Women in Resource-Poor Settings Are at Risk of Inadequate Intakes of Multiple Micronutrients1–4

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Abstract
A systematic review was conducted to identify all studies that were published between 1988 and 2008 reporting micronutrient intakes of women in resource-poor settings. Inclusion criteria were study location (resource-poor), dietary assessment method (24-h recall, estimated/weighted record, or locally validated FFQ), energy and 1 or more micronutrient intakes reported (vitamin A, vitamin B-6, vitamin B-12, vitamin C, thiamin, riboflavin, niacin, folate, iron, or zinc), age range (15–50 y), sample size (≥30), and sex (female). Of the 1560 papers identified, 52 papers were included. Results showed that, except for vitamin A (29%), vitamin C (34%), and niacin (34%), the reported mean/median intakes in over 50% of studies were below the Estimated Average Requirement (EAR). Folate intake was most often below EAR (91% of studies). Regional differences were apparent for intakes of vitamins A, C, and B-6 and riboflavin; mean/median intakes in Latin America exceeded the EAR, whereas in Asia, reported mean/median intakes of vitamin C, vitamin A, and riboflavin were below the EAR in 47, 50, and 77% of the studies, respectively, as was the case for vitamin B-6 in 75% of the studies in Africa. These results suggest that inadequate intakes of multiple micronutrients are common among women living in resource-poor settings and emphasize the need for increased attention to the quality of women’s diets. There is a need for more high-quality studies of women’s micronutrient intakes.

Introduction
In the last 2 decades, recognition of the risks and costs associated with women’s micronutrient deficiencies has increased dramatically, leading to calls for increased attention to women’s nutrition (1–9). Optimal micronutrient status is essential not only for the health, psychological well-being, and work capacity of women (1,10), but also for the growth, long-term health, and development of their children (5,11–14). Consequently, women need to enter pregnancy with adequate micronutrient stores to meet the high nutrient demands of pregnancy and lactation.

There is consensus among many nutritionists that high-quality diets are the ideal vehicle for ensuring micronutrient adequacy (1) and that poor-quality diets resulting in low intakes of micronutrients are one major cause of micronutrient deficiencies. Women in resource-poor settings are thought to be at a high risk for inadequate micronutrient intakes, because they often consume poor-quality, monotonous diets (4,6,12). However, information on the estimated adequacy of nutrient intakes is rarely collected for women in developing countries (7) and is often based on small, nonrepresentative samples from specific subgroups.

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To improve women’s nutrition, better characterization of the nature and extent of gaps between women’s intakes and requirements is essential. This includes characterization of: 1) which micronutrients are most commonly low in women’s diets; 2) how risk of inadequate intake varies between physiological groups [pregnant, lactating, and nonpregnant, nonlactating (NPNL)9 women]; and 3) regional differences in risk, if these exist. Such information will help focus international attention on the range of solutions that will be required to address these gaps.

This paper brings together available information on micronutrient intakes among poor women living in developing countries. The paper describes the nutrient intakes for women of different physiological status for vitamin A, vitamin C, thiamin, riboflavin, niacin, vitamin B-6, folate, vitamin B-12, iron, and zinc. To our knowledge, this is the first paper to summarize published information on the micronutrient intakes of poor women living in the developing world.

Methods

Literature search
A systematic search of the literature identified all studies published between 1988 and 2008 on micronutrient intakes of women in resource-poor settings. PubMed and Web of Science databases were searched using combinations of keywords and Medical Subject Headings terms (Table 1). Studies published in peer-reviewed journals in English, Spanish, French, and Portuguese were examined. In a second phase, snowballing was used to identify additional relevant studies from the bibliographies of all relevant papers identified in the initial search.

Study selection and validity assessment
Only studies that reported mean or median micronutrient intakes for women of reproductive age (15–50 y) were included (Table 2). The search was restricted geographically to studies from sub-Saharan Africa, South and Southeast Asia, and Latin America and the Caribbean.

In addition, in an attempt to restrict the review to low- and low-middle-income countries with a certain degree of food insecurity, we included only studies in countries that ranked as at least “moderate” on the Global Hunger Index (GHI) and that ranked as low or low-middle income in the same report (15). We considered the GHI to be a nutrition-relevant method for identifying and excluding middle-income countries with lower risk of micronutrient deficiencies. The risk of micronutrient deficiencies is likely to remain high for subgroups in some of the excluded countries, but a mechanism was needed to narrow the scope of the review to those settings of highest risk. The GHI criterion mainly narrowed the range of Latin American countries included.

Furthermore, only samples from nonelite groups in the eligible countries were included. For example, studies of university students and medical center staff were excluded due to their elevated socioeconomic status in many societies.

The quality of the dietary assessment method was also examined and only those studies that had used a 24-h recall, weighed or estimated records, or locally validated quantitative FFQ were judged to be of adequate quality for inclusion. Studies that used semiquantitative FFQ or FFQ that were not locally validated were excluded. Only studies with a sample size ≥30 were included; this restriction also applied to subgroups.

All article titles and abstracts located using database searches were examined for relevance by one of the authors (K.P.) and where relevance was unclear, the full article was retrieved to assess eligibility. Papers considered as potentially eligible were then reviewed by one of the authors (L.E.T., E.L.F., or M.A.) and assessed relative to the established criteria (Table 2). In cases where the reviewer was uncertain whether to include the paper, another author conducted a second review and the two discussed and resolved the assessment by consensus.

Data analysis and presentation
The following data were extracted: country, sample size, whether sampling was random or not, the sampling frame, dietary assessment method, and intakes of energy and micronutrients.

The data were not aggregated across studies, because the dietary assessment method, sampling, and statistical description of central tendency (mean or median) varied across the studies. Furthermore, the reported probabilities of inadequate micronutrient intake were not extracted, because very few studies adjusted micronutrient intake distributions to estimate usual intake distributions and used the fixed Estimated Average Requirements (EAR) cutoff or probability approach to estimate prevalence, as recommended by the Institute of Medicine (IOM) (16).

Instead, a qualitative method of presentation was chosen, with mean/median micronutrient intakes from each study presented as a percentage of their corresponding EAR and Recommended Nutrient Intake (RNI). This qualitative method is based on the principles of the EAR cutoff method (17). In cases where the intake distribution is approximately normal and the requirement distribution is normal, a qualitative judgment of the extent to which a population is at risk of inadequate nutrient intakes can be made by comparing the mean/median nutrient intake with the corresponding EAR and RNI.

Specifically, a population can be categorized as having: a very high risk of inadequate intakes when mean/median intakes are ≥EAR (level 1); likely a moderate risk of inadequate intakes when mean/median intakes are >EAR and ≤RNI (level 2); or likely a low risk of inadequate intakes when mean/median intakes are >RNI (level 3). The justification for this classification is as follows. For level 1 (very high risk), the most robust classification level, when a population’s mean/median nutrient intake is equal to or below the EAR, ≥50% of the population will be at risk of inadequate intake because the EAR represents an intake level that meets the estimated requirement of only 50% of the population (16). For level 2 (likely moderate risk), when a population’s mean/median nutrient intake is above the EAR and below the RNI, the percentage at risk of inadequate intakes would be between 5 and 50, because intake distributions are generally wider than requirement distributions and, for a normally distributed intake distribution, <50% of the distribution would lie below the EAR. For level 3 (i.e. likely low risk), the level of risk will depend on the extent to which the mean/median intake exceeds the RNI, because a mean/median intake close to the RNI will likely result in >5% of the population being at risk of inadequate intakes, again because the intake distribution is generally wider than the requirement distribution.

This qualitative classification system is most useful for indicating populations/nutrients where there is a very high prevalence of inadequate intakes (when mean/median intakes are less than or equal to EAR) and

### Table 1: Key words used when searching PubMed and Web of Science databases

<table>
<thead>
<tr>
<th>Intake</th>
<th>Gender</th>
<th>Developing countries</th>
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<tr>
<td>Micronutrient</td>
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<tr>
<td>Vitamin</td>
<td>Women</td>
<td>Africa</td>
</tr>
<tr>
<td>Mineral</td>
<td>Female</td>
<td>Asia</td>
</tr>
<tr>
<td>Trace element</td>
<td>Girl</td>
<td>Latin America</td>
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<tr>
<td>Nutrient adequacy</td>
<td>Mother</td>
<td>Central America</td>
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<tr>
<td>Diet</td>
<td>Maternal</td>
<td>South America</td>
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<td>Diet quality</td>
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<td>Dietary diversity</td>
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<td>Nutritional status</td>
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9 Abbreviations used: EAR, Estimated Average Requirement; GHI, Global Hunger Index; IOM, Institute of Medicine at the United States National Academy of Sciences; NPNL, nonpregnant, nonlactating; RNI, Recommended Nutrient Intake.
when the intake and requirement distributions are approximately normal (16).

Because of the focus on women in resource-poor settings, the EAR and RNI used for most nutrients were based on the WHO/FAO EAR and RNI for pregnant, lactating, or NPNL women in the age group 19–65 y. Where an EAR was not provided by the WHO/FAO, it was back-calculated from the RNI using the CV from the WHO/FAO (18), if available, or from the IOM (16) as described by Arimond et al. (19). For iron requirements, the EAR and RNI were based on the IOM’s Dietary Reference Intakes, adjusted for a bioavailability of 10% for NPNL women, and unadjusted for pregnant women, because absorption of iron is improved during pregnancy (20). For zinc, we used the International Zinc Nutrition Consultative Group EAR and Recommended Daily Allowance with the lowest level of absorption of 25% (for an unrefined, cereal-based diet) (21).

The data from eligible studies were tabulated by physiological status (pregnant, lactating, and NPNL/mixed/unknown status) and organized by world region (Supplemental Table 1).

To visualize how mean/median nutrient intakes compared with the EAR and RNI in the various studies, figures show the intake of each nutrient calculated as a percentage of the EAR and RNI for pregnant women and NPNL women. Summaries of the number of studies falling into the 3 categories described above (level 1: below EAR, level 2: between EAR and RNI, and level 3: above RNI) are presented (Supplemental Table 2). Because only 5 studies involving lactating women were identified, these results are presented in Supplemental Table 1 only.

### Results

#### Description of studies

In total, 1560 papers were identified from the initial systematic search (Fig. 1). Based on an initial screening of paper abstracts, 1430 (92%) papers were rejected, because they did not meet 1 or more of the inclusion criteria. Of the remaining papers that were read in entirety to assess eligibility, a further 55 papers were rejected, because they did not meet the inclusion criteria for dietary assessment method (\(n = 19\)), age group (\(n = 20\)), socioeconomic status (\(n = 10\)), or sample size (\(n = 6\)). An additional 23 papers were rejected, because nutrient intakes were not reported (\(n = 18\)) or not reported separately for women (\(n = 2\)), results

![FIGURE 1](https://example.com/figure1.png)  
**FIGURE 1** Flow diagram of the process of identifying and including studies for the systematic literature review.
were reported in another paper included in the review (n = 2), or the paper itself was a review (n = 1). Therefore, in total, 52 papers were included in this review: 20 from sub-Saharan Africa (22–41), 25 from Asia (42–66), and 7 from Latin America (67–73).

Certain countries within each region were disproportionally represented, e.g. South Africa and Malawi for sub-Saharan Africa and India for Asia. In addition, the number of micronutrient intakes reported varied from 1 to 10 (mean was 4 nutrients) (Supplemental Table 1). Many of the studies (40%) used a single day as the basis for dietary assessment; most of these were 24-h recalls. Multiple day 24-h recalls were used by 40% of the studies and 15% used multiple day weighed records. Only 6% used a validated FFQ. Participants were randomly selected in only one-third of the studies (Supplemental Table 1).

**Nutrient intakes**

The reported mean/median intakes were below the EAR in more than one-half of the studies included except for vitamin A (29% of the studies), vitamin C (34%), and niacin (34%) (Figs. 2 and 3; Supplemental Table 2). Whereas intakes of vitamin A were above the EAR in most studies from Africa and in Latin America, most Asian studies had mean/median vitamin A intakes below the RNI or even below the EAR. Similarly, mean/median intakes of vitamin C were also above the EAR in most studies in Africa and Latin America, but not in Asia. More studies among pregnant women had mean/median intakes of vitamin A, vitamin C, and niacin below EAR and RNI compared with studies among NPNL.

Intakes of thiamin and zinc were also more frequently below the EAR in the studies among pregnant women than among NPNL women (60 vs. 48% of studies, and 92 vs. 29% of studies, respectively). No regional pattern could be described for these nutrients among pregnant women. Among NPNL women, however, thiamin and also riboflavin intakes were more often below the EAR in Asia compared with Africa and Latin America (Fig. 2).

Folate intake was most often below the EAR (in all studies of pregnant women and in 82% of studies among NPNL women). Mean/median intakes of iron were more often below the EAR in studies among NPNL women (93%) compared with studies among pregnant women (78%). The same was true for vitamin

![Figure 2](https://academic.oup.com/jn/article-abstract/140/11/S18255/4630550)

**Figure 2** Intake of nutrients among pregnant and NPNL women presented as percentages of EAR. Percentages of EAR are truncated at 200%. Mean/median intakes over 200% of EAR are plotted at 200%. Studies with mean/median over 200% among pregnant women: 3 studies for vitamin A and 9 studies for vitamin C. Studies with mean/median over 200% among NPNL women: 15 studies for vitamin A, 11 studies for vitamin C, 3 studies for thiamin, 2 studies for niacin, and 1 study each for riboflavin, vitamin B-12, and zinc. Details of nutrient intakes and EAR are found in Supplemental Table 1.
B-6; however, only 3 studies on pregnant women reported results for B-6 (Fig. 2). Within regions, absolute mean/median micro-nutrient intakes were similar for pregnant and NPNL women (Supplemental Table 1).

The studies with a randomly selected sample were examined separately to see whether the pattern of inadequate intake would change; however, that was not the case (results not shown).

Overall, a mean of 3 micronutrients per study had an intake below the EAR for both pregnant and NPNL women.

Discussion

This review indicates that inadequate intakes of multiple micronutrients are likely to be common among women living in resource-poor settings in sub-Saharan Africa, South and South-East Asia, and Latin America. Intakes of iron, folate, and zinc were particularly low, providing some justification for the focus on these micronutrients in fortification/supplementation programs. However, intakes of other micronutrients that receive less attention (thiamin, riboflavin, niacin, vitamin B-6, and vitamin B-12) are also likely to be low; this may reflect monotonous diets low in fruits, vegetables, and animal products (6).

Inadequate intakes are more common among pregnant than NPNL women due to the higher EAR and RNI for pregnant compared with NPNL women. Studies did not reveal any major differences in mean/median intakes between the 2 groups, suggesting it may be particularly difficult to meet the augmented nutrient demands of pregnancy in these environments.

The results of this review also suggest that there may be regional differences in the number and types of micronutrients that are likely to be low in diets. In particular, apparent regional differences existed for vitamin A, vitamin C, riboflavin, and vitamin B-6. In Latin America, reported mean/median intakes of these nutrients generally exceeded the EAR, whereas in Asia and Africa, 25–77% and 11–75% of the mean/median intakes, respectively, were below the EAR. In contrast, intakes of iron, folate, and zinc were generally very low across all regions both among pregnant and NPNL women.

Our review had several limitations. First, few of the studies we reviewed adjusted nutrient intake distributions and employed currently recommended methods to estimate prevalence of ade-
quacy (16). Therefore, we could not quantitatively assess the risk of inadequate intakes.

Further, the qualitative classification system employed in this review is less robust for nutrient intakes with either a skewed intake or requirement distribution. In cases where the intake distribution is positively skewed and mean intakes were reported, risk may be underestimated if studies fell in categories 2 or 3 using our qualitative approach. Risk may have been overestimated if the intake distribution was negatively skewed, mean intakes were reported, and studies fell into categories 1 or 2. For nutrients with a highly positively skewed intake distribution, such as vitamins A and C, the risk of misclassification may be high depending on the extent of overlap comparing the intake and requirement distributions. Similarly, for menstruating women, the requirement distribution for iron is skewed (74), so risk of misclassification may be high. The results for these nutrients should therefore be viewed with some degree of caution.

Despite the weaknesses in our qualitative classification system, populations with nutrient intakes classified as either level 1 (mean/median intake below EAR) or level 2 (mean/median intake between EAR and RNI) will most likely require an improvement in these intakes to ensure a low prevalence of risk of inadequacy.

In this review, regional comparisons may be distorted, because certain countries are disproportionately represented in each region whereas others are excluded. Furthermore, very few studies from Latin America and the Caribbean were included in the review, in part because they did not fulfill the GHI criterion. The size and quality of the studies also varied as did the number of nutrients reported in each study. In particular, thiamin, riboflavin, niacin, and vitamin B-6 were reported less often than other nutrients, whereas iron, folic acid, and zinc were reported in most studies, thereby contributing more data points and confidence in their summaries compared with others.

Finally, dietary assessment methods are prone to systematic error and should always be interpreted with caution. Such errors can arise from errors in the survey instruments, food composition databases, assumed level of nutrient bioavailability, and choice of EAR and RNI (75).

In conclusion, this study indicates that pregnant and NPNL women from resource-poor settings are at risk of inadequate intakes for most of the micronutrients included in the review (vitamin A, vitamin C, thiamin, riboflavin, niacin, vitamin B-6, folic acid, vitamin B-12, iron, and zinc). Regional differences in the extent of risk for vitamins A, C, and B-6, and riboflavin were apparent, with women in Latin America at lower risk than women in Asia. However, very limited data were available for a number of micronutrients and certain countries were disproportionately represented in each region, which is likely to bias such comparisons. Finally, the sampling procedures and methods used to analyze the data were weak in many studies, highlighting the need for more high-quality published studies that document the risk of inadequate micronutrient intakes among women living in low-income settings. Such information will be crucial for designing appropriately targeted interventions to improve the nutritional status and health of women and their children. Our results suggest that fortification and supplementation programs that focus only on a few micronutrients are likely to miss important micronutrients for which intakes are inadequate. Dietary diversification is one safe approach toward filling a range of gaps in micronutrient intakes. Where fortification and/or supplementation are viewed as the best approach, careful documentation of micronutrient intake and status is needed as the basis for well-designed programs.

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Literature Cited


