Case 15

Preventing Iodine Deficiency Disease in China

Geographic area: China

Health condition: China bears the heaviest burden of iodine deficiency in the world. In 1995, 20 percent of children aged 8 to 10 showed signs of goiter. Overall, some 400 million people in China were estimated to be at risk of iodine deficiency disorders, constituting 40 percent of the global total.

Global importance of the health condition today: Iodine deficiency—a range of disorders including goiter (enlarged thyroids), stillbirths, stunted growth, thyroid deficiency, and mental defects—affects 13 percent of the world's population, or 740 million people. Iodine deficiency is the leading cause of preventable intellectual impairment in the world and may forfeit as much as 15 percent of a person's intellectual potential.

Intervention or program: In 1993, China launched the National Iodine Deficiency Disorders Elimination Program to eliminate iodine deficiency, with technical and financial assistance provided through the donor-funded Iodine Deficiency Disorders Control Project. Both the programs have raised awareness of the health impact of iodine deficiency, strengthened the capacity of the salt industry to iodize and package salt, monitored and enforced the quality of the salt, and promoted compliance among the salt industry through enforcement of licensing regulations and legislation banning noniodized salt.

Cost and cost-effectiveness: Fortifying salt with iodine costs approximately 2 to 7 cents per kilogram, or less than 5 percent of the retail price of salt in most countries. The Chinese government invested approximately $152 million.

Impact: By 1999, iodized salt was reaching 94 percent of the country, up from 80 percent in 1995—and salt quality had improved markedly. As a result, iodine deficiency has been reduced dramatically. Total goiter rates for children aged 8 to 10 have fallen from 20.4 percent in 1995 to 8.8 percent in 1999.

Many classic public health programs affect whole communities by reducing the risk of diseases—for example, by improving water supplies or reducing exposure to environmental hazards. In such programs, individuals do not have to take action and in many instances are unaware that the program is in place while they benefit from it. Because benefits are spread out over a vast population, these programs tend to be very inexpensive on a per capita basis. A special kind of population-based program is the fortification of foods with nutrients that all need for good health.

The story of how China introduced iodized salt to prevent the multiple disabling disorders associated with iodine deficiencies represents one such program. [Others include salt fluoridation in Jamaica (Case 18) and fortification of wheat with folic acid in Chile (Case 16).] The success derives from the appropriateness of the

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technology and the political and financial support for start-up.

Tiny Amounts of Iodine to Offset Huge Health Risks

A teaspoon of iodine, spread over a lifetime, is all that is needed to prevent a host of debilitating health problems collectively known as iodine-deficiency disorders. Although the human body needs just a minute quantity of iodine in the diet (100 to 150 micrograms each day), iodine deficiency is common throughout the world. Thirteen percent of the world's population, or 740 million people, are afflicted with iodine deficiency and suffer from a range of health problems associated with the disorder, including goiter (enlarged thyroids), stillbirths, miscarriages, neonatal and thyroid deficiency, mental defects, stunted growth, spastic weakness, and cretinism (a condition of mental retardation, deaf mutism, and short stature).[1] Furthermore, iodine deficiency is the leading cause of preventable intellectual impairment in the world, causing some 50 million people to suffer brain damage.

Iodine is essential for the proper functioning of the thyroid and for cell replication. A shortage of this micronutrient disrupts the action of the thyroid, the source of hormones that regulate body metabolism, growth, and development. Overcompensating thyroid glands become enlarged and create the visibly swollen necks known as goiter. Goiter is so frequent in many iodine-deficient countries that it has come to be regarded as normal.

During pregnancy, a severe shortage of iodine can result in stillbirths and miscarriages or babies born with spastic weakness, physical deformities, and irreversible mental retardation. After birth, iodine remains vital for optimum brain development during infancy and early childhood, and iodine-deficient people may forfeit as many as 15 IQ points—a loss of 15 percent of a person's intellectual potential.[2,3] Studies have also shown there is a generalized loss of IQ points among the whole population in areas with mild to moderate iodine deficiency.[4]

Iodine, an element found naturally in soil and water in many parts of the world, is scarce in many inland or mountainous regions. Many parts of the world, ranging from the Himalayas and the Andes to Central Africa, are notoriously deficient in iodine, where heavy rainfall, floods, or glacier melts have leached iodine-rich compounds out of the soil.

Fortunately, a simple technology exists to eliminate iodine deficiency: fortifying a commonly eaten food. Salt is the vehicle of choice in most parts of the world. Universally consumed daily in small but consistent amounts, salt can reach everyone, including the poorest members of the community. Moreover, mixing salt with an iodine-compound produces no discernable change in the product and is relatively cheap to produce. Although the technology of salt iodization is simple, implementation on a national scale requires a coordinated effort of political, administrative, legal, technical, and sociocultural changes.

Since the 1990s, the percentage of households in developing countries that use iodized salt has skyrocketed, climbing from less than 20 percent to 70 percent in 2000.[5] China's experience with iodine deficiency control is emblematic of this success, and the achievements in reducing the prevalence of iodine deficiency and goiter in China represent a tremendous public health success story.

China: 40 Percent of the World's Burden of Iodine-Deficiency Disorders

China bears the heaviest burden of iodine deficiency in the world. Studies in 1995 found that 20 percent of schoolchildren between the ages of 8 and 10 years had enlarged thyroid glands. Overall, some 400 million people in China were estimated to be at risk of iodine-deficiency disorders, constituting 40 percent of the global total.

The Chinese government spearheaded efforts in the early 1990s to address the burgeoning public health problem. The Minister of Health and other high-ranking officials became strongly committed to taking action when research showed that even mild to moderate iodine deficiencies could intellectually compromise children—posing a perceived threat to the one-child-per-family policy. In 1993, the Chinese government launched the National Iodine Deficiency Disorders Elimination Program. At the time, awareness of the dangers of iodine deficiency was weak, particularly in many regions of China at high-

est risk, where goiter was regarded as normal. Furthermore, people living in salt-producing regions or on salt hills did not buy salt because they did not want to pay for it. Ensuring a nationwide supply of commercially marketed iodized salt and promoting universal compliance were thus tremendous challenges.

To help China achieve its goal of eliminating iodine deficiency, the World Bank, the United Nations Children's Fund (UNICEF), the World Health Organization (WHO), and other agencies provided financial and technical assistance through the Iodine Deficiency Disorders Control Project from 1995 to 2000. The donor-funded project focused on supporting the development of technological infrastructure necessary to produce, package, and distribute iodized salt throughout the country. The Chinese government's national program as a whole entailed legal regulation, monitoring, enforcement, and public awareness campaigns.

National Effort

An important first step was informing the public about the seriousness of iodine deficiency and the need to buy only iodized salt. In some communities, goiter was so commonplace that even health workers did not realize the gravity of the problem. High-level political commitment of provincial governors boosted the nationwide public health campaign, which used posters on buses, newspaper editorials, and television documentaries to inform consumers and create a demand for fortified salt. Yet consumer demand on its own could not solve the problem. Public awareness of iodine-deficiency disorders was a vital first step but just as important were measures to ensure a reliable supply of the salt.

Judicious interventions in the salt production industry have helped ensure access to iodized salt (see Box 15–1). The China National Salt Industry Corporation controls the production of edible iodized salt in each province through the licensing of salt producers (factories) and of monopoly provincial salt companies that carry out wholesale and retail packaging. The variation in organizational structures between provinces has complicated reform. Some salt factories are owned by county-level governments, as in Guansu and Liaoning, and may have limited resources. By contrast, those that are owned and run by provincial salt companies, such as Guangxi Salt Company, generally have better access to financial resources, technology, and management, thanks to profits from their control over retail packaging and distribution.

During this initiative, 55 existing salt iodation factories were upgraded to increase their production, and 112 new iodation centers were established. Some 29 new bulk packaging systems complemented 147 new retail packaging centers, with carton packaging technology installed at two locations, which enabled consumers to easily recognize iodized salt. The technology for manufacturing modern packing machines was transferred from Europe to a local machinery-manufacturing firm. The domestic firm can now make the machinery required to meet future demands within China and will be in a position to compete in the international market, given its cost advantages.

The central and provincial governments in China have taken an active role in promoting compliance in the salt industry through the enforcement of licensing regulations and through legislation banning the sale of edible noniodized salt. Both government persuasion and direct assistance were necessary to motivate the salt industry to comply with iodation. As a first step, the central government made provincial governors aware of the seriousness of the problem, stimulating prompt action that reached even remote villages. The government also provided technological assistance that enabled licensed salt producers to readily adopt iodation.

Effective monitoring and enforcement, in addition to adequate incentives for industry compliance, are needed for the enforcement of quality control. First, production must be monitored because the amount of iodine added to salt matters: too little, and the treated salt is ineffective; too much, and it could be deleterious. Furthermore, distribution and retail sales must be monitored. Consumers cannot detect fraud, and because iodine in salt dissipates easily, the packaging, storage, and shelf life of the salt must be monitored to ensure adequate iodine levels. Hence, enforcement of quality controls is of paramount importance to the long-term success of salt iodation.

In China, the ability to hold producers accountable is strong, thanks to the concentration of production and distribution in a nationally controlled network.

Box 15–1

Salt Iodation in Madagascar

Iodine deficiency is also being tackled successfully in Madagascar, in a strikingly different social and industrial setting. In 1995, when salt iodation began, iodine deficiency was widespread, especially among the poorest communities living in the highlands. Nationwide, goiter rates among primary schoolchildren stood at 45 percent. The Nutrition Services of Madagascar's Ministry of Health and the United Nations Children's Fund designed a national iodine deficiency control program in Madagascar with World Bank assistance worth $1 million between 1993 and 1998.

Iodized salt was first introduced in Madagascar in 1995. In just four years, the proportion of households with iodized salt rose from zero to more than 98 percent. Over the same period, goiter rates among primary schoolchildren fell from 45 to 7 percent. Iodine levels in children's urine have also been monitored, with levels above 100 micrograms per liter a sign of adequate intake. In 1992, none of the children tested reached this level, while in 1998 an encouraging 91 percent did.

The program's success in increasing coverage with iodized salt stems from the primarily voluntary compliance of the large and medium-sized salt companies on the island. A handful of producers dominates the salt industry in Madagascar: One very large company, partially owned by the government, produces more than 40 percent of the country's salt. Four medium-sized companies manufacture another 35 percent, and a number of small companies produce the remaining 25 percent.

All the producers were targeted by the program and offered training and educational workshops, potassium iodate solution at no cost (until 2000), and leased iodating equipment. Since medium-sized producers have incentives to produce iodized salt to protect their market share in a competitive environment, they voluntarily complied. Furthermore, monitoring the five largest producers was also made easier by their small number. The Ministry of Health and Ministry of Commerce participate in monitoring and enforcement, publicizing their "check-and-seize" operations.

The program has had less success at enforcing compliance and quality control among small producers. Most of these small producers, scattered across the vast southwest coastal region, do not produce salt regularly, and when they do it is often wet, dirty, and noniodized. They sell their salt at a much lower price to distributors and have no incentives to use or repair their communal iodating equipment. Much of this poor quality salt is sold in the highland regions, where goiter is a common affliction. One solution may be for the authorities to consider shifting their focus from noncomplying small salt producers to distributors. "Small salt producers are numerous, elusive, and uncontrollable, whereas distributors are few and more manageable," reports Chor-ching Goh, a World Bank economist. "Authorities can provide disincentives—confiscation or fines—to discourage wholesale distributors from purchasing noniodized salt."[1] If distributors universally demand iodized salt, in time, virtually every salt producer should be motivated to iodize.

Provincial salt companies that produce iodized salt cooperate with local police to expose dealers of illegal salt operations, who accounted for about 10 percent of the Chinese salt market in 1998. In Wuxi and many other cities, salt inspectors patrol each day to sample salt in retail stores, restaurants, hotels, and households. The crackdown has been successful, and many illegal salt dealers have been apprehended. In any case, more

Table 15–1
Main Indicators of Iodine Status in China, 1995, 1997, and 1999

Indicator	1995	1997	1999
Iodized salt			
National mean coverage (percent)	80.2	90.2	93.9
Percentage of qualified iodated salt samples with:			
Iodine level > 20 ppm	39.9	81.1	88.9
Iodine level 20 to 60 ppm	29.7	69.0	80.6
Urinary iodine content among schoolchildren aged 8 to 10			
Median household iodine level (parts per million)	16.2	37.0	42.3
Average (μg/L)	164.8	330.2	306.0
Percentage with iodine content < 50 μg/L	13.3	3.5	3.3
Number of provinces with median iodine < 100 μg/L	5.0	1.0	1.0
Total goiter rates among schoolchildren aged 8 to 10 (percent)			
Tested by palpation	20.4	10.9	8.8
Tested with B-ultrasound	—	9.6	8.0
Grade 2 goiter	2.1	0.5	0.3

Source: Chor-ching Goh (2002). Reprinted with permission from the UNU *Food and Nutrition Bulletin* 2002;23:280–291.

than half of the "illegal salt" is itself iodized, having been smuggled out of the factories.

The more dangerous illicit commodity—noniodized salt—is either industrial salt fraudulently passed off as edible salt or raw salt consumed by local people living near salt hills or by the sea. In provinces such as Fujian, Guangdong, and Liaoning, where sea salt is traditionally produced, the China National Salt Industry Corporation encouraged selling this raw salt to refinement centers for iodation. Such interventions support small producers while at the same time reducing the amount of noniodized salt on the market. Pricing strategies are also important; smuggling of noniodized salt between provinces is inadvertently encouraged because quality salt is more costly in some provinces compared with others.

Major Health Impact

By the end of 2000, substantial progress had been made toward achieving universal salt iodation, and as a result, the virtual elimination of iodine-deficiency disorders in China. By 1999, iodized salt was reaching 94 percent of the country, compared with 80 percent in 1995. Moreover, as a result of the government's program the quality of iodized salt has improved. Salt samples with an iodine content of 20 to 60 parts per million—considered high quality—increased from 30 percent in 1995 to 81 percent in 1999.

The health impact has been striking: Surveys of schoolchildren in 1995, 1997, and 1999 showed dramatic reductions in iodine deficiency. Across the country, far fewer children now show signs of goiter. Total goiter rates for schoolchildren aged between 8 and 10 have fallen, from 20.4 percent in 1995 to 8.8 percent in 1999 (see Table 15–1).

Economic Impact

In 1993, the World Bank's *World Development Report* estimated that a comprehensive and sustainable approach to address micronutrient deficiencies would cost less that 0.3 percent of GNP a year. Yet these deficiencies continue to have a substantial economic impact throughout much of the developing world; as much

as 5 percent of GNP of many countries may be lost to deaths, disability, lower educational attainment, and decreased productivity. For China, this amounts to a loss of approximately $50 billion from micronutrient deficiencies, including iodine deficiency.[6]

The total cost of the salt iodation program in China is difficult to estimate, not least because costs are distributed across many government agencies, and practices vary across the country. In Hunan and Tianjin, for instance, provincial governments reimburse their health bureaus for carrying out tests on salt samples, while in other provinces salt testing is financed by the salt industry itself or shared between the industry and the health sector.

Costs of iodation itself are low, once the technology is in place—normally in the range of 2 to 7 cents per kilogram, which is less than 5 percent of the retail price of salt in most countries. But the industry must also provide laboratory monitoring to ensure quality control backed by a team of inspectors in the marketplace. Some estimates place the government's investment at approximately $152 million. To help finance this investment, the Chinese government set a new higher price for quality iodized salt; this price increase was estimated to represent less than 1 percent of the household budget and therefore affordable for most families. The World Bank deemed the project—financed with approximately $20 million from the Bank—extremely cost-effective, costing between 4 and 5 cents per beneficiary in external funding. Its success in saving lives and dollars has made

Box 15–2

Untapped Potential? DEC-Salt Fortification to Prevent Lymphatic Filariasis

Just as one of the most common substances on earth, salt, was used as the vehicle to carry iodine to communities with evidence of iodine deficiency, so it has been tested to treat or prevent other diseases. Experiences in China and several other countries have shown that fortifying salt with a compound called diethylcarbamazine (DEC) can help eliminate lymphatic filariasis, a mosquito-transmitted parasitic disease. Causing painful genital enlargement and elephantiasis, lymphatic filariasis is responsible for the loss of approximately 4.6 million DALYs per year.[7] Along with the physical discomfort caused by the disease, those infected with the disease often fall victim to social isolation and poverty.

Distribution of DEC tablets to individuals poses logistical challenges, and early experiences suggest that DEC salt is an attractive option for controlling the disease in endemic areas. In the 1970s, the approximately 13,000 inhabitants of Taiwan's Quemoy Islands were treated with DEC-fortified salt for six months as a final step in eliminating the disease. Follow-up surveys until 1982 showed that people who had consumed the fortified salt had no microfilaria in their blood, and thus could not transmit the disease.[8]

A larger experience in China demonstrates that DEC-fortified salt can be extremely effective as a complement to mass drug distribution. Despite its vast population and high prevalence rates of lymphatic filariasis in many provinces, this combination of approaches was successful in eliminating this infection in China, which has had no evidence of new cases or of transmission for over five years.[9]

As in the case of iodization in China, fortifying salt with DEC can be extremely cost-effective. Compared with administration of DEC in tablet form, which can cost between $4.40 to $8.10 per DALY averted, DEC-fortified salt is estimated to cost $1.10 to $3.62.[7]

China's iodation experience a model for other fortification interventions (see Box 15–2).

Commitment and Remaining Challenges

China's program to eliminate iodine-deficiency disorders continues, and a very high commitment to enforcing regulation on universal salt iodization in China remains. The country maintained a high national mean coverage—95 percent in 2002—for adequate iodized salt. Schoolchildren are regularly monitored for urinary iodine, and in 2002 the average urinary iodine (μg/L) was 241. It is estimated that only 16 percent of the population has low levels of urinary iodine (less than 100 μg/L) (Rae Galloway, personal communication, May 12, 2006).

The central government has pledged to retain control of the salt industry over at least the next decade, and in October 2003 China hosted an international conference to renew its commitment to eliminating iodine deficiency. To ensure success, the adequacy of iodine in salt must continue to be monitored and incentives must be modified as needed to increase compliance rates in the salt industry. Because national coverage of iodized salt reached over 90 percent in 2001, central and local governments concentrate on targeting resources where consumption of iodized salt is still low: the poor and remote mountainous areas in western China where fewer than half the people consume iodized salt and instead use cheaper, locally produced raw salt.

In China, local authorities in several provinces, including Guangxi, Hebei, and Shandong, have convinced residents in remote mountainous regions to buy iodized salt delivered directly to their villages. However, in provinces where local officials were not committed to the program, wholesalers were not paid and deliveries ceased. Similar problems arise in regions where inhabitants have easy access to salt hills, dehydrated salt lakes (as in Xinjian), or sea salt (as in Jiangsu) and are reluctant to pay for salt.

In such situations, careful research will be needed to find out why local people are not consuming iodized salt, and alternative remedies adopted. If price is a deterrent, subsidies may be the solution. In some cases, increasing public awareness may be sufficient to ensure compliance, but other ways of providing iodine—through well or irrigation water, for instance—may be more effective. Alternatively, the old-fashioned way of distributing iodine, in capsules containing iodized oil or via long-lasting injections, may particularly suit nomads living in remote regions. Through a variety of approaches, China is fast approaching the day when iodine deficiency will be unknown throughout its population.

A Classic Public Health Success

The success of the fortified salt program in China in reducing iodine deficiency disorders offers lessons to future public health campaigns targeting other micronutrient deficiencies such as iron and vitamin A. The Chinese government aligned social goals with the salt industry, and the health sector successfully built a commitment to eliminate iodine deficiency. Concurrently, the salt industry seized the opportunity of the investment in iodine deficiency elimination to restructure and modernize the industry, which put it on a firmer technical and commercial footing. Donor coordination was strong and effective, managed by the Chinese government and the donors themselves, and the major players offered mutual support across all activities. In addition, the financing strategy was clearly defined first. Most important, the Chinese government, on all levels, made a firm and long-standing commitment to eliminating iodine deficiency, allowing all sectors across the country to work together to achieve impressive results.

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