

Protein Requirements of Pregnant and Lactating Women

Rebecca Kuriyan and Anura Kurpad

Division of Nutrition, St John's Research Institute,
St John's National Academy of Health Sciences,
Bangalore, India

Ricardo Uauy

Pediatrics Division, School of Medicine,
Pontificia Universidad Católica de Chile (UC),
and Instituto de Nutrición y Tecnología de Alimentos
(INTA), Universidad de Chile, Santiago, Chile

Key messages

- > The protein requirement during pregnancy and lactation has been revised upward considerably.
- > The safe protein intake level during the first, second and third trimesters is now 0.7, 9.6 and 31.2 g/d respectively.
- > The efficiency of protein utilization during pregnancy needs to be re-examined in order to answer whether more nuanced recommendations are required.

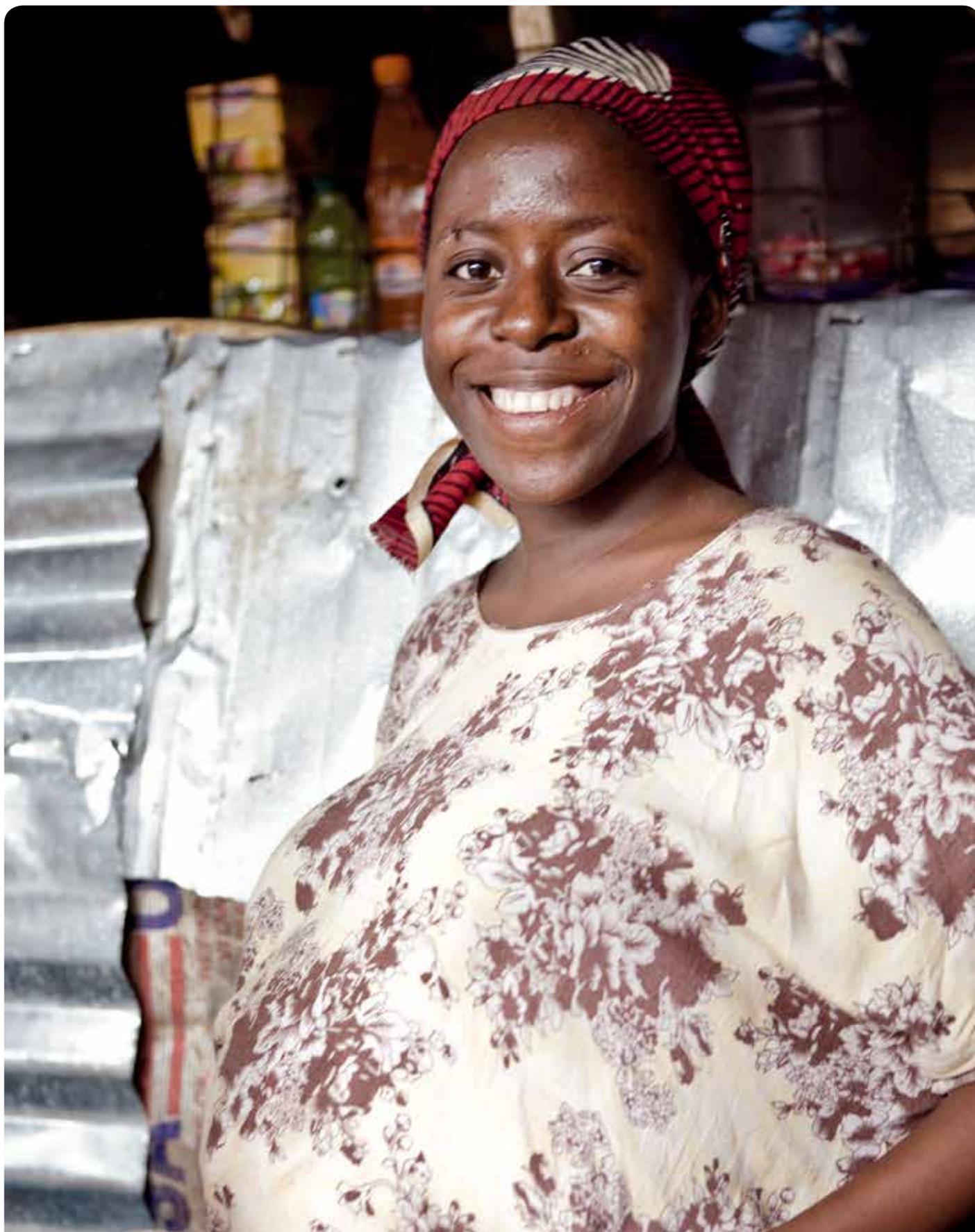
Introduction

The daily minimum protein requirement of the non-pregnant, non-lactating adult woman is based on the need to replace the daily amount of protein lost via urine and feces and to provide essential amino acids and/or other nitrogenous compounds that can be converted by human metabolism into amino acids that can be utilized by humans. The framework for determining requirements is first to determine the daily metabolic demand, which is represented by the amount of amino-nitrogen that is lost daily through urine, feces and skin on a protein-free diet. This value, based on observations across several sites across the world, has been determined to be 48 mg N/kg/day.¹

To quantitatively replace this daily metabolic demand by dietary protein requires that we assess the body's ability to utilize dietary protein. If a unit of dietary protein were to replace a unit of metabolic demand with 100% efficiency, the daily protein requirement would simply be equal to the metabolic demand. However, dietary proteins are not fully digested and utilized once absorbed, so a utilization efficiency factor must be applied to correct for incomplete absorption and utilization. The metabolic demand used to arrive at the minimum requirement for dietary protein has been determined to be about 47%.¹ Thus, in effect, the recommended dietary protein intake for healthy individuals would need to be about twice that required to meet the metabolic demand derived from obligatory losses.

Using these terms, the minimum, or estimated average, requirement of dietary protein was determined to be 0.66 g/kg/day in the FAO/WHO/UNU report.¹ Since the protein requirement varies within and between subjects in a given population, depending on factors that affect absorption and utilization, the "safe" intake (or intake that would meet the requirement of 97.5% of the population in the distribution of requirements) of 0.87 mg/kg/day was calculated, considering the need to meet the requirements of each of the indispensable amino acids (IAA) within the metabolic demand. Protein quality, in turn, is the product of the IAA composition of the protein with respect to the pattern of IAA requirement (the amino acid score) and its ability to be digested and absorbed completely in the intestine.

To cover additional needs, such as the requirement during pregnancy and lactation, the additional amount of protein deposited (during pregnancy) or lost (through lactation) needs to be determined, as well as the efficiency of dietary protein utilization to meet this additional demand. An adequate maternal protein intake during pregnancy should include needs for protein accretion of maternal tissues during pregnancy (blood cells, lactation, uterus, placenta and extra-embryonic membranes) and the amino acids necessary to support the maintenance and healthy growth and development of the fetus.²



A mother in the final stage of pregnancy. Recommended protein intakes for pregnant and breastfeeding mothers have been increased considerably.

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“Maternal protein intake during pregnancy should include needs for protein accretion of maternal tissues and the amino acids required to support the maintenance and healthy growth and development of the fetus.”

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Protein requirement during pregnancy

The revised protein requirement during pregnancy is based on a framework that takes into account the protein requirement for maintaining the weight gained by the mother during pregnancy (gestational weight gain, GWG); the protein (and its efficiency of utilization) required to support fetal deposition; and a term to account for a safe intake.¹ The maintenance requirement for the GWG for each trimester was based on the mid-trimester increase in maternal body weight and the adult maintenance value of 0.66 g/kg per day.

Protein deposition measurements were based on the measurement of the increment in total body potassium, using a whole-body counter to measure the radiation from naturally occurring body radioactive potassium (⁴⁰K) as pregnancy progressed. These measurements were derived from studies performed in the US,³ where the mean GWG was 13.8 kg. With a further assumption that there is a linear relationship between GWG and protein deposition, one can deduce a protein deposition rate for different GWG; for example, with a GWG of 12 kg, mean

protein deposited would be 1.6 and 6.5 g/day in the second and third trimester, respectively. It can reasonably be assumed that there is relatively negligible amount of protein deposited in the first trimester.

The question that might arise is, what is the optimal GWG that could be assumed for global use? There is no easy answer to this, since the actual data are limited to a few studies in developed countries. Thus the WHO/FAO/UNU Consultation assumed a GWG of 12 kg as desirable.¹ In addition, the efficiency of utilization of dietary protein to meet the deposition requirement was assumed to be 42%, which was lower than the earlier value of 70%,⁴ based on experimental data.¹ Considering this framework, the safe protein intake required was determined to be 9.6 and 31.2 g/day of protein in the second and third trimesters (Table 1). These values were higher than the earlier 1985 WHO/FAO/UNU requirement value.⁴

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“The need to resolve certain key questions remains”

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Direct experimental evidence for the dietary protein requirement during pregnancy is also available from the use of the stable isotope-based indicator amino acid oxidation method. In a study which measured the protein requirement of healthy pregnant Canadian women at 11–20 (early) and 31–38 (late) weeks of gestation,⁵ the protein requirement assessed early in gestation was 39% higher, while the late gestation figure was 73% higher in comparison to the adult Dietary Reference Intakes” (DRI) recommended Estimated Average Requirement (EAR) of 0.88 g/kg/day for protein intake during pregnancy.⁶ These values converge

TABLE 1: Recommended additional protein intake during pregnancy and lactation

Pregnancy			
Trimester	Weight gain (kg)	Additional protein requirement (g/day)	Additional safe intake (g/day) ^a
1	0.8	0.5	0.7
2	4.8	7.7	9.6
3	11	24.9	31.2
Lactation			
Months (postpartum)	Milk intake (g/day)	Additional protein requirement (g/day)	Additional safe intake (g/day) ^a
6	897	15.5	19.4
6–12	578	10.0	12.5

Adapted from FAO/WHO/UNU, 2007⁷¹

^aSafe intake – calculated as the average requirement plus allowance for an assumed coefficient of variation of 12%.

directionally with those reported above,^{1,3} particularly for US women. However, there is a need for confirmatory research in low- and middle-income countries (LMIC), where the GWG could be lower, even in healthy pregnancies, particularly in shorter women.

There is thus a need to resolve certain key remaining questions. First, as noted above, what is the optimal GWG for the average woman from LMIC – they may be shorter in height, with a lower GWG. Should therefore a uniform desirable GWG be applied globally? For example, the mean GWG found in a WHO collaborative study on maternal anthropometry and pregnancy outcomes was about 12 kg.⁷ An assessment of GWG curves in that report showed that for countries such as India, the GWG was between 8 and 10 kg at term, for birth weights ranging from < 2500 to > 3000 g, in women whose mean height was 150 cm. However, a more recent assessment of GWG in eight countries (INTERGROWTH)⁸ demonstrated that GWG in otherwise normal women who were > 153 cm tall was similar across countries, and at the fiftieth percentile was 13.69 kg at the fortieth week of pregnancy, which is similar to GWG reported above.³ In context, the mean height of rural and urban Indian women is 152 cm,⁹ and raises the question of what GWG standard should be used when evaluating quality protein needs during pregnancy and related birth outcomes; the multi-country INTERGROWTH standards might be the way forward to define what is optimal.

Second, does the conceptual framework fully capture the possible adaptations that could occur during pregnancy? For example, the efficiency of protein utilization is thought to be 42%,¹ although there is no certainty that there is no change in the efficiency of protein utilization in the “small” pregnant woman who has had a habitual suboptimal protein intake. For example, neonates recovering from severe undernutrition can use protein very efficiently, approaching an efficiency of 95–100% for absorbed protein from breast milk, after digestion. This is of course an extreme example of how the efficiency of utilization can change during recovery from acute malnutrition. However, a study on the rate of leucine (or protein) oxidation during the first and second trimester in low-BMI (body mass index) Indian women with normal protein intakes has shown that they do not have a higher efficiency of protein utilization during pregnancy.¹¹ It is important to emphasize that these low-BMI women also had a “normal” GWG for India, of about 10 kg, and that the birth weight of their babies was not different from normal-BMI women. Another possible adaptation is the reduction of protein oxidation through a reduction in urea synthesis rates,¹² and there could also be some recycling of urea N into the body amino-acid pool, through the involvement of the gut flora. There is limited evidence that this recycling does exist to the extent of being able to meet some 20% of the daily

requirement of essential amino acids,¹³ but this has not been measured during pregnancy or when there is a suboptimal protein intake. This underscores the need for research in an important area, since the term of efficiency of protein utilization is critical to the factorial calculation method.

Third, how relevant are maternal protein stores (muscle mass) in meeting some of the protein requirements of pregnancy? Detailed measurements in well-nourished women during and after pregnancy showed that there was no net accretion or loss of protein during pregnancy.³ Nevertheless, we cannot exclude the possibility that the mother could use some of her own protein stores (to make up for a deficiency in dietary protein) during pregnancy – something that might be obscured by the weight gain due to the fetus as well as to fluid gain and fat accretion. This is an important area of investigation.

Protein requirement during lactation

The recommendations for protein requirement during lactation were determined for well-nourished women, exclusively breastfeeding for 6 months and partially breastfeeding between 6 and 24 months. Once again, the factorial method framework was used to arrive at the dietary protein requirement, assuming a secretion of 9.4 g/day of protein in milk in the first six months and 6.6 g during the following 6–24 months.¹ Although the non-protein nitrogen concentration of breast milk is high (20–27% of total milk nitrogen, mainly as urea), for the purpose of calculating requirements, the dietary protein requirement was assumed to account only for the protein component of the total nitrogen in milk. Once again, an assumption had to be made about the efficiency with which dietary protein is used for the production of milk protein. This was assumed to be 47%, which is the same value that is assumed for the efficiency of protein utilization in normal, non-pregnant, non-lactating adults. The safe protein intake that would cover the needs of 97.5% of the distribution of requirements in the population was calculated as an additional term of 1.96 SD, using a coefficient of variation of 12.5%. The additional safe protein intake required during lactation was thus determined to be 19.4 g/day in the first six months of lactation, and 12.5 g/day after six months.¹

Moving forward

Moving forward, many questions still remain to be answered. Defining what is “normal” is one of them. The framework of the protein requirement ignores the demand that is placed by the environment, since primary measurements are often made in “clean” conditions, usually in developed countries. The metabolic demand, which forms the cornerstone of the factorial approach, should include terms for environmental and social determinants, and the stresses that women undergo during pregnancy and lactation. It is a sad reflection upon society that these additional



FIGURE 1: Shadow shield whole-body potassium counter facility at St John's Research Institute, Bangalore, India

demands should be considered “normal”: ideally, they should not. Further, improvements in the state of women during pregnancy have a generational timeline.

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**“The definition of what is ‘normal’
is yet to be agreed”**

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For small women in LMIC, the thought of an additional 30 g of protein/day during the third trimester might appear daunting. There is also the possibility of diminishing returns: feeding a short woman, who is likely to have a smaller GWG, with large amounts of food and protein is not without consequences, and at an extreme level, a very high protein intake has resulted in higher adverse events during pregnancy or parturition, and even in neonatal deaths.¹⁴ Therefore, some thought has to be given to whether “one size fits all”, or whether a more nuanced recommendation should be considered for the time being.

Assuming that the factorial calculations laid out above are correct, it becomes evident that there is a very high likelihood that many pregnant women in LMIC are at risk of low protein intake. It is tempting to speculate that this is the cause of the high rate of low birth weight (LBW) in many of these countries, and to jump into supplementation, but LBW is multifactorial in its cause, and some reflection is needed as to how these requirements might be evaluated and implemented. Careful and accurate measurements of protein accretion during pregnancy, particularly in LMIC and poor-resource environments, linked to accurate measurements of protein intake during pregnancy, will help answer these questions. As a first step, a state-of-the-art whole-body potassium counter has been built at St. John's Research Institute, Bangalore, India (Figure 1), and is currently being used to accurately measure protein accretion in Indian pregnant women who enter pregnancy in different nutritional states, before moving to interventional studies.

The goal of improving the protein quality in the nutritional intake of populations consuming predominantly cereal-based

diets should not be lost. The protein requirements detailed above are for a highly digestible, high-quality protein. Dietary selections favoring more quality, protein-rich foods, along with economics of access to such options, are important considerations that should guide the process of defining Protein Quality for Optimal Human Growth and Development.

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Correspondence: Dr Rebecca Kuriyan,

*Division of Nutrition, St John's Research Institute,
St John's National Academy of Health Sciences,
Bangalore- 560034, India. Email: rebecca@sjri.res.in*

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