Annex C
Estimation of the Impact of Vitamin A Fortified Foods on the Prevalence of Vitamin A Deficiency[71]

by Kevin Sullivan and Jack Bagriansky

Vitamin A deficiency (VAD) is a significant global health problem. A variety of intervention strategies have been devised to eliminate VAD and therefore prevent the morbidity and mortality associated with it. Interventions to prevent VAD include the use of vitamin A supplements and the fortification of commonly eaten foods. While vitamin A supplementation has played an important role in preventing VAD, the distribution of capsules to target groups (usually preschool children and women after delivery) can be difficult to maintain, particularly at high coverage levels over long periods. The fortification of commonly consumed processed foods is an alternative that has a number of advantages over supplementation. The impact of vitamin A fortified foods on VAD has been infrequently studied. In this manuscript, we estimate the impact of vitamin A fortified food on the prevalence of VAD.

A review of the literature identified three studies on the effect of vitamin A fortified foods on the prevalence of VAD, based on laboratory assessment in children. These studies used the prevalence of low serum retinol levels to define VAD. The studies are as follows.

- A study in Indonesia using fortified monosodium glutamate (MSG; 810 micrograms of retinol equivalent (RE)/gram), a controlled field trial, and serum retinol values in preschool children. In the study area, 80% of the MSG was fortified (Muhilal, et al., 1988).
- A study in Guatemala using fortified sugar (10 micrograms RE/gram), a "before and after" assessment of 10 sentinel sites, and serum retinol values in preschool children (Arroyave, et al., 1981).
- An assessment of sugar fortification in Guatemala using fortified sugar, serum retinol values in adults, and national estimates using a "before and after" design (Dary, 1999).

The results of the studies are depicted in Table C1. The foods fortified were either MSG or sugar; the estimated daily intake of vitamin A from the fortified foods varied from 117 to 345 micrograms; and the baseline prevalence of VAD varied from 26% to 48%. The estimated daily intake of vitamin A from the fortified food takes into account the level of fortification and estimates of the amount of the food consumed per day and the proportion of individuals consuming the fortified product. While the food vehicles and overall diets involved vary in these studies and assessments, for the purposes of projecting the impact of added vitamin A on the prevalence of VAD it is assumed that each microgram of actual vitamin A intake will have a consistent and comparable impact regardless of the vehicle.

These studies provide three point estimates. To enable an estimation of the impact of a fortified food on prevalence, we assumed the following.

1. If the daily intake were half as high as reported, then the ratio from the pre- to post-prevalence of VAD would be halved. For example, if an

[71] Annexes C, D, and E were written by consultants specifically for this report. They have not been published elsewhere.

TABLE C1. Results of studies estimating the impact of vitamin A fortification on the prevalence of vitamin A deficiency

	Food Fortified	Average Intake of Vitamin A from Fortified Food (μg)	Daily Pre-Fortification Prevalence of VAD	Post-Fortification Prevalence of VAD	Ratio: Pre-/Post-Fortification Prevalence of VAD
Field Trial	MSG	117	48%	31%	.645
Sentinel Site	Sugar	345	27%	9%	.333
National Estimates	Sugar	135	26%	16%	.615

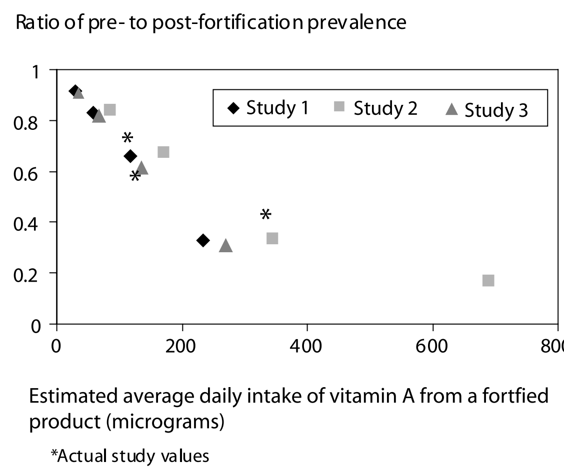
average daily vitamin A intake were 200 micrograms and the ratio was .5 (i.e., a 50% reduction in the prevalence from baseline), then with an intake of 100 micrograms we would expect a ratio of .75. For example, if a study were performed with 200 micrograms vitamin A per day and a baseline prevalence of 50%, if the ratio were 0.5, then the post-fortification prevalence estimate would be 25% (50% * .5); assuming half that intake would be 100 micrograms per day, with a baseline prevalence of 50%, the reduction would equal ([37.5% {100% - 50%} / 2] + 50%=.75). Similar relationships were assumed if the daily intake were one quarter, where the impact on prevalence would be one quarter.

2. If the daily intake were doubled, then the decline in the prevalence of VAD would be doubled; if the dose were halved, the reduction would be halved.

These estimates are presented in Figure C1 and Table C2. These points were plotted and curves were plotted to determine which type of curve fit the data best. The quadratic approach appeared to fit best. (See the "curve fit" explanation at the end of this annex.) The quadratic equation is as follows.

Post-fortification prevalence = pre-fortification prevalence x(1.019752 – .003178(vit A μg/day) + .00000282156958(vit A μg/day)^2)

FIGURE C1. Comparison of three studies on the impact of vitamin A fortication on the prevalence fo VAD in preschool children
(based on serum retino)



"Post-fortification prevalence" is the estimated prevalence (%) of vitamin A deficiency after fortification, "pre-fortification prevalence" is the estimated prevalence (%) of vitamin A deficiency prior to the fortification program, and "vit A μg/day" is the estimated daily intake from consuming a vitamin A fortified product. Use of the quadratic estimates compared with the actual reported post-fortification prevalence of vitamin A deficiency shows that the estimation procedure seems to work well. (See Table C3.)

TABLE C2. Actual daily intake of vitamin A and estimates if intake had been double, half, or one quarter of the ratio of pre- to post-fortification prevalence of VAD

		Average Daily Intake of Vitamin A (RE) (µgs)	Ratio: Pre-/Post-Fortification Prevalence of VAD
Study 1	**Double**	234.00	.3300
	Actual	117.00	.6600
	1/2	58.50	.8300
	1/4	29.25	.9150
Study 2	**Double**	690.00	.1665
	Actual	345.00	.3330
	1/2	172.50	.6670
	1/4	86.25	.8335
Study 3	**Double**	270.00	.3080
	Actual	135.00	.6150
	1/2	67.50	.8180
	1/4	33.75	.9090
For study 1:	Going from 117 to 234 micrograms: .66/2 = .33 Going from 117 to 58.5 micrograms: [(1– .66) / 2] + .66 = .83		

Table C3: Comparison of the actual vs. estimated impact of vitamin A fortified foods on the post-fortification prevalence of vitamin A using the quadratic approach

	Food Fortified	Average Intake of Vitamin A from Fortified Food (µg)	Daily Pre-Fortification Prevalence of VAC	Post-Fortification Prevalence of VAD	Estimated Post-Fortification Prevalence of VAD
Field Trial	MSG	117	48%	31%	33.0%
Sentinel Site	Sugar	345	27%	9%	7.0%
National Estimates	Sugar	135	26%	16%	16.7%

Conclusions

There are relatively few studies available that describe the impact of vitamin A fortified foods on the prevalence of vitamin A deficiency. Three studies were used to make this estimation. Linearity was assumed between the daily intake of vitamin A and the ratio from pre- to post-fortification vitamin A deficiency prevalence. It is unknown whether this linear assumption is approximately correct. In addition, these results are based on only three studies and should be interpreted cautiously. We hope that others will perform randomized clinical trials to provide additional estimates of the impact of vitamin A fortified foods.

Acknowledgements

Thanks to the following individuals for their comments and suggestions: Molly Cogswell, Glen Maberly, and Larry Grummer-Strawn.

References

Arroyave, G., Mejia, L.A., and Aguilar, J.R. The effect of vitamin A fortification of sugar on the serum vitamin A levels of preschool Guatemalan children: A longitudinal evaluation. *Am J Clin Nutr* 34 (1981): 41–9.

Muhilal, Permiesih, D., Idjradinata, Y.R., Muherdiyantiningsih, and Karyadi D. Vitamin A-fortified monosodium glutamate and health, growth, and survival of children: A controlled field trial. *Am J Clin Nutr* 48 (1988): 1271–6.

Dary, O. *Central America on the Verge of Ending VAD.* A paper delivered to a conference sponsored by the Micronutrient Initiative and the International Sugar Organization, entitled "Sugar Fortification to End VAD in Southern and Eastern Africa," June 1999.

Curve Fit Explanation

OUTPUT FROM SPSS
MODEL: MOD_5.

Dependent variable.. RATIO Method.. **LINEAR**
Listwise Deletion of Missing Data
Multiple R .87964
R Square .77376
Adjusted R Square .75113
Standard Error .13220
Analysis of Variance:
DF Sum of Squares Mean Square
Regression 1 .59771976 .59771976
Residuals 10 .17476965 .01747697
F = 34.20043 Signif F = .0002

Variables in the Equation

Variable B SE B Beta T Sig T
VITA -.001247 .000213 -.879635
-5.848 .0002
(Constant) .848117 .055134 15.383 .0000

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Dependent variable.. RATIO Method.. **QUADRATI**
Listwise Deletion of Missing Data
Multiple R .97517
R Square .95096
Adjusted R Square .94006
Standard Error .06488
Analysis of Variance:
DF Sum of Squares Mean Square
Regression 2 .73460718 .36730359
Residuals 9 .03788224 .00420914
F = 87.26339 Signif F = .0000

Variables in the Equation

Variable B SE B Beta T Sig T
VITA -.003178 .000354 -2.241152
-8.968 .0000
VITA**2 2.82156958E-06
4.9477E-07 1.425107 5.703 .0003
(Constant) 1.019752 .040471 25.197 .0000
Dependent variable.. RATIO Method.. **EXPONENT**
Listwise Deletion of Missing Data
Multiple R .94322
R Square .88966
Adjusted R Square .87863
Standard Error .19285
Analysis of Variance:
DF Sum of Squares Mean Square
Regression 1 2.9986516 2.9986516
Residuals 10 .3719104 .0371910
F = 80.62833 Signif F = .0000

Variables in the Equation

Variable B SE B Beta T Sig T
VITA -.002794 .000311 -.943217
-8.979 .0000
(Constant) .921241 .074093 12.434 .0000