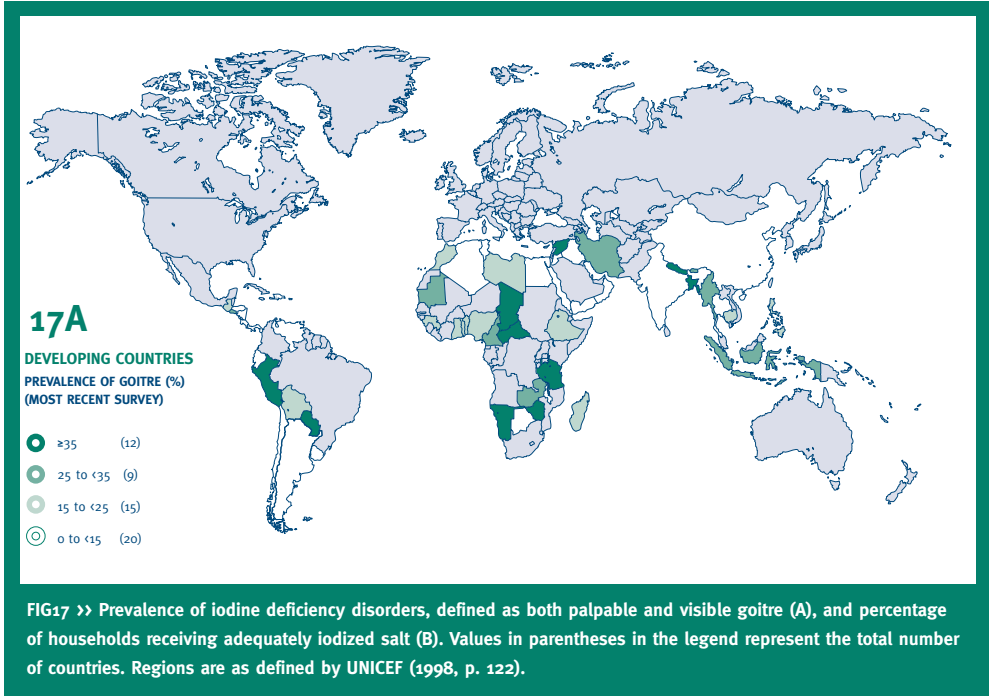
The key issue now is to improve the quality control for the iodine content of salt, which is one of major reasons that

access to iodized salt is not higher. The other main reason is that distribution and marketing of iodized salt has not yet reached the more remote areas, a particular problem in countries where there are large numbers of small, traditional producers.

Household coverage with adequately iodized salt is compared with the prevalence of goitre in Fig. 17. Countries that should have priority for assistance might be those with significant prevalence of goitre (e.g., more than 10%) and low household coverage with adequately iodized salt (e.g., less than 30%), for example, Ethiopia, Mauritania, Ghana, Philippines, and Burkina Faso.

FIG16 >> Households receiving adequately iodized salt, defined as salt with at least 15 ppm iodine, for the period 1995–1998. The data are presented in Table 14. Regions are as defined by UNICEF (1998, p. 122).





Control of Iron Deficiency

About half of the countries in the developing world reported adoption of a national policy for iron supplementation (Table 12, column E). The number is similar, and the countries are often the same, as for policies for controlling vitamin A deficiency. Only in Latin America and the Caribbean is fortification of foods with iron the priority. Only one country in another region has legislation for iron fortification (Table 12, column F).

Pregnant women are the most common target group for iron supplementation programs, and it is mainly for this group that data on program coverage are available. Program coverage for the 39 countries reporting such data varies widely (Appendix 12 and Table 16); some countries reported up to 100% (e.g., Cuba and Nicaragua), whereas others, such as Tunisia, reported only 10% coverage. The regional range was 52% to 78%, and the regional median was 55%. These coverage values are somewhat difficult to interpret, because they refer to the percentage of women registered in supplementation programs but do not include estimates of adherence to the supplementation regimen throughout pregnancy.

For this deficiency, the procurement data from UNICEF are less informative, because a much higher proportion of the supplement is obtained locally. Nonetheless, the results in Table 19 indicate that the supply of iron tablets from external sources is very low relative

to the need. To give a sense of scale, we estimated the need in terms of covering an entire pregnancy with daily supplementation, hence relating the tablet supply to the annual number of births. This calculation indicated that only about 3% of the need for pregnant women is being met by external supplies. Even if the calculation were based on weekly supplementation, the external supply would still be less than 20% of the needs of pregnant women.

The reported program coverage and external supply data are shown in Fig. 18. No doubt most of the iron tablet supply used in these countries is obtained from domestic sources. Nonetheless, because supply problems have been considered a major constraint (Gillespie et al. 1991) improving the level of external provision could be a step toward improving the effectiveness of programs.

The average estimated levels of anemia (in pregnant women) and the reported coverage by iron supplementation programs (for countries that provided data) are mapped in Fig. 19. The most striking observation is that not many countries reported supplementation programs, and for those that did, there was little relation to need. Although program coverage needs to be expanded, there is a sense that this may be waiting for better methods to be identified and demonstrated.

Tackling iron deficiency through supplementation is much more demanding than using supplementation

Table 19. Regional procurement of iron supplements in relation to need.

UNICEF region	No. of iron tablets procured (millions)					Annual average Col. E	No. of birthst (millions) Col. F	Adequacy of supply# (%) Col. G	*Reported program coverages\$		
	1993	1994	1995	1996	Median (%) Col. H				Range (%) Col. I	No. of countries reporting Col. J	
	Col. A	Col. B	Col. C	Col. D	Col. E				Col. F	Col. G	Col. H
South Asia	106.03	85.29	134.40	132.80	114.63	10.74	4.1	56	51-61	2	
East Asia and Pacific	76.96	306.00	105.85	82.13	142.74	5.77	4.7	50	30-82	7	
Latin America and Caribbean	20.91	70.59	63.75	35.18	47.61	4.85	2.4	66	20-100	10	
Eastern and southern Africa	229.38	139.95	142.72	75.42	146.87	8.09	3.1	78	20-90	6	
Western and central Africa	81.32	32.55	48.71	85.86	62.11	11.32	2.5	52	25-95	10	
Middle East and northern Africa	204.16	33.67	295.50	45.33	144.67	3.70	4.1	60	25-95	4	
Total	718.76	668.05	790.93	456.72	658.63	44.47	3.4	55	20-100	39	

Sources: UNICEF (1998), UNICEF Copenhagen Supply Division (data for 1993-1996), UNICEF field survey of country offices undertaken in 1997.

Note: Estimated total spent for iron tablets in 1996 was US\$1.075 million for 456.72 million tablets (US\$0.0024 per tablet).

*Total number of iron tablets procured represents the sum of all iron foliate and ferrous sulfate tablets procured in each year, but does not necessarily represent data for the same countries for each year. Average is for 1993-1996.

†Births in 1996 for only those countries reporting iron procurement in that year.

#For 1996, in relation to need for 300 iron tables for each 40-week term pregnancy.

\$Data on reported program coverage is for 1996 for all countries except Bhutan, Guinea, and Vietnam (for which date was not available).

to deal with deficiencies of vitamin A and iodine. Although officially reported coverage of programs seems moderately high (Table 19), most other information points to low coverage and poor adherence to supplementation through antenatal care. This approach to treating iron deficiency should be pursued, but coverage and impact of iron supplementation seem unlikely to reach the levels that are being seen for vitamin A and iodine.

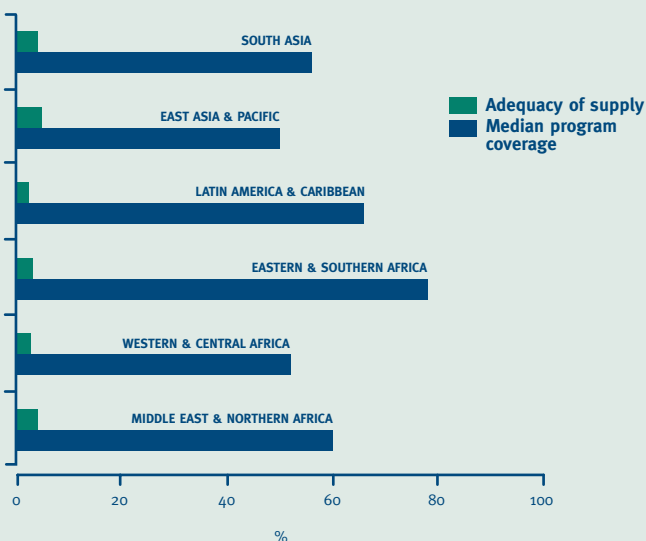
Fortification of foods with iron is of great potential importance and is being widely adopted for wheat (Table 20), which is especially relevant where wheat is the staple food. Technical problems remain for fortifying rice, and a solution to these problems would represent a major breakthrough in controlling iron deficiency; such a breakthrough is to be

anticipated in the foreseeable future. Meanwhile, several other commodities are being tried in both large-scale and experimental-scale projects. Examples include premixes to be added to rice and commercially processed foods (e.g., in Thailand), salt in India and elsewhere (which presents another set of technical challenges, particularly if the salt is iodized), and sugar.

Addressing Multiple Deficiencies

Most people who are malnourished probably suffer from multiple deficiencies. Moreover, these deficiencies interact, so increasing the intake of one nutrient alone may not be effective in improving nutritional status. Thus, there are good reasons, in terms of nutrition and health, for addressing deficiencies of several micronutrients at the same time.

FIG18 >> Reported program coverage with iron supplementation for pregnant women in 1996 and estimated adequacy of external supply. The data are presented in Table 16. Regions are as defined by UNICEF (1998, p. 122).



Furthermore, the same population groups are usually at risk for different deficiencies, so these groups are appropriate targets for programs — pregnant women, infants, and young children are good examples. Both operationally and biologically, there is good reason for programs to control deficiencies of multiple micronutrients.

Interventions may also be more effective if combined so as to share delivery methods, in terms of fortification, supplementation, and dietary change. This is not always feasible, because the fortificants themselves may interact (iron interacts with the iodine in salt, for instance). Moreover, frequencies of supplemen-

tation and dose levels may not be compatible. Vitamin A is a case in point: although infrequent, high doses of vitamin A are advantageous as a single intervention, this form of administration is not appropriate for the important target group of pregnant women, because high doses are associated with a risk of teratogenicity. Now that there is evidence suggesting that low-dose vitamin A supplementation may decrease maternal mortality (West et al. 1999), there is yet more reason to provide a regular, low dose to women, which would fit with a daily (or possibly weekly) multiple supplementation approach during pregnancy.

Table 20. Commodities being used for fortification with iron.

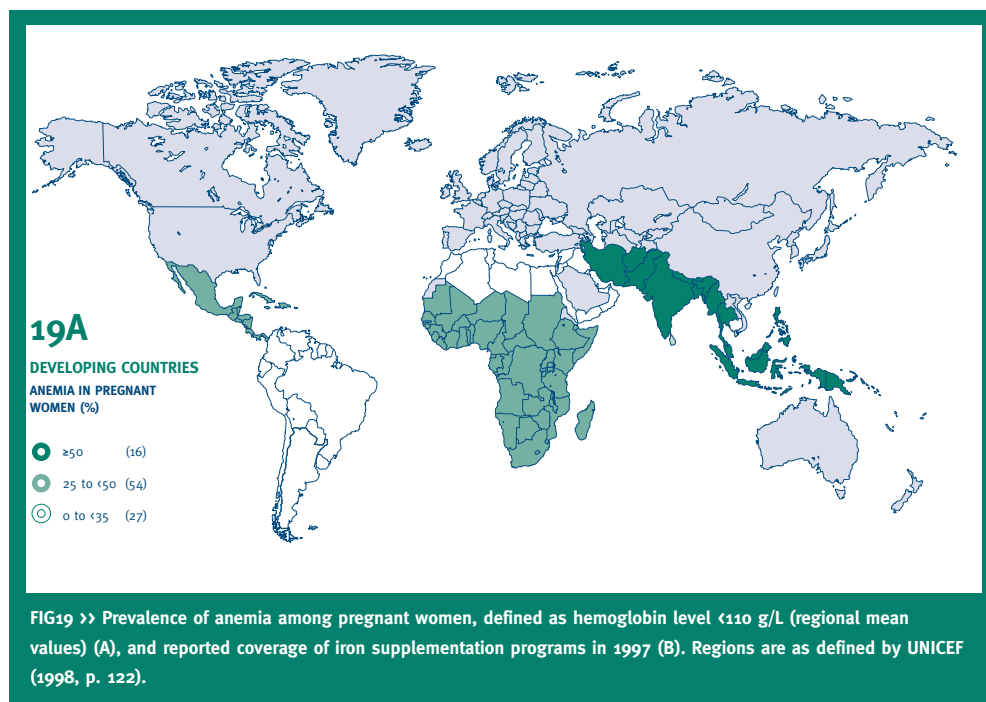
Commodity	No. of developing countries exploring fortification	Developing countries with fortification programs in place*	
		Primary program	Secondary program
Wheat flour	36	Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Jordan, Mexico, Nicaragua, Nigeria, Oman, Panama, Paraguay, Peru, Trinidad, Venezuela (<i>n</i> = 20)	Egypt,† Iran,† Lebanon (<i>n</i> = 3)
Maize flour	4	Zimbabwe (<i>n</i> = 1)	Botswana, Mexico,‡ Venezuela (<i>n</i> = 3)
Milk products	3	None	Chile (<i>n</i> = 1)
Weaning foods	3	Botswana, China, Colombia, Cuba, Ecuador, Peru (<i>n</i> = 6)	None
Others	9§	Philippines (rice premix), India (salt) (<i>n</i> = 2)	None

*In data compiled for MN-Net (MI 1999), fortified commodities are defined as “primary” and “secondary.” These terms refer to the scale of implementation, secondary methods often being at the experimental stage.

†Countries in preliminary stages of fortification trials.

‡Mexico is exploring the feasibility of a program.

§Other commodities undergoing exploration: drink mix (in Mexico and Tanzania), noodles and fish sauce (in Thailand), spice mix (in South Africa), salt (in Bangladesh, Ghana, and Guatemala), sugar (in Morocco), and juice drink (in China).



The reported coverage of various programs has been used to categorize countries according to level of coverage (Table 21, Fig. 20; individual country data in Appendix 13, columns C, D, and F). By these criteria, coverage for iodized salt is the most extensive. Vitamin A coverage by supplementation is at least 60% in one-third to one-half of the countries in Asia and sub-Saharan Africa; in Latin America, as noted earlier, more reliance is put on fortification than on supplementation. Iron supplementation is lagging, outlined earlier: only 20% to 30% of countries have at least 60% coverage for pregnant women, and these estimates probably considerably overestimate actual levels of supplementation, given the known logistic and adherence problems for iron tablets.

Overall, important opportunities exist for combining interventions with multiple micronutrient supplementation and fortification. Pregnancy and early childhood may represent the most important opportunity at present. Multiple-micronutrient supplements are now being developed for use by adults in developing countries (UNICEF et al. 2000). A need remains for a suitable pediatric preparation, at least for iron plus additional micronutrients, such as zinc (Nestel and Alnwick 1997).

Several countries have recognized the need for tackling multiple deficiencies, and 28 countries have policies for addressing all three of the deficiencies discussed in this report (Table 12, column G). Although these policies may not yet have been translated into

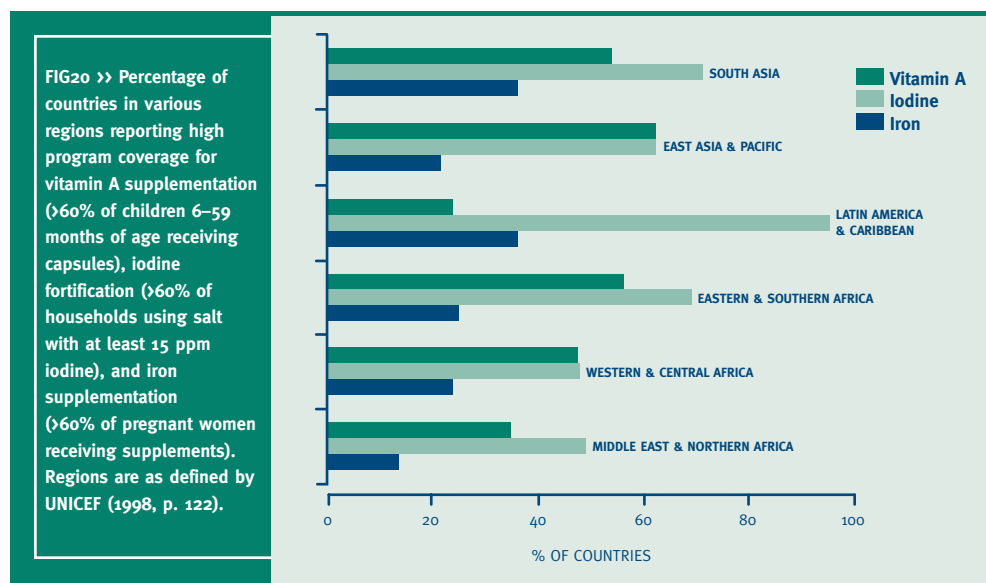


Table 21. Regional procurement in relation to need for vitamin A, iodine, and iron.

		Vitamin A										Iron										Iodine									
UNICEF region	No. of countries Col. A	No. capsules received* (millions) Col. B	No. of countries with reported levels of coverage†‡ Col. D						Adequacy of supply†† (%) Col. C	No. tablets procured in 1996 (millions) Col. E	Adequacy of supply‡‡ (%) Col. F	No. of countries with reported levels of coverage§¶ Col. G						Avg. % of households consuming iodized salt‡‡‡ Col. I													
			Low	Med.	High	na	Low	Med.				High	na	Low	Med.	High	na														
South Asia	7	6.73	1	1	3	2	9.1	132.80	4.1	0	1	1	5	0	2	4	1	65.1													
East Asia and Pacific	12	31.31	1	1	6	4	66.6	82.13	4.7	0	5	2	5	2	1	6	3	75.3													
Latin America and Caribbean	21	23.32	0	5	4	12	30.0	35.18	2.4	0	4	6	11	0	3	16	2	88.6													
Eastern and southern Africa	20	31.08	1	3	9	7	67.8	75.42	3.1	0	2	4	14	2	6	11	1	51.6													
Western and central Africa	21	36.33	2	1	8	10	36.2	85.86	2.5	0	6	4	11	4	4	8	5	73.6													
Middle East and northern Africa	18	24.73	0	1	5	12	57.6	45.33	4.1	0	2	2	14	2	3	7	6	48.9													
Total	99	153.5	5	12	35	47	38.1	456.73	3.4	0	20	19	60	10	19	52	18	70.4													

na = data not available.

Sources: UNICEF (1998, 2000), UNICEF Copenhagen Supply Division (data for 1993–1996, 1998), UNICEF field survey of country offices undertaken in 1997 and 1998.

*Total number of vitamin A capsules procured for 1998 is the sum of 100 000-IU capsules and 200 000-IU capsules for each region (sum of columns A and D in Appendix 9). Total number of capsules procured does not include capsules purchased with national funds (either government or nongovernmental organizations) or obtained through local production.

†In relation to children 12–59 months of age, for countries that received external supplies of vitamin A capsules in 1998. Estimated adequacy of capsule supply is based on policy recommending provision of one 200 000-IU capsule to postpartum women and two 200 000-IU capsules annually to children 12–59 months of age. The calculation assumes equal distribution of 200 000-IU capsules between these two population groups. Some countries have greater than 100% potential coverage of children for 1998. Potential coverage of South Asian children is low in part because procurement data for India were not available.

‡Reported program coverage for 1998, as proportion of children 6–59 months of age who received at least one vitamin A supplement in the previous 6 months.

§Low, <10% coverage; medium, 10% to 60% coverage; high, >60% coverage.

¶Estimated adequacy of iron tablet supply in countries that received UNICEF iron tablets in 1996. Based on assumed need of 300 tablets for each 40-week term pregnancy in those countries with 1996 reported procurement data.

‡‡Reported program coverage for 1996, except for Bhutan, Guinea, and Vietnam (for which data was not available).

‡‡‡Adequate iodization defined as ≥15 ppm iodine. Regional average percent of households consuming iodized salt (last column) is different from corresponding value in Table 18 because countries in central and eastern Europe and newly independent states are excluded here. Consumption of iodized salt is based on data for 1995–1998 for all reporting countries, with the exception of the following 23 countries: Argentina, Costa Rica, Cuba, Ecuador, Eritrea, Ghana, Guatemala, India, Korea DPR, Mauritania, South Africa, Venezuela, and Zimbabwe (date not available); Haiti (data for 1989); Russian Federation (data for 1992); Burundi, Gambia, and Libya (data for 1993); Botswana, Tajikistan, Uzbekistan, and Yugoslavia (data for 1994).

††For reporting countries, 1995–1998.

multiple approaches (such as multiple supplementation and fortification), this would be a logical next step, and these

countries (identified in Appendix 8, column F) might be the places to start.

5. CONCLUSIONS

High levels of coverage for vitamin A capsules were achieved in many countries in the mid-1990s. In Latin America and the Caribbean, vitamin A supplementation is not a common approach, and more reliance is placed on fortification. The supply of vitamin A capsules from UNICEF is about 10% of what would be needed if all children in developing countries were to be covered. The data presented here highlight the areas where attention should be focused. Priority should be given to program development in Burundi, Chad, India, Malawi, and Pakistan and to exploration of whether external supplies of capsules should be increased to Bangladesh and the Philippines.

For control of iodine deficiency disorders, the analyses presented here indicate that the countries that should have priority for assistance might be those with significant prevalence of goitre (e.g., >10%) and low percentages of households with adequately iodized salt (e.g., <30%) — examples are Ethiopia, Mauritania, Ghana, the Philippines, and Burkina Faso.

Regarding programs to control anemia, the supply of iron tablets from external sources is low compared to the need. Because supply problems have been

considered a major constraint (ACC/SCN 1992), this very low level of external provision — covering only about 3% of the need — could be improved as a step toward improving the effectiveness of programs. The most striking observation was that not many countries reported iron supplementation programs, and for those that did, there was little relation to need. Although program coverage needs to be expanded, there is a sense that it may be advisable to wait until better methods of supplementation have been identified and demonstrated. Although officially reported program coverage seems moderately high, most other information points to low coverage and poor adherence to supplementation through antenatal care.

For most effective program impact, multiple micronutrient deficiencies need attention. Twenty-eight countries have policies for addressing all three of the deficiencies discussed in this report. There are important opportunities now for combining intervent.

References

- ACC/SCN (Administrative Committee on Coordination, Subcommittee on Nutrition). 1987. First report on the world nutrition situation. United Nations, Geneva, Switzerland.
- 1989. Update on the world nutrition situation: recent trends in nutrition in 33 countries. United Nations, Geneva, Switzerland.
- 1992. Second report on the world nutrition situation, vol. 1: Global and regional results. United Nations, Geneva, Switzerland.
- 1993. Second report on the world nutrition situation, vol. 2: Country trends, methods and statistics. United Nations, Geneva, Switzerland.
- 1996. Update on the nutrition situation, 1996. United Nations, Geneva, Switzerland.
- Angeles-Agdeppa, I.; Schultink, W.; Sastroamidjojo, S.; Gross, R.; Karyadi, D. 1997. Weekly micronutrient supplementation to build iron stores in female Indonesian adolescents. *American Journal of Clinical Nutrition*, 66(1), 177–183.

- FAO (Food and Agriculture Organization). 1997. Agrostat [computerized database]. Economic and Social Development Statistics Division, FAO, Rome, Italy.
- Gillespie, S.; Kevany, J.; Mason, J. 1991. Controlling iron deficiency. Nutrition Policy Discussion Paper No. 9. United Nations Administrative Committee on Coordination, Subcommittee on Nutrition, Geneva, Switzerland.
- Golden, M. 1994. Is complete catch-up possible for stunted malnourished children? *European Journal of Clinical Nutrition*, 48, S58–S71.
- 1995. Specific deficiencies versus growth failure: type I and type II nutrients. *SCN News*, 12, 10–14.
- Government of Sri Lanka. 1997. Vitamin A deficiency and selected world summit goals for children in Sri Lanka. Ministry of Health and Medical Research Institute, Government of Sri Lanka, and United Nations Children's Fund, Colombo, Sri Lanka.
- Hetzel, B. 1988. The prevention and control of iodine deficiency disorders. State-of-the-Art Series Nutrition Policy Discussion Paper No. 3. United Nations Administrative Committee on Coordination, Subcommittee on Nutrition, Geneva, Switzerland.
- Howson, C.P.; Kennedy, E.T.; Horwitz, A. 1998a. Key elements in the design and implementation of micronutrient interventions. *In* Howson, C.P.; Kennedy, E.T.; Horwitz, A., ed., *Prevention of micronutrient deficiencies. Tools for policymakers and public health workers*. Institute of Medicine, National Academy of Sciences, Washington, DC, USA. p. 11–41.
- 1998b. Prevention of micronutrient deficiencies. Tools for policymakers and public health workers. Institute of Medicine, National Academy of Sciences, Washington, DC, USA.
- ICCIDD (International Council for the Control of Iodine Deficiency Disorders). 2000. Web site for ICCIDD. ICCIDD, city, country. Available from: <http://www.people.virginia.edu/~jtd/iccidd/>. Cited 2 Sept. 2000.
- Jelliffe, D. 1966. The assessment of nutritional status of the community. World Health Organization Monograph Series 53. World Health Organization, Geneva, Switzerland.
- Mason, J.B.; Mannar, V.; Mock, N. 2000. Controlling micronutrient deficiencies in Asia. *Asian Development Review*, 17(1–2):1–30.

- Mason, J.B.; Sethuraman, K.; Gilman, A.; Mason, K. 1998. Progress in controlling iodine deficiency. Unpublished report to the Micronutrient Initiative, Ottawa, ON, Canada.
- Mason, J.B.; Sethuraman, K.; Mason, K.; Gilman, A.; Mock, N. 1998. Progress in controlling iron deficiency. Unpublished report to the Micronutrient Initiative, Ottawa, ON, Canada.
- Merzenich, M.; Schultink, W.; Gross, R. 1994. Effect of iron–zinc supplementation on iron, zinc, and vitamin A status in Indonesian anaemic children. *In* Report of 16th International Vitamin A Consultative Group Meeting. International Life Sciences Institute, Washington, DC, USA. p. 87.
- MI (Micronutrient Initiative). 1999. MN-Net: information for the elimination of micronutrient malnutrition [Web site with online databases]. Available from www.micronutrient.org. Cited 30 Aug. 2000.
- MI; UNICEF; Tulane (Micronutrient Initiative; United Nations Children's Fund; Tulane University). 1998. Progress in controlling vitamin A deficiency. MI, Ottawa, ON, Canada.
- Murray, C.; Lopez, A. 1997. Global mortality, disability, and the contribution of risk factors: Global Burden of Diseases Study. *Lancet*, 349(9063), 1436–1442.
- Nestel, P.; Alnwick, D. 1997. Iron/multi-micronutrient supplements for young children. International Nutritional Anaemia Consultative Group, Washington, DC, USA.
- Schultink, W.; Gross, R. 1997. The influence of vitamin A on iron status and possible consequences for micronutrient deficiency alleviation programs. *In* Micronutrient interaction: impact on child health and nutrition (meeting report). International Life Sciences Institute, Washington, DC, USA. pp. 28–35.
- Stanbury, J.B. 1998. Prevention of iodine deficiency. *In* Howson, C.P.; Kennedy, E.T.; Horwitz, A., ed. Prevention of micronutrient deficiencies. Tools for policymakers and public health workers. National Academy Press, Washington, DC, USA. p. 167–201.
- Stoltzfus, R.J.; Hakimi, M.; Miller, K.W.; Rasmussen, K.M.; Dawiesah, S.; Habicht, J.-P.; Dibley, M.J. 1992. High dose vitamin A supplementation of breast-feeding Indonesian mothers: effects on the vitamin A status of mother and infant. *Journal of Nutrition*, 123, 666–675.

- Thu, B.D.; Schultink, W.; Dillon, D.; Gross, R.; Leswara, N.D.; Khoi, H.H. 1999. Effect of daily and weekly micronutrient supplementation on micronutrient deficiencies and growth in young Vietnamese children. *American Journal of Clinical Nutrition*, 69(1), 80–86.
- UN (United Nations). 1997. *Demographic yearbook. Population Division*, UN, New York, NY, USA.
- UNICEF (United Nations Children's Fund). 1995. *UNICEF annual report 1995*. UNICEF, New York, NY, USA.
- 1996. *UNICEF annual report 1996*. UNICEF, New York, NY, USA.
- 1998. *State of the world's children 1998*. UNICEF, New York, NY, USA.
- 2000. *State of the world's children 2000*. UNICEF, New York, NY, USA.
- UNICEF; WHO; UNU (United Nations Children's Fund; World Health Organization; United Nations University). 2000. *Report of a workshop on composition of a multi-micronutrient supplement to be used in pilot programmes among pregnant women in developing countries*, 9 July 1999, New York, NY. United Nations, New York, NY, USA.
- Viteri, F.E. 1998. Prevention of iron deficiency. *In* Howson, C.P.; Kennedy, E.T.; Horwitz, A., ed. *Prevention of micronutrient deficiencies. Tools for policymakers and public health workers*. Institute of Medicine, National Academy of Sciences, Washington, DC, USA. p. 45–102.
- West, K.P., Jr.; Katz, J.; Khatry, S.K.; LeClerq, S.C.; Pradhan, E.K.; Shrestha, S.R.; Connor, P.B.; Dali, S.M.; Christian, P.; Pokhrel, R.P.; Sommer, A. 1999. Double blind, cluster randomised trial of low dose supplementation with vitamin A or beta carotene on mortality related to pregnancy in Nepal. *The NNIPS-2 Study Group. British Medical Journal*, 318(7183), 570–575.
- WHO (World Health Organization). 1983. *Measuring change in nutritional status: guidelines for assessing the nutritional impact of supplementary feeding programmes for vulnerable groups*. WHO, Geneva, Switzerland.
- 1992. *The prevalence of anaemia in women*. WHO/MCH/MSM/92.2. WHO, Geneva, Switzerland.
- 1993. *Global prevalence of iodine deficiency disorders*. MDIS Working Paper No. 1. WHO, United Nations Children's Fund, and International Council for the Control of Iodine Deficiency Disorders. WHO, Geneva, Switzerland.
- 1994. *Indicators for assessing iodine deficiency disorders and their*

- control through salt iodization. WHO, United Nations Children's Fund, and International Council for the Control of Iodine Deficiency Disorders. WHO/NUT/94.6. WHO, Geneva, Switzerland.
- 1995. Global prevalence of vitamin A deficiency. MDIS Working Paper No. 2. WHO/NUT/95.3. WHO, Geneva, Switzerland.
 - 1996. Indicators for assessing vitamin A deficiency and their application in monitoring and evaluating intervention programmes. WHO/NUT/96.10. WHO, Geneva, Switzerland.
 - 1997. Prevalence of anaemia among different populations based on national data. MDIS Working Paper No. 3 [mimeo]. WHO, Geneva, Switzerland.
 - 1999. Progress towards the elimination of iodine deficiency disorders (IDD). United Nations Children's Fund, WHO, and International Council for the Control of Iodine Deficiency Disorders. WHO/NHD/99.4. WHO, Geneva, Switzerland.
- WHO; UNICEF; IVACG (World Health Organization; United Nations Children's Fund; International Vitamin A Consultative Group). 1997. Vitamin A supplements. A guide to their use in the treatment and prevention of vitamin A deficiency and xerophthalmia. WHO, Geneva, Switzerland.
- WHO; UNICEF; UNU (World Health Organization; United Nations Children's Fund; United Nations University). 1997. Indicators and strategies for iron deficiency control programs. WHO/NUT/96.12. WHO, Geneva, Switzerland.
- Yusuf, H.K.M.; Salamatullah, Q.; Islam, M.N.; Hoque, T.; Baquer, M.; Pandav, C.S. 1993. Report of the National Iodine Deficiency Disorders Survey in Bangladesh — 1993. Dhaka University, United Nations Children's Fund, and International Council for the Control of Iodine Deficiency Disorders, Dhaka, Bangladesh

References

- ACC/SCN (Administrative Committee on Coordination, Subcommittee on Nutrition). 1987. First report on the world nutrition situation. United Nations, Geneva, Switzerland.
- 1989. Update on the world nutrition situation: recent trends in nutrition in 33 countries. United Nations, Geneva, Switzerland.
- 1992. Second report on the world nutrition situation, vol. 1: Global and regional results. United Nations, Geneva, Switzerland.
- 1993. Second report on the world nutrition situation, vol. 2: Country trends, methods and statistics. United Nations, Geneva, Switzerland.
- 1996. Update on the nutrition situation, 1996. United Nations, Geneva, Switzerland.
- Angeles-Agdeppa, I.; Schultink, W.; Sastroamidjojo, S.; Gross, R.; Karyadi, D. 1997. Weekly micronutrient supplementation to build iron stores in female Indonesian adolescents. *American Journal of Clinical Nutrition*, 66(1), 177–183.

- FAO (Food and Agriculture Organization). 1997. Agrostat [computerized database]. Economic and Social Development Statistics Division, FAO, Rome, Italy.
- Gillespie, S.; Kevany, J.; Mason, J. 1991. Controlling iron deficiency. Nutrition Policy Discussion Paper No. 9. United Nations Administrative Committee on Coordination, Subcommittee on Nutrition, Geneva, Switzerland.
- Golden, M. 1994. Is complete catch-up possible for stunted malnourished children? *European Journal of Clinical Nutrition*, 48, S58–S71.
- 1995. Specific deficiencies versus growth failure: type I and type II nutrients. *SCN News*, 12, 10–14.
- Government of Sri Lanka. 1997. Vitamin A deficiency and selected world summit goals for children in Sri Lanka. Ministry of Health and Medical Research Institute, Government of Sri Lanka, and United Nations Children's Fund, Colombo, Sri Lanka.
- Hetzel, B. 1988. The prevention and control of iodine deficiency disorders. State-of-the-Art Series Nutrition Policy Discussion Paper No. 3. United Nations Administrative Committee on Coordination, Subcommittee on Nutrition, Geneva, Switzerland.
- Howson, C.P.; Kennedy, E.T.; Horwitz, A. 1998a. Key elements in the design and implementation of micronutrient interventions. *In* Howson, C.P.; Kennedy, E.T.; Horwitz, A., ed., *Prevention of micronutrient deficiencies. Tools for policymakers and public health workers*. Institute of Medicine, National Academy of Sciences, Washington, DC, USA. p. 11–41.
- 1998b. Prevention of micronutrient deficiencies. Tools for policymakers and public health workers. Institute of Medicine, National Academy of Sciences, Washington, DC, USA.
- ICCIDD (International Council for the Control of Iodine Deficiency Disorders). 2000. Web site for ICCIDD. ICCIDD, city, country. Available from: <http://www.people.virginia.edu/~jtd/iccidd/>. Cited 2 Sept. 2000.
- Jelliffe, D. 1966. The assessment of nutritional status of the community. World Health Organization Monograph Series 53. World Health Organization, Geneva, Switzerland.
- Mason, J.B.; Mannar, V.; Mock, N. 2000. Controlling micronutrient deficiencies in Asia. *Asian Development Review*, 17(1–2):1–30.

- Mason, J.B.; Sethuraman, K.; Gilman, A.; Mason, K. 1998. Progress in controlling iodine deficiency. Unpublished report to the Micronutrient Initiative, Ottawa, ON, Canada.
- Mason, J.B.; Sethuraman, K.; Mason, K.; Gilman, A.; Mock, N. 1998. Progress in controlling iron deficiency. Unpublished report to the Micronutrient Initiative, Ottawa, ON, Canada.
- Merzenich, M.; Schultink, W.; Gross, R. 1994. Effect of iron–zinc supplementation on iron, zinc, and vitamin A status in Indonesian anaemic children. *In* Report of 16th International Vitamin A Consultative Group Meeting. International Life Sciences Institute, Washington, DC, USA. p. 87.
- MI (Micronutrient Initiative). 1999. MN-Net: information for the elimination of micronutrient malnutrition [Web site with online databases]. Available from www.micronutrient.org. Cited 30 Aug. 2000.
- MI; UNICEF; Tulane (Micronutrient Initiative; United Nations Children's Fund; Tulane University). 1998. Progress in controlling vitamin A deficiency. MI, Ottawa, ON, Canada.
- Murray, C.; Lopez, A. 1997. Global mortality, disability, and the contribution of risk factors: Global Burden of Diseases Study. *Lancet*, 349(9063), 1436–1442.
- Nestel, P.; Alnwick, D. 1997. Iron/multi-micronutrient supplements for young children. International Nutritional Anaemia Consultative Group, Washington, DC, USA.
- Schultink, W.; Gross, R. 1997. The influence of vitamin A on iron status and possible consequences for micronutrient deficiency alleviation programs. *In* Micronutrient interaction: impact on child health and nutrition (meeting report). International Life Sciences Institute, Washington, DC, USA. pp. 28–35.
- Stanbury, J.B. 1998. Prevention of iodine deficiency. *In* Howson, C.P.; Kennedy, E.T.; Horwitz, A., ed. Prevention of micronutrient deficiencies. Tools for policymakers and public health workers. National Academy Press, Washington, DC, USA. p. 167–201.
- Stoltzfus, R.J.; Hakimi, M.; Miller, K.W.; Rasmussen, K.M.; Dawiesah, S.; Habicht, J.-P.; Dibley, M.J. 1992. High dose vitamin A supplementation of breast-feeding Indonesian mothers: effects on the vitamin A status of mother and infant. *Journal of Nutrition*, 123, 666–675.

- Thu, B.D.; Schultink, W.; Dillon, D.; Gross, R.; Leswara, N.D.; Khoi, H.H. 1999. Effect of daily and weekly micronutrient supplementation on micronutrient deficiencies and growth in young Vietnamese children. *American Journal of Clinical Nutrition*, 69(1), 80–86.
- UN (United Nations). 1997. *Demographic yearbook. Population Division*, UN, New York, NY, USA.
- UNICEF (United Nations Children's Fund). 1995. *UNICEF annual report 1995*. UNICEF, New York, NY, USA.
- 1996. *UNICEF annual report 1996*. UNICEF, New York, NY, USA.
- 1998. *State of the world's children 1998*. UNICEF, New York, NY, USA.
- 2000. *State of the world's children 2000*. UNICEF, New York, NY, USA.
- UNICEF; WHO; UNU (United Nations Children's Fund; World Health Organization; United Nations University). 2000. *Report of a workshop on composition of a multi-micronutrient supplement to be used in pilot programmes among pregnant women in developing countries*, 9 July 1999, New York, NY. United Nations, New York, NY, USA.
- Viteri, F.E. 1998. Prevention of iron deficiency. In Howson, C.P.; Kennedy, E.T.; Horwitz, A., ed. *Prevention of micronutrient deficiencies. Tools for policymakers and public health workers*. Institute of Medicine, National Academy of Sciences, Washington, DC, USA. p. 45–102.
- West, K.P., Jr.; Katz, J.; Khatri, S.K.; LeClerq, S.C.; Pradhan, E.K.; Shrestha, S.R.; Connor, P.B.; Dali, S.M.; Christian, P.; Pokhrel, R.P.; Sommer, A. 1999. Double blind, cluster randomised trial of low dose supplementation with vitamin A or beta carotene on mortality related to pregnancy in Nepal. The NNIPS-2 Study Group. *British Medical Journal*, 318(7183), 570–575.
- WHO (World Health Organization). 1983. *Measuring change in nutritional status: guidelines for assessing the nutritional impact of supplementary feeding programmes for vulnerable groups*. WHO, Geneva, Switzerland.
- 1992. *The prevalence of anaemia in women*. WHO/MCH/MSM/92.2. WHO, Geneva, Switzerland.
- 1993. *Global prevalence of iodine deficiency disorders*. MDIS Working Paper No. 1. WHO, United Nations Children's Fund, and International Council for the Control of Iodine Deficiency Disorders. WHO, Geneva, Switzerland.
- 1994. *Indicators for assessing iodine deficiency disorders and their*

- control through salt iodization. WHO, United Nations Children's Fund, and International Council for the Control of Iodine Deficiency Disorders. WHO/NUT/94.6. WHO, Geneva, Switzerland.
- 1995. Global prevalence of vitamin A deficiency. MDIS Working Paper No. 2. WHO/NUT/95.3. WHO, Geneva, Switzerland.
 - 1996. Indicators for assessing vitamin A deficiency and their application in monitoring and evaluating intervention programmes. WHO/NUT/96.10. WHO, Geneva, Switzerland.
 - 1997. Prevalence of anaemia among different populations based on national data. MDIS Working Paper No. 3 [mimeo]. WHO, Geneva, Switzerland.
 - 1999. Progress towards the elimination of iodine deficiency disorders (IDD). United Nations Children's Fund, WHO, and International Council for the Control of Iodine Deficiency Disorders. WHO/NHD/99.4. WHO, Geneva, Switzerland.
- WHO; UNICEF; IVACG (World Health Organization; United Nations Children's Fund; International Vitamin A Consultative Group). 1997. Vitamin A supplements. A guide to their use in the treatment and prevention of vitamin A deficiency and xerophthalmia. WHO, Geneva, Switzerland.
- WHO; UNICEF; UNU (World Health Organization; United Nations Children's Fund; United Nations University). 1997. Indicators and strategies for iron deficiency control programs. WHO/NUT/96.12. WHO, Geneva, Switzerland.
- Yusuf, H.K.M.; Salamatullah, Q.; Islam, M.N.; Hoque, T.; Baquer, M.; Pandav, C.S. 1993. Report of the National Iodine Deficiency Disorders Survey in Bangladesh — 1993. Dhaka University, United Nations Children's Fund, and International Council for the Control of Iodine Deficiency Disorders, Dhaka, Bangladesh

