Household income and expenditure surveys: A tool for accelerating the development of evidence-based fortification programs

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Abstract

Background. *One-third of the world's population suffers from micronutrient deficiencies due primarily to inadequate dietary intake. Food fortification is often touted as the most promising short- to medium-term strategy for combating these deficiencies. Despite its appealing characteristics, progress in fortification has been slow.*

Objective. *To assess the potential of household food-purchase data to fill the food-consumption information gap, which has been an important factor contributing to the slow growth of fortification programs.*

Methods. *Household income and expenditure survey (HIES) data about: (a) a population's distribution of apparent household consumption, which are essential to setting safe fortification levels, (b) the proportion of households purchasing "fortifiable" food, and (c) the quantity of food being purchased were used to proxy food-consumption data and develop suggested fortification levels.*

Results. *The usefulness of the approach in addressing several common fortification program design issues is demonstrated. HIES-based suggested fortification levels are juxtaposed with ones developed using the most common current approach, which relies upon Food and Agriculture Organization (FAO) Food Balance Sheets.*

Conclusions. *Despite its limitations, the use of HIES data constitutes a generally unexploited opportunity to address the food-consumption information gap by using survey data that nearly every country of the world is already routinely collecting. HIES data enable the design of fortification programs to become more based on country-specific data and less on general rules of thumb. The more routine use of HIES data constitutes a first step in improving the precision of fortification feasibility analyses and improving estimates of the coverage, costs, and impact of fortification programs.*

Key words: Evidence-based health policy, food policy, fortification, household surveys, micronutrients, nutrition

The burden of micronutrient deficiencies

One-third of the world's population—more than 2 billion people—suffers from micronutrient deficiencies [1]. The distribution of this enormous burden is highly skewed, with children under five accounting for disproportionately large shares of both the mortality burden and the disease burden attributable to micronutrient deficiencies. This cohort accounts for 93% of the mortality attributable to vitamin A deficiency (VAD), 68% of the mortality attributable to iron-deficiency anemia (IDA), and 100% of the mortality attributable to zinc deficiency (ZD), and its relative shares of the total disease burden (mortality and morbidity) attributable to VAD, IDA, and ZD are 94%, 57%, and 100%, respectively [2].

As **table 1** shows, the distribution of the burden of micronutrient deficiencies among under-five children is also highly skewed geographically. The burden is disproportionately higher in the two regions of the world with the highest general burden of disease, sub-Saharan Africa and South Asia. Sub-Saharan Africa alone accounts for more than half of the disability-adjusted life-years (DALYs) lost and deaths among children under five attributable to deficiencies of vitamin A, iron, zinc, and iodine, although it has only 11% of the world's population. Adding in South Asia brings the proportion of the world's DALYs lost and deaths among children under five attributable to these deficiencies to 82%, which is two and one-half times these two

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Food and Nutrition Bulletin, vol. 29, no. 4

TABLE 1. Estimated number of DALYs lost and deaths of children less than five years old attributable to select micronutrient deficiencies

Region	Population (in millions)	Vitamin A Deficiency	Iron Deficiency Anemia	Iodine Deficiency	Zinc Deficiency	Four Micronutrient Deficiency Total
	Thousands of DALYs lost					
East Asia and the Pacific	1,823	994	241	66	1,004	2,305
Eastern Europe and Central Asia	475	1	66	409	149	625
Latin America and the Caribbean	524	218	109	83	587	997
Middle East and North Africa	301	2,043	109	381	3,290	5,823
South Asia	1,378	4,761	704	366	8,510	14,341
Sub-Saharan Africa	674	13,552	596	748	14,094	28,990
High Income Countries	957	0	40	2	2	44
Total	6,132	21,569	1,865	2,055	27,636	53,125
	Thousands of Deaths					
East Asia and the Pacific	1,823	11	18		15	44
Eastern Europe and Central Asia	475	0	3		4	7
Latin America and the Caribbean	524	6	10		15	31
Middle East and North Africa	301	70	10		94	174
South Asia	1,378	157	66		252	475
Sub-Saharan Africa	674	383	21		400	804
High Income Countries	957	0	6		0	6
Total	6,132	627	134		780	1,541

Source: Caulfield et al. [3].

regions' 33% share of the world's population. In short, micronutrient deficiencies constitute a heavy disease burden that is shouldered disproportionately by the most vulnerable groups in the most disease-burdened countries on the planet.

Except for salt, progress in fortification has been slow

The primary cause of micronutrient deficiencies is inadequate dietary intakes. The World Health Organization (WHO) and the Food and Agriculture Organization (FAO) have adopted four main strategies for improving dietary intakes: food fortification, supplementation, nutrition education and disease control measures [1]. Fortification—the addition of micronutrients to a processed food to improve the food's nutritional quality—is often regarded as the most attractive of these four strategies because of a constellation of factors: a) fortification piggy-backs on an existing market, with existing distribution channels, and does not require changing food behaviors before it can have an impact; b) once in place, it affects people's micronutrient status without their having to choose to "participate" in the program, and there is little need to educate beneficiaries; c) it is generally regarded as cost-effective relative to the other three strategies; d) it is thought to be more sustainable than a supplementation program, which is subject to annual budget allocation competition; and e) it is a strategy that can have an impact in the short run.

Despite these appealing characteristics and the fact that there is considerable experience in implementation, progress in fortification, with the exception of salt iodization, has been slow. This has particularly been the case in middle- and lower-income countries* and is due to a number of factors, including** inadequate understanding and information about the significance of micronutrient deficiencies; private sector concerns about the public's acceptance of altered (i.e., fortified) food; inadequate understanding about what fortification will cost and who will pay for it (i.e., the incidence of the costs of fortification); uncertainty about the competitive impact of fortification—both within the same product market and on substitute product markets—due to fortification-induced higher relative costs and prices; the distinct and largely nontraditional types of activities that are required by governments to initiate, implement, monitor, and maintain a mass fortification program; the lack of knowledge or understanding about the potential coverage of such a program; and the lack of understanding of the impact of micronutrient

* Mass fortification programs began more than 80 years ago, in the 1920s, in Switzerland, Great Britain, and the United States (Allen et al. [1], p. 18).

** The discussion is directed most specifically to mass fortification programs, as distinct from targeted or market-driven programs (Allen et al. [1], pp. 26–29).

deficiencies (hidden hunger) and the potential benefits—i.e., the public health impact—that a fortification program could be expected to produce.

These factors have discouraged fortification. Even those countries that have the political will to assess the possibility of establishing a fortification program, however, are likely to find that it will be a relatively long time—more likely than not, several years—before fortified food is actually produced. This is because the development and implementation of a fortification program entails a series of relatively complex decisions and processes, including passing legislation that allows for the modification of food; selection of a food vehicle; undertaking stability tests of the proposed fortificants in the proposed food vehicles; determining the level at which the vehicle should be fortified; passing legislation that establishes fortification standards; passing laws and regulations that allow for government monitoring of the quality of fortification; developing legal enforcement mechanisms for noncompliance with quality; developing government organizational capacities to regulate, monitor, and enforce the fortification standards; and developing a mechanism for informing and perhaps training private sector food producers in fortification and quality-assurance procedures.

These decisions and processes generally require considerable public–private collaboration, which has proven to be a stumbling block in many lower- and middle-income countries. The development of this public–private partnership and the development of technically sound parameters for a fortification program are generally joint undertakings requiring several years.*

But there have also been fortification programs in many countries that were simply initiated with inadequate attention to designing a program based on sound evidence. As a result, iron-fortification programs, in particular, have often used the "wrong" iron compounds (i.e., those with low bioavailability), the level of the compound added to the food has often been too low, and the food vehicle selected has often been one that is consumed in quantities that are too small to deliver enough iron to have much of a health effect [6]. In the specific case of iron, evidence demonstrating the effectiveness of fortification in improving iron status in lower- and middle-income countries has been lacking, making it difficult for health policymakers to advocate for such a program, let alone to justify paying for it. No doubt, a substantial part of the problem has been technical in nature—foremost, the identification of an iron compound that can be adequately absorbed but does not cause sensory changes to the food vehicle. A second, technical consideration that has contributed to slowing the development of new iron-fortification efforts has been the slow progress in overcoming the bioavailability-inhibiting effects of certain dietary components, including phytic acid, phenolic compounds, calcium, and certain milk and soy proteins [7]. Now that this technical information gap has been addressed [1, 6, 8, 9], it is time to accelerate iron-fortification efforts and to increase the evidence base for iron and other micronutrient fortification programs.

Information requirements for designing a successful fortification program

For a fortification program to be effective in reducing micronutrient deficiencies, it is necessary to fortify a food that persons with the deficiencies in question eat in sufficient quantity throughout the year. The specific foods that are amenable to fortification are further limited by "technological properties (notably moisture, pH and O_2 permeability)," resulting in unacceptable changes in the organoleptic qualities of the food (i.e., changes in the food's taste, smell, or appearance) [10]. The most common staple foods that have been found to be fortifiable are salt, wheat flour, maize flour, sugar, and vegetable oil.

To design a food-fortification program, one would ideally want to know the number of individuals who have micronutrient deficiencies, the specific type or types of micronutrients in which they are deficient, the severity of each of those deficiencies, and the quantities of each of the potential food vehicles they consume. This information would enable the quantitative modeling of the "demand," or need, for a fortification program, measuring the potential coverage of a program, as well as estimating the potential impact of the program, at various levels of fortification.

Unfortunately, there is a dearth of such data. Although there are some data on select micronutrient deficiencies in some countries, what are more commonly available are proxy measures such as intake or—particularly in the case of vitamin A and iron supplementation programs and salt iodization—program coverage or participation rates. Information about food consumption is another missing piece of the data puzzle. Less than a handful of countries have nationally representative, individual-based, 24-hour-recall

* Recognizing the pivotal role and significance of a public–private partnership in moving the fortification agenda ahead, the Global Alliance for Improved Nutrition (GAIN)—an international nongovernmental organization funded by a number of international agencies (foremost the Bill and Melinda Gates Foundation) that has become the lead entity dedicated to promoting fortification in lower- and middle-income countries—requires countries that apply for its assistance to develop a national fortification alliance that is composed of members of both the public and the private sectors [4]. In October 2005, GAIN and the World Bank Institute brought together private-sector representatives and formally launched the Business Alliance for Food Fortification (BAFF) to provide an organizational base for increasing food fortification, particularly in poor populations [5].

food-consumption survey data. As a result, there is inadequate information with which to set fortification levels or to assess the potential benefits of fortification programs.

Most of the programs that do exist have established their parameters on the basis of informed guesses, generally using either the FAO Food Balance Sheets or the sales data of food companies, often supplemented by expert opinions of food-company officials or food-industry analysts. But there is an alternative possible approach that makes use of more precise evidence and takes advantage of routinely produced population-based data from a large number of statistically representative, national household surveys to assess the potential coverage of fortified wheat flour, maize flour, sugar, and vegetable oil, as well as other regional food items, such as soy sauce, fish sauce, and bouillon cubes.* The analysis of these readily available data constitutes the first step in what should become a routine approach to conducting an initial feasibility assessment of food-fortification possibilities in lower- and middle-income countries.

Household income and expenditure surveys

Household surveys have been conducted in most countries for a decade or more, and have become increasingly important routine sources of information for monitoring economic and social conditions. In most cases, periodic, routine household surveys were initiated to provide data for national income accounts, consumer and wholesale price indices, and poverty and inequality analysis. Over time, as countries' needs for detailed information on a wide variety of household characteristics and activities have grown, the surveys conducted by most countries have evolved to become integrated, multipurpose instruments. As the use of these tools has grown, starting in the mid-1980s, there has been a commensurate growth in interest in improving their design and implementation in order to make them more precise, while enabling across-country comparisons, avoiding duplication, and reducing costs.**

These efforts have produced general guidelines for conducting household surveys. There remain a variety of different types of surveys and multipurpose surveys, including a variety of different combinations of modules, depending upon a country's perceived needs and priorities. This paper makes use of a variety of different household surveys, including income and expenditures surveys, as well as the income and expenditure sections of integrated, multipurpose surveys covering different topical areas, but refers to all of them as simply "household income and expenditure surveys" (HIES).

Because of their country-specific character, as well as differences in how the fieldwork of the surveys is conducted and differences in how the data coding, data entry, and data cleaning are implemented, household survey data may vary considerably across countries in terms of quality and content. Another important type of intercountry variation in HIES data that is of particular importance in investigating fortification possibilities is the number of reported food categories. Some countries collect or record data on only a few dozen food-item categories, whereas others report hundreds. For most of the 31 countries analyzed, three of the four main candidate food vehicles analyzed here are staples. The exception is maize flour, which is a staple primarily only in sub-Saharan African and Latin American countries. In countries where maize flour is not a staple, there frequently is no maize flour food-item category.

Limitations and potential uses of HIES data to proxy food-consumption data

The HIES provide data on food expenditures, not food consumption. In essence, this is a proxy measure of food consumption. Household food expenditure, however, may differ from household food consumption, for a variety of reasons. Food consumption might be less than food expenditure, for example, because food expenditure might simply add to stocks of food in the household, or the food might be lost, wasted, or given away. Thus, the resulting measure would be most accurately described as "apparent household consumption."

Another limitation of HIES is that they provide household-level data, not individual-level data. Although they do provide information about key characteristics of the households—including the number of persons and the age, sex, and education levels of each—as well as the household's rural or urban location and its relative income (expenditure) level, they do not provide any insight into how the food that is purchased is distributed within the household or how much of it is actually consumed by each individual in

* This is not the first time expenditure data have been used to assess the feasibility or potential coverage of a food-fortification program. See, for example, the application of Imhoff-Kunsch et al. [11] in Guatemala. The intention is to make data readily accessible for a large number of countries with high prevalence rates of micronutrient deficiencies.

** Among the most important of these efforts have been the World Bank's development and promotion of Living Standards Measurement Surveys (LSMS) and their more general household survey lessons [12, 13], the United Nations Household Survey Capability Program, which is now the United Nations Demographic and Social Statistics Unit [14], and, of more recent vintage, the International Household Survey Network [15].

TABLE 2. Household income and expenditure survey databases used to assess the potential coverage of fortification programs

Country		Survey	Year	Recall period (days)	Expenditure only (X) or food quantity (Q) also reported?	Sample size (no. of households)	No. of food items reported
1	Bangladesh	Household income-expenditure survey	2000	14	Q	7,440	132
2	Bolivia	MECOVI (Medición sobre Condiciones de Vida)	2002	30	Q	5,746	60
3	Brazil	Pesquisa de Orçamentos Familiares	2002	7	Q	48,470	5,355
4	Burkina Faso	Enquête burkinabé sur les conditions de vie des ménages	2003	15	X	8,494	42
5	Burundi	Enquête prioritaire	1998	15	X	6,668	32
6	Cambodia	Household socioeconomic survey	2003	30	Q	14,938	203
7	Cameroon	Enquête camerounaise auprès des ménages II (ECAM 2)	2001	Urban area: 15 Rural area: 10	Q	10,992	278
8	Congo, Dem. Rep.	Employment, informal sector and household consumption survey	2005–06	15	Q	4,715	500
9	Côte d'Ivoire	Enquête niveau de vie des ménages	2002	30	Q/X	10,800	70
10	Ethiopia	Household income and expenditure survey	2000	7	Q	16,672	224
11	Ghana	Ghana living standards survey 4 (GLSS 4)	1998	35	X	5,998	104
12	Guatemala	Encuesta nacional sobre condiciones de vida—ENCOVI	2000	15	Q	7,276	98
13	Guinea	Enquête intégrale sur le budget et l'évaluation de la pauvreté (EIBEP QUIBB)	2002–03	Urban area : 99 Rural area : 48	X	7,095	288
14	India	National sample survey round 60 (NSS)	2004	30 for most food items	Q	29,631	153

continued

the household.* Nor do they provide information about the types or quantities of food that are consumed while household members are away from the home.

For most countries, there are a number of different food items that include the food vehicle in some form. This is most importantly the case with wheat flour. In most countries, wheat flour often has its own food-item category—reflecting the fact that households purchase the wheat flour itself as a final consumer product. Wheat flour is also contained in a number of other foods that have their own food-item categories, as well.

* It is customary to use total expenditure data as a proxy for income. The relative income level is indicated by the household's national expenditures/income quintile, which is empirically derived from the survey data.

Salient characteristics of the HIES surveys and data from 31 countries

Table 2 presents some of the key characteristics of the surveys of 31 low- and middle-income countries with high rates of micronutrient deficiencies that were analyzed. These particular surveys were especially attractive to use in this type of study, for several reasons.

First, they are of relatively recent vintage. Nearly 90% of the surveys analyzed were conducted in 2000 or later, and two-thirds were conducted in 2002 or later.

Second, all 31 of the surveys differentiate between food that is purchased by the household, food that the household itself produces, and food that the household receives from friends, relatives, or public programs—referred to as "gifted" food. Since food that is gifted or self-produced is far less likely to be available for

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Country		Survey	Year	Recall period (days)	Expenditure only (X) or food quantity (Q) also reported?	Sample size (no. of households)	No. of food items reported
15	Indonesia	SUSENAS (SUrvei Social Ekonomi NASional)	2002	7	Q	64,422	222
16	Madagascar	Enquête permanente auprès des ménages	2001	30	Q	5,078	65
17	Malawi	Malawi second integrated household survey	2004	7	Q	11,280	115
18	Mexico	Encuesta nacional de los ingresos y gastos de los hogares (ENIGH)	2004	14	Q	22,595	240
19	Mozambique	QUIBB (questionário de indicadores básicos de bem-estar)	2002	7	Q	8,700	332
20	Nepal	Nepal living standards survey	2003	30	Q	3,912	72
21	Niger	Income and expenditure survey	2005	15	X	6,689	131
22	Nigeria	Nigeria living standards survey	2003	30	X	19,158	134
23	Pakistan	Pakistan integrated economic survey	2001	30 or 14 days-varies by food item	Q	16,182	113
24	Peru	Enquesta nacional de hogares	2003	Respondent's choice	Q	18,912	336
25	Philippines	Income and expenditure survey	2003	7	X	42,094	140
26	Sierra Leone	Sierra Leone integrated household survey	2003	90	X	3,720	108
27	South Africa	Income and expenditure survey 2000	2000	30	X	26,263	122
28	Tanzania	Household budget survey	2000	30	Q	22,178	135
29	Uganda	National household survey 2002/2003	2002	7	Q	9,711	58
30	Uzbekistan	Living standards measurement survey	2003	14	Q	9,619	465
31	Vietnam	Viet Nam household living standards survey	2004	30	Q	9,189	57

Source: Authors' elaboration.

commercial market-based fortification programs, it would be prudent to focus analyses of the feasibility or design of fortification exclusively on purchased foods. As may be inferred from the data presented in **table 3**, not taking this distinction into account would result in overestimating the potential amount of food that would be fortified, as well as the coverage, impact, and cost of the program.

A third important characteristic of the data from these particular surveys is that although they all report food expenditures (as opposed to food consumption), 22 (71%) of them also directly collected food-quantity information, typically over a 2-week or 1-month recall period. This direct information on quantity avoids possible distortions caused by relying upon monetary units of analysis as a proxy.

Uses of HIES data in assessing the feasibility and in designing fortification programs

Assessing the potential coverage of a candidate food vehicle

The potential reach of three different approaches to wheat-flour fortification was investigated by

TABLE 3. The Share of Monthly Household Food that is Purchased[a]

Country	Food Item	Household expenditure quintile (%)						Q5 Share as a % of Q1 Share
		1	2	3	4	5	All	
Bangladesh	Wheat	63	85	92	100	94	94	148
	Flour	94	98	99	98	99	98	106
	Bread/ Bonroti	80	89	96	97	98	95	123
	Soybean oil	100	100	100	100	100	100	100
	Ghee		100	39	89	100	97	
	Other oil	94	72	60	47	76	58	81
	Sugar/ Misri	99	100	99	100	100	100	101
Burkina Faso	Maize	52	49	54	47	48	49	93
	Bread	100	97	98	99	99	99	99
	Oil, Butter, Margarine	88	89	91	90	91	90	103
	Sugar	99	99	100	99	100	99	101
Tanzania	Maize, grain	70	73	81	83	86	83	123
	Maize, flour	42	45	44	45	51	48	121
	Wheat, grain	64	66	76	98	75	80	116
	Wheat, flour	90	95	99	98	98	98	109
	Bread	92	92	97	100	98	98	107
	Biscuits	92	89	87	87	90	89	97
	Macaroni, spaghetti	91	95	93	100	98	98	108
	Sugar/sukari guru	93	98	96	97	98	97	105
	Cottonseed oil	100	98	96	99	99	98	99
	Groundnuts oils	97	100	97	99	100	99	103
	Butter, ghee	81	44	95	100	100	100	124
	Margarines cooking fat	53	42	73	60	88	73	168
Bolivia	Bread	80	88	89	89	91	89	114
	Maize (grains)	9	25	42	59	66	34	722
	Wheat (grain)	14	38	62	84	88	55	645
	Flour (wheat or maiz)	48	82	83	86	88	79	182
	Oil	98	97	96	93	95	95	97
	Sugar	98	97	93	90	91	93	93

Note: Although these figures were derived from actual survey data, their sampling errors were not calculated, and some of the figures are likely not to be highly significant. Therefore, it is necessary to exercise care in interpreting them. They are provided here primarily for illustrative purposes.
Source: Authors' computations
a. Total Monthly Household Food Supply = (Value of Purchases + Value of Home Production + Value of Gifts)

constructing two composite variables of different wheat products. First, consumption of wheat flour (as a final consumer product) was analyzed. Then, wheat flour was combined with all other wheat-flour-based products to provide a measure of the maximum potential reach of a program that fortified all wheat flour. Third, in the interest of examining how excluding "luxury" foods from the wheat-flour-based foods measure would affect the costs and reach of a fortification program, all wheat-flour-based staple foods were collapsed into a single composite that excluded cakes, pastries, and biscuits.* In constructing these different measures, it was necessary to estimate the flour content of the different food items in order to be able to add the flour content of the different products weighted by the quantity of the different products purchased into a single measure.

Table 4 presents the proportion of households purchasing the candidate food items. For a fortification program to be regarded primarily as a public health intervention, a rule of thumb used by food-fortification

* "Luxury" foods are defined here (in the economic use of the term) as those that have a higher income elasticity of demand; i.e., they are foods the demand for which increases more than proportionally to increases in income, other things being equal.

TABLE 4. Percentage of Households that Purchase Some of the Potential Food Fortification Vehicle (National Household Income and Expenditure Survey Data)

Country	Year	Maize Flour & Products	Wheat Flour	Wheat Flour-Based: Includes Staples Only[a]	Wheat Flour-Based: All Identified Foods	Sugar	Vegetable Oil
1 Bangladesh	2000		13	41	44	45	100
2 Bolivia	2002	31		7	85	92	91
3 Brazil	2002	7	12	87	92	38	32
4 Burkina Faso	2003					67	67
5 Burundi	1998					17	71
6 Cambodia	2003				44	77	35
7 Cameroon	2001	8	2	44	47	43	70
8 Congo, Dem. Rep.	2004		4	66	73	82	39
9 Cote d'Ivoire	2003	27	2	69	70	59	41
10 Ethiopia	2000	22	21	29	29	22	29
11 Ghana	1999	27				21	73
12 Guatemala	2000	54	10	95	96	83	60
13 Guinea	2002	10	0	67	71	66	84
14 India	2004	3	9	25	65	93	99
15 Indonesia	2002	0	15	65	76	95	94
16 Madagascar	2001	3	5		45	73	90
17 Malawi	2004	97	1	13	33	69	49
18 Mexico	2003	86	5	81	86	33	31
19 Mozambique	2002	18	1	34	35	28	34
20 Nepal	2003	20	39			85	88
21 Niger	2005	1	2		25	62	72
22 Nigeria	2003	15	2				81
23 Pakistan	2001	3				99	91
24 Peru	2003	22	34			80	59
25 Philippines	2003					100	99
26 Sierra Leone	2003	5			52	82	92
27 South Africa	2000		48			96	79
28 Tanzania	2000	71	27			63	96
29 Uganda	2002					63	14
30 Uzbekistan	2003	1	21	93	94	81	99
31 Viet Nam	2004					92	96
No. of Countries:		22	22	15	19	30	31

No. of countries in which the proportion of households purchasing the food is:

		Maize Flour & Products	Wheat Flour	Includes Staples Only	All Identified Foods	Sugar	Vegetable Oil
≥ 60%		3	0	8	10	21	21
≥ 50%		4	0	8	11	22	22
≥ 40%		4	1	10	15	24	24
≥ 30%		5	5	11	17	26	29
≥ 25%		7	7	13	19	27	30
≥ 20%		10	10	13	19	29	30
≥ 15%		12	12	13	19	30	30
≥ 10%		13	13	14	19	30	31

a. Includes wheat flour, bread, pasta, noodles, and wheat products food item categories, but not biscuits, pastries, or cakes.
Source: Authors' computations.

experts is that the food must be consumed by at least 30% of the population.* The numbers of countries in which the proportion of households purchasing the food reaches 30%, as well as various other cutoff levels, are presented in the bottom portion of **table 4**. As judged by this criterion, the "best" food vehicle candidates—in terms of the number of countries that meet this public health-related criterion—are (1) vegetable oil, (2) sugar, (3) wheat flour (including all wheat flour-based products), and (4) maize and maize flour, in that order. It is interesting to note that the most commonly discussed food vehicles—wheat flour and wheat-flour-based staple foods—meet this threshold in only 5 (16%) and 11 (35%) of the 31 countries, respectively. Recognizing that the 30% cutoff is quite arbitrary, the bottom portion of **table 4** shows how sensitive these results are to alternative minimum threshold levels.

Information for mapping and targeting micronutrient interventions

The HIES also contains information about the size and composition of the household (number, age, and sex of persons), the place of residence (rural or urban), and geographic location. In some instances, the samples are statistically representative down to the regional or the state or provincial level. Thus, the HIES can be used to investigate how the coverage of a potential food-fortification program is likely to vary according to these characteristics. This can be useful information for designing policies and programs so that complementary or substitute programs can be targeted to individuals or households with particular characteristics or targeted to specific geographic areas so as to better ensure higher coverage or more adequate impact. Conversely, the HIES can also provide a better understanding of the characteristics of the households and individuals who are likely to benefit less, or not at all, from a fortification program. For instance, **table 5** uses the Tanzanian HIES to examine how the coverage of potential food vehicles varies according to place of residence and population income quintiles (with income proxied by total expenditures).

Identifying "new" potential food vehicles

The discussion has focused up to this point on only the four most commonly considered "best" candidate food vehicles (exclusive of salt). The HIES, of course, contains information on many more potential food vehicles that might also be of interest. For instance, in the four countries in which the purchase of bouillon cubes was reported—Burkina Faso, Cameroon, Côte d'Ivoire, and Guinea—it appears as though bouillon cubes might be a promising vehicle, with 72% to 89% of all households in these countries reporting purchases of this low-priced condiment. Given that many micronutrient deficiencies cluster in low-income households, from a public health program perspective it is particularly noteworthy that the proportion of households purchasing bouillon cubes is relatively constant over all five income quintiles.

Investigating combinations of foods and potential "substitute" vehicles and key characteristics of the beneficiary population

Another potentially important use of the HIES is to investigate the combinations of specific types of foods that households purchase. A large proportion of Cambodians, for instance, consume fish sauce daily; some food-industry analysts have suggested [16] that fish sauce is a substitute for table salt, which has important implications for an iodine-fortification strategy. Analysis of the Cambodian HIES found that 46% of households purchase table salt, 62% purchase fish sauce, 75% purchase both fish sauce and salt, 13% purchase only salt, and 29% purchase only fish sauce. These findings suggest that iodizing fish sauce, rather than table salt, would enable a larger proportion of the population to be reached. The data were then reanalyzed by household expenditure quintiles, and it was found that salt purchasing patterns were independent of income quintile. Although the poorest 20% and the poorest 40% were not as likely to purchase fish sauce as were all households combined, fortifying fish sauce rather than salt would reach an additional 10% of the poorest 40% of the population, who are also more likely to be iodine deficient.

Informing the design of a fortification program: setting the fortification level

Setting the fortification level of a food involves balancing two countervailing objectives: maximizing the public health goal of improving the population's micronutrient intake and nutrition status, while at the same time ensuring that not too much of the micronutrient is added to the food, so that persons who consume large quantities of it are not put at risk of toxicity. The public

* In contrast to being primarily a public health intervention, fortification might alternatively be motivated primarily by other goals, such as the promotion of good manufacturing practices (GMP).

TABLE 5: Using HIES data to investigate the potential coverage of potential food-fortification vehicles in Tanzania: the number and percentage of households that purchase some of each of the potential food-fortification vehicles

	Nationwide		Rural		Urban	
	No.	%	No.	%	No.	%
No. of households:	6,434,534	100	5,045,528	78	1,389,006	22
Food items						
Wheat flour	1,112,852	17	675,967	13	436,885	31
Bread	1,263,497	20	541,425	11	722,072	52
Wheat flour products—staples only[a]	1,961,969	30	1,064,681	21	897,287	65
Wheat flour products—all foods	4,021,334	62	2,770,992	55	1,250,342	90
Maize (corn flour)	4,218,415	66	2,982,296	59	1,236,119	89
Sugar	4,679,455	73	3,388,525	67	1,290,929	93
Salt	5,510,105	86	4,352,030	86	1,158,075	83
Edible oils	2,901,395	45	2,022,031	40	879,364	63

	Population expenditure quintile 1		Population expenditure quintile 2		Population expenditure quintile 3		Population expenditure quintile 4		Population expenditure quintile 5	
	No.	%	No.	%	No.	%	No.	%	No.	%
No. of households:	970,934	15	1,078,996	17	1,222,744	19	1,399,590	22	1,762,270	27
Food items										
Wheat flour	76,613	8	93,002	9	180,863	15	246,595	18	515,778	29
Bread	35,538	4	115,384	11	165,320	14	268,421	19	678,834	39
Wheat flour products—staples only[a]	106,220	11	187,764	17	288,092	24	433,505	31	946,388	54
Wheat flour products—all foods	373,488	38	543,780	50	717,012	59	958,515	68	1,428,539	81
Maize (corn flour)	541,254	56	625,083	58	743,064	61	946,930	68	1,362,084	77
Sugar	435,330	45	668,189	62	864,212	71	1,133,638	81	1,578,085	90
Salt	786,720	81	875,280	81	1,060,373	87	1,229,925	88	1,557,807	88
Edible oils	304,362	31	405,480	38	574,889	47	648,938	46	967,726	55

a. Includes wheat flour, bread, pasta, and noodles, but not biscuits, pastries or cakes.
Source: Authors' computations.

health adage of "do no harm" is the guiding principle.* Usually, because individual food-consumption distributions are highly skewed, a relatively small number of persons who consume large amounts of the food vehicle in question will constrain the amount of a micronutrient that can be added to the food.

The customary approach in setting fortification levels is to use the FAO Food Balance Sheet data (or less commonly, industry data) to estimate the "average" level of consumption as the Food Balance Sheet category of "Domestic Food Quantity" divided by the total population of the country. This is a distribution-free point estimate. It is usually assumed that the highest average daily nutrient intake level that is unlikely to pose a risk of adverse health effects to almost all (97.5%) persons in the population (referred to as the Tolerable Upper Intake Level or UL) is equal to three to four times the "average" level [17].

HIES data offer the opportunity to make this approach more evidence-based in three ways, each of which has important implications for informing health and nutrition policy. First, HIES data provide information that enables all food supplies to be distinguished from those that are purchased, thereby bringing greater precision to the analysis of the quantity of the food that is commercially accessible and thus characterized as being more "fortifiable." **Tables 3** and **4** show that in many countries these are very different quantities. This has important implications for a prospective economic feasibility study of fortification: as compared with a Food Balance Sheet-based analysis, an HIES-based analysis will identify a smaller proportion of the food supply as fortifiable and will estimate the likely costs of fortification as substantially less.

Second, the HIES distinguishes between those households that purchase some of the food and those that do not. This has important implications for prospective studies estimating the potential coverage and potential impact of introducing fortification. As compared with a Food Balance Sheet-based analysis, an HIES-based analysis will identify a smaller number of persons and a smaller proportion of the population that will be covered by a fortification program and will estimate that the public health impact of the program will be relatively less.

Third, the HIES provides data about the right-skewed nature of the distribution of consumption, rather than simply making some assumptions about these key parameters.

Given the information void about individual consumption levels and the use of household purchases as its proxy, however, setting the amount of fortificant to be added to a vehicle still requires making one or more assumptions about the intrahousehold distribution of the vehicle purchased by the household. The simplest approach makes use of the HIES information about household size and implicitly assumes that all individuals in the household receive equal amounts of the food. This approach does not take into account differences in the age or sex of household members, which (as reflected in the age- and sex-specific Estimated Average Requirements, (EARs) give rise to differences in need.

An alternative approach would be to make use of the HIES information about the number of household members and their ages and sex and either calculate the "adult consumption equivalents" (ACE) using the FAO algorithms (presented the Annex), which are based on energy requirements, or, when a single micronutrient—vitamin A in this case—is analyzed, use the vitamin A-specific EAR age and sex categories to calculate vitamin A-specific adult consumption equivalents. **Table 6** presents an example using Tanzanian HIES estimates and reports the mean, median, and the 5th and 95th percentile consumption levels per household, per individual, and per ACE.

Although the ACE approach makes use of more detailed empirical data, it is important to note that its application implicitly assumes that the food purchased by the household is distributed within the household in direct proportion to need, as reflected in which of the two specific algorithms is applied.** Another alternative would be to use the HIES data to model some other intrahousehold assumptions and to test their sensitivity. Even though operationalizing this approach requires making some critical assumptions, this approach is likely to be an improvement over less comprehensive, less systematic, and less verifiable approaches. Still—because of the need to base the final decision on a key assumption—it is imperative to make any and all assumptions explicit and transparent and to conduct

* This is a simplification.The WHO/FAO guidelines [1] discuss two additional factors that enter into the calculations: technical and economic considerations. The technical considerations involve the need not to add so much fortificant that the organoleptic characteristics of the food are changed. The economic considerations involve the need not to add so much fortificant that the cost of the food is increased "too much" and the portion of the increased cost that is passed onto the consumer is not increased "too much" so that it affects the food's sales and the profitability of production. A rule of thumb commonly employed by fortification experts is that the costs of fortification should not be more than 2% of the price per metric ton of the unfortified food. It should be noted, however, that the impact of a 2% increase in costs will vary according to the food, even when the analysis is limited to staple foods. The extent to which increased costs are likely to affect price depends on the elasticity of supply and the elasticity of demand. This is another area in which there is a need for a more evidence-based approach.

** This simplifying assumption "smooths" the intrahousehold distribution of food consumption, resulting in an underestimation of extreme values and thereby increasing the potential risk of pushing individuals who are outliers (in terms of their level of consumption of the food vehicle) over the UL for a given level of fortification.

TABLE 6: HIES Data Useful for Informing the Design and Assessing the Value of a Fortification Program: Setting the Level of Fortificant to be Added and Estimating the Program's Potential Impact (An Example Using Tanzanian HIES Data)

	Nationwide				Rural				Urban			
Food items	Mean	5th %tile	Median	95th %tile	Mean	5th %tile	Median	95th %tile	Mean	5th %tile	Median	95th %tile
Quantity per household												
Wheat flour	4.85	0.54	2.14	16.07	4.68	0.54	2.14	13.39	5.13	0.54	2.14	17.14
Bread	2.46	0.13	1.21	9.21	2.05	0.10	0.96	9.21	2.77	0.26	1.61	9.16
Wheat flour products—staples only[a]	3.84	0.14	1.71	12.32	3.67	0.12	1.65	10.71	4.06	0.23	1.77	13.39
Wheat flour products—all foods	2.82	0.03	0.96	10.43	2.31	0.02	0.60	9.02	3.94	0.08	1.81	12.86
Maize (corn flour)	31.87	1.07	19.29	107.14	32.73	1.07	19.29	111.43	29.82	2.14	19.29	86.79
Sugar	4.81	0.48	3.21	13.79	4.38	0.31	2.81	12.59	5.94	0.75	4.44	15.00
Salt	2.04	0.27	1.37	5.36	2.15	0.27	1.61	5.57	1.63	0.21	1.07	4.45
Edible oils	1.88	0.08	1.05	6.43	1.55	0.07	0.80	5.36	2.63	0.11	1.55	8.11
Quantity per person												
Wheat flour	1.22	0.09	0.54	3.75	1.13	0.09	0.46	3.43	1.37	0.11	0.54	4.29
Bread	0.68	0.03	0.31	2.66	0.55	0.02	0.19	2.66	0.77	0.05	0.42	2.63
Wheat flour products—staples only[a]	0.99	0.03	0.40	3.18	0.90	0.02	0.36	2.57	1.10	0.05	0.44	3.36
Wheat flour products—all foods	0.73	0.01	0.21	2.58	0.58	0.00	0.13	2.25	1.05	0.03	0.48	3.32
Maize (corn flour)	7.22	0.31	4.55	23.04	7.15	0.27	4.29	23.57	7.41	0.54	5.09	21.43
Sugar	1.19	0.09	0.80	3.41	1.04	0.08	0.64	2.95	1.59	0.21	1.14	4.29
Salt	0.53	0.05	0.33	1.55	0.54	0.05	0.36	1.61	0.46	0.05	0.27	1.29
Edible oils	0.49	0.02	0.23	1.71	0.38	0.02	0.18	1.38	0.73	0.03	0.41	2.24
Quantity per ACE[b]												
Wheat flour	1.56	0.13	0.62	4.82	1.44	0.11	0.62	4.70	1.74	0.13	0.63	5.36
Bread	0.84	0.04	0.39	3.13	0.69	0.03	0.23	3.41	0.95	0.07	0.54	3.01
Wheat flour products—staples only[a]	1.25	0.04	0.53	3.76	1.15	0.03	0.49	3.29	1.38	0.06	0.58	4.30
Wheat flour products—all foods	0.92	0.01	0.28	3.21	0.74	0.01	0.17	2.88	1.31	0.03	0.61	3.96
Maize (corn flour)	9.24	0.40	5.95	29.30	9.18	0.34	5.56	29.49	9.37	0.69	6.50	26.79
Sugar	1.51	0.11	1.04	4.29	1.32	0.10	0.85	3.72	1.99	0.27	1.46	5.21
Salt	0.66	0.07	0.43	1.86	0.69	0.08	0.45	1.95	0.57	0.06	0.37	1.61
Edible oils	0.62	0.02	0.30	2.15	0.49	0.02	0.24	1.70	0.93	0.04	0.51	2.95

a. Includes wheat flour, bread, pasta, and noodles, but not biscuits, pastries, or cakes.
b. ACE: Adult Consumption Equivalent (see Annex for calculation)
Source: Authors' computations.

sensitivity analyses.*

For ease of exposition, we will consider the fortification of sugar and oil with vitamin A, and we will assume that only safety—and not economic or technical constraints—is the binding consideration in determining the fortification level. To determine the level at which to fortify, it is necessary to know what the current level of intake of the nutrient in question is, as well as the quantity of the food vehicle that is consumed by persons in the 95th percentile. Given that the UL for vitamin A is 3,000 µg per day and assuming that the usual daily intake of vitamin A (from all sources) is 600 µg the maximum safe fortification level can be estimated by the following equation: [1]**

Safe fortification limit = (UL – usual intake)/(95th percentile of consumption)

For example, according to the Tanzania data in **table 6,** the per capita consumption of sugar is 3.41 kg/month or 113.7 g/day (2400/113.7 = 21 mg/kg). The adult consumption equivalent of sugar is 4.29 kg/month, or 143 g/day (2400/143 = 17 mg/kg). If alternatively, the food vehicle is vegetable oil, and again using the Tanzanian data in **table 6**: the per capita consumption of oil is 1.71 kg/month or 57 g/day. 2400/57 = 42 mg/kg. The ACE of oil is 2.15 kg/month or 71.7 g/day. 2400/71.7 = 33 mg/kg. In contrast, with the use of the Food Balance Sheet in combination with the population-based approach and on the assumption that the 95th percentile of consumption is three times greater than the median, the safe fortification limit is calculated as 39 mg/kg for sugar and 64 mg/kg for oil, roughly twice the levels obtained by the HIES-based approaches. The HIES approach is more conservative.

The relative merits of the HIES become particularly apparent when the fortification of more than a single food is considered. With the HIES, it is possible to examine which households consume which food vehicles and the quantities in which they are consumed. The Food Balance Sheet-based approach provides only a one-dimensional, point estimate of the national per capita level of a food, and of only one food at a time. Moreover, the HIES approach allows the investigation of how the distribution of household food purchases varies according to household characteristics, which can be used to estimate the impact of fortification on persons with micronutrient deficiencies, as well as provide insights about how to target other micronutrient interventions to persons who are not likely to be reached or adequately affected by fortification efforts. These are important issues for health and nutrition program design and policy-making.

Conclusions

Despite the enormous need for fortification programs in lower- and middle-income countries, political and technical obstacles, together with information gaps, have acted to throttle the pace of development of evidence-based fortification interventions. The most pressing information gap has been the nearly total absence of food-consumption data. Despite its various limitations, the use of HIES data provides an opportunity to begin to address the consumption information gap. Moreover, it is possible to make HIES an even more powerful tool if the international nutrition community recognizes their potential, makes a concerted effort to use them, and works proactively to engage the international agencies that provide technical assistance to or finance these surveys and the agencies in lower- and middle-income countries that conduct them to ensure that they provide the types of information that are needed to make these tools more precise.

Apparent household-consumption data alone, of course, are not sufficient to answer all of the questions that must be addressed in conducting a feasibility analysis of a fortification program, but they are the logical starting place. The next step in the development of a more evidence-based approach to mass fortification programs involves gaining a better understanding of the size (output) distribution and of the technology, capacity utilization, and costs of the producers and processors of the candidate food vehicle. Given the still enormous burden of micronutrient deficiencies and the fact that they are borne disproportionately by the most vulnerable members of the most vulnerable societies, the time is past due to use these readily available datasets to help accelerate the pace of development of evidence-based fortification programs.

Acknowledgments

This work was supported by A2Z: The USAID Micronutrient and Child Blindness Project (GHS-A-00-05-00012-00), the World Bank, and the Global Alliance for Improved Nutrition (GAIN). The views expressed are those of the authors and do not necessarily reflect those of the agencies or institutions that supported the work.

* If there are data on the location (e.g., region or rural vs. urban place of residence) or other characteristics of the population with micronutrient deficiencies, this information can be used to assess how well a potential fortification program is likely to cover this target population. Or it can identify (by location or other characteristics) the deficient population that will not be reached by the fortification. One potential use of this information would be to target a supplementation program to the areas or persons that will not be reached by the fortification program (at least not immediately).

** This is the equivalent of assuming that a fortification program should provide 80% of the EAR for vitamin A, on the assumption that the population consumes little or no seafood, meat, or dairy products [17].

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ANNEX. FAO adjustment factors for calculating the number of adult equivalent consumption units

Age (yr)	Males	Females
< 1	0.27	0.27
1–3	0.45	0.45
4–6	0.61	0.61
7–9	0.73	0.73
10–12	0.86	0.78
13–15	0.96	0.83
16–19	1.02	0.77
≥ 20	1.00	0.73