

5

Examples of Planning for Groups

SUMMARY

Several applications of group planning are presented in this chapter. Two examples focus on normal group feeding situations where the distribution of intakes is shifted but the shape of the distribution is not explicitly changed. Two examples focus on planning for heterogeneous groups using a simple and a complex (but theoretically more correct) nutrient density approach. The final two examples discuss the problem of planning interventions designed to change the shape of the usual intake distribution of one or more nutrients in a targeted population group.

It is often difficult to plan diets that will achieve exactly the desired effect. Therefore, when planning normal diets or dietary interventions it is critically important to assess the likely effects not only on the target group, but also on other groups that would be affected by the intervention.

Important unpredictable factors such as food preferences, participation rates in food assistance programs, or population-based educational programs make the job of an intervention planner very difficult. Typically, forecasting the effect of an intervention is not straightforward, and several cycles of planning followed by assessment may be needed. The applications developed in this chapter are hypothetical.

INTRODUCTION

Planning diets for population subgroups is carried out in many diverse settings and thus has multiple and varied applications. Some of the more visible group-planning applications include planning diets for institutionalized groups, food and nutrition assistance programs, food fortification, nutrition education for groups, and military food and nutrition planning.

The discussion below provides an in-depth analysis of six specific planning applications. Examples (1) an assisted living facility for seniors and (2) school nutrition programs, present the principles described in Chapter 3 for shifting the distribution of usual intakes. Examples (3) a group of teen boys, adult men, and adult women using the simple nutrient density approach and (4) a group of teen boys, adult men, and adult women using the nutrient density distribution approach, present the approaches described in Chapter 4. Finally, examples (5) nutrient supplementation and (6) food fortification, illustrate how interventions intended to shift the distribution of usual intakes may also change the *shape* of the usual intake distribution. This discussion is not intended to prescribe how these planning activities should be conducted. Rather, based on the principles for group planning developed in Chapters 3 and 4, the discussion of these examples is intended to present the issues involved in these planning applications.

The group-planning framework should be applied in pilot situations before it is adopted for large-scale programs.

PLANNING DIETS IN AN ASSISTED-LIVING FACILITY FOR SENIOR CITIZENS

An example of planning diets for institutionalized groups is menu planning for senior citizens who reside in an assisted-living facility. Menus planned for these institutions usually assume that the residents have no other sources of foods or nutrients, and thus the menus are designed to meet all nutrient needs of the residents.

Based on the framework developed in Chapter 3, the goal of menu planning is to provide meals that supply adequate nutrients for a high proportion of the residents, or conversely, to ensure that the prevalence of inadequate intakes are acceptably low among the residents. An important note, and caveat perhaps, is that to fully implement the planning approaches described in this report, data on usual intakes must be available. Unfortunately, such data are seldom available; planners for these and other institutionalized groups

(e.g., prisons, boarding schools) frequently do not collect dietary intake data in order to evaluate their menu planning. It is possible to generate usual intake data on the target population through daily food intake records or intake recalls on each individual. However, if the facility is large (e.g., more than 100 residents), intakes could be measured on a representative subsample of residents. Using this technique, two nonconsecutive days or three consecutive days of food intake records or recalls are necessary. Alternatively, records of amounts served and plate waste data for individuals monitored, again for a minimum of two nonconsecutive or three consecutive days, can be used. In both cases, data should be adjusted to remove within-person variability and to obtain the usual nutrient intake distribution by using procedures such as those developed by Nusser and colleagues (1996) or the National Research Council (NRC, 1986).

Another possibility is to use usual nutrient intake distributions from another group in which the members are of similar age to the target group. Ideally, such data would also be for a similar (e.g., gender mix, ethnicity) institutionalized population, since the variation in the distribution of usual intakes is likely to differ among individuals who live in institutionalized settings and those who do not. If such comparable usual intake data are not available, then the only option may be to use usual intake distributions from national surveys such as the Continuing Survey of Food Intakes by Individuals (CSFII) or the Third National Health and Nutrition Examination Survey (NHANES III).

From the most appropriate data set available as described above, the planner examines the proportion of the group with usual intakes less than the Estimated Average Requirement (EAR) (for each of the nutrients for which EARs have been established) as an estimate of the prevalence of inadequate intakes. If the prevalence is unacceptably high for one or more nutrients, then intakes need to be increased. As described in Chapter 3, to estimate the amount of the increase for a given nutrient, the difference between the EAR for that nutrient and the usual intake level corresponding to the selected percentile of the current usual intake distribution (which is the chosen acceptable prevalence of inadequacy) is determined. The median usual intake should be increased by this amount, assuming the shape of the distribution is not expected to change. It is crucial to reassess intakes after the change is made, especially if the change is large, because it is possible (even likely) that the shape of the distribution will change.

As an example, consider a planner who is developing a menu for

an assisted-living facility in which the residents are retired nuns aged 70 years and above. For this age group, the EAR for vitamin B₆ is 1.3 mg/day (IOM, 1998a). Assume that no data can be located on the distribution of usual intakes of this group or a similar group, and that resources are not available to conduct a dietary survey in the institution. How could the planner proceed to determine the target intake distribution of vitamin B₆ needed to attain an acceptable prevalence of inadequacy?

Step 1. Determine an acceptably low prevalence of inadequacy.

For vitamin B₆, the EAR was set at a level adequate to maintain plasma pyridoxal phosphate levels at 20 nmol/L (IOM, 1998a). This plasma level is not accompanied by observable health risks, and thus allows a moderate safety margin to protect against the development of signs or symptoms of deficiency. This cutoff level was selected recognizing that “its use may overestimate the B₆ requirement for health maintenance of more than half the group” (IOM, 1998a). For this reason, assume that the planner has determined that a 10 percent prevalence of inadequacy (i.e., 10 percent with intakes below the EAR) would be an acceptable planning goal.

Step 2. Determine the target usual nutrient intake distribution.

Next, the planner needs to position the intake distribution so the nutrient intake goals are met. In this example, the planner decides that the prevalence of inadequacy in the group will be set at 10 percent, and as a result the usual intake distribution of the group should be positioned such that only 10 percent of the group has usual intakes less than the EAR. Using the EAR as a cut point for estimating the prevalence of inadequate intakes builds directly on the approaches previously described for assessing intakes (IOM, 2000a).

Because data on the usual nutrient intake distributions of the residents are not available, other sources must be used to estimate the target usual nutrient intake distribution. Data on the distribution of usual dietary intakes of vitamin B₆ from CSFII (conducted in 1995), NHANES III (conducted between 1988 and 1994), and the Boston Nutritional Status Survey (conducted between 1981 and 1984) are available (IOM, 1998a).¹ The adjusted percentiles for

¹ Caution should be used when selecting data sets. If more recent data sets were used in this example, it would provide a better reflection of changes in fortification levels.

women aged 70 years and above (in the Boston survey, aged 60 years and above) are summarized in Table 5-1. Assuming there are no changes in the shape of the distribution, the amount of the shift can be calculated as the additional amount of the nutrient that must be consumed to reduce the proportion of the group that is below the EAR. This is accomplished by determining the difference between the EAR and the intake at the acceptable prevalence of inadequacy (in this case, the 10th percentile of the usual intake distribution). Examination of the data from the three surveys shows that estimated usual intakes of vitamin B₆ vary by as much as 30 percent among the surveys. As a result, the difference between the EAR of 1.3 mg and the intake at the 10th percentile varies, depending on which data are used: for NHANES III the difference is 0.26 mg (1.3 mg – 1.04 mg = 0.26 mg); for CSFII, the difference is 0.42 mg (1.3 mg – 0.88 mg = 0.42 mg), and for the Boston survey, the difference is 0.7 mg (1.3 mg – 0.6 mg = 0.7 mg). In this example, the planner may have no reason to choose data from one particular survey as “more applicable” to his group than another, so he may estimate target usual nutrient intake distributions using all three data sets. Accordingly, the target intake distributions shift up by 0.26 mg, by 0.42 mg, and by 0.7 mg using NHANES III, CSFII, and the Boston survey, respectively. In each case the target usual nutrient intake distribution would lead to the accepted prevalence of inadequacy. Rather than choosing one set of survey data over another, the planner could simply average the summary measures described in the next section.

TABLE 5-1 Selected Percentiles of the Distributions of Usual Intake of Vitamin B₆ from Foods in Older Women

Study ^a	n	Percentile of Usual Intake Distribution of Vitamin B ₆ (mg/day)						
		5th	10th	25th	50th	75th	90th	95th
CSFII	221	0.76	0.88	1.11	1.41	1.76	2.12	2.35
NHANES III	1,368	0.92	1.04	1.24	1.53	1.93	2.43	2.76
Boston	281	0.5	0.6	0.7	1.0	1.3	1.6	1.8

^a CSFII = Continuing Survey of Food Intakes by Individuals (women > 70 y), NHANES III = Third National Health and Nutrition Examination Survey (women > 70 y), Boston = Boston Diet Study (women > 60 y).

SOURCE: IOM (1998a).

Step 3. Select a summary measure of the target usual nutrient intake distribution to use in planning.

After the planner has estimated a target usual intake distribution, this information needs to be operationalized into a menu. In order to do this, the planner will first have to select a summary measure of the target usual nutrient intake distribution to use as a tool in planning the menu. The median of the target intake distribution is the most useful; it can be calculated as the median of the current intake distribution, plus (or minus) the amount that the distribution needs to shift to make it the target usual intake distribution.

In the current example, although the baseline intakes at the 10th percentile and the median differ among the three surveys, the estimates of the medians of the target usual intake distributions are quite similar, as shown in Table 5-2. Assuming that a 10 percent prevalence of intakes below the EAR was considered acceptable, a median intake for vitamin B₆ of 1.7 to 1.8 mg/day would be the planning goal. Accordingly, the menu would need to be planned so that vitamin B₆ intakes would be at this level.

Estimates of target nutrient intakes must be converted to estimates of foods to purchase, offer, and serve that will result in the usual intake distributions meeting the intake goals. As discussed previously, designing menu offerings to meet intake targets is a dif-

TABLE 5-2 Identification of the Target Median Intake^a of Vitamin B₆ to Obtain a 10 Percent Prevalence of Inadequacy in Older Women

Study ^b	EAR (mg/day)	Intake at 10th Percentile (mg/day)	Difference (EAR – intake at 10th percentile)	Median Intake (mg/day)	Target Median Intake (mg/day)
CSFII	1.3	0.88	0.42	1.41	1.83
NHANES III	1.3	1.04	0.26	1.53	1.79
Boston	1.3	0.6	0.7	1.0	1.70

^a The target median intake is estimated by adding the difference between the Estimated Average Requirement (EAR) and the intake at the acceptable prevalence of inadequacy (in this case, 10%) to the observed median intake.

^b CSFII = Continuing Survey of Food Intakes by Individuals, NHANES III = Third National Health and Nutrition Examination Survey, Boston = Boston Diet Study.

SOURCE: IOM (1998a).

ficult task. Meals with an average nutrient content equal to the median of the target usual nutrient intake distribution may not meet the planning goals, as individuals in a group tend to consume less than what is offered and served to them. Thus, the planner might aim for a menu that offers a choice of meals with a nutrient content range that includes, or even exceeds, the median of the target usual nutrient intake distribution.

Step 4. Assess implementation of the plan.

Ideally, after the menu has been planned and implemented, a survey would be conducted to assess intakes and determine whether the planning goal has been attained. This would then be used as the basis for further planning.

PLANNING MENUS FOR A SCHOOL NUTRITION PROGRAM

Probably the largest group planning application in the United States is for the nutrition assistance programs sponsored by the U.S. Department of Agriculture (USDA). These include the Food Stamp Program; the Supplemental Nutrition Program for Women, Infants, and Children; the Child and Adult Care Feeding Program; the National School Lunch Program (NSLP); the School Breakfast Program (SBP); and the Summer Food Service Program.

The NSLP and SBP are federally administered nutrition programs that operate daily in the nation's schools. The primary objective of these programs is "to safeguard the health and well-being of the Nation's children" (Richard B. Russell National School Lunch Act, 42 U.S.C. § 1751(2) [2002]). The Recommended Dietary Allowances (RDAs) have long formed the basis for food-based menu planning in the school nutrition programs. USDA regulations require that NSLP lunches provide, over time, one-third of the RDA for key nutrients. The goal of the SBP is to provide one-fourth of the RDA. Findings from two school nutrition dietary assessment studies indicate that, on average, school meals meet or exceed their goals of *offering* one-third of the RDA for lunch and one-fourth of the RDA for breakfast (Burghardt et al., 1995; Devaney et al., 1995; Fox et al., 2001).²

² It is important to note that program regulations are based on the former RDAs. In addition to the implications of the framework developed for group planning in this report, the concepts underlying the new RDAs and differences between the new and old RDAs are important considerations in planning school meals.

Thus, planning for the school nutrition programs has focused on what is offered in school meals. Since it can be assumed that the intent of the USDA programs is to protect the intakes of the target population, the following approach to planning is indicated.

Multiple program objectives for school-based meals lead to important analytic issues in applying the group-planning framework. If the objective of the school nutrition programs were simply to provide meals that would replicate what school children would get in the absence of the programs, then application of the group-planning framework discussed in Chapter 3 would not be appropriate. Planners would simply examine the distributions of usual nutrient intake at breakfast and lunch and attempt to provide school meals that would result in these same usual intake distributions.

Since the school nutrition programs, however, have nutritional objectives—such as safeguarding the health of the nation's children through the provision of nutritionally adequate meals in school (as stated in the language of the federal legislation)—then the group-planning framework developed in Chapter 3 is relevant and the question is how best to apply it. Actual application of the framework is difficult since school meals supply only part of children's usual daily intake, while Dietary Reference Intakes (DRIs) are defined on the basis of usual daily intake. USDA has addressed this issue in its current regulations that specify that school lunches and breakfasts must provide, on average, one-third and one-fourth of the RDA, respectively. However, the current practice of prorating of the RDA for meals offered does not imply that it is appropriate to prorate the DRIs for dietary planning or assessment. The DRIs are a set of dietary reference values based on nutrient intakes over a period of time and are not meant to be divided into parts of a day. In addition, the proportion of usual intake accounted for by breakfast and lunch varies considerably among individuals.

Despite these difficult conceptual issues, there are some options for applying the framework for planning school meals. The first step is to examine daily usual intakes of a representative group of children covered by the school nutrition programs. Table 5-3 presents data on the usual intakes of vitamin A, vitamin C, and zinc for boys 9 to 13 years of age from the Third National Health and Nutrition Examination Survey and the Continuing Survey of Food Intakes by Individuals (IOM, 2000b, 2001). These data suggest a low prevalence of inadequacy for the intakes of vitamin C and zinc. For vitamin A, the estimated prevalence of inadequacy is 5 to 10 percent.

Suppose planners were interested in using information on the usual intakes of school children to plan the school meals consumed

TABLE 5-3 Daily Usual Intake of Vitamins A and C and Zinc, Boys 9 to 13 Years of Age

Percentile	Vitamin A (RAE) ^a (EAR = 445 µg RAE)	Vitamin C (mg) ^b (EAR = 39 mg)	Zinc (mg) ^b (EAR = 7.0 mg)
1	311	44.1	5.4
2	350	47.9	6.0
3	377	51.7	6.3
5	415	59.2	6.9
10	480	65.9	7.7
25	606	85.6	9.1
50	774	119.3	11.2
95	1,330	334.6	18.5
99	1,635	598.3	28.5
Approximate percent < EAR	5–10%	0%	5%
Target median intake	774 + 80	—	—

^a Usual intake from food only. Taken from the Continuing Survey of Food Intakes by Individuals and converted to retinol activity equivalents (RAE) using data on vitamin A and carotenoid intakes. EAR = Estimated Average Requirement.

^b Usual intake from food and supplements. Taken from the Third National Health and Nutrition Examination Survey and adjusted for day-to-day variation using the Iowa State University method.

SOURCE: IOM (2000b, 2001).

by program participants. As described in Chapter 3, determining the target usual intake distribution first involves selecting a group prevalence of inadequacy. In the case of these selected nutrients, planners are likely to conclude that the usual intakes of vitamin C and zinc are adequate, and would therefore plan to maintain current intakes. For vitamin A, however, if the acceptable group prevalence of inadequacy is set at 2 to 3 percent rather than the current 5 to 10 percent, planners would aim to shift the usual intake distribution by about 80 µg retinol activity equivalents (RAE) so only 2 to 3 percent are below the EAR, resulting in a target median intake of 854 µg RAE.

The next step in applying the group-planning framework is to decide how the school nutrition programs should or could be used to achieve the targeted usual intake distribution. Two possible options are (1) to derive the target daily usual intake distribution

and prorate the target intakes across meals, or (2) to derive the target daily usual intake distribution, estimate the deficit in 24-hour intakes, and plan for intakes from school meals to make up these deficits.

The first of these options is consistent with the way in which the school nutrition programs currently operate, where the amount offered in the school meals is a specified proportion of the RDAs. Implementing this option in the case of vitamin A, for example, would entail prorating the target usual intake distribution, with the target median intake of 854 μg RAE, in such a way that a certain proportion is consumed at breakfast and at lunch.

The second option makes the nutritional objectives of the school nutrition programs more explicit. Implementing this option involves planning school breakfasts and lunches such that the distribution of usual daily intakes of participants is the target usual intake distribution. In this case, the school meals are expected to make up the deficit in usual daily vitamin A intake of 80 μg RAE. The deficit could be made up by planning menus that would add 80 μg RAE to the median intake at breakfast or lunch. This amount could also be split between the two meals. Tailoring food choices or portion sizes at the point of service may be impractical. Thus, a methodology of planning for heterogeneous groups may be needed.

In summary, application of the group-planning framework for the U.S. food and nutrition assistance programs is a complex task that involves several considerations related to program goals, nutritional considerations, and program implementation. Like any new paradigm, it must first be tested for its feasibility and practicality. The discussion of the school nutrition programs above is intended to identify the main issues involved in applying the framework and options to consider in its implementation—it is not intended to prescribe how this framework should be implemented in the context of school feeding.

PLANNING DIETS FOR A HETEROGENEOUS GROUP USING A NUTRIENT DENSITY APPROACH

The examples provided to this point have assumed that planning is occurring for a group that consists of a single life stage and gender group or life stage and gender groups with similar requirements. Frequently, however, planning will occur for groups that encompass multiple life stage and gender groups with very different nutrient and energy requirements. Two examples that incorporate the nutrient density approaches described in Chapter 4 are provided

below. The first illustrates the simple nutrient density approach, in which the target median intake for each subgroup is compared to the average energy needs of the subgroup. The second example illustrates the nutrient density distribution approach, which includes a consideration of the variability of energy and nutrient needs within each subgroup.

To compare and contrast the two approaches, both examples consider the vitamin C intakes of a group consisting of adolescent boys aged 14 to 18 years, women aged 19 to 50 years, and men aged 19 to 50 years. As in most of the examples in this chapter, data used here are real data, in this case collected in the 1994–1996 Continuing Survey of Food Intakes by Individuals. Intake distributions of vitamin C and of energy for the three subgroups were adjusted using the Iowa State University method (IOM, 2000a; Nusser et al., 1996). The estimated usual intake distributions of energy in each of the subgroups were used as estimates for the distributions of requirements of energy. The examples were constructed using the data presented in Table 5-4.

Simple Nutrient Density Approach

Step 1. Obtain the target median vitamin C intake for adolescent boys, adult women, and adult men.

Adolescent Boys. The estimated prevalence of vitamin C inadequacy in this particular subgroup of adolescent boys is approximately 19 percent when comparing usual intakes to their Estimated Average Requirement (EAR) of 63 mg/day. Thus, a target vitamin C intake distribution would be obtained by shifting the baseline usual intake distribution by an amount sufficient to move the 3rd percentile of the distribution from its current 31 mg to approximately 63 mg (assuming that a prevalence of inadequacy of 2 to 3 percent is what is desired). By shifting the intakes of vitamin C by 32 mg/day (EAR – 3rd percentile: $63 - 31 = 32$), the target vitamin C intake distribution is obtained (as was described in Chapter 3). In this target vitamin C intake distribution, the 3rd percentile is now approximately at the EAR of 63 mg/day. The target median intake is now 139 mg/day.

Adult Women. The prevalence of inadequacy among the women in this example is approximately 33 percent compared to their EAR of 60 mg. To obtain the target vitamin C intake distribution, it is necessary to shift the distribution by approximately 37 mg/day (EAR – 3rd percentile: $60 - 23 = 37$), so that the proportion of

TABLE 5-4 Usual Vitamin C and Energy Intakes of a Group Containing Three Discrete Subgroups

Subgroup	EAR ^a	<i>n</i>	Median	Mean	SD ^b
<i>Usual Vitamin C Intake (mg/day)</i>					
Boys 14–18 y	63	474	107		70
Women 19–50 y	60	2,498	77		48
Men 19–50 y	75	2,726	95		67
<i>Usual Energy Intake (kcal/day)</i>					
Boys 14–18 y			2,801	2,881	782
Women 19–50 y			1,685	1,719	430
Men 19–50 y			2,561	2,659	809

^a EAR = Estimated Average Requirement.

^b SD = standard deviation.

SOURCE: USDA/ARS (1997).

target usual intakes below the EAR of 60 mg/day is about 3 percent. The target median intake is now 114 mg/day.

Adult Men. The prevalence of inadequacy among the men in this example is approximately 35 percent based on their EAR of 75 mg. To obtain the target vitamin C intake distribution, it is necessary to shift the distribution by approximately 49 mg/day (EAR – 3rd percentile: $75 - 26 = 49$), so that the proportion of target usual intakes below the EAR of 75 mg/day is now about 3 percent. The target median intake is now 144 mg/day.

Step 2. Divide the target median vitamin C intake by the mean energy intake or expenditure in each subgroup to obtain the target median nutrient intake relative to energy.

In this step, the median of the target usual intake distribution of the nutrient (vitamin C), which has been developed to exceed the requirements of most members of the group, is divided by the mean energy intake. The mean energy intake, rather than the median, is used because for energy, assuming the group (or subgroup) is in energy balance, the mean energy intake is equal to the mean energy requirement, and there are negative effects to providing energy above or below the requirement.

Percentile			Prevalence of Inadequacy (%)
3rd	5th	95th	
31	38	256	19
23	28	178	33
26	31	238	35
	1,747	4,288	
	1,071	2,248	
	1,537	4,112	

Adolescent Boys. The target median vitamin C intake for adolescent boys in this example is 139 mg/day. With a mean energy intake of 2,881 kcal/day, this leads to a target median vitamin C intake of 48.2 mg/1,000 kcal.

Adult Women. The target median vitamin C intake for adult women of 114 mg/day is divided by their mean energy intake of 1,719 kcal/day, for a target median intake of 66.3 mg/1,000 kcal.

Adult Men. The target median vitamin C intake for adult men of 144 mg/day is divided by their mean energy intake of 2,659 kcal, for a target median intake of 54.2 mg/1,000 kcal.

Step 3. Compare the target median nutrient intakes relative to energy for each discrete subgroup to identify the subgroup with the reference intake (i.e., the highest nutrient requirement relative to energy intake) and set planning goals for the whole group. Ensure that intakes of the other subgroups will not be above the Tolerable Upper Intake Level (UL).

Among these three groups, women have the highest target median vitamin C intake relative to their mean energy intake. Thus, the target reference intake for planning purposes would be 66.3 mg/1,000 kcal.

Whether the target reference intake would lead to intakes above the UL cannot be accurately determined using the simple density approach. However, an indication of the likelihood of excessive intakes can be obtained by calculating the anticipated intake at the 95th percentiles of the energy intake distribution, using the reference density. For adolescent boys, the 95th percentile of energy intake is 4,288 kcal/day, which would be associated with a vitamin C intake of 284 mg/day ($4,288 \text{ kcal} \times 66.3 \text{ mg}/1,000 \text{ kcal}$). This intake remains considerably below the UL of 1,800 mg/day for adolescents. Similarly, for adult men the 95th percentile of energy intake is 4,112 kcal/day, which would be associated with a vitamin C intake of 273 mg/day using the reference density. This too is well below the UL of 2,000 mg/day for adult men.

Step 4. Assess whether the plan was successfully implemented.

Ideally, after the plan has been implemented, assessment of intakes would be conducted to confirm whether the acceptable prevalence of inadequacy has been attained and whether the prevalence of intakes above the UL is low.

Nutrient Density Distribution Approach

Step 1. Obtain the target usual vitamin C intake distribution.

The first step in the nutrient density distribution approach is similar to the first step in the simple nutrient density approach. However, instead of focusing on one point of the target usual intake distribution (the median), in this case the entire distribution is of interest.

Adolescent Boys. As described in the simple nutrient density approach, the target usual vitamin C intake distribution for adolescent boys would be shifted up by 32 mg/day. This would lead to a distribution with a median intake of 139 mg/day, and 5th and 95th percentiles of 70 and 288 mg/day, respectively.

Adult Women. For adult women, the usual vitamin C intake distribution would be repositioned by 37 mg/day to obtain the target intake distribution. It would have a median of 114 mg/day and 5th and 95th percentiles of 65 and 215 mg/day, respectively.

Adult Men. The usual intake distribution for adult men would be shifted up by 49 mg/day to obtain a target intake distribution with a

median of 144 mg/day, and 5th and 95th percentiles of 80 and 287 mg/day, respectively.

Step 2. Define the target usual vitamin C density intake distribution for each definable subgroup.

Given a target nutrient intake distribution and a usual energy intake distribution, it is now possible to derive the *target nutrient density intake distribution* for each subgroup. This is done by using one of the two equations presented in Chapter 4 to compute the average nutrient density intake for each individual in each subgroup (or for a sample of individuals in each subgroup). The average nutrient density intake for each individual is then combined to form the target nutrient density intake distribution for each subgroup.

In this example, an average (over a number of possible energy intake values) vitamin C density intake was computed for a random sample of 400 individuals from each of the subgroups (boys, women, men). For each individual in each subgroup sample, a random sample of 400 energy intakes was drawn from the usual energy intake distribution for that subgroup. The target vitamin C density intake was constructed using equation (2) from Chapter 4:

$$\text{Average nutrient density intake} = (1/m) \sum_{j=1}^m (\text{usual nutrient intake/energy intake}_j) \times 1,000$$

Equation (2) was used rather than equation (1) because the calculation was performed on a random sample of each subgroup (Monte Carlo approach) rather than the entire distribution of all possible nutrient and energy intake combinations.

This procedure was accomplished as follows:

- A random sample of 400 intakes was drawn from the target usual vitamin C intake distribution for each subgroup.
- Next, for each of those 400 vitamin C intakes in each subgroup, a random sample of 400 energy intakes was drawn from the usual energy intake distribution in the corresponding subgroup. Thus, a given vitamin C intake (e.g., 46 mg) was associated with 400 different energy intakes (e.g., 46 mg/1,750 kcal, 46 mg/3,002 kcal, 46 mg/2,222 kcal, and so on). From those 400 different densities for each nutrient intake, the average nutrient density intake was calculated using the second equation (nutrient density intake = $[1/m] \sum_{j=1}^m [\text{usual nutrient intake/energy intake}_j] \times 1,000$) where m is equal to 400.

- This process was repeated a total of 400 times in each subgroup (for each of the 400 vitamin C intakes in each subgroup).
- Then, for each subgroup, the 400 average nutrient density intakes were used to construct the target vitamin C density intake distribution.

Adolescent Boys. In the case of boys aged 14 to 18 years, the target nutrient density intake distribution has a median of 52 mg of vitamin C/1,000 kcal, and 5th and 95th percentiles of 26 and 112 mg/1,000 kcal, respectively.

Adult Women. In this example, the target vitamin C density intake distribution for women aged 19 to 50 years has a median of 71 mg/1,000 kcal, a 5th percentile of 42 mg/1,000 kcal, and a 95th percentile of 135 mg/1,000 kcal.

Adult Men. For the subgroup of men aged 19 to 50 years, the resulting target vitamin C density intake distribution has a median of 57 mg/1,000 kcal, and 5th and 95th percentiles of 33 and 115 mg/1,000 kcal, respectively.

Step 3. Compare the target median vitamin C density for each discrete subgroup to set planning goals for the group as a whole.

In this example, the target vitamin C density distribution for women had the highest median (71 mg/1,000 kcal compared to 57 mg/1,000 kcal for adult men and 52 mg/1,000 kcal for adolescent boys). This amount would normally be chosen as the reference nutrient density intake distribution for the group as a whole, and intakes would be planned on this basis. The planned menus resulting from this activity should be checked for both total milligrams of vitamin C and milligrams of vitamin C/1,000 kcal.

Comparison of the Simple Nutrient Density Approach and the Nutrient Density Distribution Approach

It is useful to compare the planning results that would be achieved when using the two nutrient density methods described above (and in Chapter 4). Recall that for the same group of boys, women, and men, the median of the target nutrient density intake distribution that would be obtained by simply dividing the target median vitamin C intake by the mean energy requirement in each of the groups was 48, 66, and 54 mg/1,000 kcal, respectively. Based on these values, the planner would aim for a target nutrient density intake distribution in each of the subgroups with a median equal to the

highest of the three values, or 66 mg/1,000 kcal. Using this method, which does not take into account the distribution of energy requirements in the group, results in a prevalence of vitamin C inadequacy of approximately 8 to 9 percent for the women in the group (for adolescent boys and men the resulting intakes would be adequate for all individuals). In contrast, using the nutrient density distribution approach results in a projected prevalence of inadequacy of approximately 2 to 3 percent for the women, and essentially zero for the men and adolescent boys. Because the nutrient density distribution approach accounts for variability in energy intakes, it is more likely to achieve planning goals.

INTERVENTIONS THAT MAY CHANGE THE SHAPE OF THE INTAKE DISTRIBUTION: NUTRIENT SUPPLEMENTATION

Some planning applications involve interventions that aim to modify food or nutrient intakes. One way to modify nutrient intakes when a food-based approach is not possible is to incorporate use of a nutrient supplement within a group. If every individual in the group consumed the identical supplement every day, the distribution of usual intakes would simply shift up, with no change in shape, by the dose of the supplement. In practice, however, all individuals in a group may not take the supplement on a regular basis, and, among those who do take it, the dose may not be constant. As a result, misleading conclusions and practices may result if uniform supplement usage is assumed.

As an example, suppose a planner wished to reduce the predicted prevalence of zinc inadequacy among a group of free-living teenage girls through the use of a supplement. The first step would be to examine the current intake distribution. Let us assume that the group of teenage girls being targeted is similar to the sample of girls aged 14 to 18 years surveyed by the Third National Health and Nutrition Examination Survey (NHANES III), so that data from NHANES III can be used to estimate the current intake distribution. Participants in NHANES III are free-living and have not been the target of any national public health intervention regarding the use of zinc supplements. Table 5-5 presents information on the distribution of usual intake of zinc from foods (adjusted for within-person variation) and from supplements. The EAR for zinc in girls aged 14 to 18 years has been set at 7.3 mg/day. As shown in Table 5-5, more than 25 percent of teen girls had inadequate usual intake of zinc from food alone. If the acceptable group risk of inad-

TABLE 5-5 Estimated Usual Zinc Intake Distribution for Girls, 14 to 18 Years of Age (mg/day)

Percentile of Usual Intake	Zinc from Foods	Zinc from Supplements	Total Zinc ^a
1	4.0	0.83	3.9
3	4.7	0.9	4.8
5	5.1	1.0	5.2
10	5.8	1.0	5.8
25	7.1	2.5	7.2
50	8.8	8.0	9.0
75	10.9	15.0	11.6
90	13.2	15.0	13.8
95	16.4	37.5	16.0
99	18.6	45.5	26.6
Sample size	949	48	949
Mean	9.27	9.75	9.82

^a Because only 48 of the 949 girls used supplements containing zinc, total zinc intake does not equal the sum of the zinc intakes from food and supplements.

SOURCE: IOM (2001).

equacy were set at 3 percent, then the 3rd percentile of usual intake should be increased to the level of the Estimated Average Requirement (EAR). That is, the 3rd percentile value of 4.7 in Table 5-5 should increase to 7.3, an increase of 2.6 mg. Assuming that the usual intake distribution does not change its shape, the median intake would be the existing median intake + 2.6 mg (8.8 mg + 2.6 mg = 11.4 mg). This new usual intake distribution could be achieved if everyone took a supplement containing 2.6 mg of zinc.

Before recommending consumption of a supplement containing 2.6 mg of zinc, however, it is important to determine current supplement use. Accordingly, the next step is to examine the reported use of zinc supplements and the computed distribution of intakes from both sources, which are shown in Table 5-5. Note that only 48 of the 949 teen girls in the survey reported taking a zinc supplement (approximately 5 percent), so including supplements does not affect the total intake for most participants. Indeed, the distribution of total zinc intake differs primarily in the upper percentiles, with very little change in the lower percentiles. The third percentile increases only 0.1 mg/day, from 4.7 to 4.8 mg/day. Thus, there is almost no effect of current use of zinc supplements on the predicted prevalence of inadequacy. The increase that is needed to reduce

the prevalence to 3 percent is now 2.5 mg/day (7.3 – 4.8) versus 2.6 mg/day when food alone is considered.

In theory, planners could develop an education intervention that recommended that teen girls consume a supplement that provides 2.5 mg of zinc/day. Special supplements providing this level of intake could even be marketed. However, several observations regarding supplement usage patterns in free-living populations are important to highlight:

- Although the average supplement provided 9.75 mg of zinc, the change in the median intake of zinc, when adding in supplement use, was only 0.2 mg (9.0 mg – 8.8 mg).
- Although the median intake of zinc increased by 0.2 mg when supplements were included, the magnitude of the change at the 3rd percentile was only 0.1 mg.
- The prevalence of inadequate intake of zinc still exceeds 25 percent, even when intake from currently consumed supplements is added to the intake from food.
- As is usually the case, supplement usage was not uniform across this group of individuals. Teen girls with higher intakes of zinc from food were more likely to take a supplement and perhaps more likely to take a higher-dose supplement.

Thus, supplement use by a free-living population may not achieve the planner's goals, and the challenge is to determine how to either shift the whole distribution by 2.5 mg/day or to increase the use of supplements or zinc-rich foods by individuals in the lower percentiles. If an additional supplement of 2.5 mg/day of zinc was distributed *and consumed* by the entire population, then the distribution would shift as desired. As the data in Table 5-5 illustrate, it may take an intensive intervention to achieve this goal.

An alternative approach is to ensure supplement use by those in the lower percentiles. This might be possible if there are characteristics that would identify individuals with low intakes (such as income level or age). Such interventions to increase supplement use are likely to be more successful in a confined population (where supplement use could be monitored) than in a free-living one.

The important conclusion from this example of planning is that an intervention to change usual intakes through supplementation can be difficult to design and implement. In a free-living population, not every person can be expected to consistently take a supplement (or a given food or food group rich in a specific nutrient), and interventions in such a group may be expected to change both

the location and shape of the usual intake distribution. It is important to understand the patterns and predictors of supplement use in order to model and plan such interventions. Simply assuming uniform use of a supplement in free-living populations would likely result in a failure to achieve the planning goals.

FOOD FORTIFICATION

Fortification is often seen as a potentially desirable public health measure that could achieve an increased intake of specified nutrients without changes in food consumption practices or compliance with specific nutrient supplement usage. Historically, mandatory fortification programs have been applied in many countries as a means to address particular public health concerns. In these programs, public health authorities determine both the food vehicles and levels of fortification, and only fortified versions of the selected foods are permitted on the market. One such example is the mandatory fortification of table salt with iodine in Canada, a measure undertaken to reduce iodine deficiency in the population. Alternatively, food fortification programs may be voluntary, with food manufacturers having the option of adding particular nutrients (sometimes within prescribed limits) to foods, but not being required to do so. One example of this approach is the fortification of orange juice with calcium; because the program is voluntary, it is possible to purchase orange juice with or without calcium added. Regulations on food fortification differ between Canada and the United States, with voluntary fortification permitted in the United States.

Regardless of whether fortification is mandatory or voluntary, if it is intended to achieve public health goals, then it is often necessary to “target” the fortification. Such targeting could be accomplished by selecting only foods for fortification that are used exclusively or in substantially greater amounts by the group targeted by a fortification program, or by mounting an educational program to promote the use of specific fortified foods by the target group.

Fortification, however, also carries the potential for detrimental effects. Fortification of foods might increase nutrient intakes to excessive levels among those persons who have high intakes of the fortified food or those who already have high intakes of the nutrient and then consume the newly fortified food. Minimally controlled fortification of foods, even at low levels in individual foods, can have unexpected effects, ranging from negligible benefits to public health concerns about potentially detrimental high intakes. Further, unless fortified foods reach only the target group (unusual

in practice, except for infant foods), it is possible that the risk of detrimental effects will appear in other sectors of the population (i.e., nontarget groups). Because of the range of potential effects that can accompany fortification programs, both beneficial and detrimental, the potential impact of proposed fortification is usually examined before implementation.

In general, no simple method can be used to predict the effects of fortification. Fortifying foods with nutrients will have impacts on the nutrient intakes of those who consume the fortified foods and will not have impacts on those who do not consume them. Further, the degree of impact depends not only on the level of the nutrient added, but also on the distribution of usual intakes of the food. In recent years, predicting the effect of fortification has been complicated in the United States by introduction of food products fortified with a nutrient while the evaluation of the need for fortification is still in progress. Thus, it is difficult to anticipate changes in the usual intake distribution of the nutrient when even changes in the *amount* of the nutrient in the food supply are almost impossible to predict. A more extended discussion on the issue of voluntary fortification is presented in Appendix D.

The approach presented below involves modeling and estimating the effects of a mock fortification effort by using data on foods and nutrients consumed and then calculating the change in nutrient intake after the foods are fortified. The predicted benefits and risks associated with the fortification can be assessed through application of assessment methods based on the Estimated Average Requirement (EAR) and Tolerable Upper Intake Level (UL) (IOM, 2000a).

Such an approach was utilized by Lewis and colleagues (1999) to examine the impact of folate fortification of cereal-grain products in the United States if increased fortification of foods was mandated. A similar approach is illustrated below for the hypothetical addition of vitamin A to fluid milk. For simplicity, this example assumes that only one food will be fortified with vitamin A. As was discussed earlier, this assumption is unlikely to hold when voluntary fortification of foods with vitamin A is permitted.

Addition of Vitamin A to Fluid Milk

Two levels of requirements for vitamin A have been established with different functional endpoints in mind (IOM, 2001). For adult women, the EAR for prevention of functional deficiency of vitamin A is 300 μg retinol activity equivalents (RAE)/day while the EAR to establish and maintain desirable levels of liver vitamin A

stores has been set at 500 μg RAE/day. For adult women 19 to 50 years of age, examination of the 1994–1996 CSFII (USDA/ARS, 1997) data suggests that about 15 percent have intakes below 300 μg RAE/day and hence have intakes apparently inadequate to meet their own functional requirements. The same data suggest that about 44 percent may have intakes inadequate to provide minimal stores of vitamin A. These descriptors of a potential problem may motivate planning interventions to raise vitamin A intakes in this target group, although planners would also obtain other types of data (e.g., biochemical or clinical outcome information such as incidence of night blindness) before proceeding with an intervention.

Suppose that in order to increase vitamin A intake by adult women, a fortification program is considered that adds vitamin A to all fluid milk. In the United States milk is frequently fortified with vitamin A, but it is not required. This example assumes that no fortification is currently taking place.

Based on data from the CSFII (USDA/ARS, 1997), Table 5-6 illustrates the predicted impact of this fortification on the distribution of total vitamin A intake of adult women. Total intake equals reported

TABLE 5-6 Impact of the Addition of Vitamin A to Milk on the Expected Distribution of Total Vitamin A Intake in Women 19–50 Years of Age

Percentile of Intake	Level of Addition of Vitamin A (as Retinyl Ester) to Fluid Milk ($\mu\text{g}/100$ ml)						
	0	50	100	150	200	250	300
1	135	138	140	143	145	147	149
5	225	238	247	253	259	268	276
10	272	287	298	308	319	327	337
25	368	398	421	445	465	484	505
50	542	592	635	670	711	747	787
75	785	872	964	1,083	1,151	1,245	1,333
90	1,150	1,259	1,389	1,549	1,679	1,811	1,954
95	1,390	1,560	1,715	1,915	2,084	2,234	2,411
99	2,026	2,154	2,372	2,573	2,777	3,067	3,325

NOTE: $n = 2,325$ women. In this example, the amount by which vitamin A increases reflects the initial fluid milk consumption of those in the various percentile groups. For example, those in the 1st percentile drink little milk, so their vitamin A intake increases only slightly as the level of addition of vitamin A to milk increases. In contrast, those in the 99th percentile, who drink much more milk, have a much greater increase.

SOURCE: USDA/ARS (1997) as reported in IOM (2001).

intake of vitamin A plus the increase that would come from consuming fortified milk. It is possible to determine the theoretical increase because the CSFII database can be disaggregated to determine the amount of milk consumed by each individual. Thus, the amount of the increase in vitamin A intake will reflect the amount of milk consumed: those women who consume large amounts of fluid milk will increase their intake substantially, while those who consume little or no fluid milk will not increase their intake.

Table 5-7 provides some information on the likely benefits and potential risks of this fortification. Based on the results for adult women, adding vitamin A to fluid milk could be expected to have beneficial impacts by raising intakes without a major concern about possible detrimental effects. That is, as the level of fortification increases, the prevalence of usual intake of vitamin A less than the EAR to prevent night blindness (300 µg RAE) declines from approximately 15 percent at no fortification to approximately 7 percent at a fortification level of 300 µg of retinol/100 mL of milk. The prevalence of usual intake less than the EAR for maintaining stores (500 µg RAE) declines from 44 percent at no fortification to 24

TABLE 5-7 Apparent Benefits and Potential Risks Associated with the Addition of Vitamin A to all Fluid Milk as a Function of Level of Addition, Women 19–50 Years of Age

Level of Addition ^a (µg/100 ml)	Prevalence of Inadequate Intakes ^b (below the EAR)		Prevalence of Potentially Excessive Intakes ^c
	% < EAR (300 µg RAE)	% < EAR (500 µg RAE)	% > UL (3,000 µg)
0 (baseline)	14.6	44.3	0.0
50	12.1	38.9	0.0
100	10.2	35.6	0.1
150	8.8	33.3	0.1
200	8.0	29.9	0.2
250	7.6	28.8	0.3
300	6.9	24.3	0.7

NOTE: *n* = 2,325 women.

^a Added as a retinyl ester.

^b Based on total vitamin A intake as µg of retinol activity equivalents (RAE). EAR = Estimated Average Requirement.

^c Based on preformed vitamin A only. UL = Tolerable Upper Intake Level.

SOURCE: USDA/ARS (1997).

percent at a fortification level of 300 μg of retinol/100 ml of milk. In contrast, as the level of fortification increases, the prevalence of usual intake above the UL increases only slightly from 0 to 0.7 percent. On the basis of this evidence only, the decision to fortify milk with vitamin A would seem a worthwhile endeavor.

Other subgroups, however, may not have the same benefits or risks at that level of vitamin A fortification. Table 5-8 shows the impact of this fortification of fluid milk for boys 9 to 13 years of age. In this case, the prevalence of inadequate vitamin A intake without fortification (at baseline) is lower than for adult women. With fortification, the prevalence of inadequate intakes based on maintaining stores (EAR = 445 μg RAE for this age group) declines from about 11 percent to 3.5 percent. Since there is very little prevalence of inadequate intake of vitamin A based on preventing night blindness (EAR = 230 μg RAE for this age group) without fortification, the addition of more vitamin A to milk would have a negligible effect on prevalence of this criterion of inadequate intake. On the other hand, the potential detrimental effect with fortification is

TABLE 5-8 Apparent Benefits and Potential Risks Associated with the Addition of Vitamin A to all Fluid Milk as a Function of Level of Addition, Boys 9–13 Years of Age

Level of Addition ^a $\mu\text{g}/100\text{ ml}$	Prevalence of Inadequate Intakes ^b (below the EAR)		Prevalence of Potentially Excessive Intakes ^c
	% < EAR (230 μg RAE)	% < EAR (445 μg RAE)	% > UL (1,700 μg)
0 (baseline)	0.5	11.1	0.9
50	0.3	8.2	2.6
100	0.3	7.0	5.9
150	0.3	5.6	12.2
200	0.3	4.5	19.0
250	0.3	4.2	30.0
300	0.3	3.5	37.8

NOTE: $n = 574$ boys.

^a Added as a retinyl ester.

^b Based on total vitamin A intake as μg of retinol activity equivalents (RAE). EAR = Estimated Average Requirement.

^c Based on preformed vitamin A only. UL = Tolerable Upper Intake Level.

SOURCE: USDA/ARS (1997).

high, as shown by increasing percentages with usual intake above the UL as the level of fortification increases. Specifically, with no fortification, the prevalence of usual intakes above the UL for this age group is approximately 1 percent, while at a fortification level of 300 μg of retinol/100 mL of milk, the prevalence of usual intakes above the UL would increase to 38 percent. The reason for these differential impacts for adult women and boys 9 to 13 years of age is that the latter group has a higher initial intake of vitamin A, and an overall higher consumption of the vehicle chosen for fortification—milk.

By combining the analyses for adult women and boys 9 to 13 years of age, the relationship between the potential benefits to women and the potential risks to adolescent boys of fortifying milk at the various levels is demonstrated. Figure 5-1 summarizes the benefits to adult women by the declining percentage with inadequate intake and the increasing potential risk to boys 9 to 13 years of age by the increasing percentage over the UL. Based on these results, planners would have to consider the predicted potential risk to boys 9 to 13 years of age and the predicted benefits to the target group of adult women before reaching a decision on whether to fortify and at what

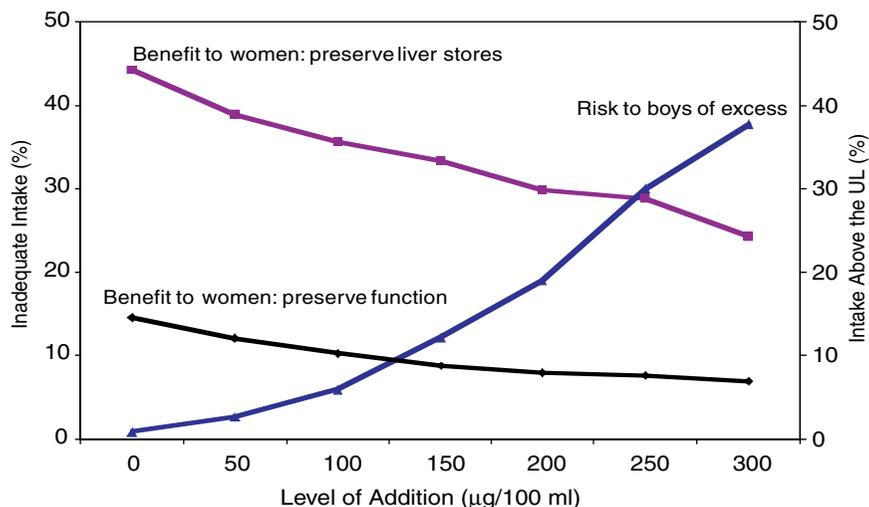


FIGURE 5-1 Projected benefits and potential risk associated with the addition of vitamin A to fluid milk. UL = Tolerable Upper Intake Level.

amount. Of course, this exercise should be repeated for other subgroups of the population before final decisions are made.

When only a few foods are involved in compulsory fortification, regulatory agencies run mock fortification studies (like the vitamin A example above) and weigh the expected benefits and potential risks associated with different levels of fortification. However, with voluntary fortification such as what is currently the practice in the United States, as the number of fortified foods increases, it becomes extremely difficult to run meaningful mock fortification scenarios. In addition, it has not been possible to keep food composition databases current with regard to brand-specific fortified foods, and not all nutrient composition databases in the United States are designed to do so. Food composition databases in the United States used in national surveys usually reflect the average composition of foods that are available in the market, with varieties or brands weighted by general market share. Thus, it is difficult to investigate the effect of voluntary fortification of specific brands of foods unless all brands within a category are fortified. More detailed survey data, as well as more specific food composition tables, are needed for investigation of brand-specific fortification.

Planning Fortification: General Conclusion and Recommendation

The principal conclusion drawn from this fortification application is the importance of examining the potential impacts on all groups—not just on the targeted subgroups that have a higher than desired prevalence of inadequate intakes without fortification. It is recommended that a modeling approach, such as that presented here, be conducted prior to any major introduction of fortification.