The last 50 years have witnessed a steadily increasing understanding of the biochemistry of vitamins and trace minerals and their role in human nutrition and intermediary metabolism. There also has been a growing public awareness of the sometimes dramatic clinical impact of vitamin and mineral administration in deficiency states.

As nutritional needs became more clearly defined, essential vitamins and minerals were incorporated into processed formulas with the aim of providing an essentially complete food for infants; specific nutrients likely to be lacking in the diet of older infants and children were also used to fortify certain food products, such as infant cereal. Supplementary vitamin and mineral drops or tablets continued to be used, probably to a greater extent than necessary considering the more extensive fortification of food.

Vitamin and/or mineral supplements are relatively inexpensive and available without prescription; therefore, it is understandable that they are used by a substantial portion of the population. The widespread consumption of these products is also fostered by a combination of advertising pressure and concern about dietary adequacy. Many individuals regard vitamin and/or mineral supplements as a reliable method of ensuring that real or imagined dietary shortcomings are corrected. Others, on far less rational grounds, have come to regard supplements in a wide range of doses as the philosopher's stone for good health or as treatment for a wide array of ailments from mental retardation to the common cold. As a result, vitamin and mineral supplements are widely abused by the general public, occasionally to the point of toxicity.

This statement will review the usual need for supplements in normal infants and children in the United States. In addition, the special needs of preterm and low-birth-weight infants and those of infants whose mothers are inadequately nourished will be reviewed. This statement will not consider the special requirements of infants and children with overt nutritional deficiencies, malabsorptive and other chronic diseases, rare vitamin dependency conditions, inborn errors of vitamin or mineral metabolism, or deficiencies related to the intake of drugs. Many children with these disorders may require pharmacologic doses of vitamins, which should be individually prescribed by the physician.

GOVERNMENT REGULATIONS AND COMMERCIAL PRACTICE RELATING TO VITAMIN AND MINERAL SUPPLEMENTS

Currently available vitamin and mineral preparations for infants and children in the United States are in accord with Food and Drug Administration regulations in effect until early 1979. These regulations, designed to minimize misuse, covered the specific vitamins and minerals and the minimum and maximum levels allowed and/or required in multivitamin and/or multimineral supplements for infants, children, adults, and pregnant or lactating women.

New regulations are in preparation. The new regulations may be somewhat different and will probably use updated US Recommended Daily Allowances (US RDAs), based on the revised 1980 RDAs developed by the Food and Nutrition Board, National Academy of Science. The distinctions between the RDA and the US RDA are as follows: recommended dietary allowances (RDAs) are established for numerous age groups and according to sex, and they are periodically published by the Food
and Nutrition Board of the National Academy of Sciences, National Research Council. Using the RDAs as a basis, the FDA established US RDAs as reference figures for the nutrition labeling of foods and supplements. US RDAs are established for only three groups: infants, children from 1 to 4 years old, and adults and children 4 or more years old. The scientific basis for the types of supplements considered proper for infants and children has not changed substantially.

The intention of the FDA regulations was to require multivitamin and multimineral supplements to contain appropriate combinations of vitamins and/or minerals at levels which ranged from lower limits (considered sufficient to minimize risk of deficiency) to upper limits (estimated to fully meet nutritional needs without undue excess). In almost all instances, the lower limits for individual nutrients were about 25% to 50% of the US RDA, and the upper limits were 100% to 150% of the US RDA. This type of regulation is useful because some previously available products called multivitamin or multimineral supplements omitted important nutrients considered conducive to good health. In addition, many preparations contained insignificant amounts of certain nutrients, and some contained levels of nutrients deemed excessive and possibly harmful if taken over a long period of time.

The products on the market for infants and children consist primarily of:

1. Liquid drop preparations for infants (a) vitamins A, D, and C, with or without iron; (b) vitamins A, D, C, and E, thiamin, riboflavin, niacin, vitamin B₆, and vitamin B₁₂, with or without iron.

2. Chewable tablets for young children (a) vitamins A, D, and C, with or without iron; (b) vitamins A, D, E, and C, thiamin, folic acid, riboflavin, niacin, vitamin B₆, and vitamin B₁₂, with or without iron.

Folic acid is omitted from liquid dietary supplements because it is relatively unstable in liquid preparations. No liquid multivitamin supplements containing folate are commercially available for this reason. To call attention to this omission, the following statement is required on the label immediately following the list of vitamins (and minerals) in the product: “This product does not contain the essential vitamin folic acid.”

The foregoing combinations are also available with fluoride for infants and children residing in areas where water is not fluoridated. However, because of their fluoride content, these products are only available on prescription. Supplements containing 0.25, 0.5, or 1.0 mg fluoride per dose enable physicians to prescribe the appropriate amount of fluoride supplements, when necessary, along with the vitamins or vitamins and iron recommended for a particular child and age group.

Supplements of individual vitamins rarely are used for infants, except for specific indications. Examples are the administration of vitamin K at birth to prevent hemorrhagic disease of the newborn and vitamin E to prevent hemolytic anemia in small, premature infants. Iron is the only mineral supplement commonly used in infants, either alone or in combination with vitamins.

**GUIDELINES FOR SUPPLEMENTATION**

The Table summarizes the following guidelines for the use of supplements in healthy infants and children. The indications for vitamin K and fluoride are discussed in the text only.

**Newborn Infants**

Vitamin K administration to all newborn infants is effective as a prophylaxis against hemorrhagic disease of the newborn. This 1961 recommendation was strongly reaffirmed in 1971 to prevent or minimize the postnatal decline of the vitamin K-dependent coagulation factors (II, VII, IX, and X). Vitamin K₁ is considered the vitamin derivative of choice in a single, intramuscular dose of 0.5 to 1 mg or an oral dose of 1.0 to 2.0 mg. In rare instances, the dose may have to be repeated after about four to seven days.

**Breast-fed Infants**

The renewed emphasis on human milk as an ideal food has raised the question whether breast-fed infants require any vitamin or mineral supplements prior to the introduction of solid foods. This subject bears further discussion, particularly with respect to the most widely used supplements: vitamins A, C, D, and E, iron and fluoride.

Rickets is uncommon in the breast-fed term infant, despite the fact that human breast milk appears to contain small amounts of vitamin D (ie, about 22 IU/liter). One possible explanation is that the vitamin D in breast milk is in the form of an easily absorbed sulfate analogue, but this needs to be confirmed. The antirachitic properties of breast milk seem to be adequate for the normal term infant of a well nourished mother. However, if the mother’s vitamin D nutrition has been inadequate and if the infant does not benefit from adequate ultraviolet light (due to dark skin color and/or little exposure to light) supplements of 400 IU of vitamin D daily may be indicated.

Vitamin A deficiency rarely occurs in breast-fed infants. Historically, vitamin A supplementation
TABLE. Guidelines for Use of Supplements in Healthy Infants and Children*

<table>
<thead>
<tr>
<th>Child</th>
<th>Multivitamin-Multimineral</th>
<th>Vitamins</th>
<th>Minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>Term infants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breast-fed</td>
<td>0</td>
<td>±</td>
<td>0</td>
</tr>
<tr>
<td>Formula-fed</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Preterm infants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breast-fed†</td>
<td>+‡</td>
<td>+</td>
<td>±§</td>
</tr>
<tr>
<td>Formula-fed†</td>
<td>+‡</td>
<td>+</td>
<td>±§</td>
</tr>
<tr>
<td>Older infants (after 6 mo)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>High-risk</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Children</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>High-risk</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pregnant teenager</td>
<td></td>
<td>±±</td>
<td>±</td>
</tr>
<tr>
<td>Normal</td>
<td>±</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>High-risk§</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* Symbols indicate: +, that a supplement is usually indicated; ±, that it is possibly or sometimes indicated; 0, that it is not usually indicated. Vitamin K for newborn infants and fluoride in areas where there is insufficient fluoride in the water supply are not shown.
† Iron-fortified formula and/or infant cereal is a more convenient and reliable source of iron than a supplement.
‡ Multivitamin supplement (plus added folate) is needed primarily when calorie intake is below approximately 300 kcal/day or when the infant weighs 2.5 kg; vitamin D should be supplied at least until 6 months of age in breast-fed infants. Iron should be started by 2 months of age (see text).
§ Vitamin E should be in a form that is well absorbed by small, premature infants. If this form of vitamin E is approved for use in formulas, it need not be given separately to formula-fed infants. Infants fed breast milk are less susceptible to vitamin E deficiency.
¶ Multivitamin-multimineral preparation (including iron) is preferred to use of iron alone.
§§ Multivitamin-multimineral preparation (including iron and folate) is preferred to use of iron alone or iron and folate alone.

was coupled with vitamin D supplementation because both were provided by cod liver oil. Currently there is little reason to provide vitamin A supplements; thus, there would be no harm in omitting vitamin A from supplements designed to provide vitamin D for infants who are breast-fed. Similarly there is no evidence that supplementation with vitamin E is needed for the normal, breast-fed term infant.

Vitamin B<sub>12</sub> deficiency has been reported in breast-fed infants of strict vegetarian mothers, but this is relatively rare in North America. The recent report of a 6-month-old infant of a vegan mother with severe megaloblastic anemia and coma<sup>17</sup> is a reminder that the maternal diet strongly influences the concentration of certain water-soluble vitamins in breast milk.<sup>18</sup> Thiamin deficiency can also occur in breast-fed infants of thiamin-deficient mothers, but this situation is virtually restricted to infants in developing countries. In the United States, the rare breast-fed infants of mothers who are themselves malnourished should receive multivitamin supplements.

Iron deficiency rarely develops before 4 to 6 months of age in breast-fed infants because neonatal iron stores can supply the major portion of iron needs during this period. Although breast milk may contain little more than 0.3 mg iron per liter,<sup>19</sup> about half of this iron is absorbed in contrast to the much smaller proportion that is assimilated from other foods.<sup>20</sup> This iron helps to delay the depletion of neonatal iron stores, but other sources of iron are required in midinfancy. In normal, breast-fed term infants, the addition to the diet of iron-fortified cereal after 6 months of age probably is desirable to supply adequate amounts of iron.<sup>21</sup>

The benefit of fluoride supplementation in the breast-fed infant is controversial.<sup>22</sup> This is understandable because of the dearth of evidence that fluoride supplementation in the first six months of life alters the prevalence of dental caries in the secondary dentition. In addition, the low level of fluoride in breast milk, even in areas where water is fluoridated, may provide a teleologic argument for not supplying extra fluoride in early infancy. However, the view that fluoride supplementation is unnecessary during the first six months of life is tempered by the knowledge that unerupted teeth are being mineralized in early infancy; consequently, supplemental fluoride would be expected
to have a beneficial effect during this period. In weighing these opposing views, the Committee re-
cently favored initiating fluoride supplements shortly after birth in breast-fed infants, but also
recognized that fluoride supplementation could be
initiated at 6 months of age.22

Fluoride supplements are available alone and in
combination with vitamins, with or without iron.
Thus, if iron or vitamin D supplements are indi-
cated, it is acceptable to include 0.25 mg fluoride if
the water supply contains less than 0.3 ppm of
fluoride.22

Formula-Fed Term Infants

Infants consuming adequate amounts of commer-
cial cow’s milk formulas which are in keeping with
the recommendations of the Committee23 do not
need vitamin and mineral supplementation in the
first six months of life. They do not require supple-
ments during the latter part of the first year if
formula continues to be used in appropriate com-
bination with solid foods. After 4 months of age,
iron-fortified formula and/or iron-fortified cereal
are convenient sources of iron and are preferable to
the use of iron supplements.21 If powdered or con-
centrated formula is used, fluoride supplements
should be administered only if the community water
contains less than 0.3 ppm of fluoride. Ready-to-use
formulas are now manufactured with water low in
fluoride, and recommendations for fluoride supple-
mentation should be similar to those for breast-fed
infants.

Vitamin K deficiency is seen occasionally in in-
fants. It is usually associated with diarrhea and
especially with the administration of antibiotics,
through a decrease in the synthesis of vitamin K by
the intestinal microflora. In the past, the feeding of
soy or other non-milk based formulas24,25 was asso-
ciated with vitamin K deficiency, which was related
in part to the type of oil used in the formula.26 In
1976, the Committee recommended that all infant
formulas, particularly non-milk-based formulas, be
required to contain an appropriate level of vitamin
K23

Preterm Infants

The needs of preterm infants for certain nutrients
are proportionately greater than those of term in-
fants because of the increased demands of a more
rapid rate of growth and less complete intestinal
absorption.12

During the first weeks of life (prior to consump-
tion of about 300 kcal per day or reaching a body
weight of 2.5 kg), a multivitamin supplement that
provides the equivalent of the RDAs for term in-
fants should be supplied. The components of this
supplement should ideally include vitamin E in a
form well absorbed by preterm infants, such as d-
\( \alpha \)-tocopheryl polyethylene glycol 1000 succinate.27

Folic acid deficiency has been reported in preterm
infants,28,29 and folic acid should be included in the
regimen. Folic acid is not in liquid multivitamin-
multimineral mixes because of its lack of stability.
However, because the period of administration will
generally be in a hospital, folate can be added to a
multivitamin preparation in the hospital pharmacy
in a concentration to provide 0.1 mg (the US RDA)
per daily dose. The shelf life should be limited to
one month, and the label should read “shake well”
because folate will gradually precipitate. Iron sup-
plementation is best delayed until after the first few
weeks of life because extra iron may predispose to
anemia when there is insufficient absorption of
vitamin E.30 Neonatal iron stores are still abundant,
and iron needs for erythropoiesis are relatively
small during the physiologic postnatal decline in
hemoglobin concentration.

After several weeks of age, when the infant is
consuming more than 300 kcal/day or when the
body weight exceeds 2.5 kg, a multivitamin supple-
ment is no longer needed, but it is a convenient
method for providing the few specific nutrients that
still may be required. These include vitamin D,
iron, and possibly folic acid.28

There have been sporadic reports of rickets, par-
icularly in breast-fed premature infants.31,32 This
probably results from the low phosphorus content
of breast milk, which has only 150 mg/liter in
contrast to about 450 mg/liter in formulas. The
condition is also correctable with phosphate supple-
mentation. However, there is also evidence that
vitamin D supplementation is helpful.33 Iron is re-
quired at a level of 2 mg/kg/day starting by 2
months of age because neonatal iron stores may
become depleted earlier than in term infants—be-
fore it is appropriate to supply iron in the form of
fortified solid foods. Iron-fortified formula also sup-
plies sufficient iron for the prevention of iron defi-
ciency in preterm infants.

Home-Prepared Evaporated Milk or Cow’s Milk
Formulas

Home-prepared formulas are seldom used in
North America, but they are in extensive use in
other countries. The need for supplements with
evaporated milk will depend on whether the prepa-
ration is fortified. Term and premature infants
may need additional vitamins C and D (at US RDA
levels). Supplemental iron should be started no
later than 4 months of age (at a dose of 1 mg/kg/ day)
for term infants and no later than 2 months of
age (at a dose of 2 mg/kg/day) for preterm infants.
Preterm infants will also need a daily multivitamin preparation that includes a well absorbed form of vitamin E and will require folate.29

Older Infants

During the second six months of life, the normal infant may be on a diet of milk or formula, mixed feedings, and increased amounts of table food. Cow's milk, if used at this time, should be fortified with vitamin D and cereal fortified with iron. Other vitamin and mineral supplements are usually not required, although it is important that the diet include an adequate source of vitamin C. Infants at special nutritional risk as a result of lifestyle, economic disadvantage, or intercurrent illness may require multivitamin and mineral supplements.

After Infancy

Recent national dietary and health surveys34,35 have shown little evidence of vitamin or mineral inadequacies, with the exception of iron. In preschool children of lower socioeconomic status, the most prevalent nutritional lack was simply an insufficiency of food.34 Thus, there is little basis for routine vitamin and mineral supplementation in normal children, especially as the growth rate decreases after infancy. An exception is the need for fluoride where there is insufficient fluoride in the drinking water. The Committee recently revised its dosage recommendations for fluoride supplements.32

When evidence of significant nutritional inadequacy arises, as with iron, the fortification of foods seems to be the most effective means of dealing with the problem. Among the disadvantages of relying on vitamin and/or mineral supplements to supply essential nutrients is the fact that some of those most at risk do not have access to the supplements or may not comply with long-term medication. Poor long-term compliance is a difficult problem with respect to supplying fluoride supplements in children residing in areas where drinking water contains inadequate fluoride. There are, nonetheless, some situations in which supplements may be indicated, and these will be listed. When used for these groups of children, the supplements should be composed of the multivitamins and minerals that provide these nutrients at approximately RDA levels.

Groups at particular nutritional risk include:

1. Children and adolescents from deprived families. Although evidence from the national surveys34-36 indicates that economically underprivileged families, in general, eat wisely and do not require vitamin supplements, there is a special subset within this group that may be malnourished.

2. Children and adolescents with anorexia, poor and capricious appetites, or poor eating habits; also children on dietary regimens to manage obesity.

3. Pregnant teenagers. Iron and probably folic acid are needed by these young women, but uncertainty about overall nutritional status in those considered at special nutritional risk warrants use of a multi-vitamin-multimineral supplement. The nutritional needs of the pregnant woman are discussed more fully in the recommendations of an ad hoc committee on nutrition of the American College of Obstetricians and Gynecologists.37

4. Children and adolescents consuming vegetarian diets without adequate dairy products may need supplementation, particularly with vitamin B12 which is absent from vegetable foods. This vitamin deficiency has been described in recent reports in the literature.17,36-40

PROVIDING VITAMIN AND MINERAL NEEDS WITH AVAILABLE PREPARATIONS

In most respects, these guidelines for the use of supplements can be conveniently met with currently available preparations. However, at present, it is difficult to supply trace minerals other than iron to infants and children who are considered to be in high nutritional risk categories. This is because multimineral preparations have required the inclusion of calcium, phosphorus, and magnesium in relatively large quantities that would be difficult to supply in a liquid or small tablet form. However, there may prove to be a clinical role for a multivitamin-trace mineral supplement that would include iron, zinc, and copper, and possibly other trace minerals, which could probably be more readily prepared in liquid or small tablet form.

There is sufficient evidence to support the inclusion of zinc41 and copper in multivitamin-multimineral preparations in tablet form.42 The requirements for other trace minerals,43 (such as selenium,44 chromium, manganese, and molybdenum) are under investigation; figures for these nutrients are included in the 1980 RDAs. These trace minerals might eventually be considered for inclusion in supplements for infants and children because evidence to warrant their use may be forthcoming.

However, at present, there is insufficient information on which to base detailed recommendations for dosage and appropriate ages for administration.

The combination of vitamin A, C, and D for infants (with vitamin E and/or iron as optional ingredients) was originally designed to complement home-prepared formulas. Now that most infants are fed proprietary formulas or breast milk, these
needs have shifted somewhat. In referring to the Table, there would seem to be roles in infant feeding for combinations of vitamin D with iron, vitamin D with vitamin E and possibly folate, and vitamins D, E, folate, and iron.

Although some comments in this statement are relevant to future developments in supplementation, currently available supplements and foods can be used to meet all recognized nutritional needs of infants and children. It must also be emphasized that, although deficiencies have been recorded in the infant of a malnourished mother,45,46 the normal, breast-fed infant of the well-nourished mother has not been shown conclusively to need any specific vitamin and mineral supplement. Similarly, there is no evidence that supplementation is necessary for the full-term, formula-fed infant and for the properly nourished normal child.

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38. Finberg L: Human choice, vegetable deficiencies, and vege-
Of all the therapies I have read about for stammering, the following, published in 1831, is the most unusual. One wonders whether "tincture of time" was not far more important than the use of cathartics.

A boy of robust form and florid aspect, of a healthy constitution, of more than ordinary activity both of mind and body, when between two and three years old, and after having acquired considerable readiness in speaking, was suddenly affected with so great a degree of stammering as to be almost incapable of uttering a single syllable. Two eminent physicians were consulted: they confessed their inability to propose any specific plan of treatment which might afford a prospect of success, but in consequence of a somewhat plethoric state of the child, they advised that a strong purgative should be given. The effect of the medicine appeared so favourable, that it was repeated three or four times, and each time with such decided benefit, as to leave no doubt on this point in the minds either of the parents or the practitioners. The complaint, however, shortly recurred, and was again attacked with the same remedy, and was again subdued. After this plan had been continued for some time, it was conceived that, in addition to the purgative system, the effect of which, although so salutary, was temporary, further advantage might be obtained by adopting a system of diet which should permanently reduce the plethoric habit, and obviate the necessity for the continual repetition of the purgatives. This was accordingly done, and was rigidly adhered to for several years. Animal food was totally abstained from, and even vegetables were taken in as sparing a quantity as was consistent with the support of the system . . .

By a steady adherence to this discipline for about eight years, the complaint was kept at bay; but whenever any relaxation in the diet took place, or when the purgatives were omitted or too long delayed, symptoms of the impediment immediately appeared. At length, when about twelve years of age, the tendency seemed so far subdued, that a relaxation of the restrictions was not followed by the usual unfavourable consequences, and the boy being then at a public school, it was not so easy to maintain the former discipline. For some time no bad effects ensued, but at length the complaint recurred, and was unusually obstinate, so as to require a long and severe course of purgatives, which, however, was finally successful . . .

With respect to the purgatives employed in this case, it appeared to be of little importance which were used, provided the bowels were very completely evacuated. What was the most frequently employed was a full dose of calomel and jalap, succeeded by Epsom salts . . . .

Noted by T.E.C., Jr, MD

REFERENCE
Vitamin and Mineral Supplement Needs in Normal Children in the United States

Pediatrics 1980;66;1015

The online version of this article, along with updated information and services, is located on the World Wide Web at:
/content/66/6/1015