Will fortification of staple foods make a difference to the dietary intake of South African children?

Abstract

Objectives: To evaluate the estimated dietary intake of children at population level who consume fortified staple foods.

Methods: In this study, a secondary data analysis of the database of the National Food Consumption Survey (NFCS) 1999 on dietary data of a nationally representative sample of children (n = 2 200) in South Africa was performed. Prior to 2003 there was no mandatory fortification of staple foods, with the exception of iodine added to salt. Mandatory fortification of maize and wheat flour was introduced in October 2003. Micronutrient values of fortified wheat and maize food sources were determined by chemical analyses of these foods. These values were then interpolated in the original staple food nutrient analysis determined in the primary analysis of the NFCS database.

Findings: The findings of the present study indicated that the addition of micronutrients to staple foods made a significant difference to the intake of vitamin A, thiamine, niacin, vitamin B6, folic acid and iron. These improvements were particularly important in rural areas where children have the lowest mean dietary micronutrient intake.

Conclusions: Based on the results of the secondary data analysis of the national dietary data together with the chemical analyses of fortified foods, it would appear that fortification of two of the most commonly eaten staple foods in the country will significantly improve the micronutrient intake of children under nine years of age and will improve the overall micronutrient density of their diets. It is recommended that appropriate educational messages on the fortification of staple foods in the country should be utilised to improve children’s dietary intake at population level, provided such messages facilitate the consumption of the fortified staples by children.

Introduction

A number of dietary surveys have been undertaken in South Africa, both before and after democratisation in 1994.1, 2 These studies have repeatedly shown, albeit to differing extent, that certain nutritional disorders are rife and that young children are particularly vulnerable to nutritional insults. In brief, the most common dietary inadequacies documented include a low energy intake resulting in a high prevalence of stunting4 (national level = 21.6%); a low fat intake7 particularly of essential fatty acids; and an inadequate intake of specific micronutrients (iron and vitamin A7 [also shown biochemically] calcium, zinc, vitamin C, niacin, folic acid, vitamin B6 and riboflavin).1, 4 Such dietary deficits have always appeared to occur with a higher frequency in rural areas.9

In 1999, the first National Food Consumption Survey (NFCS) was undertaken in South Africa on one- to nine-year-old children.4 One of the main objectives of this study was to determine, on a population basis, the nutrients that were most commonly deficient in these children’s diets, and secondly to identify the most commonly consumed foods by children at both pre- and early school level. The NFCS confirmed at the national level the findings of earlier isolated dietary studies, namely that the dietary intake of calcium, iron, zinc, vitamins A, D, C and E, riboflavin, niacin, vitamin B6 and folic acid were below two-thirds of the Recommended Dietary Allowances (RDAs) used at that time.10 The reason for such dietary inadequacies4 was attributed to the monotonous nature of the diet. In this regard, the most commonly consumed foods identified by the NFCS were maize, sugar, tea, and bread, which are known, on their own, to be inadequate sources of micronutrients to meet daily requirements. The two most commonly used staple foods identified by the NFCS were maize meal and bread.11

A number of options are available to health policy makers when making decisions regarding the improvement of the dietary intake of children at a national level. In the short term, such decisions have included supplementation with either oral supplements such as iron and vitamin A12 or the provision of enriched complementary foods or beverages such as milk powder, and staple foods rich in energy.13, 14 School feeding has also been a favoured method to reach older children.15, 16 Longer-term recommended solutions include dietary diversification and fortification of food.17 Fortification of staple foods with selected micronutrients is an option that has been introduced in many developed and developing countries with varying degrees of success.18, 19 However, food fortification benefits the target population effectively only if the correct foods are fortified and in the appropriate doses. In South Africa, school feeding20 and vitamin A supplementation21 have been used for some years with varying degrees of success. However, targeting of the needy segments of the population has remained rather elusive. Hence the Department of Health elected to enact mandatory fortification to ensure better coverage and improved dietary micronutrient intake of the population at large.
Since maize meal and bread were shown to be the most commonly consumed staples in the country, it was decided to use these foods as the vehicles for fortification. Hence vitamin A, iron, zinc, folic acid, thiamine, niacin, vitamin B12 and riboflavin have been added to maize meal and wheat flour in South Africa since October 2003 (Tables Ia–Ib).22 This was considered to be a sustainable and relatively inexpensive way to address the documented inadequate intake of vitamins and minerals without changing the traditional food consumption patterns. The effectiveness of this mandatory fortification legislation in the amounts supplied to the average South African child has not so far been evaluated. Although ideally one would evaluate such effectiveness by determining the concentrations of the relevant micronutrients in the blood of those consuming fortified food products at the national level, a simpler and less expensive approach is to analyse dietary micronutrient intake pre- and post-fortification using existing dietary data, which is the aim of the present study.

Table Ia: Fortificant mix for wheat flour (white and brown bread flour) as stipulated by the South African government regulations22

<table>
<thead>
<tr>
<th>Fortificant and diluent</th>
<th>Micronutrient requirements (per 1 kg flour)</th>
<th>Fortificant requirements (per 1 kg flour)</th>
<th>Fortification mix (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A palmitate</td>
<td>1.78675 μgRE</td>
<td>23.8095 mg</td>
<td>119.0475 g</td>
</tr>
<tr>
<td>Thiamine mononitrate</td>
<td>1.9444 mg</td>
<td>2.4929 mg</td>
<td>12.4644 g</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>1.7778 mg</td>
<td>1.7778 mg</td>
<td>8.8889 g</td>
</tr>
<tr>
<td>Nicotinamide/niacinamide</td>
<td>23.6842 mg</td>
<td>23.6842 mg</td>
<td>118.4210 g</td>
</tr>
<tr>
<td>Pyridoxine HCI (Activity: 81% min)</td>
<td>2.6316 mg</td>
<td>3.2489 mg</td>
<td>16.2443 g</td>
</tr>
<tr>
<td>Folic acid (Activity: 90.5% min)</td>
<td>1.4286 mg</td>
<td>1.5786 mg</td>
<td>7.8927 g</td>
</tr>
<tr>
<td>Electrolytic iron (Activity: 98% min)</td>
<td>35.00 mg</td>
<td>35.7143 mg</td>
<td>178.5714 g</td>
</tr>
<tr>
<td>Zinc oxide (Activity: 80% min)</td>
<td>15.00 mg</td>
<td>18.7500 mg</td>
<td>93.7500 g</td>
</tr>
<tr>
<td>Diluent</td>
<td>-</td>
<td>To complete 200 mg</td>
<td>To complete 1 000 g</td>
</tr>
</tbody>
</table>

a. Protected, stabilised Vitamin A palmitate containing 75 000 μg RE activity per gram
b. Retinol equivalents (RE) = 1 μg retinol = 3.33 IU (International Units) vitamin A
c. Elemental iron powder where more than 95% passes through a 325 mesh (<45 micron particle size) made by an electrolytic process

Table Ib: Fortificant mix for maize meal (super, special, sifted, unsifted) as stipulated by the South African government regulations22

<table>
<thead>
<tr>
<th>Fortificants and diluent</th>
<th>Micronutrient requirements (Per 1 kg meal)</th>
<th>Fortificant requirements (Per 1 kg meal)</th>
<th>Fortification mix (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A palmitate</td>
<td>2085 μgRE</td>
<td>27.8000 mg</td>
<td>139.0000 g</td>
</tr>
<tr>
<td>Thiamine mononitrate</td>
<td>2.1875 mg</td>
<td>2.8045 mg</td>
<td>14.0224 g</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>1.8875 mg</td>
<td>1.8875 mg</td>
<td>8.4375 g</td>
</tr>
<tr>
<td>Nicotinamide/niacinamide</td>
<td>25.000 mg</td>
<td>25.0000 mg</td>
<td>125.0000 g</td>
</tr>
<tr>
<td>Pyridoxine HCI (Activity: 81% min)</td>
<td>3.1250 mg</td>
<td>3.8580 mg</td>
<td>19.2901 g</td>
</tr>
<tr>
<td>Folic acid (Activity: 90.5% min)</td>
<td>2.0000 mg</td>
<td>2.2099 mg</td>
<td>11.0497 g</td>
</tr>
<tr>
<td>Electrolytic iron (Activity: 98% min)</td>
<td>35.0000 mg</td>
<td>35.7143 mg</td>
<td>178.6714 g</td>
</tr>
<tr>
<td>Zinc oxide (Activity: 80% min)</td>
<td>15.00 mg</td>
<td>18.7500 mg</td>
<td>93.7500 g</td>
</tr>
<tr>
<td>Diluent</td>
<td>-</td>
<td>To complete 200 mg</td>
<td>To complete 1 000 g</td>
</tr>
</tbody>
</table>

a. Protected, stabilised Vitamin A palmitate containing 75 000 μg RE activity per gram
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Methods

Study sample

The survey population comprised children aged one to nine years (12–108 months) in South Africa and comprised a nationally representative sample (n = 2 200, randomly selected, weighted for provincial representation). A detailed description of the sampling has been described elsewhere.23

Dietary intake

Dietary data was collected by 24-hour recall. This method has been used in the majority of population-based studies.24–26 The 24-hour recall was conducted with the caregiver of each child by trained interviewers who visited the homes of the participants. Dietary aids comprising household utensils and wax food models were used to determine portion sizes. A training video was developed and utilised to standardise field workers nationally.8 Relative validity was determined by comparison of the 24-hour recall data with that obtained from the same participants with a quantitative food frequency questionnaire. Furthermore, three 24-hour recalls were repeated in 10% of the sample population. The full details of the dietary methodology employed have been described elsewhere.5,11

Data analysis

In order to determine the nutrient quality of the children’s diets, a Nutrient Adequacy Ratio (NAR) was calculated for each nutrient. NAR was calculated as the ratio of the intake of a nutrient divided by the Recommended Nutrient Intake (RNI) for a given nutrient using the WHO/FAO recommended intakes,27 which are set at two standard deviations above the average nutrient requirements. In the case of iron and zinc, the category for moderate bioavailability was used. The Mean Adequacy Ratio (MAR) was calculated as the measure of the adequacy of each child’s overall diet. MAR was calculated as the sum of each NAR (truncated at 1) divided by the number of micronutrients of which the intake is inadequate, irrespective of whether such micronutrients were included in the food fortification legislation or not. For both NAR and MAR a value of 1.0 (or 100%) is the ideal, since it means that the intake is the same as the requirement.

The documented micronutrient intakes of the children were re-calculated by substituting the nutrient values for maize meal porridge and bread of the non-fortified products (Table II) with values of the chemically analysed fortified samples of maize meal porridge and fortified white and brown bread currently available on the market.28,29 The amount of these foods consumed by each child (per capita consumption) was also calculated.

Results

The low levels of the specified nutrients prior to the 2003 food fortification legislation, as reported by the NFCS (Table III), indicate that the lowest mean nutrient intake and NAR values were for folic acid and vitamin B12 levels, particularly in seven- to eight-year-old children, who had NAR values of 54.5% and 68.6% respectively. Some nutrients such as vitamin B12, thiamine and riboflavin had mean NAR values above 100% in the one- to three-year-olds but these values fell below 100% in the older children. Zinc was the only nutrient with mean values above 100%. Nevertheless, the MAR was below the level recommended.
In relation to urban/rural comparisons (Table IV), urban mean nutrient intake and NAR values were overall higher than those of rural children. All mean NAR values of the urban children, with the exception of folate acid (68.4%) and iron (92.3%), were above 100% of recommendations. By contrast, in children living in rural areas only the mean NAR value for thiamine was above 100% of recommendations. Although food fortification made a significant (p < 0.05) difference in both mean nutrient intakes and NAR values among rural children (Table IV; Figures 1 and 2), the MAR remained significantly lower when compared with the MAR (fortified) of children living in urban areas. In essence, food fortification made a large difference to mean NAR values in rural areas with all values, except for vitamin A (93.5%), increasing to above 100% of the recommended level. For some nutrients, the mean rural NAR values increased to above those found in urban areas (rural vs urban: thiamine (145% vs 134%), folate acid (118.3% vs 95.4%) and iron (151.4% vs 136.3%)). These changes could more than likely be attributed to the much higher percentage of children who consumed maize porridge (88.9% vs 66.8%) and in larger quantities (437.3 g vs 263.6 g) when compared with urban children (Figure 3). Urban children, by contrast, had a higher mean intake of white bread when compared with rural children (35.3 g vs 17.1 g), which was also consumed in much smaller quantities.
The mean MAR(%) for the children's overall diets remained below 100% of the recommendation, irrespective of the fortification status of the food products (Figure 4), since there were still additional nutrients that remained inadequate in the diet because they had not been included in the legislated fortification mix (calcium, vitamin C, D and E) but were found to be deficient in the NFCS survey. The MAR of the children's diets, however, with respect to micronutrient intake, increased by about 10% overall in both urban and rural areas (Figure 4).
Discussion

The findings of this study indicate that, at the usual dietary intake, the NAR and MAR levels of the current fortification strategy mandated by the Department of Health do make a significant difference to the quality of the diet of all children but particularly to that of children living in rural areas. This of course is of great importance since the most vulnerable group of children who consume diets of the poorest nutrient density have been reported to live in rural areas. Such children have also been documented to have the highest mean prevalence of stunting (26.5% in rural vs 16.7% in urban areas), the most common nutritional disorder in the country.

Evidence from other countries that have successfully implemented national fortification programmes indicates that certain important requirements need to be satisfied in order to ensure long-term sustainability of such programmes. Perhaps the most important of these requirements in the South African context is access to and affordability of the fortified foods, a consideration that should be high on the priority list of the overall micronutrient strategy of the Department of Health. Furthermore, the success of such programmes also depends on the need of continued dialogue between the various sectors that have to collaborate closely on issues relating to the production, promotion, distribution and consumption of fortified foods. Food fortification also needs to be supported by adequate monitoring and evaluation, food regulations, labelling and quality assurance.

In South Africa the process of mandatory fortification has been efficiently and effectively managed and most of the mentioned factors have been closely adhered to. A special task team comprising Department of Health officials, NGOs, academics and representatives of the largest maize and wheat flour (bread) producers planned the development and implementation procedures, also based on the outcomes of the NFCs. The food industry role-players were closely involved and carried most of the costs related to the introduction of the staple foods fortification, such as the buying of specialised equipment and the purchasing and testing of fortificants. These procedures allowed for a smooth and effective introduction of the mandatory process. Furthermore, procedures were introduced for the effective monitoring of the fortification process at manufacturing and consumer levels.

In conclusion and based on the results of this secondary analysis of the NFCS dietary data together with the data on the chemical analyses of foods used in this study, as provided by the industry, it would appear that fortification of the two most commonly eaten staple foods is likely to significantly improve the micronutrient intake of children under nine years of age. It is, therefore, recommended that fortification should be utilised to its full potential to improve children’s dietary intake at population level and to ensure access to and affordability of the fortified staples so that they are consumed by all children in the country. Of course the time required for these beneficial changes in dietary micronutrient intake, brought about by the legislation on the fortification of food staples, to be reflected in an improvement of the blood concentrations of such micronutrients at the population level, remains to be determined.

References