Indian social safety net programs as platforms for introducing wheat flour fortification: A case study of Gujarat, India

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Abstract

Background. *Micronutrient deficiencies exact an enormous health burden on India. The release of the National Family Health Survey results—showing the relatively wealthy state of Gujarat having deficiency levels exceeding national averages—prompted Gujarat officials to introduce fortified wheat flour in their social safety net programs (SSNPs).*

Objective. *To provide a case study of the introduction of fortified wheat flour in Gujarat's Public Distribution System (PDS), Integrated Child Development Scheme (ICDS), and Mid-Day Meal (MDM) Programme to assess the coverage, costs, impact, and cost-effectiveness of the initiative.*

Methods. *India's 2004/05 National Sample Survey data were used to identify beneficiaries of each of Gujarat's three SSNPs and to estimate usual intake levels of vitamin A, iron, and zinc. Comparing age- and sex-specific usual intakes to Estimated Average Requirements, the proportion of the population with inadequate intakes was estimated. Postfortification intake levels and reductions in inadequate intake were estimated. The incremental cost of fortifying wheat flour and the cost-effectiveness of each program were estimated.*

Results. *When each program was assessed independently, the proportion of the population with inadequate vitamin A intakes was reduced by 34% and 74% among MDM and ICDS beneficiaries, respectively. Both programs effectively eliminated inadequate intakes of both iron and zinc. Among PDS beneficiaries, the proportion with inadequate iron intakes was reduced by 94%.*

Conclusions. *Gujarat's substitution of fortified wheat flour for wheat grain is dramatically increasing the intake of micronutrients among its SSNP beneficiaries. The incremental cost of introducing fortification in each of the programs is low, and, according to World Health Organization criteria, each program is "highly cost-effective." The introduction of similar reforms throughout India would largely eliminate the inadequate iron intake among persons participating in any of the three SSNPs and would have a significant impact on the global prevalence rate of inadequate iron intake.*

Key words: Cost analysis, cost-effectiveness, food policy, fortification, household consumption and expenditures surveys (HCES), micronutrient deficiencies, nutrition

Introduction

India has made considerable progress in the past two decades in improving many key health status indicators. From 1992/93 to 2005/06, for instance, its infant and child mortality rates fell by 29% and 28%, respectively. At the same time, however, the prevalence of most nutritional disorders remained relatively constant and in some cases actually increased. Between 1998/99 and 2005/06:

- The prevalence of iron-deficiency anemia among children 6 to 59 months of age fell only modestly and remains high at 69.6% [1–3];
- The prevalence of iron deficiency among women 15 to 49 years of age increased from 51.8% to 55.3% [2, 3];
- The prevalence of stunting among preschool children—an indicator of chronic malnutrition and a proxy indicator for zinc deficiency—increased from 45.5% to 48.0% [2, 3];
- The prevalence of vitamin A deficiency among preschool children stalled at 57% after falling in the early 1990s [4–6].

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Nutritional disorders exact an enormous toll on India. Applying the HarvestPlus methodology [7], it is estimated that vitamin A, iron, and zinc deficiencies annually account for a total of 7.4 million Disability-Adjusted Life-Years (DALYs) lost. Of this total, vitamin A accounts for the largest share, 41% of total DALYs, with zinc the next most burdensome (32%) and iron-deficiency anemia accounting for the residual 27%.

A plethora of large food and nutrition programs, a paucity of impact

India has had policies and programs in place to address malnutrition for several decades. The three major food distribution and feeding programs—the Integrated Child Development Scheme (ICDS), the Targeted Public Distribution System (TPDS), and the Mid-Day Meal (MDM)—and the iron and vitamin A supplementation programs are all enormous programs in terms of geographic coverage and numbers of beneficiaries and costs, but a variety of shortcomings have limited their impacts.

Integrated Child Development Scheme

The ICDS operates under the auspices of the Ministry of Women and Child Development (MOWCD) and is the largest early child development program in the world. First established in 1975, over time it has grown rapidly, especially since 2000. In 2007, ICDS provided food supplements through a network of 700,000 community-level *Anganwadi* Centers (AWCs), covering 39 million children under 6 years of age and 8 million pregnant and lactating women.* ICDS provides a daily feeding for preschool children who attend the AWCs. It also provides pregnant and lactating women and children under 3 years of age a fortnightly take-home ration (adequate food for 25 days a month).

ICDS has been extensively studied and has not been found to be effective in reducing malnutrition [8–10]. A particularly rigorous study using data from the National Family Health Survey (NFHS-2 and NFHS-3) found little evidence of the program's impact on nutritional status. According to the analysts, this was attributable to a combination of factors: low coverage in poorer states, higher coverage among higher socioeconomic classes in which malnutrition is less prevalent and less severe, poor targeting across and within states, and smaller budget allocations to the poor northern states where nutrition deficiencies are more prevalent [6].

Targeted Public Distribution System

The TPDS sells highly subsidized food to qualified beneficiaries in its three target populations:

» Below Poverty Line (BPL), directed to the poorest families, who are eligible to purchase 35 kg of food grains per month;
» *Anatyodaya Anna Yojana* (AAY), directed to the poorest 20% of BPL families;
» Above Poverty Line (APL), directed to families that are not among the poorest but that have low incomes that put them at risk for food insecurity. APL families are eligible to purchase 20 kg of food grains per month at a less highly subsidized price [11].

TPDS is enormous, distributing food through a network of more than 300,000 retail stores (known as PDS Fair Price Shops) located throughout the country. The TPDS food grain allocation for April 2010 to March 2011 was 49.4 million MT.

The program, however, has not been effective in achieving its aims of transferring income and reducing poverty, or in improving nutritional status. Its major shortcomings include:

» Bogus identification cards and other causes of excess identification of BPL and APL households;
» Nonissuance of ration cards to eligible beneficiaries;
» The quantity of food households are entitled to is inadequate;
» High administrative costs (annually, 40% to 70% of the value of the food subsidies provided);
» A strong urban bias;
» Leakages, with diversion of as much as one-third of the program's food grains [12–14].

Mid-Day Meal

MDM is a program of the Department of Education of the Ministry of Human Resource Development, started in 1995 and covering students in public primary and secondary schools. The MDM provides a prepared mid-day meal with a minimum energy content of 300 kcal and 8 to 12 g of protein each day of school for a minimum of 200 days per year. In 2006/07, the Government of India allocated 2.16 million MT of food grains (wheat and rice) to feed the 118.5 million children in 988,000 institutions participating in the MDM [11]. A 2007 assessment of the Gujarat MDM program noted that the program is mandated to provide the equivalent of only about 15% of the daily caloric requirements and that there is no guarantee that the children will get the other 85% of their daily required calories at home. It concluded that "the implementation of the MDM scheme may be wanting on the grounds of nutrition and food safety" [15]. Other evaluations of the MDM have similarly found it to be wanting on a number of evaluation criteria [15–17].

Micronutrient supplementation programs

India's two largest supplementation programs are the iron and folic acid program and the vitamin A program. Population-based survey measures of the

* Pelletier D. A review of "best practices" in ICDS. Consultancy report prepared for the Micronutrient Initiative and submitted to the World Bank, 2007.

coverage of the antenatal care-based distribution of iron and folic acid (IFA) supplements from the three most recent national surveys are presented in **figure 1**. In 1992/93, the IFA program reached 51% of its targeted beneficiary population with some IFA tablets. In 1998/99, coverage improved to 58% before slipping by 41% in 2005/06 (the most recent available data) to just 34%, and the percentage of the eligible target population that received an adequate supply of IFA in 2005/06 fell even more rapidly [2, 3].

The performance of the vitamin A supplementation program has not been good but has been substantially better than that of the IFA program. Moreover, it appears to be improving. In 2005/06, the percentage of children 12 to 35 months of age who were reported to have ever received a dose of vitamin A increased from 17% to 25% over the 1998/99 level, and the percentage who received at least one dose of vitamin A within the previous 6 months increased from 30% to 53% over the 1998/99 level. Since then, the vitamin A supplementation coverage in most states has continued to improve due to increased advocacy for the program, increasing partner support, and the adoption of a more regular and more structured biannual approach by many states.*

Food fortification

Food fortification regulations date from 1953, when iodine-fortified salt and vitamin A–fortified hydrogenated oil were mandated. The coverage of fortified foods, however, remains low; the constitution assigns responsibility for health to the states, and no state has mandated fortification. Nor have there been any national, market-driven initiatives. Most advances have been the result of public–private partnerships, sparked in many cases by the efforts of international agencies. The progress that has been made to date has resulted from the introduction of fortification in a series of piecemeal, program-by-program, state-by-state efforts that have consisted of approaches enabling voluntary fortification. As a result, progress has been slow and impacts have been limited.

The Gujarat Wheat Flour Fortification Initiative

Efforts to promote fortification in the state of Gujarat began more than a decade ago. Initially, a number of different models were piloted and assessed. From the start, these initiatives were intended either to be of limited duration or to work exclusively with informal, small-scale stone grinding mills. This early work was led by international development agencies,

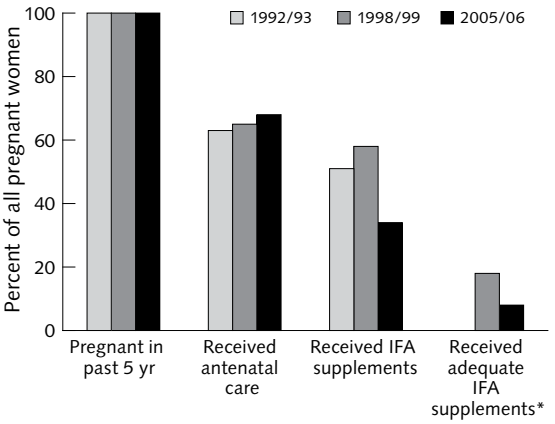

FIG. 1. Coverage of the antenatal care-based, IFA-based supplementation program in India in 1992/93, 1998/99, and 2005/06. The denominator for all measures is the number of women 15 to 49 years of age who were pregnant at least once in the past 5 years.

* "Adequate supplements" are defined as at least a 90-day supply. Source: National Family Health Survey (NFHS)-2 1998/99, NFHS-3 2005/06. [2, 3]. IFA, iron–folic acid

in particular, the Micronutrient Initiative (MI), the World Food Programme (WFP), the Global Alliance for Improved Nutrition (GAIN), and UNICEF.

The most significant of these early efforts and the one that proved to be the most valuable and enduring for Gujarat was a model that was distilled from the experiences of MI in West Bengal. In the hilly Darjeeling District of West Bengal, where traveling is difficult and where there are few flour mills, MI supported the Public Distribution System (PDS) substituting fortified wheat flour for wheat grain in an attempt to reduce the efforts and costs that ICDS beneficiaries incurred while improving their nutrition status. Key MI staff Ms. Saraswati Bulusu and Dr. Rajan Sankar, who were both involved in the West Bengal initiative, subsequently became involved in Gujarat and transferred critical technical and operational lessons to Gujarat. Continued advocacy by MI, together with support from the Indian Flour Fortification Network (IFFN)** and GAIN, in combination with the provision of technical and financial assistance at different stages in the development of these various initiatives over the course of the past decade, were critical in helping to spawn a partnership between the Gujarat Roller Flour Millers Association (GRFMA) and the state government.

* Houston R, Babu S. Scaling-up vitamin A supplementation for child survival in India: A program review of lessons learned, better practices and opportunities with a focus on 10 states. Consultancy report prepared for UNICEF India and Micronutrient Initiative India, 2009.

**The IFFN was founded in 2009 and is composed of National Wheat Flour Fortification Alliance members: the National Institute of Nutrition (NIN)–Indian Council on Medical Research, the International Council for the Control of Iodine Deficiency Disorders (ICCIDD), the Roller Flour Millers Federation of India, the Wheat Products Promotion Society, UNICEF, the World Health Organization (WHO) country office for India, WFP, MI, GAIN, and the US Agency for International Development (USAID).

While the development agencies were advocating with the state government for adoption of food fortification models at scale, the data on nutritional status from the NFHS-3 [3] were released. Then, in January 2006, the ICDS established guidelines on the micronutrient content of food distributed through the program's supplemental feeding component. The fortuitous timing of these three forces—the advocacy of international agencies, the release of what were widely regarded as "appalling" NFHS-3 findings, and the ICDS issuance of guidelines for the micronutrient content of ICDS foods—constituted a "perfect storm," giving impetus to the Gujarat government to consider providing fortified wheat flour through its ICDS program.

Gujarat is among the economically more developed states of India. In 2007, out of 35 states and union territories, Gujarat ranked sixth in gross domestic product (GDP) (US$47,481 million) and ninth in per capita GDP (US$950). Although Gujarat's economic indicators place it well above the national average, it generally lags behind national averages in several key health and nutrition indicators or is less advanced than might be expected, given the strength of its economy. For instance, in anemia prevalence Gujarat ranks 11th among children 6 to 59 months of age, 12th among women 15 to 49 years of age, and 16th among men 15 to 49 years of age [3]. As measured by the infant mortality rate, the state performs a bit better: its rate is 50 deaths per 1,000 live births, compared with the national average of 53 deaths per 1,000 live births [18]. However, when limited to just the rural population, the Gujarat infant mortality rate is 58 deaths per 1,000 live births, the same as the national average.

Gujarat's leaders found the results of the NFHS-3 shocking, embarrassing, and unacceptable. The need to more directly and effectively address malnutrition became a common topic of public discourse, as well as a goal of many key public figures, including Dr. S. K. Nanda. Then Principal Secretary of the Government of Gujarat's Ministry of Food, Civil Supplies and Consumer Affairs, Dr. Nanda became a catalyst for reinvigorating interest in fortification. Nanda, who had been the principal secretary in the ministry of health prior to being appointed to the Ministry of Food and Civil Supplies, was well aware of the nutritional challenges in the state and provided critical leadership in devising a strategy and mobilizing support from different levels of government and from other stakeholders to design and implement a plan.

The Gujarat wheat and wheat flour market

Table 1 provides information about major characteristics of Gujarat's wheat and wheat flour markets. There are four different types of flour mills in Gujarat. The largest and the most modern mills are the roller mills, with an average daily capacity of 80 to 100 MT. In January 2006, there were 32 roller mills in Gujarat. At that time, roughly three-quarters of the flour milled in Gujarat was milled by stone grinding mills, referred to as *chakkis*. There are three different categories of chakki. The largest ones, which have a daily capacity of 25 to 30 MT, together with the roller mills, constitute the organized milling sector in Gujarat. The other two categories of chakki are both small-scale mills that together comprise the informal milling sector. *Nukkad chakkis* are commercial enterprises with a daily capacity of 100 to 200 kg. They differ from the large chakkis of the organized sector not only in their smaller scale (they are often set up on street corners), but also by the more mixed nature of their enterprise. Many of them do not sell a product (such as flour) but instead sell only a service, the grinding of grain that customers bring to them. The smallest chakkis are called *ghar ghantis*. Ghar ghantis are not commercial enterprises. They are the property of a household and are used exclusively by the household to meet its own milling needs.

Two types of flour are consumed in Gujarat, *maida* and *atta*. Maida is a highly refined white flour, and atta is a less refined whole wheat flour. Of the 3 million MT of flour produced annually, 18% (540,000 MT) is maida, with atta accounting for most of the rest. Roller flour mills are able to produce different varieties of flour (maida as well as semolina flour, in addition to atta), whereas chakki plants (of all sizes) can only produce atta. An estimated 74% of the wheat milled in

TABLE 1. Characteristics of the Gujarat flour milling industry

Mill type	Market	Flour type	Number	Capacity	Market share (%)
Roller mills	Formal/organized	Atta or maida	32 (in 2006)	80–100 MT/day	26
Chakkis (stone mills)		Atta			
Large-scale chakki	Formal/organized	Atta	28 (in 2006)	25–30 MT/day	
Nukkad chakki	Unorganized/street corner	Atta	Unknown, estimated at 22,000–28,000	10-kg batches. Maximum daily capacity 100–200 kg	74
Ghar ghanti	Unorganized/ household-based	Atta			

Gujarat is milled by ghantis, with the organized sector accounting for the remaining 26%. Looking at the demand side of the market, most of the open market sales of maida are made to institutional consumers, such as bakeries, hotels, and restaurants. Households purchase only small quantities of maida, primarily for making snacks and sweets. A 2006 report on wheat marketing found that "In Gujarat, consumers prefer to buy whole wheat as they prefer to convert it into flour as and when they need" [19].

Open market test and the "three-phase strategy"

In November 2005, the Government of Gujarat, led by Nanda, began fortification discussions with the GRFMA. The discussions culminated in the government making a conditional offer to the GRFMA: if millers voluntarily fortified wheat flour sold on the open market, and it was found to be acceptable to consumers, then the government would substitute the fortified wheat flour for wheat grain in its food-providing social safety net programs (SSNPs): ICDS, PDS, and MDM. During this period, which became known as "the open market test," the government provided branding with a logo for the fortified products, thereby helping to educate the public about the beneficial effects of fortified flour, while promoting its use.

Although the government wanted to promote the fortification of wheat flour, it was reluctant to make it mandatory. Instead, it chose to make the fortification of wheat flour more feasible in all three milling channels (the three phases), while providing incentives to one of the three phases (the organized, larger-scale sector) to fortify. By retaining the voluntary nature of the program, the government could promote fortification while not being susceptible to charges that it was forcing anything upon consumers, since consumers retained the right to choose to purchase fortified or nonfortified wheat flour.* The open market test was an ingenious strategy. It provided the government with a means to evaluate the risk and challenges, especially those related to consumer acceptability, before committing whole-heartedly to the initiative.

Initially, the GRFMA was reluctant to enter into the partnership. Members of the association feared that the introduction of fortification would result in government interference in their open market operations. The allure of introducing wheat flour into the SSNPs, which would generate what the GRFMA estimated could be a 50% increase in the size of the wheat flour market in Gujarat, however, proved hard to resist. Adding to the appeal of the plan was the fact that the milling industry's excess installed capacity, estimated by industry sources at 60% at that time, enabled the millers to meet the increased demand with little risk and a modicum of additional investment. The potential financial gains from implementing the proposal overshadowed the doubts the GRFMA had about increased government involvement in the wheat market. They agreed to participate.

The outcome of the discussions between the Government of Gujarat and the GRFMA was what has come to be known as the "three-phase strategy." The three phases refer to both the staged timing of implementation of the initiative and the type of mill that was to become involved in the initiative in each phase. Phase I was the roller flour miller-related plan, phase II the organized, large-scale chakkis plan, and phase III the nukkad chakkis plan. The objective of the government in adopting the three-phase strategy was to encourage each of the three distinct channels of the milling industry to introduce fortified atta so that no channel would be left out of the plan, thereby maximizing the potential coverage of fortification and concomitantly its potential impact.

As envisaged, the open market sale of fortified flour was useful to test its acceptability to consumers. During the open market test during the first half of 2006, the state government and industry sources monitored consumer reactions through retailers and institutional buyers. According to the bakers, hoteliers, and some of the retail storekeepers interviewed for this case study, fortification had no effect on the taste, color, or consistency of the flour. They felt, however, that there could be problems of discoloration if the flour was stored for too long and that there could be rapid discoloration when the flour was turned into dough and stored. They further noted that these were potential concerns primarily of household consumers, not institutional consumers, because the latter's much faster turnover of the product prevents these shelf-life-related problems from arising.

The open market test also provided an opportunity to better educate the public and dispel misconceptions about fortification, thereby better ensuring the gradual and smooth introduction of the new product. For instance, from the start of the initiative, an often expressed concern, especially of vegetarians (who constitute an important percentage of the entire Gujarati population), has been the origin of the micronutrients in the premix. The strong, proactive political leadership demonstrated in championing the fortification initiative, however, and the conscious and unrelenting efforts to keep the media well informed about the program during the open market experiment paid off in helping to obviate these concerns and, more generally, the triggering of any controversy.

Overall, the open market test provided positive feedback enabling the extension of the fortification initiative to the more politically sensitive SSNPs. In addition to these assessments of responses of consumers and

* Maintaining the freedom to choose a fortified or unfortified product has been an important point that consumer groups and others have insisted on in the fortification debate throughout India.

TABLE 2. Growth in the coverage of fortified wheat flour supplied through Gujarat's SSNPs[a]

Program change	Coverage domain	ICDS	Component of the TPDS		MDM
			AAY	BPL	
June 2006	Several AWCs in Ahmedabad	X			
	16 AWCs in Deskrohi Block	X			
March 2007	City of Ahmedabad		X		
September 2007	3 additional cities		X		
November 2007	All AWCs (~40,000) Statewide	***X***			
April 2008	All AAY, Statewide		***X***		
August 2009	One Taluka in Sabarkantha District				X
September 2009	Statewide (~32,000 schools)				***X***
April–September 2010	All BPL and all PDS Statewide			***X***	

AAY, *Anatyodaya Anna Yojana*; AWC, *Anganwadi* Center; BPL, Below Poverty Line; ICDS, Integrated Child Development Scheme; MDM, Mid-Day Meal; PDS, Public Distribution System; SSNP, Social Safety Net Program; TPDS, Targeted Public Distribution System

a. ***X*** identifies when the program became statewide.

institutional users, there were two assessments of the effect of fortified flour on hemoglobin levels. The government analyzed the effect among ICDS beneficiary groups in a pilot area, and the GRFMA assessed the effect on a group of athletes. The government also commissioned an external agency to conduct two population-level investigations of the perceptions of various stakeholders, as well as to assess the general public's understanding of the importance of micronutrients and the potential impact of fortified flour on health status. Although both the impact assessments and the population-based surveys had limitations in terms of the robustness of their designs and methods of implementation (and thus might be regarded as providing, at best, evidence of a "plausible" causal relationship), they nevertheless provided some evidence that was useful to the proponents of flour fortification to push their agenda through, mostly, accepting channels [20].* With what was nearly universally regarded as the successful demonstration of the acceptability of fortified flour through the open market test, the government introduced fortified wheat flour into its public food and nutrition programs. **Table 2** shows the growth in the coverage of fortified wheat flour supplied through each of the SSNPs, which was deliberately phased in. **Table 3** shows the amount of flour and estimated number of beneficiaries of each of the programs.

Impact of the flour fortification initiative on the wheat and flour markets of Gujarat

The introduction of 604,000 MT of fortified whole wheat flour into the SSNP schemes dramatically affected the wheat flour market of Gujarat. The big winners were the formal sector millers (the roller flour millers and the large chakkis), whose market sales increased from 780,000 to 1.384 million MT, an increase of 43% (**table 4**). Their market share increased from 26% to 46%. Although the share of the informal sector fell by 22%, it is not clear how much of this loss was suffered by the small-scale commercial chakkis and how much of it was accounted for by households that no longer had to mill the wheat grain they received from an SSNP.

The fortification initiative did not affect the amount of maida produced. The roller mills continued to produce 540,000 MT of maida. Thus, they came to produce 1,128,000 MT of the total of 1,384,000 MT, 82% of all of the flour (maida and atta) produced by the formal sector. The residual 18% (256,000 MT) was produced by the large chakkis.

With the fortification initiative, the amount of atta flour produced grew from 240,000 MT annually to 844,000 MT, a more than threefold increase. With maida production remaining constant in absolute terms, its commercial market share fell from 69% to 48%.

The increased demand for flour has been met both by increasing the capacity of large chakkis and roller mills and by building and bringing on line more of both types of mill. There are currently 44 roller flour mills and 40 chakki plants in the state, and all are producing fortified flour for one or more of the SSNPs.

Political economy of change

The introduction of fortified wheat flour into the SSNPs has not been welcomed by all. Given the magnitude of the nukkad chakkis' loss of market share, it is hardly surprising that this group opposed the initiative. Although it is difficult to determine the exact quantity of wheat being milled by the nukkad chakkis, it is safe

* Sanguine Management Services. Impact assessment study on food fortification initiative in Gujarat. A study commissioned by the Gujarat State Civil Supplies Corporation, 2007. Sanguine Management Services. Review of new initiatives on food fortification and their impact assessment. A study commissioned by the Gujarat State Civil Supplies and Consumer Affairs Department, 2007.

TABLE 3. Reach of the SSNPs that provide fortified wheat flour in Gujarat

Scheme (date of going to statewide scale)	Quantity per beneficiary per month	Volume (MT/mo)	Estimated no. of people reached per month
TPDS (AAY, Apr 2008; BPL, Apr 2010)	AAY: 18 kg wheat flour/household BPL: 13 kg wheat flour/household	45,000	3,502,684 families (~ 17,513,420 people, average family size of 5) BPL: 12,063,619 AAY: 5,449,801
MDM (Sep 2009)	Primary and upper primary school children (180 g/meal; 50 g wheat/meal; 1 meal/day, 200 days/yr)	4,000	3,935,214 children (~ 135/school)
ICDS (Nov 2007)	Only children 3–6 yr old receive spot feeding 5 days/wk. We assume that on 3 of those days they are provided 180 g/meal; 50 g wheat flour	2,000	1,741,045 children

AAY, *Anatyodaya Anna Yojana*; BPL, Below Poverty Line; ICDS, Integrated Child Development Scheme; MDM, Mid-Day Meal; SSNP, Social Safety Net Program; TPDS, Targeted Public Distribution System

TABLE 4. Impact of the introduction of fortified wheat flour into Gujarat's SSNPs

	Prior to introduction		After introduction		
Channel of delivery	Annual production (MT)	%	Annual production (MT)	%	Remarks
All open market products by roller mills and large chakki plants	780,000	26	780,000	26	540,000 MT maida, 240,000 MT atta
All welfare schemes (PDS, MDM, and ICDS)	0	0	604,000	20	PDS: 540,000 MT; MDM: 40,000 MT; ICDS: 24,000 MT
Wheat grain milled by households at small, informal sector, chakkis, or using their own mills (ghantis)	2,220,000	74	1,616,000	54	Stone mills in the informal sector, and home-based mills. No verifiable source of information
Total consumption in the state	3,000,000	100	3,000,000	100	

ICDS, Integrated Child Development Scheme; MDM, Mid-Day Meal; PDS, Public Distribution System; SSNP, Social Safety Net Program

to assume that the provision of fortified flour instead of wheat grain through PDS has reduced their business by roughly that same volume, about 25%.

In July 2007, the Government of Gujarat issued an official circular directing the owners of nukkad chakkis to fortify the wheat flour they were milling with iron and folic acid. The nukkad chakki owners questioned the validity of the circular in the courts, claiming that they did not sell flour but were instead providers of a service, i.e., the milling of the grain that consumers bring to them for that purpose. They also argued that the process of fortification for nukkad chakkis is cumbersome and that they should not be required to fortify because they can only add something, including fortificant, to the wheat their customers bring them if the customers so direct them or at minimum give their consent. In October 2007, the court dismissed these concerns and commended the fortification initiative of the government.

Another source of opposition to the introduction of fortified flour has been the owners of the Fair Price Shops (FPSs), the licensed shops for selling PDS supplies. Many FPS owners also own ghantis in rural areas, and much of the grain diverted illegally from the PDS used to find its way to these ghantis (and also to some of the large roller flour mills). Although the authenticity of claims about the role of owners of FPSs and ghantis in rural Gujarat could not be verified, the nukkad chakki owners seem to be one group that has economically suffered with the introduction of fortified flour. This group, together with several local nongovernmental organizations (NGOs), brought a case before the High Court of Gujarat demanding the cessation of the wheat flour initiative, primarily on the grounds that the flour's much shorter shelf-life made it unacceptable to consumers. Based on the opinion of experts from the National Institute on Nutrition (NIN), the court ruled against the group and praised the state for its fortification program. This case was a benchmark, paving the way for the government to continue with expansion of fortification under AAY to the entire state, and later to include all BPL beneficiaries as well.

The incremental costs of atta fortification

The introduction of fortified atta in the three SSNPs required substituting wheat flour for wheat grain, as well as the introduction of fortification in the mills producing the wheat flour. The goal of the government in introducing fortified wheat flour was foremost the improvement of the micronutrient status of Gujaratis, and the analysis here will focus on just the costs attributable to the introduction of micronutrient-fortified wheat flour. Costs not considered in the current study because they are attributable to the introduction of flour and not to micronutrient fortification per se include those incurred by transporting grain to the mills, transporting flour from the mills, cleaning the grain, milling the grain, enforcing regulatory restrictions on the milling of other grain and on the production of products other than atta when the flour for SSNPs is being produced, packaging atta into packages of specific sizes, and quality control related to flour characteristics unrelated to micronutrient fortification.

There are three major determinants of the costs of wheat flour fortification: the type of mill (roller or chakki), the size and technology of the plant, and the fortification formulation [21]. The roller mills in Gujarat are nearly all exactly the same size, and all use the same equipment. The same is true of the larger, formal sector chakkis. Given the similarities in the size and technology of the mills, the estimates of the incremental costs of fortification were developed from case studies of just three roller mills and two large chakki mills. The cost of fortification per metric ton of flour varies substantially by fortification formulation. The Open Market Sales (OMS) and PDS are fortified with only iron and folic acid, whereas the MDM and ICDS formulation includes nine micronutrients and fortification levels that are considerably higher, as may be seen in **table 5**.

TABLE 5. Gujarat's ICDS and MDM fortification formulations

Micronutrient	Fortification level (per 50 g wheat flour)	
	Initial program level	New level as of Oct 2011
Vitamin A (μg)	200	150
Iron (mg)	7.5	7.5
Zinc (mg)	5	0
Calcium (mg)	225	250
Iodine (μg)	50	0
Riboflavin (mg)	0.5	0.33
Ascorbic acid (mg)	20	10
Folic acid (μg)	20	50
Vitamin B12 (μg)	0.5	0
Niacin	0	3.5
Thiamin (mg)	0	0.3

ICDS, Integrated Child Development Scheme; MDM, Mid-Day Meal

Cost by type of mill and type of program

The introduction of fortification required only relatively minor changes in the production lines of both types of mill. From the outset of the fortification initiative, all of the roller mills and large chakkis already had worm conveyors that were long enough to ensure uniform mixing of the premix with the flour. As a result, the only capital equipment required to begin fortification in either type of mill was a microfeeder for the premix. From the start of the initiative, all interested owners of roller mills and large chakki plants were offered locally fabricated microfeeders, which they purchased.* Irrespective of the type or size of the mill, the size and cost of the microfeeders was the same, 18,000 INR (US$400). According to the secretary of the GRFMA, the useful lifespan of these microfeeders is approximately 10 years. In this analysis, the cost of the microfeeders was annualized using straight-line depreciation.The annual maintenance cost of the feeder was estimated at 7% of its cost or 1,260 INR (US$28).

All three of the roller mills analyzed for this study produced fortified atta flour for the OMS and PDS, and two of them also fortified flour for the MDM and ICDS programs. A weighted average of the costs of the three mills was also developed for the purpose of providing an overall Gujarat average cost per metric ton of roller mill fortification.

The MDM-ICDS premix costs 99.6 times more per metric ton than the OMS-PDS premix. As a result, the share of total incremental costs of MDM-ICDS fortification attributable to premix is much higher: 99% compared with 52% for the PDS-OMS. On average, a roller mill's annual incremental cost of fortifying flour for the OMS-PDS program is US$0.48/MT, and the cost of fortifying for the MDM-ICDS is US$25.11/MT. When the cost of the premix—the primary source of the marked difference in the cost per metric ton—is excluded, the roller mills' incremental cost per metric ton is nearly identical: the OMS-PDS cost per metric ton is slightly higher at US$0.23, compared with US$0.22 for the MDM-ICDS.

The large chakkis in Gujarat only produce fortified atta for PDS and OMS; none produces it for the ICDS or MDM. Given the very different costs of the premix used in the PDS-OMS as compared with the ICDS-MDM, direct comparisons of the two mill types are restricted to the one program in which they both participate, PDS-OMS. The large chakkis' average incremental cost (exclusive of annualized capital costs) is about 27 rupees per metric ton for PDS-OMS atta, which is 33% greater than the cost for the roller mills. Two factors account for this substantial difference.

* The MI paid for half of each miller's premix costs for the first 2 years.

TABLE 6. Comparing the annual incremental costs of fortification: By type of mill and program

Cost item	Cost (rupees/MT)		As a percent	
	PDS and OMS	ICDS and MDM	PDS and OMS	ICDS and MDM
Large chakki mills				
1. Premix	11.25		38.7	
2. Internal QA/QC costs	1.69		5.8	
3. External quality control	6.61		22.8	
4. Incremental production costs	7.85		27.0	
Total without annualized capital costs	27.40		94.4	
Annualized capital costs (depreciated over 10 yr) and training costs (depreciated over 5 yr)	1.64		5.6	
Total costs (with annualized capital costs)	29.036		100	
Total cost (US$)	0.645			
Total cost exclusive of fortificant (US$)	0.395			
Roller mills				
1. Premix	11.25	1,120.00	51.5	99.1
2. Internal QA/QC costs	1.04	0.96	4.7	0.1
3. External quality control	6.08	6.06	27.9	0.5
4. Incremental production costs	2.64	2.32	12.1	0.2
Total without annualized capital costs	21.00	1,129.34	96.2	99.9
Annualized capital costs (depreciated over 10 yr) and training costs (depreciated over 5 yr)	0.82	0.74	3.8	0.1
Total costs (with annualized capital costs)	21.824	1,130.076	100	100
Total cost (US$)	0.485	25.113		
Total cost exclusive of fortificant (US$)	0.235	0.224		

ICDS, Integrated Child Development Scheme; MDM, Mid-Day Meal; OMS, Open Market Sales; PDS, Public Distribution System; QA/QC, quality assurance/quality controls

First, the cost structures of the two types of mill are different (**table 6**). Although the absolute costs of the fortificant per metric ton are identical in the two mill types, the percentage of total costs they constitute varies, due primarily to the large chakkis' much higher incremental production cost, which is threefold that of the roller mills, accounting for 81% of the difference in the costs for the two types of mill.

The second factor accounting for the large chakkis' relatively high incremental cost per metric ton of atta is the chakkis' much lower average production level. On average, a large chakki produces slightly less than one-third the amount of wheat flour produced by a roller mill. The roller mills enjoy economies of scale in the production of fortified atta. These economies are revealed only when the two types of mills are compared, because the average output levels within each mill type category are very similar.

Estimated statewide private industry costs of fortification

Annually, the 44 roller flour mills and 40 large chakkis operating in Gujarat together produce about 240,000 MT of fortified atta for open market sale, 540,000 MT for PDS, and about 64,000 MT for MDM and ICDS. Roller mills reportedly produce 588,000 MT of the total of 844,000 MT of atta flour (GRFMA communication). Combining this information with the average unit costs of production of the roller mills and chakki plants provides us with an estimate of the annual statewide private industry's incremental costs of fortification of US$419,260 for PDS-OMS and US$1,607,232 for MDM-ICDS, or a total of US$2,026,492 (**table 7**, section A).

Despite the fact that the quantity of fortified atta produced for PDS-OMS is nearly 11 times greater than the quantity produced for MDM-ICDS, the much more costly MDM-ICDS fortificant formulation results in the total incremental costs of MDM-ICDS being more than four times greater than those of the PDS and OMS. When premix costs are excluded from the calculations, private sector costs fall from US$2,026,492 million to US$238,596, about 12% their full cost level (**table 7,** section B).

Public sector costs

The Gujarat state government has incurred two distinct types of cost as a result of the wheat flour fortification program: one-time startup costs to establish regulations

TABLE 7. Estimated statewide private sector incremental costs of fortification of atta

Type of mill	PDS and OMS			MDM and ICDS			Grand total cost of fortification in the state (US$)
	Fortified atta for open market sale and PDS (MT)	Cost of fortification (US$/MT)	Total cost of fortification in the state (US$)	Fortified atta for MDM and ICDS (MT)	Cost of fortification (US$/MT)	Total cost of fortification in the state (US$)	
A. Total costs							
Roller flour mills	524,000	0.485	254,140	64,000	25.113	1,607,232	1,861,372
Large chakki plants	256,000	0.645	165,120				165,120
Total	780,000	0.538	419,260	64,000	25.113	1,607,232	2,026,492
B. Costs, exclusive of fortificant costs							
Roller flour mills	524,000	0.235	123,140	64,000	0.224	14,336	137,476
Large chakki plants	256,000	0.395	101,120				101,120
Total	780,000	0.288	224,260	64,000	0.224	14,336	238,596

ICDS, Integrated Child Development Scheme; MDM, Mid-Day Meal; OMS, Open Market Sales; PDS, Public Distribution System

and initially train millers, and annual recurrent, regulatory costs related to the monitoring of fortified atta production, quality control, and some additional management costs. The fortification of wheat flour for OMS, whether it be atta or maida, is not monitored by the government. The public sector costs discussed here, therefore, include only those being incurred for the inspection of that flour that is being fortified for distribution through the ICDS, PDS, and MDM.

Millers who are interested in selling fortified atta to the Government of Gujarat must submit a proposal stipulating the quantity of wheat grain that they are willing to mill and the amount they want to be paid for doing so. The proposals are submitted to the Food and Civil Supplies Corporation (FCSC), which reviews the proposals and awards a 6-month contract for each district.

According to government directive, the milling for SSNPs is to be done over a stretch of 10 to 15 days in each month, with the precise number depending upon the quantity being produced. During that time, no other milling by the contractors is permitted, and compliance is monitored daily by the government inspector that the FCSC appoints to each mill. According to the officials of the FCSC, no new government personnel were hired to monitor the mills or to manage fortification-related activities; the entire process has been handled by existing staff.

It is estimated from interviews with several of the FCSC inspectors that they spend about half of their monthly working days inspecting mills while they are producing fortified atta. It is further estimated that about 20% of that time (i.e., 10% of their total time) is spent on specifically fortification-related activities.

The government itself is not conducting the quality control testing of the flour samples; it contracts private laboratories to do so. While many of the quality control activities stem from monitoring the quality of the flour (such as moisture content, ash content, and gluten levels) and are not attributable to fortification, the external laboratories also test the micronutrient levels. In their daily monitoring during the 10- to 15-day period when the mills are exclusively dedicated to producing fortified atta, FCSC inspectors at each mill take one sample for each 50 MT of flour produced. They certify the packaging of these samples and send them to the external laboratories and to the state FCSC headquarters for quality control.

Total incremental costs of atta fortification in Gujarat

The total annual incremental costs of atta fortification are the sum of the incremental, annual, private sector statewide costs plus the incremental fortification costs incurred by the government: US$2,026,492 plus US$72,747, a total of US$2,099,239. The private sector costs are incurred in producing 844,000 MT and average US$2.40/MT. The public sector costs are

TABLE 8. Annual incremental total (private + public sector) costs of fortification of atta in three SSNPs in Gujarat

Program	Annual incremental cost (US$)	MT/yr of fortified atta	Average annual incremental cost/ MT (US$)	No. of beneficiaries	Annual incremental cost/beneficiary (US$)
TPDS	355,860	540,000	0.659	17,513,420	0.020
MDM	1,009,360	40,000	25.234	3,935,214	0.229
ICDS	605,616	24,000	25.234	1,741,045	0.202
Total	1,970,836	604,000	3.263	24,913,420	0.079

ICDS, Integrated Child Development Scheme; MDM, Mid-Day Meal; SSNP, Social Safety Net Program; TPDS, Targeted Public Distribution System

incurred in monitoring and regulating the production of 604,000 MT of fortified wheat (and are exclusive of the costs of wheat fortified for OMS). They total US$72,747 and average US$0.121/MT.

Disaggregating the private sector's fortification costs into those incurred for fortifying only PDS atta and those incurred for fortifying only MDM-ICDS atta, and assigning public sector costs to each SSNP in direct proportion to its share of fortified atta, yields the total incremental costs of fortifying atta for each program. **Table 8** shows the annual incremental total costs, the average cost per metric ton, and the cost per beneficiary for each of the three programs.

Methods

Estimating the impact of the Gujarat Atta Fortification Programme

Estimating individuals' "usual intakes"

Micronutrient status is most directly and precisely measured by using biochemical indicators. Ideally, to measure the impact of the introduction of fortified atta on the nutrition status of the Gujarat SSNP target populations, one should conduct an effectiveness trial with baseline and endline evaluations in which there is a control population that is not receiving the intervention, and with biochemical measurements of each individual's micronutrient status at baseline and at endline (i.e., after the introduction of fortification). Unfortunately, no such study has ever been done, and the only biochemical measurements available for any of the micronutrients included in the fortification formulas are the NFHS-3 blood sample-based hemoglobin measurements used to measure anemia rates. Those measurements were last taken in 2004/05, just prior to the beginning of the pilot of the fortification program. Rather than disregarding the fundamentally important issue of impact, we choose to estimate it using the next best—but an admittedly second-best—approach, using the National Survey Sample round 61 (NSS-61).*

The NSS was conducted in 2004/05 and was designed to provide statistically representative samples for each of India's 35 states and union territories. The Gujarat sample included 4,275 households composed of 20,677 individuals. We used the survey data in two ways: to identify households participating in each of the three SSNPs and to estimate the nutrition status of each household member. The survey included questions that enabled the identification of households that participated in each of the three SSNPs. Interviewees were asked if their household was a PDS ration cardholder, and whether or not anyone in the household had participated in the ICDS or the MDM in the previous 365 days. No information was collected, however, on whether or not the household actually participated in the program. We assume that those households that were eligible to do so, participated. (This is the equivalent of what is referred to as the "intention-to-treat" approach in program evaluation literature.) Twenty-seven percent of the surveyed Gujarat households reported having either an AAY or a BPL ration card, 8% reported that at least one household member had been a beneficiary of the ICDS in the previous year, and 21% reported that at least one member of the household had been an MDM beneficiary in the previous year.

Using a 154-food-item list, the NSS asked households about the specific types and quantities of food the household consumed in the past 30 days from purchases, own production, and food that it received as in-kind payment and food "gifts." We combined these data with information from India's NIN food composition tables [22] to estimate the household's total caloric intake and its total nutrient intakes of vitamin A, iron, and zinc, assuming that all of the food was distributed within the household in direct proportion to each member's share of the household's total adult consumption equivalents [23].** Next, we quantified each individual's "usual daily intake" from the household's total nutrient intake over the recall period and compared

* National Survey Sample Office (NSSO) Ministry of Statistics and Public Information, Government of India. Socio-Economic Survey, Sixty-First Round: July 2004-June 2005.

** This implicitly assumes that the distribution of food among household members is in direct proportion to their share of the household's total adult consumption equivalents (ACEs).

TABLE 9. Estimated impact of the introduction of fortified wheat flour in the four SSNPs of Gujarat vitamin A (μg/day), iron (mg/day), zinc (mg/day)

Population/ type of program beneficiary	Nutrient intakes prior to fortification						Nutrient intakes with fortification							
	Vitamin A		Iron		Zinc		Vitamin A formula 1[a]		Vitamin A formula 2[b]		Iron		Zinc	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
All Gujaratis	202.1	167.0	13.1	12.8	10.1	9.8								
MDM[c]	132.4	110.1	11.3	10.9	8.8	8.7	332.4	310.1	282.3	260.1	18.8	18.4	13.8	13.7
ICDS[d]	102.8	88.9	8.0	7.7	6.6	6.3	302.8	288.9	252.8	238.9	15.5	15.2	11.6	11.3
PDS: AAY[e]	157.4	123.9	13.4	12.8	10.3	9.7	157.4	123.9	157.4	123.9	16.4	15.8	10.3	9.7
PDS: BPL[e]	157.4	123.9	13.4	12.8	10.3	9.7	157.4	123.9	157.4	123.9	15.8	15.1	10.3	9.7

AAY, *Anatyodaya Anna Yojana*; BPL, Below Poverty Line; ICDS, Integrated Child Development Scheme; MDM, Mid-Day Meal; PDS, Public Distribution System; SSNP, Social Safety Net Program

Source: Authors' calculations based on National Survey Sample round 61 (NSS-61) data and [22]

a. Vitamin A formula 1: 200 μg 50 g, which was in effect from the beginning of the program until October 2010.

b. Vitamin A formula 2: 150 μg 50 g, which has been in effect since October 2011.

c. Based on intake estimates for children 6 to 13 years of age from households that reported participating in the MDM program.

d. Based on intake estimates for children 3 to 6 years of age from households that reported participating in the ICDS program.

e. Based on intake estimates from households that reported having a PDS (AAY or BPL) card.

AAY and BPL are both fortified with iron at 30 ppm.

the individual micronutrient intake levels with their age- and sex-specific Estimated Average Requirement (EAR) levels to characterize the individual's micronutrient intake level as "adequate" (for levels equal to or greater than the EAR) or "inadequate" (for levels less than the EAR).

It is likely that our estimates of inadequate intake are somewhat higher than "true" deficiency levels. Of the three micronutrients analyzed here, the greatest uncertainties involve the estimation of the adequacy of intake of vitamin A. The estimations of inadequate zinc intake involve the least uncertainties, with iron being intermediate. In the case of vitamin A, the uncertainties stem from two sources: our ignorance about whether or not the individual was suffering from an infection and the possibility that the amount of vitamin A in the food might have dissipated due to conditions of storage or food preparation (as vitamin A is heat and light sensitive).* In the case of iron, our lack of information about the individual's infection status is a source of uncertainty about our measure of intake adequacy, and for both iron and zinc, lack of knowledge of the bioavailability of these minerals resulting from the level of phytates in the person's diet constitutes another source of uncertainty. We refer to our estimates as "adequate/inadequate intake," as distinct from "nondeficient/deficient," to help the reader bear in mind the limitations of the methodology.

Another shortcoming of the estimated intake levels is that the NSS inadequately accounts for food consumed away from home. Although the NSS asks respondents about the number of meals that they consume outside the home, no information is collected on the types or quantities of the food consumed. This results in underestimation of total nutrient intake and overestimation of levels of inadequate intake.**

Estimating the additional nutrient intakes due to the fortification program

For the target population of each SSNP, we modeled the additional intake of micronutrients due to consumption of the program's fortified wheat flour ration. The estimated change in an individual's micronutrient intake level is a function of the quantity of fortified atta wheat flour the household acquired and the individual apparently consumed, and the specific fortification formula of the program or programs of

* We assume that the levels of fortification at retail are those required by the Government of Gujarat, which includes an "overage." The losses referred to here are additional losses due to storage that the food might undergo before it is consumed.

** Smith L. The great Indian calorie debate: An investigation of divergent trends in poverty and undernourishment during India's rapid economic growth. Report prepared for the Food and Agriculture Organization of the United Nations. Technical Assistance for Non-Government Organizations (TANGO). Tucson, Ariz, USA, 2011.

which the household indicated it was a beneficiary and in which members of the household who met any age requirements (such as in the ICDS and MDM) were presumed to be participants. The program's impact is estimated—using the difference in individuals' pre- and postfortification micronutrient intake levels—as the reduction in the prevalence of inadequate intake.

We estimated the usual (or baseline) micronutrient intake levels of all of the households and individuals in the sample, as well as of those households identified as participating in each of the SSNPs. The analysis of the impact of fortification on the nutrient intake of ICDS beneficiaries is based on our analysis of the pre- versus postfortification change in the prevalence rates of inadequate intakes among the 3- to 6-year-olds in households that reported having at least ICDS beneficiary in the previous year. To assess the impact of fortification on MDM beneficiaries, we analyzed nutrient intake changes of children 6 to 13 years old (the ages of students in the first to seventh grades, the target population of the program) in households that reported having at least one MDM beneficiary in the previous year. For PDS (both the AAY and BPL components), the analysis is based on all persons in those households who reported having an AAY or BPL PDS ration card.

In analyzing the impacts of the MDM and ICDS programs, it was assumed that all of the beneficiaries consumed the same amount of fortified wheat flour, 50 g per day, which is the official minimum daily wheat ration per person in both programs. For PDS beneficiaries, the quantity of wheat flour consumed was estimated as the household's monthly allocation of wheat flour (18 and 13 kg for AAY and BPL beneficiaries, respectively) divided by the individual's share of the household's total adult consumption equivalents (which is used to proxy the unknown intrahousehold distribution of the fortified flour). **Table 9** presents the estimated average (mean and median) intakes of vitamin A, iron, and zinc before and after fortification for the entire Gujarat population, as well as for the beneficiaries of each of the three SSNPs. These calculations consider each of the programs independently, i.e., they do not take into account the additional nutrient intakes provided by more than one program for those persons who are beneficiaries of two or three programs.

Results

Estimates of the impact of the fortification program

Forty-four percent of Gujarat households participated in at least one of the three SSNPs. About three-quarters of the households that participated in one of these programs participated in only one of them, most commonly PDS. Thirteen percent of households participated in two or all three of the programs, most commonly PDS and MDM. About half of the households participating in two or more programs (7% of all households) were in both PDS and MDM.

Within a household eligible to participate in a program, usually only some of the household members are eligible to participate. ICDS and MDM are targeted only to children from 3 to 6 and from 6 to 13 years of age, respectively, and the prepared meals in which the fortified wheat flour-based foods are provided in both programs are eaten away from home. Thus, although it is important to look at household coverage to understand how well these programs are doing in helping Indian households deal with food and nutrition security and vulnerability, to understand the effectiveness of these programs it is essential to identify who within the household is eligible to participate and to focus the analysis exclusively on these individuals.

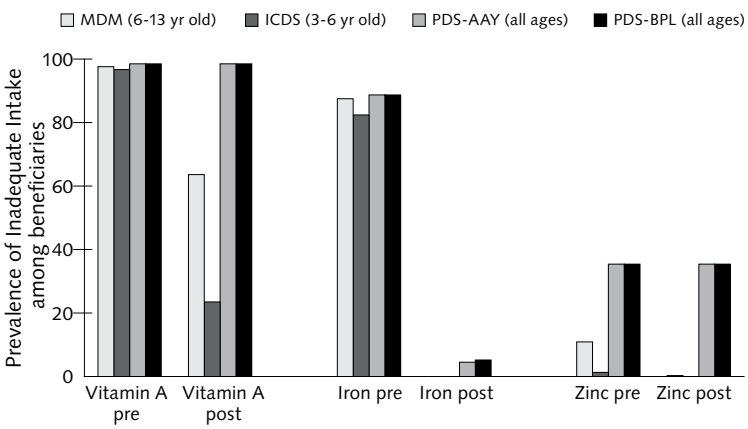

FIG. 2. Estimated impacts of the introduction of fortified wheat flour in MDM, ICDS, and PDS in Gujarat. AAY, *Anatyodaya Anna Yojana*; BPL, Below Poverty Line; ICDS, Integrated Child Development Scheme; MDM, Mid-Day Meal; PDS, Public Distribution System

TABLE 10. Coverage of SSNPs in Gujarat

Program participation status	Persons in household by household program status		Persons in households with coverage who are eligible and presumed to participate	
	No.	%	No.	%
No program participation	28,933,613	47	39,816,263	64.2
Participation in only 1 program				
PDS	8,601,664	14	15,058,007[a]	24.3
ICDS	3,606,252	6	947,581	1.5
MDM	9,042,027	15	3,407,902	5.5
Total in only 1 program	21,249,943	34	4,355,483	7.0
Participation in 2 programs				
PDS-ICDS	1,083,963	2	307,144	0.5
PDS-MDM	6,707,453	11	2,263,787	3.7
ICDS-MDM	2,710,475	4	120,621	0.2
Participation in 3 programs	1,285,598	2	49,740	0.1
Total in 2 or 3 programs	11,787,489	19	2,741,292	4.4
Total Gujarat population	61,971,045	100	46,913,038 86,729,301	76
Total participants in each program				
PDS	17,678,678	38	17,678,678	70.9
ICDS	8,686,288	19	1,425,086	6
MDM	19,745,553	43	5,842,049	23
Total SSNP beneficiaries	46,110,519	100	24,945,813	100

ICDS, Integrated Child Development Scheme; MDM, Mid-Day Meal; PDS, Public Distribution System; SSNP, Social Safety Net Program

a. Includes persons who lived in households that had PDS and one other program but who personally were not eligible to participate in the other program (ICDS or MDM)

Table 10 presents information about the SSNP coverage of household and individuals, and clearly shows that the overall coverage rates of individuals are considerably lower than those of households. The individual-based view of the programs' coverage also makes the significance of PDS more readily apparent: it covers 71% of the Gujaratis who are covered by one or more of these three programs.

Figure 2 presents the pre- and postfortification estimates of the prevalence of inadequate intakes of vitamin A, iron, and zinc. The estimated impacts are large. The proportion of the population with inadequate vitamin A intake is reduced by 35% among the MDM population and by 76% among the ICDS population. The proportion of the population with inadequate intake of iron is reduced even more, by 100%—that is, inadequate iron intake is virtually eliminated—within both the MDM and the ICDS populations. Inadequate zinc intake, whose prevalence was already very low relative to that of inadequate vitamin A and iron intake, is also effectively eliminated by fortification.

The PDS Programme, which uses a fortification formula containing only iron and folic acid and has an iron fortification level that is only 15% of the MDM-ICDS level, has a more modest impact on the prevalence of inadequate iron intake than do the MDM-ICDS Programmes, decreasing it from 89% to about 5% in both the PDS-AAY and the PDS-BPL programs. Still, the impact is enormous. The impact of AAY, which provides 38% more fortified wheat flour per household per month than BPL, is only slightly larger than that of BPL, reducing the prevalence of iron deficiency among the beneficiary population to 4.5%, compared with 5.2% for the BPL. This is probably due to differences in the degree of severity of the baseline deficiencies of the most deficient among these two populations of beneficiaries; those who still have inadequate intakes after the introduction of fortification are so severely deficient that although the additional fortified atta improves their iron status, it does not do so enough to enable them to cross the EAR threshold level required to qualify as having adequate intake.

Figure 3 shows the effect of the October 2010 change in the ICDS-MDM vitamin A fortification formula. The modification, a 25% reduction in the amount of vitamin A, resulted in a 28% increase in the prevalence of inadequate vitamin A intake among MDM beneficiaries and a more than twofold increase in the prevalence of inadequate vitamin A intake among ICDS beneficiaries compared with the levels reached

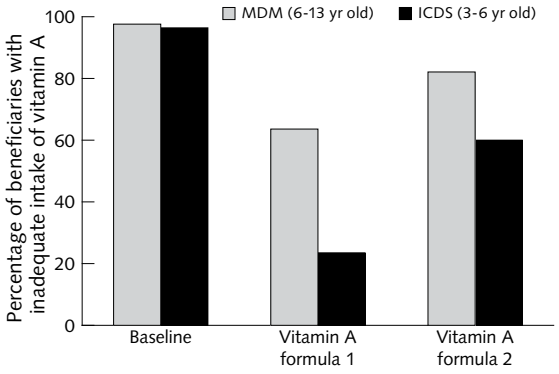

FIG. 3. Effect of reducing vitamin A fortification level in the Gujarat ICDS-MDM fortification formulation on the prevalence of inadequate vitamin A intake. ICDS, Integrated Child Development Scheme; MDM, Mid-Day Meal. Source: authors' calculations based on National Survey Sample round 61 (NSS-61) data.

with the first fortification formula. Dropping zinc from the fortificant resulted in foregoing the gains of reducing inadequate zinc intake among 10.6% of MDM beneficiaries and 1.3% of ICDS beneficiaries whose inadequate zinc intakes had been eliminated with the original formula (**Figure 2**). The impact of that modification pales in comparison to the cutting of the vitamin A level. Whether the change resulted in increases in vitamin A deficiency, however, is uncertain, because the change was prompted by the introduction of vitamin A–fortified vegetable oil by the ICDS. Ascertaining this would require further analysis that would take into account the coverage and intake levels of ICDS' vitamin A fortification of vegetable oil, an important undertaking but an activity outside the scope of this study.

Using the same DALY estimating methodology discussed earlier but with Gujarat-specific data, it is estimated that the number of DALYs annually lost to micronutrient deficiencies in the state is 396,694. As may be seen in **table 11**, the priority that the government has given to fortifying with iron, given the state's deficiencies, has been appropriate.

A first approximation of the cost-effectiveness of wheat flour fortification in Gujarat's SSNPs

WHO's CHOICE (Choosing Interventions that are Cost Effective) Working Group has established criteria for assessing the cost-effectiveness of health programs by measuring their cost per DALY relative to per capita GDP. It classifies health interventions as "cost-effective" if their cost per DALY saved is less than between one and three times per capita GDP, and it classifies as "very cost-effective" those interventions with costs per DALY saved that are less than per capita income [24]. India's 2009 per capita GDP was US$1,134 [25], and Gujarat's was US$950 [26]. By this measure, the introduction of fortified wheat flour in all three of these programs is "very cost-effective," whether we measure income by the Indian or the Gujarati per capita GDP.

The approach here considers each of the SSNPs independently. When they are all considered jointly, the cost-effectiveness measures of any one of the programs may decrease, because some individuals may benefit from more than one of the programs, since—although costs would not change—the number of DALYs saved would decrease, as some portion of the DALYs saved by one program would no longer be "available" to be saved by another program. To avoid double counting of DALYs in considering the dual coverage of some individuals, it is necessary to specify the sequencing of the programs. This analysis is outside the scope of this paper.

TABLE 11. Estimated DALYs saved and cost-effectiveness of atta fortification in each SSNP in Gujarat

Program	Total no. of beneficiaries	No of beneficiaries with DALY impacts	No. of DALYs saved	Incremental cost (US$)	Cost/DALY saved (US$)
ICDS	1,741,045	870,523			
Formula 1			66,013	605,616	9.2
Formula 2			27,427		22.1
MDM	3,935,214	787,043			
Formula 1			4,185	1,009,360	241.2
Formula 2			4,185		241.2
PDS	17,513,420	17,439,970	39,821	355,860	8.9
Total	23,189,679	19,097,536			
Formula 1			110,019	1,970,836	17.9
Formula 2			71,433		27.6

DALY, Disability-Adjusted Life-Year; ICDS, Integrated Child Development Scheme; MDM, Mid-Day Meal; PDS, Public Distribution System; SSNP, Social Safety Net Program

Discussion

The burden of micronutrient deficiencies in India is enormous and has proven largely intractable. After several decades of implementation, the coverage rates of both the iron and folic acid and, to a lesser extent, the vitamin A supplementation programs remain low. Newer technologies, such as biofortification—including high-provitamin A pearl millet and high-zinc and high-iron biofortified rice and wheat—look promising but are still under development, and will then still confront a number of uncertainties before being able to reach a substantial proportion of the population. At least in the short term, the fortification of staples may provide the most viable strategy for combating micronutrient deficiencies on a significant scale.

There are five lessons from the Gujarat experience:

» The support of international agencies can play a seminal role in raising awareness about micronutrient deficiencies and means for combating them.
» In India, with its now long tradition of highly independent views, priorities, and approaches, and particularly given its strong federalist government, local champions are essential. Gujarat was fortunate to have three, one of whom was a Permanent Secretary, particularly well prepared in terms of personal experience, commitment, and powers of persuasion, and who crafted a win-win plan for a state–private sector partnership that required little risk-taking.
» The existence of relatively large, modern millers with significant excess capacity predisposed this segment of the private sector to agreeing to the open market test as a means of securing a large and lucrative new market, with little risk.
» A pilot or small-scale implementation, particularly when combined with a phase-in plan, is useful for providing a period during which to build confidence and trust and dispel misconceptions.
» The overwhelming majority of Gujarat wheat flour consumers only knew that their SSNP had introduced flour to take the place of grain and did not know that the flour was being fortified. In states where fortification will be entirely voluntary (as opposed to its piggy-backing on a captive market, such as the SSNPs), social marketing to consumers will be more important, and it will be necessary to do considerably more to sell fortification than had to be done in Gujarat.

Where else in India might these lessons be applied and how important might they be in fighting malnutrition?

India is the world's second largest producer of wheat, with an annual production of about 80 million MT [26]. In 14 of India's 25 major states (which together have more than 60% of India's population), wheat is the main staple food. These states are the obvious initial targets for introducing wheat flour fortification.

There are a number of characteristics of the sizes and structures of SSNPs in other states that suggest that replicating the Gujarat experience may be difficult. For instance, although it proved relatively easy to introduce fortified wheat flour in both the ICDS and MDM in Gujarat, in part because Gujarat has a single state agency, the Department of Food and Civil Supplies, that procures and supplies commodities for both programs. The coverage, size, and structure of the SSNPs in other states vary, but they are generally more complex than those in Gujarat, suggesting that implementing a Gujarat-like fortification initiative that involves all three SSNPs may be considerably more difficult. Gujarat is one of just 14 states that have a fully implemented MDM scheme. In nine other states, MDM is implemented only in select districts, and in four states, the MDM does not serve cooked meals but distributes food grains. Still, these potential obstacles can be addressed and they are surmountable. Moreover, given the dearth of available effective alternative strategies and the enormous potential for reducing the burden of micronutrient deficiencies throughout the country, it appears that fortification is the current best option. **Tables 12, 13,** and **14** use the same NSS-61-based methodology applied earlier to provide state-specific estimates of the current levels of inadequate intakes of vitamin A, iron, and zinc and to estimate their post-fortification levels. The introduction of fortified wheat flour in the SSNPs of India could reduce micronutrient deficiencies in more than 200 million Indians, and, by virtue of India's enormous population, it will result in a sizeable reduction in the global number of persons who are micronutrient deficient.

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TABLE 12. Potential impact of substituting fortified wheat flour for wheat grain in the ICDS program

State or union territory	No. of persons	Prevalence of inadequate vitamin A intake (%)			Prevalence of inadequate iron intake (%)		Prevalence of inadequate zinc intake (%)	
		Prior to wheat flour	After wheat flour formula 1	After wheat flour formula 2	Prior to wheat flour	After wheat flour	Prior to wheat flour	After wheat flour
1. Jaminu & Kashmir	20,682	59	0	7	88	0	11	0
2. Himachal Pradesh	119,363	91	23	43	80	0	3	0
3. Punjab	41,248	52	0	10	74	0	0	0
4. Chandigarh								
5. Uttaranchal	36,121	100	40	79	78	0	2	0
6. Haryana	20,682	55	2	10	76	0	0	0
7. Delhi								
8. Rajasthan	119,363	83	11	37	72	0	0	0
9. Uttar Pradesh	41,248	95	50	77	68	0	0	0
10. Bihar	138,105	71	12	25	73	0	0	0
11. Sikkim	20,682	85	2	13	96	0	9	0
12. Arunachal Pradesh	119,363	60	13	27	81	0	3	0
13. Nagaland	41,248	68	0	1	83	0	0	0
14. Manipur	12,613	89	13	47	95	0	4	0
15. Mizoram	20,682	50	3	8	86	0	7	0
16. Tripura	119,363	96	33	66	96	0	14	0
17. Meghalaya	41,248	97	30	56	96	0	21	0
18. Assam	396,845	95	15	38	94	0	19	0
19. West Bengal	20,682	95	20	48	93	0	5	0
20. Jharkhand	119,363	100	67	100	86	0	4	0
21. Orissa	41,248	97	32	67	94	0	12	0
22. Chhattisgarh	999,567	98	28	70	94	0	12	0
23. Madhya Pradesh	20,682	100	52	83	81	0	13	0
24. Gujarat	119,363	97	24	60	82	0	1	0
25. Daman & Diu	41,248	100	28	37	91	0	22	0
26. Dadra & Nagar Haveli	1,575	100	24	62	94	0	38	0
27. Maharastra	20,682	99	39	72	78	0	5	0
28. Andhra Pardesh	119,363	100	40	78	96	0	30	0
29. Karnataka	41,248	92	13	39	83	0	11	0
30. Goa	82	100	100	100	96	0	100	0
31. Lakshadweep	20,682	100	66	88	75	0	9	0
32. Kerala	119,363	96	44	80	90	0	25	0
33. Tamil Nadu	41,248	99	36	73	96	0	34	0
34. Pondicheri	12,748	100	5	31	93	0	10	0
35. Andaman & Nicober	1,272	100	28	67	95	0	29	0
Total	13,370,827	95	30	62	86	0	10	0
No. of persons whose inaequate intake would be eliminated			8,611,965	4,393,692		11,515,162		1,389,844

ICDS, Integrated Child Development Scheme

Source: authors' calculations based on National Survey Sample Office (NSSO) Ministry of Statistics and Public Information, Government of India. Socio-Economic Survey, Sixty-First Round: July 2004-June 2005.

TABLE 13. Potential impact of substituting fortified wheat flour for wheat grain in the MDM program

State or union territory	No. of persons	Prevalence of inadequate vitamin A intake (%)			Prevalence of inadequate iron intake (%)		Prevalence of inadequate zinc intake (%)	
		Prior to wheat flour	After wheat flour formula 1	After wheat flour formula 2	Prior to wheat flour	After wheat flour	Prior to wheat flour	After wheat flour
1. Jaminu & Kashmir	28,174	17	9	11	79	0	13	0
2. Himachal Pradesh	829,199	93	47	64	87	0	3	0
3. Punjab	222,705	72	22	32	84	0	9	0
4. Chandigarh								
5. Uttaranchal	985,302	96	48	68	87	0	2	0
6. Haryana	1,565,453	59	19	30	79	0	3	0
7. Delhi	223,696	80	29	49	90	0	6	0
8. Rajasthan	5,344,230	92	44	59	65	0	0	0
9. Uttar Pradesh	13,662,521	94	60	75	77	0	2	0
10. Bihar	4,296,793	91	61	75	85	0	1	0
11. Sikkim	60,148	85	29	44	97	0	31	0
12. Arunachal Pradesh	75,528	72	36	45	91	0	12	0
13. Nagaland	12,734	86	13	27	94	0	0	0
14. Manipur	74,104	92	62	81	93	0	8	0
15. Mizoram	58,489	61	18	30	90	0	20	0
16. Tripura	413,497	95	59	74	97	0	33	0
17. Meghalaya	179,209	88	54	69	97	0	30	0
18. Assam	2,012,255	95	46	64	96	0	15	0
19. West Bengal	8,870,494	94	53	70	95	0	16	0
20. Jharkhand	1,062,084	99	67	84	92	0	11	0
21. Orissa	4,032,016	97	67	83	95	0	23	1
22. Chhattisgarh	3,759,330	99	67	89	96	0	30	0
23. Madhya Pradesh	8,307,851	97	66	85	81	0	5	0
24. Gujarat	5,230,275	98	64	82	87	0	11	0
25. Daman & Diu	13,512	100	59	77	93	0	6	0
26. Dadra & Nagar Haveli	37,570	100	92	99	95	0	45	0
27. Maharastra	9,116,904	98	74	89	84	0	16	0
28. Andhra Pardesh	5,722,788	100	73	90	96	0	36	0
29. Karnataka	5,930,985	97	66	84	89	0	31	0
30. Goa								
31. Lakshadweep	15,147	99	90	99	73	0	10	0
32. Kerala	2,471,120	99	84	95	95	0	42	0
33. Tamil Nadu	5,347,952	100	74	90	98	0	52	0
34. Pondicheri	71,052	100	74	89	98	0	54	0
35. Andaman & Nicober	19,679	100	74	90	95	0	41	0
Total	90,052,798	95	62	79	87	0	16	0
No. of persons whose inadequate intake would be eliminated			29,657,887	14,847,809		77,955,519		14,662,468

MDM, Mid-Day Meal

Source: authors' calculations based on National Survey Sample Office (NSSO) Ministry of Statistics and Public Information, Government of India. Socio-Economic Survey, Sixty-First Round: July 2004-June 2005.

TABLE 14. Potential impact of introducing fortified wheat flour in the PDS program: Prevalence of inadequate intake of iron prior to and after introduction of wheat flour in AAY and BPL

	AAY			BPL		
		Prevalence of inadequate intake (%)			Prevalence of inadequate intake (%)	
State or union territory	No. of beneficiaries[a]	Prior to wheat flour	After wheat flour	No. of beneficiaries[a]	Prior to wheat flour	After wheat flour
1. Jaminu & Kashmir	28,156	91	5	1,134,269	93	5
2. Himachal Pradesh	439,708	91	4	765,757	88	3
3. Punjab	25,685	91	1	2,475,057	86	3
4. Chandigarh				11,866	89	3
5. Uttaranchal	142,189	92	1	1,908,386	89	3
6. Haryana	739,631	84	4	3,924,126	86	3
7. Delhi				640,498	97	6
8. Rajasthan	1,114,884	67	3	9,153,529	75	3
9. Uttar Pradesh	5,325,276	78	3	27,720,528	79	4
10. Bihar	1,925,051	78	3	13,045,248	87	4
11. Sikkim	5,544	99	9	218,107	98	10
12. Arunachal Pradesh	7,374	86	7	143,074	88	6
13. Nagaland	2,021	100	3	48,234	95	3
14. Manipur	1,844	100	13	426,741	96	10
15. Mizoram	6,915	83	3	199,504	90	5
16. Tripura	35,900	98	4	1,148,732	98	8
17. Meghalaya	66,338	99	15	497,490	98	15
18. Assam	185,281	98	5	2,808,761	96	7
19. West Bengal	1,991,514	97	7	19,962,445	97	10
20. Jharkhand	699,313	95	7	6,410,812	94	9
21. Orissa	695,310	97	8	17,072,445	97	12
22. Chhattisgarh	1,107,375	98	11	8,663,399	97	13
23. Madhya Pradesh	2,243,501	87	4	20,248,797	85	3
24. Gujarat	562,117	88	2	15,236,667	89	5
25. Daman & Diu				23,261	92	4
26. Dadra & Nagar Haveli	25,279	96	7	91,469	96	10
27. Maharastra	2,548,258	87	6	23,711,303	84	4
28. Andhra Pardesh	1,769,785	97	7	37,263,986	98	10
29. Karnataka	3,523,583	87	4	20,799,177	90	5
30. Goa	82,923	99	14	183,369	99	10
31. Lakshadweep	425	35	0	6,300	81	3
32. Kerala	509,956	96	6	8,906,535	96	10
33. Tamil Nadu	641,330	98	5	9,024,246	99	9
34. Pondicheri	2,416	96	2	300,849	98	12
35. Andaman & Nicober	833	98	4	16,169	95	6
Total	26,455,717	87	5	254,191,137	90	7
No. of persons whose inadequate intake would be eliminated			21,701,668			212,113,767

a. Number of beneficiaries is estimated from PDS report of amount of wheat taken-off, assuming each AAY eligible household acquires and consumes 18 kg/month and each BPL household acquires and consumes 14 kg/month of fortified wheat flour

AAY, *Anatyodaya Anna Yojana*; BPL, Below Poverty Line; PDS, Public Distribution System

Source: authors' calculations based on National Survey Sample Office (NSSO) Ministry of Statistics and Public Information, Government of India. Socio-Economic Survey, Sixty-First Round: July 2004–June 2005.

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