Should calcium and vitamin D be added to the current enrichment program for cereal-grain products?\textsuperscript{1,2}

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ABSTRACT
Mean dietary intakes of calcium and vitamin D in the US adult population are far below the adequate intake (AI) values recommended by the Food and Nutrition Board, Institute of Medicine of the National Academy of Sciences, and thus substantial segments of the American population have inadequate intakes and elevated risks of osteoporosis and colon cancer. The current Code of Federal Regulations, Title 21, sets standards for the optional addition of moderate amounts of calcium and vitamin D in the enrichment of cereal-grain products, a provision that is essentially not used. We propose that the addition of calcium and vitamin D to currently enriched cereal-grain products be mandated in the United States: this would result in an increase in mean daily dietary intakes in the United States of \textasciitilde 400 mg Ca and \textasciitilde 50 IU (or possibly \textasciitilde 200 IU) vitamin D. The benefits would be a significant reduction in the incidences of osteoporosis and colon cancer over time and overall improvement in health, with little risk and a modest financial cost because of the ability to capitalize on existing technology. We suggest a full scientific review of cereal-grain enrichment with calcium and vitamin D. \textit{Am J Clin Nutr} 2004;80:264–70.

KEY WORDS
Cereal-grain product enrichment, calcium, vitamin D, osteoporosis, colon cancer

The Standing Committee on the Scientific Evaluation of Dietary Reference Intakes (DRIs), Food and Nutrition Board, Institute of Medicine (National Academy of Science), has established standards of adequate intake (AI) for dietary calcium and vitamin D for various age groups (1). The concept and definition of AI, as described by the Committee (1), is as follows:

AI, (Adequate Intake): observed or experimentally derived intake by a defined population or subgroup that, in the judgment of the DRI Committee, appears to sustain a defined nutritional state, such as normal circulating nutrient values, growth, or other functional indicators of health.

Comparison of the recommended intakes with actual intakes of calcium and vitamin D in the US population indicates inadequate intakes of both of these nutrients in large segments of the population, as discussed briefly below.

For calcium, the gap between the AI or recommended intake and the actual mean intake from the 1994 Continuing Survey of Food Intake by Individuals is shown in Figure 1 (2). After age 10 y, the data indicate that the mean intake of calcium does not achieve the recommended values for either females or males. After age 50 y, the mean intakes of calcium in females and males are only \textasciitilde 600 and \textasciitilde 700 mg/d, respectively, and the combined mean intake is only slightly over one-half of the recommended intake. Given normal population variability from the mean, the data indicate that large segments of the US population have inadequate dietary calcium intake.

Vitamin D is largely supplied by synthesis in the skin with sunlight exposure, and this synthesis may be adequate in white-skinned people who are active outdoors, especially in southern states. Older, less active people, especially those with heavily pigmented skin, are more prone to have vitamin D inadequacy. Thomas et al (3) showed that more than one-half the patients admitted to the Massachusetts General Hospital for general medical and surgical conditions had serum 25-hydroxyvitamin D\textsubscript{3} concentrations that were below the laboratory reference value. A recent publication from a group at the Centers for Disease Control and Prevention in Atlanta indicated a high prevalence of hypovitaminosis D in African American women (\textasciitilde 40\%) and a lower prevalence in white women (\textasciitilde 4\%) (4). The study was based on data from the third National Health and Nutrition Examination Survey (NHANES III), which measured circulating 25-hydroxyvitamin D\textsubscript{3} concentrations and used rather conservative criteria for assessment of vitamin D status. An increased lower reference limit, as suggested by newer data (5–7), would substantially increase the estimate of the prevalence of vitamin D insufficiency. In a recent editorial, Holick (8) points out that very few foods contain significant amounts of naturally occurring vitamin D and that the incidence of hypovitaminosis D in males would likely be...

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similar to that found in females. Sunlight skin exposure, a significant source of human vitamin D, is essentially lacking in the winter in the northern United States, and it has long been known that body stores of vitamin D from summer skin exposure may be inadequate by the end of the winter. Tangpricha et al (9) recently reported on a study in Boston that indicated that >30% of young adults aged 18–29 y were vitamin D insufficient at the end of the winter. A conference in October 2003 that was organized by the US National Institutes of Health found an “alarming prevalence of low circulating levels of Vitamin D,” with an apparent resurgence of rickets in the United States (10).

The role of an AI of calcium in reducing the risk of diseases such as osteoporosis and colon cancer has been reviewed extensively elsewhere (2, 11–14), and it is not our intent to recapitulate that body of evidence. Instead, we cite only enough examples to illustrate the magnitude of the effect and to underscore the urgency of making the policy changes that we recommend below.

Osteoporosis is generally characterized by a progressive diminution of bone mass, which causes skeletal weakness. Bone formation and bone resorption are normally closely coupled in a balanced and continuous process. In the development of osteoporosis, however, the net rate of bone resorption exceeds the rate of bone formation, which brings about the characteristic decrease in bone mass. One of the principal contributors to this imbalance is low dietary calcium intake. Bone resorption varies inversely with absorbed calcium intake (2, 15). Put simply, the bony reserves compensate for what is lacking in the diet. In women this decrease in bone mass is precipitous at menopause because of the effect of the decrease in estrogen on calcium conservation. Furthermore, at ages ≥60 y, bone-forming osteoblast activity decreases in both men and women. A significant protective factor is adequate dietary calcium intake during the period of maximum growth (ages ≈9–25 y), so that proper peak bone mass is achieved by age 20–30 y and maintained until mid-life, with only slow bone loss in the following years. Continued adequate dietary calcium intake after age 30 y is also a factor in the reduction of osteoporosis risk (2). As already noted, dietary surveys indicate a significant gap between the recommended calcium intake and the actual intake in the United States in the critical years of adolescence and young adulthood and later in life. This is particularly true for women of all ages after childhood (see Figure 1).

The risk of colon cancer has also been related to inadequate dietary calcium intake by both early epidemiologic studies (16, 17) and animal studies (11–14). In addition, several large-scale, recent studies in humans indicate a role for increased dietary calcium in reducing colon cancer risk, as briefly discussed below.

In a blinded, placebo-controlled clinical study of >800 subjects, Baron et al (18) found a modest but significant reduction (≈20%) in the recurrence of sporadic adenomatous colon polyps after 4 y of calcium supplementation (1200 mg Ca as calcium carbonate/d). Sporadic adenomatous polyps are currently considered a reliable indicator of colon cancer risk.

An observational study by Wu et al (19) reported the findings from 2 large-scale, prospective studies in the United States: in almost 88 000 women (Nurses’ Health Study) and >47 000 men (Health Professionals Follow-up Study), higher calcium intake was associated with a significant reduction in the risk of distal colon cancer but not of proximal colon cancer. The authors found that, compared with subjects with a calcium intake ≤ 500 mg/d, those with an intake ≥ 700–800 mg/d had a 40–50% lower risk of distal colon cancer. The authors also cite the results of other studies that indicate a potential protective effect of moderately higher dietary calcium intake primarily against distal colon cancer. In the United States today, colon cancer cases in the left-sided or distal colon [descending or sigmoid colon as described by Wu et al (19)] constitute about two-thirds of all colon cancer cases (20). Thus, on the basis of the study by Wu et al (19), the net total reduction in colon cancer by higher dietary calcium intake can be estimated at ≈30% (ie, a 40–50% reduction of two-thirds of all colon cancer cases). From the data, the authors suggest that “even a modest increase in calcium intake may confer protection against distal colon cancer among those with low intakes” (19). The authors conclude that, “considering the public health importance of colon cancer, even a modest protective effect of higher dietary calcium intake on colon cancer could result in the prevention of a large number of colon cancer cases” (19). In a large-scale, observational prospective study of >61 000 women in Sweden who were followed for an average time of ≈11 y, Terry et al (21) reported on the association between dietary calcium intake and the development of colorectal cancer. An inverse association was found: compared with women in the lowest intake quartile (median intake of 486 mg/d), those in the highest intake quartile (median intake of 914 mg/d) had a relative risk (RR) of colon cancer of 0.72 (P for trend = 0.02). Terry et al (21) also indicated that “the inverse association may be strongest in relation to distal cancers and among older women.” The results suggest a total reduction in colon cancer risk of ≈28%, which is similar to the ≈30% reduction calculated from the data of Wu et al (19). In a 5-y, observational prospective study of >60 000 men and >66 000 women in the Cancer Prevention Study II Nutrition Cohort (United States), McCullough et al (22) found that, compared with men and women in the lowest quintile of total calcium intake from diet plus supplements, those in the highest quintile had a marginally lower colorectal cancer risk (RR = 0.87; P for trend = 0.02). The association between calcium intake and colorectal cancer risk was even stronger for calcium from dietary supplements only: compared with subjects with no intake of calcium from dietary supplements, those with an intake ≥ 500 mg/d had an RR of 0.69 (95% CI: 0.49, 0.96). Supplementation of the diet with ≥500 mg Ca/d suggests an ≈30% total reduction in colon cancer risk, which is similar to both the reduction
calculated from the data of Wu et al (19) and the reduction found by Terry et al (21).

At present in the United States, the incidence of colon and rectal cancer cases is \( \approx 147,000/y \), with \( \approx 57,000 \) deaths annually (23). Although a precise dose-response estimate of dietary calcium intake in colon cancer prevention is not currently known, from the data of the large studies described above (18, 19, 21, 22), we suggest that a modest increase of \( \approx 400 \) mg Ca in the daily diet may thus reduce both the incidence of and the death rate from colon cancer by \( \approx 20\% \), which would possibly save \( \approx 11,000 \) lives and prevent \( \approx 29,000 \) cases annually. Cases of colon and rectum cancer represent slightly \( >10\% \) of all cancer cases in the United States (23). The National Institutes of Health estimates that overall direct medical costs (total of health expenditures) for cancer in 2002 were \$60.9 billion (23). With cases of colon and rectum cancer constituting \( \approx 10\% \) of total cancer cases, it is reasonable to estimate that the direct medical costs associated with colon and rectum cancer were \( \approx \$6 \) billion in 2002. A reduction of 20\% of these cancer cases, which we estimate would occur as a result of increasing the current dietary intake of calcium (and vitamin D), could result in a reduction of these direct health costs by \( >\$1 \) billion/y.

The best-recognized biological function of vitamin D in humans is to maintain serum calcium and phosphorus concentrations within the normal range by enhancing the efficiency of absorption of these minerals from the diet (1). On this basic understanding, the systemic biological efficacy of calcium from an adequate dietary intake also depends on adequate vitamin D availability.

The nutrient interdependence of calcium and vitamin D is directly applicable to osteoporosis (24). Two principal controlled trials (25, 26) showed a 40–55\% reduction in nonvertebral fracture rates that began immediately after supplementation with higher daily intakes of calcium and vitamin D was started, and that continued for a moderate time period (3 y). Data for spine fracture prevention are sparse. Thus, as an estimate of the effect of a moderate increase in calcium and vitamin D in the diet, we use a conservative figure of only a 20\% reduction, or 300,000 fewer fractures/y in the United States (from an estimated current annual total of 1.5 million).

Only a few human studies have reported on the effects of vitamin D by itself on colon cancer. Martinez et al (27) found a suggestion of an inverse association between total vitamin D intake and the risk of colorectal cancer in a prospective study of \( >88 \) 000 women (Nurses’ Health Study). The study was aided by the unusually wide range of total vitamin D intake in their quintiles (<92 to \( >477 \) IU/d), possibly from the multivitamin supplements used by this health-conscious study group. In the analogous study of Swedish women (21), no effect of vitamin D on colon cancer risk was found, but the reported intake of vitamin D was fairly low (=130 IU/d) and generally uniform. In a prospective study of \( >1900 \) men in Chicago over a 19-y period, Garland et al (16) found a significant inverse relation between dietary intake of vitamin D and colon cancer (\( P \) for trend \(<0.05 \)). In a later, small study in Maryland, they found a significant inverse relation between colon cancer and vitamin D assessed by measuring serum 25-hydroxyvitamin D concentrations in stored blood samples (\( P < 0.05 \)) (17). In a 5-y, observational prospective study of \( >126,000 \) men and women in the Cancer Prevention Study II Nutrition Cohort (United States), McCullough et al (22) also found an inverse association between vitamin D intake (from diet and supplements) and the risk of colorectal cancer. The association between vitamin D intake and the risk of colorectal cancer was particularly strong among men (\( RR = 0.71; 95\% CI: 0.51, 0.98; P \) for trend = 0.02).

Thus, it appears desirable to increase both the dietary intake of calcium from food and the availability of vitamin D from the combined sources of sun exposure and diet toward the recommended values (1). However, because of the perceived risk of skin cancer, etc, incurred with an increase in sun exposure, an increased dietary intake of vitamin D, such as that obtained by moderate, well-dispersed, low-level enrichment of broadly consumed foods, may be preferable. The use of pharmaceutical-type dietary supplements such as multivitamins, minerals, etc, could also accomplish the desired increases in calcium and vitamin D intakes. However, this route has many pitfalls and disadvantages: the relatively high cost of manufacture and distribution, large-scale education to ensure proper intake, risk of overdosing, etc. An alternative would be the utilization of the existing and proven food-enrichment program, which has long been used in the United States to reduce nutrient deficiencies and their associated diseases. Modifying the enrichment program to include calcium and vitamin D would have low material cost, insignificant risk of overdosing, wide population distribution, and ready affordability for low-income groups, with no requirement for individual motivation and adherence to a supplement-dosing regimen.

In the United States, enrichment of certain cereal-derived products with low amounts of essential nutrients has been practiced for \( >60 \) y. In the early years, thiamine, riboflavin, niacin, and iron were added in defined amounts to flour, bread and rolls, corn grits and corn flour, farina, rice, and macaroni and noodle products (28, 29). As of 1 January 1998, all enriched cereal grains (eg, enriched bread, pasta, flour, breakfast cereal, and rice) are also required to be fortified with folate at 1.4 mg/kg grain (30). The qualitative and quantitative specific fortifications of these foods are governed by Federal law and are incorporated into the Code of Federal Regulations, Title 21. The details of specific regulations and standards of identity for these cereal-grain products are found in the current Code of Federal Regulations, Title 21, Sections 136, 137, and 139 (also see reference 29, particularly Chapter 20, pages 535–87, by AJ Iannerone).

Enrichment of these food products has been credited with notable success in reducing some diseases in the United States and Canada (28, 29). An example of the effect of cereal enrichment with niacin in eliminating \( =3000 \) deaths/y from pellagra in the United States is shown in Figure 2, as presented by Miller (31). The data indicate a rapid decrease in pellagra deaths during the early, voluntary, experimental years (1938–1942), which was followed by a continuing decrease when mandatory enrichment began in 1943 (28, 29). A recent report indicated that folic acid enrichment of cereal-grain products, which was instituted in 1996–1997 to reduce neural tube defects in infants (30), also produced a benign, unintended consequence of a 60\% reduction in neuroblastoma, the most prevalent extracranial solid tumor in children younger than 5 y (32). The results of this study, by the Pediatric Oncology Group of the Province of Ontario, Canada, probably represent the first significant reduction in cancer incidence due to simple nutrient enrichment of cereal-grain products.

An opportunity exists within the framework of the existing US Code of Federal Regulations, Title 21, Sections 136, 137, and
139, which currently permits the optional addition of modest amounts of calcium and vitamin D to products of cereal-grain origin when they are enriched with the 5 current mandatory nutrients (thiamine, riboflavin, niacin, iron, and folate). The parts of the existing specific paragraphs that relate to enrichment (fortification) of these products with calcium and vitamin D are shown in Table 1.

The potential effect on the US diet of the mandatory addition of currently allowable amounts of calcium or vitamin D to cereal-grain products (Table 1) can be roughly estimated. Estimates of increased calcium and vitamin D intake can be made on the assumptions that calcium and vitamin D are currently omitted in all cereal-grain products, except self-rising flour (Table 1), and that mandatory enrichment would be practiced on all the products listed, and in the amounts listed, in the current Code of Federal Regulations, Title 21 (Table 1), except rice, for which enrichment poses unsolved technological problems. Data on year 2000 per capita annual consumption of cereal products are from the US Department of Agriculture, Economic Research Service (33). In Table 2, the total proposed additions of calcium and vitamin D to the average US daily diet are estimated at around 400 mg (350–450 mg) and 50 IU (30–70 IU), respectively, if the additions described in Table 1 were to become mandatory. (Note that the estimates of increased calcium and vitamin D intakes in Table 2 are based on using the middle value of the range of permissible additions listed in Table 1.) Park and Calvo (34) of the US Food and Drug Administration estimated in 1995 that mandatory calcium fortification of cereal-grain products would increase calcium intakes by 10–20% of the recommended dietary allowance, a significant increase for most persons whose intake is inadequate.

### Table 1

Selected parts of the US Code of Federal Regulations (2001), Title 21, Sections 136, 137, and 139, that relate to calcium and vitamin D.

<table>
<thead>
<tr>
<th>Section and paragraph nos.</th>
<th>Title</th>
<th>Statement on calcium</th>
<th>Statement on vitamin D</th>
</tr>
</thead>
<tbody>
<tr>
<td>136. 115</td>
<td>Enriched bread, rolls, and buns</td>
<td>May contain 600 mg Ca/lb</td>
<td>—</td>
</tr>
<tr>
<td>137. 165</td>
<td>Enriched flour</td>
<td>May contain 960 mg Ca/lb</td>
<td>—</td>
</tr>
<tr>
<td>137. 185</td>
<td>Enriched self-rising flour</td>
<td>Will contain 960 mg Ca/lb</td>
<td>—</td>
</tr>
<tr>
<td>137. 260</td>
<td>Enriched corn meals</td>
<td>May contain 500–750 mg Ca/lb</td>
<td>May contain 250–1000 IU vitamin D/lb</td>
</tr>
<tr>
<td>137. 305</td>
<td>Enriched farina</td>
<td>May contain ≥500 mg Ca/lb</td>
<td>May contain ≥250 IU vitamin D/lb</td>
</tr>
<tr>
<td>137. 350</td>
<td>Enriched rice</td>
<td>May contain 500–1000 mg Ca/lb</td>
<td>May contain 250–1000 IU vitamin D/lb</td>
</tr>
<tr>
<td>137. 115</td>
<td>Enriched macaroni products</td>
<td>May contain 500–625 mg Ca/lb</td>
<td>May contain 250–1000 IU vitamin D/lb</td>
</tr>
<tr>
<td>139. 117</td>
<td>Enriched macaroni products with fortified protein</td>
<td>May contain 625 mg Ca/lb</td>
<td>—</td>
</tr>
<tr>
<td>139. 135</td>
<td>Enriched vegetable products</td>
<td>May contain 500–625 mg Ca/lb</td>
<td>May contain 250–1000 IU vitamin D/lb</td>
</tr>
<tr>
<td>139. 155</td>
<td>Enriched noodle products</td>
<td>May contain 500–625 mg Ca/lb</td>
<td>May contain 250–1000 IU vitamin D/lb</td>
</tr>
</tbody>
</table>

\(^{1}\) 1 lb = 0.45 kg.
Mandatory calcium enrichment of cereal-grain products that resulted in the addition of 400 mg Ca to the daily diet could fill a good part of the gap between actual dietary intakes and the recommended intake in the United States, as shown in Figure 1, especially in women. Approximately one-fourth of daily caloric intake in the United States is from cereal-grain products, and the intake of cereal-grain products does not vary greatly by income or geographic region (28, 29, 35). Thus, cereal-grain product enrichment represents a proven vehicle for the addition of nutrients to enhance the health of the general population. Responding to evidence of a potential risk of nutrient inadequacy for a series of nutrients, including dietary calcium, the Food and Nutrition Board of the National Research Council proposed, as long ago as 1974, to enlarge the program of cereal-grain enrichment from the then current 4 nutrients to 10 nutrients, where technically feasible (36). An industrial development program indicated that the addition of all 10 items was readily feasible with small technical modifications, with the exception of white rice, for which, because of the color of riboflavin and the mass of calcium, enrichment required further technological advances (29, 35, 37). Therefore, we have omitted rice from consideration as an enrichment vehicle in Table 2.

The health risks of the mandatory addition of calcium and vitamin D to the currently enriched cereal-grain products shown in Table 1 appear to be negligible. The Food and Nutrition Board, Institute of Medicine of the National Academy of Sciences has established a tolerable upper intake level (UL) (1) for daily caloric intake in the United States is from cereal-grain products, and the intake of cereal-grain products does not vary greatly by income or geographic region (28, 29, 35). Thus, cereal-grain product enrichment represents a proven vehicle for the addition of nutrients to enhance the health of the general population. Responding to evidence of a potential risk of nutrient inadequacy for a series of nutrients, including dietary calcium, the Food and Nutrition Board of the National Research Council proposed, as long ago as 1974, to enlarge the program of cereal-grain enrichment from the then current 4 nutrients to 10 nutrients, where technically feasible (36). An industrial development program indicated that the addition of all 10 items was readily feasible with small technical modifications, with the exception of white rice, for which, because of the color of riboflavin and the mass of calcium, enrichment required further technological advances (29, 35, 37). Therefore, we have omitted rice from consideration as an enrichment vehicle in Table 2.

The financial cost of the mandatory fortification of cereal-grain products with the optional amounts described in Table 1 is not high, especially when compared with the potential benefits of reduced risks of osteoporosis and colon cancer and the overall health benefits from moving the general population safely toward a better dietary intake. The total annual financial cost can be estimated as follows. Commercially available, stabilized, dry-powder forms of vitamin D₃ that are suitable for enrichment and contain 100 000 IU vitamin D₃/g (10⁴ IU/kg) are currently available at ≈$30/kg [L Johnson (Roche Vitamins Inc, Parsippany, NJ), personal communication, 2003]. To supply ≈50 IU vitamin D₃ · person⁻¹ · d⁻¹ to almost 300 million people in the United States by using products that are currently approved (Table 2) would require ≈10¹⁴ IU annually, which would cost ≈$1.5 million/y, or ≈0.5 cents · person⁻¹ · y⁻¹. Note that this cost could rise to almost 4 cents · person⁻¹ · y⁻¹ if vitamin D is also added to wheat products (flour, bread, rolls, buns, and enriched flour) as suggested below.

We have chosen milled-grade calcium carbonate, which is used for farm animal feeds and some human foods, as a representative agent for estimating the cost of enrichment. Its price is currently ≈7 cents/lb (≈15.6 cents/kg; J Elliott (Roche Vitamins Inc), personal communication, 2003). To supply ≈400 mg Ca ·
person⁻¹ · d⁻¹ to 300 million people in the United States would require \(=44 \times 10^6 \) kg Ca/y and would cost \(=17 \) million/y, or \(=6\) cents · person⁻¹ · y⁻¹. Thus, the combined cost of enrichment with vitamin D₃ and calcium (as calcium carbonate) comes to \(=19\) million/y, or \(<7\) cents · person⁻¹ · y⁻¹.

A comparison between costs and benefits in economic terms for the United States can be approximated as follows. The cost for ingredients is estimated at \$19 million/y, which is equivalent to \(<7\) cents · person⁻¹ · y⁻¹ in a US population of \(=300\) million people. The processing cost is difficult to estimate precisely, but both calcium sources and stabilized vitamin D have been added to flour and other carriers as parts of enrichment programs of the US Agency for International Development, US State Department, for many years with no difficulty or significant cost additions (S Kahn, US Agency for International Development, personal communication, 2003). Many foreign countries include calcium in the list of nutrient ingredients added to wheat flour (see Table 91-5 in reference 28).

The potential benefits of this modest increase in calcium in the US daily diet would partially, but not completely, bridge the larger gap between the DRI for calcium (1) and actual dietary intakes, as shown in Figure 1. This could result in a significant reduction in the incidence of osteoporotic fractures. The 2 principal controlled trials of this topic (25, 26) showed a 40–55% reduction in nonvertebral fracture rates beginning immediately after supplementation with calcium and vitamin D was started. However, these studies used higher amounts of supplemental dietary calcium and vitamin D than we propose for cereal-grain enrichment. Thus, we take as a conservative estimate only a 20% reduction, or 300 000 fewer fractures/y in the United States (from an estimated current annual total of 1.5 million), for an annual savings of over \$2 billion. The reduced incidence and mortality rate of colon cancer that would be obtained with this modest increase in calcium intake (a reduction of \(=20\%\), or a possible reduction of \(=11\) 000 colon cancer deaths/y and \(=27\) 000 cases/y) would represent a cost savings of \(>\$1\) billion in annual medical treatment costs.

We believe that the time has come for a full scientific review of cereal-grain enrichment with calcium and vitamin D as a low-cost, safe, and useful route for the reduction of osteoporosis and colon cancer in the United States in both men and women. This effort should include representatives of academic, technological, industrial, and regulatory (US Food and Drug Administration) interests, and the participants in this effort should review and recommend a practical course of action.

In addition, such a scientific review should consider some minor changes to the existing regulations. An example is eliminating the omission of vitamin D enrichment of wheat products (wheat flour, self-rising flour, bread, rolls, and buns) shown in Table 1. We estimate that the addition of vitamin D to wheat products, in similar fashion to that of other products in Table 1 and in amounts in the middle of the current optimal range as for the permitted products listed in Table 2, would add \(>200\) IU vitamin D to daily dietary intake in the United States. Thus, including vitamin D in the enrichment of wheat products would add considerably to total dietary vitamin D intake in the United States and undoubtedly help to eliminate current low intakes of vitamin D from all sources in the United States (10). Increased vitamin D intake should have a measurable effect over time on osteoporosis and colon cancer, especially in Northern states and in dark-skinned groups such as African Americans. Another example of a needed minor change to the existing regulations is reducing the range of enrichment with vitamin D for several of the food items (Table 1).

In summary, we propose that calcium and vitamin D enrichment no longer be optional and that these nutrients be added to currently enriched cereal-grain products in the United States. The US Code of Federal Regulations, Title 21, prescribes the present enrichment of these products with 5 nutrients on a mandatory basis and with calcium and vitamin D on an optional basis. If the addition of calcium and vitamin D became mandatory (except for rice) in the currently prescribed optional amounts, we estimate that \(=400\) mg (350–450 mg) Ca/person and \(=50\) IU (30–70 IU) per person would be added to the mean daily diet of persons in the United States. The benefits would be a significant reduction in the incidences of osteoporosis and colon cancer over time and an overall improvement in health at a modest financial cost and with minor modification of existing technology.

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