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Fortified Foods Are Major Contributors to Nutrient Intakes in Diets of US Children and Adolescents☆

Louise A. Berner, PhD; Debra R. Keast, PhD; Regan L. Bailey, PhD, RD; Johanna T. Dwyer, DSc, RD

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ABSTRACT

Background Even in an era of obesity and dietary excess, numerous shortfall micronutrients have been identified in the diets of US children and adolescents. To help tailor strategies for meeting recommendations, it is important to know what foods contribute greatly to micronutrient intakes. Data are lacking on specific contributions made by added nutrients.

Objective Our aims were to examine the impact of fortification on nutrient adequacy and excess among US children and adolescents and to rank food sources of added nutrient intake and compare rankings with those based on total nutrient intake from foods.

Design and statistical analyses Data were from 7,250 respondents 2 to 18 years old in the National Health and Nutrition Examination Survey 2003-2006. Datasets were developed that distinguished nutrient sources: intrinsic nutrients in foods; added nutrients in foods; foods (intrinsic plus added nutrients); and total diet (foods plus supplements). The National Cancer Institute method was used to determine usual intakes of micronutrients by source. The impact of fortification on the percentages of children having intakes less than the Estimated Average Requirement and more than the Upper Tolerable Intake Level was assessed by comparing intakes from intrinsic nutrients to intakes from intrinsic plus added nutrients. Specific food sources of micronutrients were determined as sample-weighted mean intakes of total and added nutrients contributed from 56 food groupings. The percentage of intake from each grouping was determined separately for total and added nutrients.

Results Without added nutrients, a high percentage of all children/adolescents had inadequate intakes of numerous micronutrients, with the greatest inadequacy among older girls. Fortification reduced the percentage less than the Estimated Average Requirement for many, although not all, micronutrients without resulting in excessive intakes. Data demonstrated the powerful influence of fortification on food-source rankings.

Conclusions Knowledge about nutrient intakes and sources can help put dietary advice into a practical context. Continued monitoring of top food sources of nutrients and nutrient contributions from fortification will be important.
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EVEN IN THE CONTEXT OF EPIDEMIC OBESITY AND dietary excess, numerous shortfall micronutrients have been identified in American diets, including some vitamins and minerals of particular concern for children and adolescents.[1] To help tailor strategies for meeting nutrient recommendations, it is valuable to know what specific foods contribute greatly to micronutrient intakes. Important sources of nutrients in American diets are not necessarily foods that are intrinsically nutrient rich; nutrients can also come from dietary supplements or from foods that are frequently consumed and/or fortified.[2,3]

Fortification (this term is used generically throughout this article to refer to any addition of nutrients to foods) is one potential means of addressing micronutrient shortfalls. In fact, micronutrients have been added to fortify foods in the United States for more than half a century, and the practice played a major role in virtually eliminating classical nutrient-deficiency diseases, such as rickets and pellagra.[4] At the present time, some fortification is carried out in accordance with specific requirements of the US Food and Drug Administration, such as standards of identity for enriched grain foods or addition of vitamin A to reduced-fat milk to meet nutritional equivalency of whole milk, and other fortification has been termed *discretionary*[5] because it is done voluntarily

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and at the discretion of food manufacturers (although, of course, within technological, regulatory, and other constraints). Despite its historical success, fortification has come under scrutiny because of concerns that it could lead to overconsumption of nutrients.[4,5] However, although fortification has undoubtedly increased vitamin and mineral intakes in the United States,[4,6] data are lacking on the specific contributions made by fortification of foods with micronutrients[5] other than folic acid.[7,8]

To ascertain the effects of fortification on children's dietary quality, it is essential to examine the specific sources of nutrients as well as the overall levels of nutrient intake. Subar and colleagues determined which food sources contributed the highest amounts of nutrients to diets of US children in 1989-1991.[2] Although they concluded that fortified foods, especially ready-to-eat (RTE) cereals, made large contributions to intakes of many nutrients,[2] the amounts contributed by added nutrients contained in fortified foods were not specifically examined. There has been a lack of information about the impact of fortification on nutrient adequacy and excess among children in the United States, and what foods are making the largest contributions to intakes of added nutrients.

Recently, Fulgoni and colleagues[9] quantified nutrient intakes contributed from naturally occurring and added nutrients contained in foods consumed by Americans 2 years of age and older, using data from the National Health and Nutrition Examination Survey (NHANES) 2003-2006. Fortification contributed greatly to intakes of many micronutrients, reducing the percentage of the population having intakes below the Estimated Average Requirement (EAR) without adding appreciably to the percentage having intakes above the Upper Tolerable Intake Level (UL).[9] Fulgoni and colleagues' analysis reported data only for children aged 2 to 18 years as a group,[9] yet food-consumption patterns might differ greatly by age and sex. Therefore, one goal of this report was to quantify the impact of fortification by age and sex subgroups of children.

Another goal of this report was to determine the food sources of added nutrient intake, to rank them, and to compare these rankings of added nutrient sources with rankings based on total (both intrinsic and added) nutrient intake from foods consumed by children and adolescents.

METHODS

Study Population

The 2003-2004 and 2005-2006 What We Eat in America dietary intake components and dietary supplement data from NHANES, a continuous nationally representative population-based survey, were combined for this study. Details of NHANES study design, implementation, datasets, analytic considerations, and other documentation are available online.[10,11] The analytic sample included participants aged 2 to 18 years having complete, reliable 24-hour dietary recall data, and excluded pregnant and/or lactating females. As described in online documentation,[10,11] in-person health examinations, which included a 24-hour dietary recall, were completed at the Mobile Examination Center, and a second 24-hour recall was collected via telephone 3 to 10 days later. Parents/guardians of children aged 2 to 5 years provided the dietary recalls and children aged 6 to 11 years were assisted by an adult. All participants or proxies provided written informed consent and the Research Ethics Review Board at the National Center for Health Statistics approved the survey protocol.[12]

Nutrient Sources in Foods and Nutrient Intakes

The sources of nutrients added by enrichment or fortification were separated from naturally occurring (intrinsic) nutrients in foods eaten by NHANES participants. Enrichment was defined as the addition of thiamin, niacin, riboflavin, folic acid, and iron to refined grain foods/ingredients as determined by US Food and Drug Administration standards of identity for enriched cereal grain products, and fortification included nutrient additions to all other foods (such as breakfast cereals, granola bars, juice drinks, and milk). The underlying databases and strategies used to develop the nutrient sources food composition data are described in detail elsewhere.[9] Briefly, this was a data-based approach that used databases, such as the US Department of Agriculture (USDA) Food and Nutrient Database for Dietary Studies, versions 2.0 and 3.0[13,14]; the USDA Standard Reference datasets, versions 18 and 20[15,16]; and the USDA MyPyramid Equivalent Database, version 2.0.[17] Added nutrients in foods were identified using different strategies, depending on the nutrient and food. For example, added folic acid, vitamin E, and vitamin B-12 data are readily available in the Standard Reference. Besides folic acid, amounts of other nutrients added during grain enrichment (thiamin, riboflavin, niacin, and iron) were determined by calculating the difference between nutrient content of enriched and unenriched versions of grain foods/ingredients in the Standard Reference. A similar approach was taken for foods such as juices, where nutrient composition data were available for comparable fortified and unfortified versions of the food. As another example, amounts of intrinsic nutrients contained in manufactured fortified foods, such as RTE cereals, were first calculated by applying representative nutrient data to food compositional data available from the MyPyramid Equivalent Database, and then added nutrients were calculated as the difference between total nutrient content and estimated intrinsic nutrient content of the food. Additional details of the approaches used have been published previously.[9]

Also, as described previously,[9] nutrient intakes from food sources and dietary supplements were determined using 2 days of 24-hour dietary recall data, along with dietary supplement questionnaire data. Components of the dataset included the intake per day of total nutrients (from both food and dietary supplements), nutrients from food (both intrinsic and added), and nutrients added to food. Sample-weighted mean intake of each nutrient and percentages of total nutrient intake contributed from each source were determined using day 1 recall data because the mean is an unbiased estimate of the group's usual mean nutrient intake.[18]

The appropriate way to estimate nutrient intake inadequacy in a population is to determine the percentage of the group with usual intake below the Estimated Average Requirement (%<EAR), and possible excessive intakes are best estimated as the percentage of the group with usual intake above the Upper Tolerable Level (%>UL).[19] The National Cancer Institute method,[20,21] applied to the 2 days of dietary intake data, was used to determine usual nutrient intakes as described elsewhere.[9] The %<EAR was determined

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