COST BENEFIT ANALYSIS OF FORTIFYING THE FOOD SUPPLY WITH IODINE

REPORT BY
ACCESS ECONOMICS PTY LIMITED

FOR

FOOD STANDARDS AUSTRALIA NEW ZEALAND

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ACCESS ECONOMICS

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Professor Cresswell Eastman
Westmead Hospital, NSW

Dr Basil Hetzel
Chairman Emeritus, International Council for Control of Iodine Deficiency Disorders

NZ and Australian salt manufacturers and manufacturers of processed cereal products.

GLOSSARY AND ACRONYMS

Cretinism	Cretinism results from severe iodine deficiency during pregnancy which leads to severe mental impairment. There are two types (Hetzel (ed) 2004): i Neurological cretinism which is the result of iodine deficiency in the first half of pregnancy, and is characterised by severe brain damage, deaf mutism, spastic state of the hands and feet, and squint. ii Hypothyroid cretinism which is the result of iodine deficiency late in pregnancy and which is characterised by dwarfism, brain damage and hypothyroidism. It occurs where iodine intake is below about 25µg/day.
Estimated Average Requirement (EAR)	EAR refers to a daily nutrient level estimated to meet the requirements of half the healthy individuals in a particular life stage and gender group.
Goitre	Enlargement of the thyroid caused by Graves' or Hashimoto's disease, or iodine deficiency. Goitre itself is usually harmless, but is an indicator that other damaging effects of iodine deficiency may be present. Goitre is the most visible sign of moderate to severe iodine deficiency.
Graves' disease	Graves' disease — inflammation of the thyroid — is the most common cause of hyperthyroidism (see below). It is an autoimmune disease in which the body's antibodies attack the body's organs. The antibodies stimulate the thyroid to make excessive amounts of thyroid hormone Graves' disease usually begins in those aged 30 years or more (Health Matters Library, 2006)
Hashimoto's disease	Hashimoto's disease is an autoimmune disease which causes a failure of the thyroid (Health Matters Library, 2006).
Hyperthyroidism	Hyperthyroidism (or thyrotoxicosis) occurs when the thyroid becomes overactive, secreting too much thyroid hormone and speeding up metabolism. Symptoms include: weight loss, anxiety, tiredness, rapid pulse, shaking, sweating and diarrhoea. Causes of hyperthyroidism include Graves' Disease (see above), viral infection, a nodule in the thyroid or a multinodular goitre (Health Matters Library, 2006)
Hypothyroidism	In hypothyroidism, the thyroid fails to secrete enough thyroid hormone and metabolism slows. Symptoms include: lethargy and tiredness, concentration difficulties, depression, hair loss and constipation. Causes of hypothyroidism include Hashimoto's disease (see above), lack of iodine in the diet, and certain drugs such as lithium. It is also a longer term effect of Graves' disease and subacute thyroiditis. Severe hypothyroidism is known as myxoedema which can cause progressive lethargy and coma if not treated (Health Matters Library, 2006). This is more common in elderly people who have suffered a heart attack, stroke infection or have undergone surgery.
Nodule	Small discrete lump or lumps in the thyroid (Health Matters Library, 2006).
ICCIDD	International Council for the Control of Iodine Deficiency Disorders
IDD	Iodine Deficiency Disorder

Iodine induced hyperthyroidism (IIH)	Iodine-induced hyperthyroidism is an overproduction of thyroid hormones in response to an increased intake of iodine. Prolonged iodine deficiency, even if mild, can lead to physical changes in the thyroid that predispose individuals to the development of iodine-induced hyperthyroidism if iodine intake increases. These thyroid changes develop over a prolonged period of deficiency with those over 40 and a lifetime of deficiency at greatest risk.
IQ	Intelligence quotient
mg	Milligram (one-thousandth of a gram)
MUIC	Median urinary iodine concentration
NINS	National Iodine Nutrition Survey (Australia) (Li et al 2006)
NPV	Net present value
UIC	Urinary iodine concentration
μg	Microgram (one-millionth of a gram)
Upper Level of Intake (UL)	UL refers to the highest average daily nutrient intake level likely to pose no adverse health effects to almost all individuals in the general population. The Upper Level is based on level of iodine intake resulting in disturbance of thyroid related hormone levels. An uncertainty factor of 1.5 has been applied. As intake increases above the UL, the potential risk of adverse effects increases.
WHO	World Health Organization

EXECUTIVE SUMMARY

Food Standards Australia New Zealand (FSANZ) commissioned Access Economics to investigate the benefits and costs in Australia and New Zealand of fortifying salt used in some key cereal based products with iodine. The genesis of the FSANZ iodine fortification proposal resides in concerns amongst the medical community about the recent re-emergence of iodine deficiency in New Zealand and some parts of Australia.

Iodine is integral to the functioning of the thyroid gland and iodine intake within a defined range is important for healthy functioning. Both relatively high and relatively low iodine intake levels can cause illness. However, not all thyroid illness is related to intake of iodine. Genetics and other factors in an individual's medical history can lead to thyroid disease.

Iodine deficiency and its impact on health

Iodine deficiency can lead to illness and functional impairment. The degree of seriousness of the disorder (or the extent of impairment in function) depends on the severity and duration of iodine deficiency (FSANZ health benefit-risk assessment). Iodine deficiency disorders (IDDs) include goitre, impaired mental and motor function, impaired growth, infant mortality, low birth weight (which is an indicator of poor health outcomes later in life), and stillbirths. Cretinism can occur where iodine deficiency is severe. For the purposes of this analysis, it needs to be noted that:

- Adequate iodine intake is essential for the normal development of the brain and nervous system during foetal growth and for the first 2 to 3 years. Impairment of the brain due to iodine deficiency during this period can be **irreversible**.
- Research suggests that some iodine deficiency disorders amongst children and adults are **reversible** if the deficiency is addressed. However, because of the nature of the problem, the extent to which IDDs are reversible is not clear.

Access Economics is not aware of data revealing the prevalence or incidence of IDDs in Australia or New Zealand. The extent of iodine deficiency has been used internationally as an indicator of the prevalence of IDDs. It is only possible to surmise that IDDs exist in Australia and New Zealand because studies of various segments of the population (including pregnant women and school children) in New Zealand and in some Australian states identified mild or in some cases mild-to-moderate iodine deficiency.

> Studies have found **mild to moderate iodine deficiency amongst various investigated groups (including school children and pregnant women) in South Eastern Australia and New Zealand**. Iodine concentrations have not been tracked over time so from the information available, it is not possible to know whether iodine status is trending down over time, or whether current levels reflect a new steady state. Iodine status may continue to fall in future or it may not. For the purposes of this analysis, it has been assumed that current levels reflect the new steady state and there will be no further deterioration in iodine status. However, iodine status could conceivably fall, in which case the benefits of a fortification program would increase.

Most available scientific evidence has focussed on the impact of severe iodine deficiency particularly on the impact of children born to severely deficient mothers. IDDs associated with mild and moderate deficiency are more difficult to detect, and thus to study. Hence, there is a great deal of uncertainty around the *quantum* of effects associated with mild to moderate iodine deficiency. In any research undertaken, it is difficult to distinguish between the impact on functioning due to iodine deficiency occurring at the time the study was undertaken and the impact of iodine deficiency on the subject during previous periods (eg. formative years). While there is evidence that damage due to iodine deficiency is reversible, there is no scientific evidence of the magnitude of reversibility.

Previous research on international and Australian iodine fortification programs

A large number of countries have introduced voluntary iodine fortification, but very few economic analyses (including cost benefit analyses) have been undertaken. Mandatory fortification has been introduced in Canada and Denmark but no cost benefit analyses of these programs are available. Most of the literature records the experience of iodine fortification in underdeveloped countries with severe long standing iodine deficiency. Experience in these countries is not comparable with the situation in Australia or New Zealand. No cost benefit analysis is available for the voluntary fortification program introduced in Tasmania in 2001, although a study of urinary iodine concentration of Tasmanian schoolchildren undertaken in 2003 suggested that their iodine status was borderline/replete.

THE FSANZ FORTIFICATION PROPOSAL

The FSANZ fortification proposal has two components:

1. mandatory addition of iodised salt, in place of non-iodised salt, in processed cereal based foods[1] at 30mg iodine per kg salt; and
2. reduction in the voluntary iodine fortification of discretionary (retail) salt to 20mg iodine per kg salt.

FSANZ modelling of the impact of this fortification proposal on the dietary intake of iodine in three target groups in Australia and New Zealand — children aged 0-3 years, women of child bearing age, and the Australian population aged 2 years and above and the New Zealand population aged 15 years and above — is outlined in Table 1:1. The ranges reflect different assumptions about iodisation of discretionary salt.

- In the case of the EAR (Estimated Average Requirement), the lower number in the range is the percentage of the population group with dietary iodine intakes that are less than the EAR when all discretionary salt is iodised; the upper number in the range is the percentage of the population group with dietary iodine intakes that are less than the EAR when all discretionary salt is not iodised.
- In the case of the UL (Upper Level of Intake), the lower number in the range is the percentage of the population group with dietary iodine intakes that are greater than the UL when all discretionary salt is not iodised; the upper number in the range is the percentage of the population group with dietary iodine intakes that are greater than the UL when all discretionary salt is iodised.

[1] Processed cereal based foods include bread and bread products (English muffins, buns, bread rolls, fruit breads, pizza bases, crumbed products and stuffings), biscuits (sweet & savoury) and breakfast cereals (pers. comm., FSANZ, 6 June 2006).

TABLE 1:1 MODELLING PROJECTED IMPACT OF FORTIFICATION ON INTAKE OF IODINE

Group	Age (years)	% population with intake<EAR[a]		%population with dietary iodine intake>UL[b]	
		Aust	NZ	Aust	NZ
Children	2-3	1	na	6 to 16	na
Females — not pregnant	16-44	6 to 14	3 to 19	0	0
Females — pregnant	16-44	43 to 74	68 to 81	0	0
Females — lactating	16-44	68 to 89	85 to 91	0	0
Total population	2 and above (Aust)	3 to 7		<1	
	15 and above (NZ)		1 to 11		<1

[a] EAR (Estimated Average Requirement) refers to a daily nutrient level estimated to meet the requirements of half the healthy individuals in a particular life stage and gender group. [b] UL (Upper Level of Intake) refers to the highest average daily nutrient intake level likely to pose no adverse health effects to almost all individuals in the general population.

It should be noted that the FSANZ modelling in table 1.1 was undertaken on a slightly broader selection of processed cereal products than is proposed in footnote 1. As a result, the costs and benefits have a different scope — the costs have been estimated based on the selection of goods actually proposed. The scope difference arises because the proposal was refined by FSANZ during the period of this particular analysis to better target only those products that have a material impact on intake of iodine through use of iodised salt. The modelling reflects an earlier version of the proposal which defined processed cereal based foods as: *breads (sweet & savoury), biscuits (sweet & savoury), cakes, cake/biscuit style puddings, scones, slices, muffins, crumpets, pancakes & pikelets, doughnuts, pastries, pizza bases, breadcrumbs and breakfast cereals.* **The impact on the estimated benefits is unlikely to be material given removal of products from the proposal was based on their very small impact on intake of iodine.**

The modelled projections of intake show that:

- mandatory fortification of the food supply cannot deliver sufficient amounts to all pregnant and lactating women. Even after fortification, most pregnant and lactating women will have intakes below the EAR and will need to take an iodine supplement. Examination of alternative options that may capture a greater proportion of the benefits associated with preventing irreversible harm caused by iodine deficiency during pregnancy or infancy was outside the scope of this brief.
- In Australia, iodine intakes of a significant proportion of 2-3 year olds and possibly 0.5% and 1.2% of 4-8 year old children may exceed the upper limit depending on the amount of discretionary iodised salt in their diet. Projections for this age group were not available for New Zealand because of the nature of the underlying data on which the modelling was based.

The modelling is based on the best available information. However, there is a high degree of uncertainty associated with the projections given gaps in the underlying data.

- There is uncertainty surrounding the intake of discretionary salt, and no data on consumption of iodine supplements. Supplement intake was not able to be included in the FSANZ projections.
- The FSANZ projections are based on nutritional/dietary intakes data from 1995 in Australia and 1997 in New Zealand (the most recent data available).

- In Australia, there was geographic diversity in iodine status which could not be taken into account in the projections of intake by FSANZ (because of the lack of state/territory food composition data). The projections cannot show whether fortification will result in those living in Victoria and NSW, Tasmania and SA will become replete — the modelling indicates only that the average Australian will become replete. Similarly, it cannot determine whether those already replete populations in WA and Queensland will be at greater risk of iodine intakes above the upper limit.
- The modelling reveals that a proportion of toddlers are likely to have intakes above the upper limit, but does not indicate where or in what demographic groups they are so it is not possible to target monitoring of possible negative health impacts. Likewise, the nature of the data available as the basis for modelling, in concert with the lack of detailed information about the prevalence or incidence of those likely to be susceptible to adverse health effects (for example, people with Graves disease), means that monitoring of these groups will be difficult.

There will therefore be a large variation around the national average intakes projected by FSANZ, but given data limitations, very little indication of the extent of this variation, or which demographic groups or which geographic areas might be most affected by either continued deficiency or consumption above the upper limit.

Method

The cost benefit analysis in this report compares the benefits of avoiding reversible cognitive harm caused by iodine deficiency, with the costs to industry and government associated with mandatory fortification. The analysis focuses on avoiding reversible harm because fortification as proposed cannot deliver sufficient amounts to all pregnant and lactating women.

> Productivity and other gains due to cognitive harm avoided (the Benefits) minus Costs of mandatory fortification = Net benefit (+ or -)

Briefly, a 15 year snapshot is modelled in which:

- fortification gives rise to benefits one year after implementation; and
- benefits accrue to those who become iodine replete before the age of 15 years and remain iodine replete to the age of 15 years.

The net benefits are calculated on the basis that iodine fortification is implemented consistently over a 15 year period. (The net present value of the stream of benefits is compared with the net present value of the stream of costs over 15 years.) This is the minimum period required for iodine fortification to benefit all children aged between 0 and 13 years at time period zero (see Figure 1 in the body of this Report). It is envisaged that monitoring and review would occur at intervals during this time period (consistent with COAG Guidelines that regulation should be reviewed at intervals of less than 10 years (COAG 2004)).

Benefits

The 'in principle' benefits of iodine fortification include reduced morbidity from reduction in iodine deficiency disorders (IDDs), fewer years of life lost due to premature death, reduction of absenteeism from work by sufferers of IDDs or their carers and related management costs, improved productivity as a result of increased IQ and improved concentration and hearing, improved school attendance and enhanced performance at school. However, not all of these are able to be measured in this study because of the paucity of data. While the analysis of benefits here focuses on productivity losses avoided due to fortification, this comprises a subset of the potential positive outcomes from fortification (albeit, the major component of benefit). Even though some of the benefits are not quantified, they should not be ignored.

The basis for the modelling is that an increase in the average IQ of a proportion of the population as a consequence of fortification is linked to an increase in their average weekly earnings. The implicit and probable economic assumption is that the numbers of such people would not be of sufficient magnitude to substantially influence the overall clearing of the labour market, thus making a net addition to productive capacity. However, if the proportion of the population was large enough, a wholesale rise in the number of people with a certain IQ may affect the level of earnings at which the market clears — more specifically, in the long term, while average IQ may increase, earnings may not be affected. A full economic analysis examining the long-run situation where the impact of an increase in average IQ would be passed on to society through adjustments in wages and prices is not in scope here. However, considerable sensitivity analysis has been undertaken to account for the partial nature of the study.

> There is a paucity of data allowing quantification of the benefits of fortification. Randomised controlled trials of the effectiveness of iodine fortification are scarce and not necessarily comparable either with the situation in Australia and New Zealand, or with iodine fortification of the type proposed by FSANZ. While there is evidence of health benefits arising from addressing iodine deficiency, an **empirical** relationship between iodine status and improvements in productivity and health has not been established. **It is therefore very difficult to quantify the benefits except within a large range to account for the high degree of uncertainty.** This is not to say that there is no potential for benefit arising from the FSANZ proposal, just that it is very difficult to quantify.

The evidence base underlying the treatment of key variables in the analysis of benefits is discussed in detail in section 6. Sensitivity analysis was undertaken to address as much as possible the high degree of uncertainty surrounding most variables. The treatment of age, gender and iodine status in the model — determined by data limitations and evidence — is summarised in Table 1.2.

TABLE 1:2 TREATMENT OF POPULATION VARIABLES IN MODELLING THE BENEFITS

Variable	Treatment
Age groups	Children aged 0-14 years benefit from iodine fortification. The model assumes that children must become iodine replete prior to age 15 and must remain replete until age 15.
Gender	The model treats males and females identically (except, in the Australian case, for the wages and rates of employment). The proportion of the population experiencing an increase in IQ, the size of the increase in IQ experienced, and the size of increase in productivity per extra IQ point is assumed to be the same for males and females.
Iodine status	The modelled benefits reflect a reduction in the proportion of the population whose iodine intake is below the EAR. More specifically, it is assumed that all those whose iodine intake was below the EAR before fortification (and who use iodised salt), will have an iodine intake above the EAR as a result of fortification.

Increase in IQ by age	Modelling is based on all age groups reacting to fortification in the same way — that is, the increase in IQ points is the same at every age.

The population proportions benefiting from fortification are specified in more detail in Table 1.3.

TABLE 1:3: MODELLING SCENARIOS

	Australia	New Zealand
Beneficiaries	All people whose iodine intake moves from below the EAR to above the EAR as a result of fortification.	All people whose iodine intake moves from below the EAR to above the EAR as a result of fortification.
Population Share	0-4yrs 11 per cent 5-9yrs 11 per cent 10-14yrs 12 per cent (FSANZ modelling)	0-14yrs 10 per cent (FSANZ modelling for 15-18 year olds)

The values assigned to key variables determining the magnitude of the productivity benefit per person from mandatory fortification are summarised in Table 1.4.

TABLE 1:4: SIZE OF BENEFITS PER PERSON

	Unit	Distribution for sensitivity analysis	Distribution parameters
Size of IQ increase from mild deficiency to replete	IQ point	Lognormal	Mean = 0.8 point, standard deviation = 1 point, minimum = 0 points,
Size of productivity increase per IQ point	Per cent increase in earnings	Lognormal	Most likely = 0.9% minimum = 0%, maximum = 3.5%
Size of total productivity increase per person	Calculated as the product of the above variables	Distribution parameters drawn from simulation using @Risk.	Mean = 0.48%, standard deviation = 1.06%, minimum = 0.0005%, maximum = 28.25% 90% CI = (0.01%,1.93%)

Lastly, evidence suggests that cognitive functioning does not improve immediately after iodine status becomes replete (although the exact timeframe has not been scientifically determined). It was therefore assumed here that cognitive function improves one year after fortification is introduced.

Costs

The costs of mandatory fortification quantified here include the costs to government of administering and enforcing mandatory fortification, the costs to industry of fortification and the costs of health monitoring. Other potential costs include restriction of consumer choice, potential adverse health effects from excess iodine intake (likely to be rare), and the introduction of policies complementary to fortification but which are outside the purview of FSANZ (for example, public health advice for pregnant women on the need to supplement their iodine intake). These have not been quantified in this analysis due to lack of data and FSANZ advice on scope.

Cost estimates were obtained from close to a census of salt suppliers, and from a sample of cereal processing firms (manufacturers of bread and bread products, biscuits and breakfast cereals). While the sample is small and not necessarily representative, both large and small firms from all three industry sectors provided data. Costs of iodine fortification for cereal processing firms were calculated by dividing total cost estimates from each company by the amount of salt input the company purchased, to obtain a cost per kilogram of salt. These unit costs were then multiplied by the total production of salt supplied to the processed cereal products industry to obtain total industry costs.

Australian jurisdictional **government** costs were based on indicative estimates from two jurisdictions and New Zealand government cost estimates were provided by the New Zealand Food Safety Authority.

Results

The Benefits

The estimated benefits arising from mandatory fortification are described in Table 1.5. The estimated mean productivity gain from the proposed fortification policy is A$1.85 billion for Australia and NZ$286 million for New Zealand. It is most likely that the size of productivity gain resulting from mandatory fortification will fall in the interval (A$44.9 million, A$7.23 billion) for Australia, and in the interval (NZ$6.56 million, NZ$1.14 billion) for New Zealand.

Table 1:5: Distribution of Productivity Gains

	Australia (A$)	*New Zealand (NZ$)*
Minimum	2,125,429	289,031
Mean	1,850,000,000	286,000,000
Maximum	91,300,000,000	16,700,000,000
Std Dev	3,980,000,000	629,000,000
5^{th} Percentile	44,900,940	6,560,331
95^{th} Percentile	7,231,350,000	1,136,772,000

The Costs

Consumer choice

As a result of mandatory fortification, **consumers** will face reduced choice and a slight increase in the price of processed cereal products. The cost of reduced choice was not quantified. However, given the possible adverse effects of excess iodine intake, *mandatory* fortification prevents consumers from avoiding fortified products unless they make considerable changes to their dietary habits. This may result in significant costs in terms of consumer choice. A willingness-to-pay vehicle could be used to estimate this cost, but was not able to be undertaken for this project. It was beyond the scope if this brief to examine alternatives to mandatory fortification (such as expanding the range of voluntary fortification allowed).

Industry

Estimates of salt production used by Australian cereal processing firms were in the range 20,000 tonnes per year to 30,000 tonnes per year. Salt production for cereal processing in New Zealand is around 2,900 tonnes.

Salt manufacturers indicated that

- some machinery and equipment would need to be installed to expand output of iodised salt. In addition, where salt products are certified as an organic allowed input, firms need to ensure that there are no cross contamination issues, so a separate processing area would be required. The cost of installation and maintenance were included in the cost estimates as well as the initial outlay on the machines.
- In some cases, changes to labelling would be necessary of a type to ensure that iodised and non-iodised salt are not confused.
- an iodine compound would be added in a premix of fine salt.
- analytical testing would be undertaken, with the approach differing across firms
- additional ware-housing costs may be incurred to separately store multipurpose non-iodised salt with sector specific iodised salt.
- In one case (Australia), there would be additional transport costs because only one plant would be upgraded and iodised salt from that plant would be transported to satisfy customers in other parts of Australia.
- a transition period of six to 12 months would ameliorate the costs of stock in trade and allow preparation of plant and installation of machinery.

In Australia, the net present value (NPV) of the costs of fortification for salt manufacturers over a 15 year period would be A$5.9 million. The net present value of the costs of fortification for salt manufacturers over a 15 year period in New Zealand would be NZ$508,000. Given that costs for salt manufacturers were based on close to a census of firms, no sensitivity testing has been undertaken on the estimates.

Manufacturers of processed cereal products affected by the proposed iodine fortification strategy would include makers of breakfast cereals, bread and bread products and biscuits. Data from a one-off survey undertaken in 1998-99 suggested that the three sectors (breakfast cereals, bread and bread products and biscuits) make up around one third each of total production of foods that would be affected by iodine fortification. Cost centres affected by the fortification proposal include: changes to labels, analytical testing and trade related costs. There may also be transitional costs.

- While iodised salt would cost cereal processing firms around 10% more than non-iodised salt this is reflected in the estimates of the costs of fortification to salt manufacturers.
- If mandatory fortification were introduced, cereal processing firms would be obliged to redesign label templates to ensure compliance with labelling standards for food containing salt. The upfront costs of labelling changes required if fortification was introduced would be around A$15.5 million in Australia and NZ$341,000 in New Zealand.
- Indicated approaches to analytical testing varied. Taking an average of the estimates provided and applying this to total salt used in cereal processing, ongoing costs per year for analytical testing would result in outlays each year of A$413,000 in Australia and NZ$51,000 in New Zealand.

- A number of stakeholders indicated in submissions to FSANZ (for example, the New Zealand Food and Grocery Council) that iodine fortification would increase trade related costs because imports of foods fortified with iodine are proscribed in some countries, for example, Japan. Companies exporting to these countries need to maintain separate product lines, with the associated ongoing warehousing and label switching costs[2]. Trade related costs could entail over A$2.3 million in ongoing outlays per year in Australia and more than NZ$280,000 in ongoing outlays per year in New Zealand. **Importantly, trade related costs comprise 85% of all ongoing costs to cereal processing firms per year associated with iodine fortification.**
- Firms have requested a transition period of 12 months to four years to ameliorate labelling costs, and facilitate adjustments necessary to accommodate exports of unfortified products. Based on labelling estimates for the folic acid cost benefit analysis (Access Economics 2006), **implementation of folic acid and iodine fortification together would save industry A$2.5million in Australia and NZ$220,000 in New Zealand compared with the separate implementation of these policies.**

Sensitivity testing was undertaken on the cost estimates for cereal processing firms because of the uncertainty surrounding some of the input variables.

- In Australia, the mean of the NPV over 15 years of costs for cereal processing firms is A$38 million. While the maximum possible NPV of costs could be A$245 million, it is most likely that costs will fall below A$64 million.
- In New Zealand, the mean of the NPV of costs over 15 years for cereal processing firms is NZ$3 million. While the maximum possible NPV of costs could be NZ$5.8 million, it is most likely that costs will fall below A$4.6 million.

Government

Cost centres included training and awareness, auditing, administration, and dealing with complaints. Interpreting the estimates as an indicative range, the average **ongoing** cost used in the calculation of the overall net benefits of the fortification proposal was A$156,045 per year (which is similar to that estimated for folic acid (Access Economics 2006)). The higher of the two estimates for **upfront** costs has been adopted for the net benefit calculations (A$138,182) on the basis that in a cost benefit analysis it is better to err on the side of overestimating rather than underestimating compliance costs.

In New Zealand, the New Zealand Food Safety Authority estimated that it might spend NZ$7,800 upfront and then NZ$84,800 on an ongoing basis per year to administer and enforce the proposed regulations.

Other costs

- The health benefit-risk assessment commissioned by FSANZ concluded that there may be small health risks to identified vulnerable groups, but that any adverse effects would be extremely rare. While potential adverse health effects should not be ignored, not least because of the potential impact on quality of life of those possibly affected, assessment of their costs is outside the designated scope of this particular project. Even so, there is a lack of data available to quantify the possible adverse effects. For these reasons, the associated costs are not included in the calculations here.

[2] Man hours involved in switching labels for domestic good to labels for exported good for the same product line.

- There are a number of programs that are outside the purview of FSANZ, but are nevertheless important complements to fortification.
  - One is monitoring of population iodine status and iodine intake — particularly important because of the reduced margin of safety associated with the impact of fortification on the intakes for young children, the potential for adverse effects of fortification on those susceptible, the likely differential impact of fortification across Australian geographic regions and the uncertainty surrounding the underlying data. The costs of monitoring included in the analysis encompass costs of surveys of nutrient intake (based on estimates provided to Access Economics by FSANZ) and the cost of monitoring population urinary iodine concentration (based on the costs of the Australian National Iodine Nutrition Survey).
  - The other two complementary programs include the provision of advice to pregnant and lactating women on the need for iodine supplementation (necessary because even after fortification, most pregnant and lactating women will have intakes below the EAR and will need to take an iodine supplement), and awareness raising amongst health practitioners of the possibility of adverse health consequences associated with fortification. Costing of these was not in scope for this project.

Summary of costs

Financial costs, incorporating the costs to salt manufacturers, cereal processing firms, government and monitoring costs, but excluding the costs of consumer choice, complementary policies and any adverse health effects, are presented in Table 1.6 for Australia and New Zealand.

TABLE 1:6 SUMMARY OF COSTS OF FORTIFICATION (ROUNDED), AND COST PER HEAD

		Australia (A$)	New Zealand (NZ$)
Upfront costs			
	Government - administration and enforcement of regulation	138,000	7,800
	Salt industry (machines and labelling)	159,000	303,000
	Cereal processing industry (labelling)	15,500,000	341,000
	Total upfront	15,800,000	651,556
Ongoing costs (per year)			
	Government - administration and enforcement of regulation	156,000	84,800
	Salt industry (maintenance, iodine, analytical testing, transport and storage)	488,000	18,170
	Cereal processing industry (analytical testing and trade related costs)	2,675,000	331,500
	Total ongoing (per year)	3,319,000	434,000
Monitoring costs			
	Monitoring (nutritional survey) (in 2007 and 2017)	110,000	117,000
	Monitoring (MUIC) (in 2010 and 2015)	522,000	89,700
Discount rate		3.3%	3.8%
Net Present Value of costs (over 15 years)		55,600,000	5,882,000
Costs of iodine fortification per person			
	Population	20,111,297	4,120,900
	Upfront cost per head	A$0.79	NZ$0.16
	Ongoing cost per head	A$0.17	NZ$0.11

Monitoring cost per head	A$0.03	NZ$0.05

NET BENEFITS

In light of the high degree of uncertainty surrounding many of the underlying variables, the figures are indicative only and the caveats discussed in sections 5, 6 and 7 should be kept in mind. The net benefit ranges (including by percentile) are outlined in Table 1.7.

- For Australia, the most likely outcome is that fortification as proposed will lead to net benefits of A$1.8 billion. While there is a chance that the proposal will result in a net cost of (A$162 million), it is more likely that net benefits will be in the range (–A$9.8 million) and A$7.3 billion.
- For New Zealand, the likely outcome is that fortification as proposed will lead to net benefits of NZ$265 million. While there is a chance that the proposal will results in a net cost of (NZ$7.9 million), it is more likely that net benefits will be in the range NZ$910,000 to NZ$1.0 billion.

TABLE 1:7 NET BENEFITS OF IODINE FORTIFICATION

	Australia (A$)	New Zealand (NZ$)
Minimum	-161,840,400	-7,885,350
Mean	1,759,772,000	265,180,900
Maximum	124,026,500,000	10,706,680,000
Standard Deviation	3,991,378,000	559,302,000
5th percentile	-9,835,839	909,763
10th percentile	27,649,490	6,078,189
50th percentile	571,817,400	89,968,930
85th percentile	2,986,907,000	471,879,400
90th percentile	4,168,812,000	664,897,800
95th percentile	7,329,940,000	1,044,035,000

CONCLUSION

In conclusion, there is a large degree of uncertainty surrounding the calculation of net benefits for the FSANZ proposal. This high degree of uncertainty in the results reflects the lack of research of a nature which facilitates quantification of the links between iodine status, cognitive impairment and productivity.

It should be noted that

- the benefits as estimated do not include all potential benefits of the proposal. Lack of data precluded the estimation of other potential benefits of fortification — such as the potentially positive impact on improvement in quality of life for those with IDDs, and the benefits of reducing harm from lack of iodine on hearing ability, concentration, reproduction, fertility and infant survival.
- There are also some elements of costs that were not able to be covered by the analysis, including the costs of complementary policies such as dietary supplementation of the majority of pregnant and lactating women (outside the purview of FSANZ), and the costs associated with possible adverse health outcomes for those susceptible to Iodine induced hyperthyroidism, or hypothyroidism.

- The basis for the modelling is that population iodine status will remain the same in future. However, iodine concentrations have not been tracked over time so from the information available, it is not possible to know whether iodine status is trending down over time, or whether current levels reflect a new steady state. Iodine status may conceivably fall in future or it may not. If iodine status continued to fall, the benefits of a fortification program would increase.

The current proposal does not capture all the benefits that may arise from assisting those who are currently iodine deficient to repletion, and it may therefore be worth exploring an alternative proposal that embraces all of the potential benefits. Further, another vehicle may be available which better targets those in need, including targeting those in geographic regions in Australia where iodine deficiency was identified.

ACCESS ECONOMICS

JUNE 2006

1. BACKGROUND

Food Standards Australia New Zealand (FSANZ) commissioned Access Economics to investigate the benefits and costs in Australia and New Zealand of fortifying salt used in cereal based products with iodine. The genesis of the FSANZ iodine fortification proposal resides in concerns amongst the medical community about the recent re-emergence of iodine deficiency in New Zealand and some parts of Australia.

Iodine is integral to the functioning of the thyroid gland. The thyroid gland secretes thyroid hormones that contain iodine and which:

- regulate metabolism;
- boost protein synthesis;
- increase heart rate and blood flow to other organs; and
- are essential for the normal development of organs such as the heart and brain in children and for normal reproductive functioning (Health Matters Library, 2006).

Iodine intake within a defined range is important for healthy functioning. Both relatively high and relatively low iodine intake levels can cause illness.

- Iodine deficiency (ID) can have serious adverse health consequences — or iodine deficiency disorders (IDDs).
- Relatively high iodine intakes — on the other hand — can also result in serious illness.

It should be noted, however, that not all thyroid illness is related to intake of iodine. Genetics and other factors in an individual's medical history such as anaemia (Allen and Gillespie 2001) can lead to thyroid disease.

2. METHOD — COST BENEFIT ANALYSIS

The cost benefit analysis in this report compares the benefits of avoiding cognitive harm caused by iodine deficiency, with the costs to industry and government associated with mandatory fortification.

Productivity and other gains due to cognitive harm avoided (the Benefits) minus Costs of mandatory fortification = Net benefit (+ or -)

Benefits

The 'in principle' benefits of iodine fortification are outlined in Table 2:1, however, not all of these are measured in this study because of the paucity of data. While the analysis of benefits here focuses on productivity losses avoided due to fortification, this comprises a subset of the potential positive outcomes from fortification. Even though some of the benefits are not quantified, they should not be ignored. The methodology and assumptions for the calculation of benefits are discussed in detail in section 6.

TABLE 2:1 IN PRINCIPLE BENEFITS OF IODINE FORTIFICATION

Beneficial outcome of fortification	Realisation of economic benefit	Included in this analysis
Reduced morbidity from reduction in IDDs	Reduction in health care spending	✗
Fewer years of life lost due to premature death (eg. still birth and neonatal death)	Improved productivity due to increased labour force	✗
Reduction of absenteeism from work by sufferers of IDDs or their carers and related management costs	Improved productivity at work	✗
Increased IQ	Improved productivity at work	✓
Improved school attendance and performance at school	Greater efficiency in education spending	✗

Costs

The 'in principle' costs of iodine fortification are outlined in Table 2:2. The costs of mandatory fortification quantified here include the costs to government of administering and enforcing mandatory fortification, and the costs to industry of fortification. Other potential costs include restriction of consumer choice, potential adverse health effects from excess iodine intake, and the introduction of complementary policies that would need to be introduced alongside fortification but which are outside the purview of FSANZ (for example, advice to pregnant women on supplementing their iodine intake). These have not been quantified in this analysis or are only provided on an indicative basis due to lack of data, and FSANZ advice on scope.

TABLE 2:2 IN PRINCIPLE COSTS OF IODINE FORTIFICATION

Type of cost	Data source	Included in this analysis
Restriction of consumer choice		×
Cost to government of administering and enforcing regulation	governments	✓
Cost to industry of complying with regulation	Industry	✓
Potential adverse health effects from excess iodine intake		×
Cost of monitoring nutrient intake and urinary iodine concentration	FSANZ and Professor Eastman	✓
Complementary policies required alongside fortification but outside the purview of FSANZ		×

Modelling approach and time period

The evidence and details of the approach used in this project to model the benefits is discussed in more detail throughout the document. However, briefly, and in order to summarise the methodology, a 15 year snapshot is modelled in which:

- fortification gives rise to benefits one year after implementation; and
- benefits accrue to those who become iodine replete before the age of 15 years and remain iodine replete to the age of 15 years.

The modelling approach is depicted in Figure 1 below. The shaded cells indicate the children who benefit and their age. As a consequence of fortification, these children have improved cognitive functioning for the rest of their lives (reflected in higher productivity and earnings). On the other hand, child O and child P do not necessarily benefit from fortification because they do not become iodine replete before the age of 15 years.

Net benefits are calculated on the basis that iodine fortification is implemented consistently over a 15 year period. This is the minimum period required for iodine fortification to benefit all children aged between 0 and 13 years at time period zero (see Figure 1). It is envisaged that monitoring and review would occur at intervals during this time period (consistent with COAG Guidelines that regulation should be reviewed at intervals of less than 10 years (COAG 2004)).

Figure 1 Approach to modelling the benefits of iodine fortification

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**…**
Fortification of salt in selected processed cereal products with iodine																	
Age (years)																	
child A	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	…
child B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	…
child C	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	…
child D	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	…
child E	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	…
child F	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	…
child G	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	…
child H	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	…
child I	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	…
child J	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	…
child K	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	…
child L	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	…
child M	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	…
child N	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	…
child O	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
child P	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	

Discount rate

Choosing an appropriate discount rate for present valuations is a subject of some debate, and can vary depending on which future income or cost stream is being considered. There is a substantial body of literature, which often provides conflicting advice, on the appropriate mechanism by which costs should be discounted over time, properly taking into account risks, inflation, positive time preference and expected productivity gains.

The absolute minimum option that one can adopt in discounting future income and costs is to set future values in current day dollar terms on the basis of a risk free assessment about the future (that is, assume the future flows are similar to the certain flows attaching to a long term Government bond). We have settled upon the following as the preferred approach for Australia.

- **Positive time preference**: The long term nominal bond rate of 5.8% pa from recent history is used as the parameter for this aspect of the discount rate. If there were no positive time preference, people would be indifferent between having something now or a long way off in the future, so this applies to all flows of goods and services.
- **Inflation:** The Reserve Bank has a clear mandate to pursue a monetary policy that delivers 2 to 3% inflation over the course of the economic cycle. This is a realistic longer run goal and we therefore endorse the assumption of 2.5% pa for this variable. It is important to allow for inflation in order to derive a real (rather than nominal) rate.
- **Productivity growth**: The Australian Government's Intergenerational report assumed productivity growth of 1.7% in the decade to 2010 and 1.75% thereafter. We suggest 1.75% for the purposes of calculating the value of earnings over an individual's life time with a life expectancy of 70 years or so.

The discount rate applied to estimates of the **benefits** is therefore: 5.8 - 2.5 - 1.75 = 1.55%. The discount rate applied to estimates of the **costs** differs to that of benefits since productivity growth is incorporated in the cost estimates The discount rate used is: 5.8 – 2.5 = 3.3%.

In selecting discount rates for New Zealand, we have settled upon the following as the preferred approach.

- **Positive time preference**: The long term nominal bond rate of 6.0% pa (from recent history in trading of NZ Government 10 year bonds) is used as the parameter for this aspect of the discount rate.
- **Inflation:** The Reserve Bank of New Zealand has an agreement with the New Zealand government to pursue monetary policy that delivers 1% to 3% inflation on average over the medium term. Over the past few years inflation has consistently remained in the top half of this band, and is expected to remain above 2.5% until 2008 (New Zealand Treasury) and so we use an assumption of 2.2% pa for this variable.
- **Productivity growth**: The New Zealand Treasury expects labour productivity growth of around 2% per annum in the year to March 2007, before returning to its long-term trend of around 1.5% per annum (New Zealand Treasury, 2005). For New Zealand based disease costing, this estimate of 1.5% will be used.

The discount rate applied to estimates of the **benefits** is therefore: 6.0 - 2.2 - 1.5 = 2.3%. The discount rate applied to estimates of the **costs** differs to that of benefits since productivity growth is incorporated in the cost estimates The discount rate used is: 6.0 - 2.2 = 3.8%.

3. IODINE DEFICIENCY AND IDDS

Iodine deficiency can lead to illness and functional impairment. The degree of seriousness of the disorder (or the extent of impairment in function) depends on the severity and duration of iodine deficiency (FSANZ health benefit-risk assessment). Iodine deficiency disorders include goitre, impaired mental and motor function, impaired growth, infant mortality, low birth weight (which is an indicator of poor health outcomes later in life), and stillbirths. Cretinism can occur where iodine deficiency is severe. For the purposes of this analysis, it needs to be noted that:

- Adequate iodine intake is essential for the normal development of the brain and nervous system during foetal growth and for the first 2 to 3 years. Impairment of the brain due to iodine deficiency during this period can be **irreversible**.
- Research suggests that some iodine deficiency disorders amongst children and adults are **reversible** if the deficiency is addressed. However, because of the nature of the problem, the extent to which IDDs are reversible is not clear.

Prevalence and incidence of IDDs

Access Economics is not aware of data revealing the prevalence or incidence of IDDs in Australia or New Zealand.

- According to data from the AIHW hospital morbidity data base, during the period 1998-99 to 2004-05, there were 34,091 separations for disorders of the thyroid gland, of which less than 20 separations were attributed to a principal diagnosis related to iodine deficiency (pers. comm., AIHW, 6 June)[3]. However, it is difficult to know how accurately thyroid problems attributable to iodine deficiency are coded, and whether the proportional relationships for hospitalisation of thyroid disorders by cause also apply to primary or community care.
- In 1996, advice from clinicians and nutritionists to Mathers et al (1999) suggested that the proportion of goitre attributable to dietary iodine deficiency was very low (around 5%), with most goitre due to thyroid diseases. Mathers et al (1999) based their burden of disease estimates for goitre due to iodine deficiency on the assumption that 5% of the annual admissions for goitre at that time (1225 males and 6048 females) were grade 2 goitre (palpable and visible goitre) due to iodine deficiency, and that any resulting disability lasted for 2 years. They assumed the incidence of other sequelae (for example, developmental disability and cretinism) was zero. Given studies since 1996 suggesting some states in Australia are iodine deficient, it is possible that the proportion of goitre attributable to iodine deficiency has increased, but it is unclear by how much. The incidence of sequelae is also unclear.
- Given that there is no severe iodine deficiency in Australia (Li et al 2006), the prevalence of cretinism is likely to remain zero.

The extent of iodine deficiency has been used internationally as an indicator of the prevalence of IDDs. It is only possible to surmise that IDDs exist in Australia and New Zealand because the population (including pregnant women and school children) in

[3] ICD codes relating to IDDs are E00 Congenital iodine-deficiency syndrome, E01 Iodine-deficiency related thyroid disorders and allied conditions, and E02 Subclinical iodine-deficiency hypothyroidism.

New Zealand and in some Australian states have been found to be iodine deficient (see below).

The extent of iodine deficiency and the types of IDDs

Urinary iodine concentration is the preferred measure of iodine status by the International Council for the Control of IDDs (ICCIDD) and World Health Organization (WHO) as it is the most sensitive indicator of recent changes in iodine intake and therefore the most appropriate for assessing fortification strategies. Table 3:1 outlines the ICCIDD criteria for assessing iodine status in a population based on median urinary iodine concentration (MUIC) amongst school aged children.

TABLE 3:1 IODINE STATUS BASED ON MUIC IN SCHOOL AGED CHILDREN

Median urinary iodine concentration (μg/L)	Iodine intake	Iodine status
< 20	Insufficient	**Severe** iodine deficiency
20 – 49	Insufficient	**Moderate** iodine deficiency
50 – 99	Insufficient	**Mild** iodine deficiency
100 – 199	Adequate	**Optimal**
200 – 299	More than adequate	Risk of iodine induced hyperthyroidism in susceptible groups
>300	Excessive	Risk of adverse health consequences

Source: provided to Access Economics by FSANZ.

IDDs associated with each level of deficiency (or sufficiency) are summarised in Table 3:2. Whether a certain level of deficiency will result in the disorders listed in Table 3:2 depends on thyroid functioning, family history, or other factors in the individual's medical history (such as anaemia [Allen and Gillespie 2001]). However, for the purposes of modelling the benefits here (see below), we have assumed that there is a direct correlation between iodine status and reversible cognitive harm.

TABLE 3:2 IODINE DEFICIENCY LEVELS AND ASSOCIATED HEALTH CONDITIONS

Iodine status	Associated health conditions
Severe deficiency	Children born to severely deficient mothers are at risk of cretinism, or premature death.
Moderate to mild deficiency	Children born to moderately deficient mothers, and who are moderately deficient during childhood and adolescence may have: reduced IQ (possibly 4 to 7 IQ points and increased risk of an IQ below the 85th percentile)[a] Impaired visual acuity Impaired fine motor control reduced ability to concentrate lower learning capacity hearing impairment
Mild deficiency	Children born to mildly deficient mothers, and who are mildly deficient during childhood and adolescence may have: Elevated hearing threshold Reduced performance in tests of cognitive function (fluency, concentration, hand movements) and reduced IQ of up to 3 points Mild iodine deficiency for a sustained period can result in the development of autonomous nodular goitres. Those over 40 with lifelong deficiency are considered at greatest risk. Iodine fortification increases the risk of iodine induced hyperthyroidism in these people.
More than adequate iodine	Can lead to subclinical hypothyroidism
Excessive iodine	Can lead to hypothyroidism (subclinical or clinical) and goitre

[a] The average IQ is by definition 100 with a standard deviation of 15 points.

Source: FSANZ health benefit-risk assessment and Tiwari et al 1996.

Most available scientific evidence has focussed on the impact of severe iodine deficiency particularly on the impact on children born to severely deficient mothers. IDDs associated with mild and moderate deficiency are more difficult to detect, and thus to study. Hence, **there is a great deal of uncertainty around the quantum of effects associated with mild to moderate iodine deficiency.** In any research undertaken, it is difficult to distinguish between the impact on functioning due to iodine deficiency occurring at the time the study was undertaken and the impact of iodine deficiency on the subject during previous periods (eg. formative years). **While there is evidence that damage due to iodine deficiency is reversible, there is no scientific evidence of the magnitude of reversibility.**

3.1 IODINE STATUS OF THE AUSTRALIAN AND NEW ZEALAND POPULATION

A number of studies of the prevalence of iodine deficiency in Australia and New Zealand have been undertaken. FSANZ concluded from these studies that there is **mild to moderate**

deficiency among various investigated groups (including school children and pregnant women) in South Eastern Australia and New Zealand. Notably:

- The largest and most recent study, the National Iodine Nutrition Survey (NINS) of year 4 primary school children (aged 8 to 10 years old) from NSW, Victoria, SA, WA and Queensland undertaken in 2003-4, found that primary school children in NSW and Victoria suffered from mild deficiency and those in SA had borderline iodine status (Li et al 2006). There were no severe cases of iodine deficiency (pers. comm. Mu Li, 14 June 2006). Tasmania was excluded from the study as it has an iodine fortification program, and the Northern Territory was excluded because of logistical problems.
- Recent studies in Melbourne and Sydney suggest that many pregnant women border on moderate deficiency. Compared to school age children, pregnant women appear to be more deficient (literature review by FSANZ).
- The 2002 Children's Nutrition Survey conducted amongst New Zealand children aged 5 to 14 years showed an overall mild deficiency, with a substantial proportion of children being moderately deficient (25% of males and 31% of females). In addition, breast fed infants in New Zealand showed moderate deficiency indicating a poor iodine status in their mothers and formula fed infants were bordering on mildly deficient (literature review by FSANZ).

Iodine status over time — deficiency duration and future trends

It is important to understand the duration of deficiency because — as noted earlier — duration determines the likelihood of adverse health effects arising from increasing iodine intake through a fortification program. Iodine deficiency in Australia is a relatively recent phenomenon. Studies indicated that iodine status was sufficient in 1992, so iodine deficiency in Australia is not longstanding.

Iodine concentrations have not been tracked over time so from the information available, it is not possible to know whether iodine status is trending down over time, or whether current levels reflect a new steady state. Iodine status may continue to fall in future or it may not. For the purposes of this analysis, it has been assumed that current levels reflect the new steady state and there will be no further deterioration in iodine status. However, iodine status could conceivably fall, in which case the benefits of a fortification program would increase.

4. RELATED EXPERIENCE WITH IODINE FORTIFICATION

4.1 INTERNATIONAL AND AUSTRALIAN EXPERIENCE

4.1.1 INTERNATIONAL EXPERIENCE

Iodine deficiency generally occurs in populations living in areas where iodine is leached from the soil through glaciation, flood or high rainfall.

- The highest prevalence of severe IDDs (such as cretinism) associated with severe iodine deficiency appears to exist in developing countries such as around the Andes, the Himalayas, Bangladesh and India and other countries in Asia and South East Asia. A wide variety of vehicles have been used in these countries for supplementation with iodine, including: salt, oil (injected), and drinking and irrigation water (Allen and Gillespie 2001).
- Populations exhibiting mild to moderate iodine deficiency that are more comparable with Australia and New Zealand include Canada, Germany, Switzerland, Denmark and the Netherlands (FSANZ 2004). Of these, most have introduced some form of voluntary iodine fortification. Only Canada and Denmark have mandatory fortification programs (FSANZ 2004).
  - Mandatory fortification of table salt was introduced in 1949 in Canada but does not appear to have been monitored or assessed (FSANZ 2004).
  - In Denmark, the population had mild or moderate iodine deficiency that varied geographically with the iodine content of ground water. Iodine deficiency was correlated with a very high prevalence of goitre and hyperthyroidism, especially in elderly subjects, and thyroid function of pregnant women was slightly impaired. Mandatory iodisation of household salt and salt used in commercial production of bread and cakes was introduced in July 2000, after a voluntary program lacked sufficient population coverage. Stocks of non-iodised salt were allowed to be used up. Iodine content and use of salt is monitored, and iodine intake and occurrence of thyroid disorders is tracked in populations previously having mild or moderate deficiency (Laurberg et al 2003). There were plans to undertake a study post-fortification, in 2004-05. The results do not appear to be available yet.

4.1.2 AUSTRALIAN EXPERIENCE — TASMANIA

Iodine fortification and supplementation schemes have been introduced in Tasmania at various times to avoid iodine deficiency[4]. Most recently, in 2001, the Tasmanian Government introduced a voluntary iodine supplementation program encouraging bakeries to use iodised salt in preference to regular salt in bread. There was a 12 month phase-in of the policy to allow Tasmanian bakeries to use up their packaging (pers. comm., Tasmanian Department of Health and Human Services (DHHS), 31 May 2006). Around 70% of bakeries were participating in the supplementation program in July 2003 (Turnbull et al 2004). After some initial variation in iodine concentration in bread, the concentration is now between 25μg and 75μg per 100grams of bread (pers. comm., Tasmanian DHHS 1 June 2006).

[4] Tasmanian iodine monitoring program, **http://www.iodine.com.au/content.php?page=aboutprogram** accessed 1 June 2006

Discussion with a large plant bakery participating in the Tasmanian fortification program (pers. comm., 5 June 2006) suggested:

- Consumer surveys showed that the switch to use of iodised salt did not affect the taste or quality of bread.
- Iodised salt is more expensive, but given the negligible amounts of salt in bread made by that particular bakery, the additional cost was negligible.
- The 12 month transition period meant that old labelling could be used before new labels were printed. Print runs can last between 12 weeks and 2 years depending on whether the product is a high seller or not.
- A change was made to the ingredients list to specify the use of 'iodised salt'. Typesetting changes cost around $2000 per plate, and alterations to more complex coloured designs cost around $5000 per plate. Bread recipes change only infrequently so the costs of any labelling change would be attributable to iodine fortification alone.
- There was no additional analytical testing undertaken for the iodine fortification program. The bakery instead relied on monitoring by the Tasmanian government for information about iodine intake more generally.

Excluding the initial set up costs, the total Government outlays per year on the Tasmanian supplementation program have been $140,000 per annum over 5 years (pers. comm. Tasmanian DHHS, 1 June 2006). This is made up of some salary costs to cover a range of issues and outsourcing for monitoring health impacts. Monitoring costs are around $100,000 per year. The monitoring program involves measuring urinary iodine in school children and pregnant women, and checking indicators associated with potential negative side effects including use of thyroid drugs, referrals for thyroid function tests, admission to hospital for thyroid procedures and neonatal thyroid stimulating hormone levels.

There is some evidence that the program has contributed to improved iodine status. A study undertaken in 2000 found the MUIC in school children was 84 μg/L and the percentage of school children with MUIC below 50 μg/L was 20%, suggesting mild iodine deficiency. While these results are not necessarily comparable to more recent surveys, monitoring of urinary content amongst a sample of school children aged around 9 years in Tasmania in 2003[5] found that the MUIC was 105 μg/L (confidence interval 98.5 μg/L - 111.5 μg/L), with 10.9% of school children below 50 μg/L. Based on these results, the DHHS has suggested that the Tasmanian population is now iodine replete, in part due to the supplementation program (although acknowledging that many different factors can influence the level of iodine in the diet)[6]. However, concerns have been expressed that this level of iodine may be insufficient to address the needs of pregnant and lactating women (for example, pers. comm. Tasmanian DHHS, 1 June 2006), and results of a similar order of magnitude for MUIC in South Australia (Li et al 2006) were interpreted as indicative of borderline deficiency. Given its voluntary nature, concerns have also been expressed about the sustainability of the program.

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[5] Under the school children monitoring program, urine samples were collected from 347 children, in 31 different classes from 29 different schools.

[6] Tasmanian iodine monitoring program, **http://www.iodine.com.au/content.php?page=results**, accessed 1 June 2006

4.2 THE BENEFITS OF IODINE FORTIFICATION/ SUPPLEMENTATION POLICIES

> *Prospective detailed epidemiological studies of the effects of iodine supplementation on a population are scarce even though several billion people in the world are more or less covered by some public iodine supplementation program. (Laurberg et al 2003 p. 56)*

> *The obvious need for interventions probably explains why there have been relatively few randomised, placebo-controlled trials of the efficacy of iodine supplementation on different aspects of human function. (Allen and Gillespie 2001, in the chapter titled 'Preventing and treating iodine deficiency')*

There is a paucity of research allowing quantification of the links between iodine fortification or supplementation programs and consequent improvements in health and productivity associated with reduced IDDs. Most studies of the health impacts of ID have been undertaken in developing countries with severe rather than mild deficiency. In addition, the studies that have been undertaken generally had very small sample sizes which are likely to have large statistical errors. By way of illustration, the frequently cited meta-analysis by Bleichrodt and Born (1993) which concluded that iodine deficiency could lead to a reduction in IQ of around 13 points was based on 21 studies (of which only 18 were useable for their purposes) — all samples sizes were between 20 and 200, except one from China which had a sample size of 499. The countries covered were: Indonesia (3 studies), New Guinea (1), Spain (3), China (4), Ecuador (7), Zaire (1), Chile (1) and Bolivia (1).

4.2.1 IMPACTS ON COGNITIVE IMPAIRMENT

The lack of data on which to base a cost benefit analysis reflects in part the difficulties associated with measurement of the impact of iodine fortification or supplementation on cognitive impairment. Measurement of cognitive impairment is most often measured by IQ tests. In order for the results of research to be transferable, IQ tests need to be selected carefully to rule out the impact of environment and culture. Further, around seven different cognitive processes have been identified for measurement by IQ tests and iodine deficiency may not affect all of these. Even if an appropriate test is selected,

- The underlying distribution of IQs amongst those in iodine deficient populations is unknown.
- It can be difficult to isolate the impact of iodine deficiency, particularly in developing countries where a number of vitamin and mineral deficiencies may result in cognitive harm and generally work in concert with environmental and geographical factors that can limit intellectual development.

4.2.2 REVERSIBILITY

Reversibility is important to the analysis here because the FSANZ proposal will not increase iodine intakes in all pregnant women to repletion — it is projected that after fortification, most pregnant and lactating women will have intakes below the estimated average requirement. (The FSANZ proposal is discussed in detail in Section 5.) The major benefit to the Australian and New Zealand population is therefore to ameliorate reversible adverse effects of iodine deficiency in children.

As noted above, the evidence on reversibility is not conclusive because it is hard to measure, and hence there are few robust studies of the effects of iodine supplementation on cognitive function in children (with the exception of a recent study by Zimmerman et al. (2006) outlined below). Allen and Gillespie (2001) cited a joint Pan American Health Organization-World Bank review of this question which concluded that:

> *the data from childhood supplementation studies are less clear than those from maternal supplementation studies, probably because so few studies have been undertaken with this design (Bank PW 1999 Nutrition, Health and Child Development. Research Advances and Policy Recommendations. Washington DC: Pan American Health Organization).*

While the impact of iodine deficiency on children does appear to have a reversible element (Zimmerman 2006), the empirical relationship between moderate to mild iodine deficiency and the reversible impacts of this on IQ is not well established.

Estimates of the impact on productivity of **permanent (irreversible)** brain damage due to iodine deficiency — that is, the loss in productivity caused by mental impairment of children born to iodine deficient mothers — are cited by Horton (1999). The cost estimates for India, Pakistan and Vietnam are presented here in Table 4:1. The estimates are based on evidence from seven countries suggesting that approximately 3.4% of all infants born to iodine deficient women are cretins and another 10.2% are mentally impaired (Horton 1999). It was assumed that cretins have 100% productivity loss (are unproductive), that the other severely mentally impaired infants are 25% less productive relative to children born to iodine replete mothers, and that the rest of the children born to mothers with palpable goitre (86.4%), are 5% less productive than 'normal' children. The rate of palpable goitre was used as the measure of iodine deficiency amongst pregnant women, but the iodine status of these women was not stated in Horton (1999) — i.e. whether mothers in these countries were severely, moderately or mildly deficient. Even so, given the assumptions about cretinism, (which does not exist in Australia), it is unlikely that these estimates are comparable with the situation in Australia and New Zealand.

Table 4:1 Losses of adult productivity due to iodine deficiency as a per cent of GDP

Country	Loss of productivity (%GDP)
India	0.3
Pakistan	3.3
Vietnam	1.0

Source: Horton (1999) based on calculations for adult productivity from Administrative Staff College (1998), AERC (1998) and Horton (1998) — references cited in Horton (1999).

Overall, the majority of evidence on the benefits of iodine fortification or supplementation relates to treatment with iodine of pregnant women and the consequent impacts on their children. However, the FSANZ proposal will not increase intakes in all pregnant women by enough to ensure they are iodine replete.

There is a paucity of data allowing quantification of the benefits of fortification. Randomised controlled trials of the effectiveness of iodine fortification are scarce and not necessarily comparable either with the situation in Australia and New Zealand, or with iodine fortification of the type proposed by FSANZ. While there is evidence of health benefits arising from addressing iodine deficiency, an **empirical** relationship between iodine status and improvements in productivity and health has not been established. **It is therefore very difficult to quantify the benefits except within a large range to account for the high degree of uncertainty.** This is not to say that there is no potential for benefit arising from the FSANZ proposal, just that it is very difficult to quantify.

4.2.3 COSTS

While many studies quote data from other sources on the costs of iodine fortification programs, in most cases, it is not clear where the data originated or how the costs were estimated (see for example, Darn ton-Hill et al 2005, table 1). Estimates of costs included in a World Bank publication (World Bank 2006), are listed here in Table 4:2. In the time frame for this project, Access Economics was not able to obtain the source publications to verify whether these cost estimates provide a valid comparator for the FSANZ proposal analysed here.

TABLE 4:2 EXAMPLES OF COST ESTIMATES OF VARIOUS IODINE FORTIFICATION PROGRAMS

Type of program	Year	Country	Cost per child (USD)	Cost per death averted (USD)	Cost per DALY gained (USD)
Oil injection					
	1994	Peru	2.75 per child		
		Zaire	0.80 per child		
			1.25 per child		
Fortification					
Water	Not provided	Indonesia	0.05 per child		
Salt	Not provided	Italy	0.02–0.05 per child	1000	34-36
Salt	Not provided	India	0.05 per child		

Source: Table taken directly from World Bank, 2006, *Disease Control Priorities in Developing Countries, second edition*, Editors: Dean T. Jamison Joel G. Bremen Anthony R. Meacham George Allene Miriam Clawson David B. Evans Rabat Johan Anne Mills Philip Musgrove. Sources of data in this table listed as Institute of Medicine. 1998. *Prevention of Micronutrient Deficiencies: Tools for Policy Makers and Public Health Workers* Washington DC: National Academy Press. World Bank. 1994. *Enriching Lives: Overcoming Vitamin and Mineral Malnutrition in Developing Countries* Washington, DC World Bank.

4.2.4 COST BENEFIT ANALYSES

There are no cost benefit analysis studies of iodine fortification programs that could be usefully compared with the situation in Australia and New Zealand. In his discussion of key economic issues associated with micronutrient fortification in Allen and Gillespie (2001), Pipkin notes that there have been very few economic analyses of the elimination of micronutrient deficiencies through fortification:

> *At this point, the major gap appears to be application of economic analysis to actual large-scale fortification efforts.*

Part of the problem is the lack of data allowing quantification of the benefits of fortification. Pandav (1997) noted the problem when he compared the impacts of the introduction of an iodised oil program and an iodated salt program in preventing the *irreversible* effects of iodine deficiency in Skim — an area with severe endemic iodine deficiency. Both programs were found to be preferred to the status quo, but iodised oil was preferred to iodated salt. The quantification of the costs and benefits was not outlined (i.e. no numbers were included in the version seen by Access Economics). Pandav (1997) outlined the many gaps in data which hindered the analysis, for example, there was no information on the age and sex distribution of goitre prevalence, the prevalence of irreversible IDDs, the reduction in goitre prevalence for the programs analysed, health care utilisation by those with IDDs, and estimated productivity losses associated with cretinism, mild motor and mental impairment and care givers of severely impaired cretinous individuals. The analysis focussed on goitre, since information on the other physical consequences of iodine deficiency (cretinism, mild IDD and deaths due to iodine deficiency) was not available. The benefits of prevention programs were measured in terms of the savings in resources allocated to the treatment of IDDs and the savings in lost work time (productivity gains) due to prevention of IDDs.

5. FORTIFICATION PROPOSAL AND IMPACT ON IODINE INTAKE

The FSANZ proposal has two components:

1 mandatory addition of iodised salt, in place of non-iodised salt, in processed cereal based foods[7] at 30mg iodine per kg salt and

2 reduction in the voluntary iodine fortification of retail salt to 20mg iodine per kg salt.

5.1 FSANZ MODELLING

FSANZ undertook modelling of the impact of fortification on the dietary intake of iodine in Australia and New Zealand focussing on three groups:

- Children aged 0-3 years;
- Women of child-bearing age; and
- The Australian population aged 2 years and above and the New Zealand population aged 15 years and above.

Measured in terms of nutritional intake, a healthy adult aged 19 years or more requires around 150µg iodine per day, which corresponds to a MUIC of 100µg/L. Children aged 1-3 years need around 65µg per day to remain healthy, but pregnant or lactating women require 160µg per day and 190µg per day respectively. The details of nutrient reference values for iodine in selected groups are outlined in Table 5:1.

TABLE 5:1 NUTRIENT REFERENCE VALUES FOR INTAKE OF IODINE BY SELECTED GROUPS

Group	Age (years)	EAR[1] (µg/d)	UL[2] (µg/d)
Children	1-3	65	200
Adults	19+	150	1100
Pregnant women	14-18	160	900
	19-50	160	1100
Lactating women	14-18	190	900
	19-50	190	1100

[1] EAR (Estimated Average Requirement) refers to: “A daily nutrient level estimated to meet the requirements of half the healthy individuals in a particular life stage and gender group.”

[2] UL (Upper Level of Intake) refers to: “The highest average daily nutrient intake level likely to pose no adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects increases.”

It should be noted that the FSANZ modelling in Table 5:1 was undertaken on a slightly broader selection of processed cereal products than is proposed in footnote 7. As a result, the costs and benefits have a different scope — the costs have been estimated based on the selection of goods actually proposed. The scope difference arises because the proposal was

[7] Processed cereal based foods include bread and bread products (English muffins, buns, bread rolls, fruit breads, pizza bases, crumbed products and stuffings), biscuits (sweet & savoury) and breakfast cereals (pers. comm., FSANZ, 6 June 2006).

refined by FSANZ during the period of this particular analysis to better target only those products that have a material impact on intake of iodine through use of iodised salt. The modelling reflects an earlier version of the proposal which defined processed cereal based foods as: *breads (sweet & savoury), biscuits (sweet & savoury), cakes, cake/biscuit style puddings, scones, slices, muffins, crumpets, pancakes & pikelets, doughnuts, pastries, pizza bases, breadcrumbs and breakfast cereals.* **The impact on the estimated benefits is unlikely to be material given removal of products from the proposal was based on their very small impact on intake of iodine.**

5.2 FINDINGS OF THE FSANZ MODELLING

The impact of fortification on the three target groups is summarised in Table 5:2. The ranges reflect different assumptions about iodisation of discretionary salt:

- In the case of the EAR (Estimated Average Requirement), the lower number in the range is the percentage of the population group with dietary iodine intakes that are less than the EAR when all discretionary salt is iodised; the upper number in the range is the percentage of the population group with dietary iodine intakes that are less than the EAR when all discretionary salt is not iodised.
- In the case of the UL (Upper Level of Intake), the lower number in the range is the percentage of the population group with dietary iodine intakes that are greater than the UL when all discretionary salt is not iodised; the upper number in the range is the percentage of the population group with dietary iodine intakes that are greater than the UL when all discretionary salt is iodised.

TABLE 5:2 MODELLING PROJECTED IMPACT OF FORTIFICATION ON INTAKE OF IODINE

Group	Age (years)	% population with intake<EAR[a]		%population with dietary iodine intake>UL[b]	
		Aust	NZ	Aust	NZ
Children	2-3	1	na	6 to 16	na
Females — not pregnant	16-44	6 to 14	3 to 19	0	0
Females — pregnant	16-44	43 to 74	68 to 81	0	0
Females — lactating	16-44	68 to 89	85 to 91	0	0
Total population	2 and above (Aust) 15 and above (NZ)	3 to 7	1 to 11	<1	<1

[a] EAR (Estimated Average Requirement) refers to a daily nutrient level estimated to meet the requirements of half the healthy individuals in a particular life stage and gender group. [b] UL (Upper Level of Intake) refers to the highest average daily nutrient intake level likely to pose no adverse health effects to almost all individuals in the general population.

The modelled projections of intake show that:

- mandatory fortification of the food supply cannot deliver sufficient amounts to all pregnant and lactating women. Even after fortification, most pregnant and lactating women will have intakes below the EAR and will need to take an iodine supplement. Examination of alternative options that may capture a greater proportion of the benefits associated with preventing irreversible harm caused by iodine deficiency during pregnancy or infancy was outside the scope of this brief.
- In Australia, iodine intakes of a significant proportion of 2-3 year olds and possibly 0.5% and 1.2% of 4-8 year old children may exceed the upper limit depending on the

amount of discretionary iodised salt in their diet. Projections for this age group were not available for New Zealand because of the nature of the underlying data on which the modelling was based.

The modelling is based on the best available information. However, there is a high degree of uncertainty associated with the projections given gaps in the underlying data.

- There is uncertainty surrounding the intake of discretionary salt, and no data on consumption of iodine supplements. Supplement intake was not able to be included in the FSANZ projections.
- The FSANZ projections are based on nutritional/dietary intakes data from 1995 in Australia and 1997 in New Zealand (the most recent data available).
- In Australia, there was geographic diversity in iodine status which could not be taken into account in the projections of intake by FSANZ (because of the lack of state/territory food composition data). The projections cannot show whether fortification will result in those living in Victoria and NSW, Tasmania and SA will become replete — the modelling indicates only that the average Australian will become replete. Similarly, it cannot determine whether those already replete populations in WA and Queensland will be at greater risk of iodine intakes above the upper limit.
- The modelling reveals that a proportion of toddlers are likely to have intakes above the upper limit, but does not indicate where or in what demographic groups they are so it is not possible to target monitoring of possible negative health impacts. Likewise, the nature of the data available as the basis for modelling, in concert with the lack of detailed information about the prevalence or incidence of those likely to be susceptible to adverse health effects (for example, people with Graves disease), means that monitoring of these groups will be difficult.

6. BENEFITS

As noted earlier, studies of the health impacts of iodine deficiency suggested benefits from fortification across a range of human capabilities — intelligence, hearing, concentration, reproduction, fertility and infant survival (for example). However, for the purpose of a cost benefit analysis, there is a dearth of the type of evidence required to enable the potential benefits to be quantified for Australia and New Zealand.

The most critical period of iodine nutrition is from the second trimester of pregnancy to the third year after birth (FSANZ citing ICCIDD, 2001). The key benefit of iodine fortification identified by the health benefit-risk assessment commissioned by FSANZ would be to prevent intellectual impairment of children suffering iodine deficiency up to age three years that can be **irreversible**. However, as noted above, not all pregnant women will become iodine replete as a result of fortification and many will still need to take supplements. **Hence, the major health benefit from fortification as proposed by FSANZ — which is central to the analysis here — is the avoidance of any reversible decrease in cognitive function which may affect productivity (measured as loss of some proportion of lifetime earnings).**

Given the lack of information about reversible IDDs (for example, an estimate of the quantum of their impact on quality of life [i.e. disability weight], or prevalence or incidence data) it was not possible to calculate the impact on quality of life (disability adjusted life years), or the health, education or other types of expenditure (for example on carers) avoided through iodine fortification. However, given that the impact of fortification on productivity is likely to comprise the most significant component of financial benefit for **reversible** illness, the analysis remains a useful basis for determining whether fortification will result in a net benefit.

6.1 MODELLING THE BENEFITS

6.1.1 METHOD

Access Economics measures the lost earnings and production due to both disability and premature death using a 'human capital' approach.

> The human capital method estimates production losses based on expected lifetime earnings for an individual.

The lower end of such estimates includes only the 'friction' period until a worker can be replaced, which would be highly dependent on labour market conditions and un(der)employment levels. In an economy operating at near full capacity, as both Australia and New Zealand are at present, a better estimate includes the discounted stream of lifetime earnings lost due to lower productivity. It is likely that, by preventing cognitive impairment through mandatory fortification, those otherwise affected would participate in the labour force and obtain employment at the same rate as other Australians or New Zealanders, and earn the same average weekly earnings. In other words, the basis for the modelling is that an increase in the average IQ of a proportion of the population is linked to an increase in their average weekly earnings.

The implicit and probable economic assumption is that the numbers of such people would not be of sufficient magnitude to substantially influence the overall clearing of the labour market, thus making a net addition to productive capacity. However, if the proportion of the population was large enough, a wholesale rise in the number of people with a certain IQ may affect the level of earnings at which the market clears — more specifically, in the long term, while average IQ may increase, earnings may not be affected. A full economic analysis examining the long-run situation where the impact of an increase in average IQ would be passed on to society through adjustments in wages and prices is not in scope here. However, considerable sensitivity analysis has been undertaken to account for the partial nature of this study.

6.1.2 QUANTIFYING THE EXTENT OF COGNITIVE IMPAIRMENT

A literature review was undertaken to find an estimate of the number of IQ points lost due to mild or moderate iodine deficiency that might be restored with fortification.

While Bleichrodt and Born (1993) is the most cited study of the quantum of the impact of iodine deficiency on IQ, it focussed on severe deficiency and so is not relevant to the Australia or New Zealand case.

The research most relevant to the Australian and New Zealand situation (finding that mild iodine deficiency is associated with reduced cognitive abilities) is Santiago-Fernandez et. al. (2004), who studied the link between IQ and iodine status in a group of 1221 Spanish children aged between 6 and 16 years of age (mean age 10.8). The median urinary iodine level in this group was 90μg/L, with 54.7 per cent of the children having a UIC < 100μg/L, and 26.2 per cent with a UIC < 50μg/L, indicating a mildly iodine deficient population. The prevalence of goitre for the group was 19.4 per cent. The authors found a significant difference of **2.63 points** between the IQ of children with UIC < 100μg/L and the IQ of those with UIC ≥ 100 μg/L (96.40 ± 17.46 *vs.* 99.03 ± 15.81 μg/litre). Children with UIC < 100μg/L also had a greater risk of having an IQ below 70 and were significantly more likely to have an IQ below the 25^{th} percentile.

However, while demonstrating a possible quantum IQ difference due to mild iodine deficiency, this research does not exclude the possibility that at least some of the difference in IQ was due to iodine deficiency during brain development, which may therefore be irreversible. Hence, the estimate of difference in IQ between the two groups of children should be treated as the maximum increase in IQ that can be expected as a consequence of fortification.

6.1.2.1 REVERSIBILITY

A randomised, placebo controlled, double-blind study by Zimmerman et al. (2006) probably provides the best evidence of reversibility. The cognitive performance (as assessed by a series of 7 tests assessing different cognitive skills) of 310 Albanian children (aged 10 to 12) was assessed before receiving 400 mg of iodised oil (or placebo) and then 24 weeks after. A significant improvement was found for the iodine treatment group on four of the seven tests administered, as compared with the placebo group. These results suggested that information processing, fine motor skills, and visual problem solving are all improved by iodine repletion in moderately iodine-deficient schoolchildren. Because this study applied tests of specific cognitive skills rather than a more general test of IQ, it is not possible to quantify the degree of improvement in IQ resulting from the iodine supplementation. However, the authors note:

> *The adjusted treatment effect of 4.7 points on Raven's Coloured Progressive Matrices suggests that iodine repletion was associated with a small but significant increase in intelligence.*

Given the differences between the Zimmerman et al (2006) study and the Australian and New Zealand situation and also the FSANZ fortification proposal, the study is simply noted as evidence of reversibility.

No studies were available documenting a link between the Estimated Average Requirement (EAR) for iodine and impaired cognitive ability, but there is a link between the EAR and MUIC as noted above in section 5.

Sensitivity testing was undertaken of the size of the IQ increase resulting from the proposed fortification policy. The modelling here was based on a lognormal distribution for the points increase in IQ, with a mean IQ increase of 0.8 points, and a standard deviation of 1 point.

Up to what age is cognitive impairment as a result of iodine deficiency reversible?

The Zimmerman et al (2006) study found improved cognitive performance in children aged 10-12. In modelling benefits from productivity gains, it was assumed that similar benefits could be achieved in younger children, on the basis that the brain is still developing in this period, and for children up to age 14 (because data are available in 5 year age groups). It is not known whether cognitive improvement is possible above the ages of 10-12.

6.1.3 QUANTIFYING THE LINK BETWEEN REVERSIBLE COGNITIVE IMPAIRMENT AND PRODUCTIVITY

From the economics literature, Zax and Rees (2002) assessed the effect on earnings of IQ, as well as other contextual variables including family, academic performance, and peer group. All of the variables which potentially affected IQ were observed in the last year of high school (age 17), while earnings were measured at ages 35 and 53. The study was based on a sample of 2,959 male students from a wider data set of a cohort of 10,317 students in Wisconsin in 1957 (continuing in 1964, 1975 and 1993). The study found a small, but significant effect of IQ on earnings when other effects such as academic performance and family were controlled for. Zax and Rees modelled three scenarios — IQ alone; IQ and conventional measures of family context; and the second model with the addition of variables for respondent and parental college aspirations as well as all other contextual variables.

- For the first model (IQ alone), Zax and Rees found that an increase in IQ of one point resulted in a 0.744 per cent increase in earnings at age 35; and a 1.39 per cent increase in earnings at age 53.
- Controlling for a broad range of contextual variables, Zax and Rees found an increase in IQ of one point resulted in a 0.363 per cent increase in earnings at age 35; and a 0.898 per cent increase in earnings at age 53.

As a cautionary note, the study only included males and there may be cultural or other differences between the US and Australia/New Zealand. In addition, Zax and Rees cited other studies which found no significant relationship and studies which found a larger increase in earnings (although these did not include contextual variables). While Zax and Rees found that the effect of IQ on earnings was greater for the group at age 53 than at 35, for simplicity, in our model we have assumed a constant affect on earnings.

The link between IQ and earnings has been used in other studies of the economic benefits of health programs which address cognitive impairment (due for example, to lead or methyl mercury exposure) in large segments of a population (for example, Trasande et al 2005, and Grosse et al 2002). These studies based their estimates of the economic benefits of the relevant health programs on larger figures for the influence of IQ on productivity than those in Zax and Rees (2002).

- Trasande et al. (2005) use Walkover's (1995) estimate of a percentage loss in lifetime earnings per IQ point among men of 1.931 per cent and women of 3.225 percent, and assumed that this relationship remains linear across the population range of IQ. However these figures were based on the relationship between blood lead levels and earnings (and the relationship between blood lead levels and IQ), rather than being a direct study of the link between IQ and earnings.
- Grosse et al. (2002) estimated that each IQ point raises worker productivity 1.76–2.38 per cent. The results included not only the direct effect of IQ on earnings but the indirect effect whereby IQ increases educational effectiveness, hence increasing educational attainment, hence increasing earnings.

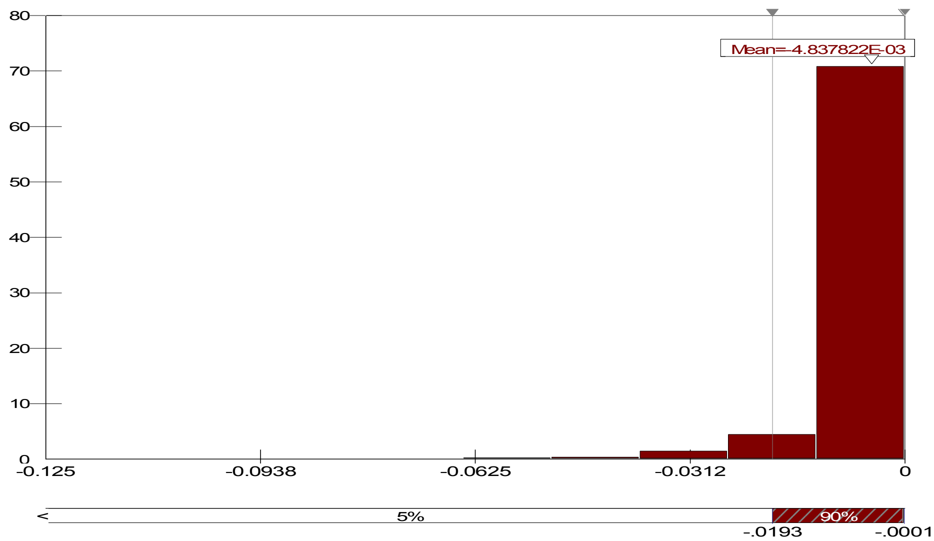
Sensitivity testing was undertaken of the relationship between IQ and earnings. A range of estimates for the increase in productivity associated with a one point increase in IQ was elicited from the three articles discussed: an increase of 0.363 per cent (Zax and Rees) to an increase of 3.225 per cent (Trasande et al.). **The modelling here was based on a (truncated) lognormal distribution for the increase in productivity per IQ point, with a mean value for the impact of IQ on productivity of 0.9 per cent, a minimum of zero, and a maximum of 3.5 per cent.**

IQ-related productivity impact per person

The total productivity impact per person experiencing a beneficial IQ effect as a result of fortification was calculated as the product of the size of the IQ increase (in terms of the number of IQ points), and the per-point productivity impact of IQ on earnings. It was assumed that individuals continue to experience this increase in productivity over their entire working life.

Using the distributions given above for the size of the increase in IQ and the size of the increase in productivity per IQ point, a simulation was run using the @Risk program to determine the potential distribution of the change in productivity (Figure 2). The results from this simulation suggest a mean change in productivity of 0.48 per cent, and a standard deviation of 1.06 per cent. The minimum change in productivity from the simulation was 0.0005 per cent, and the maximum change in productivity from the simulation was 28.25 per cent. Ninety per cent of the simulated values for the change in people's productivity due to the fortification policy were between 0.01 per cent and 1.93 per cent.

FIGURE 2: DISTRIBUTION FOR TOTAL % CHANGE IN PRODUCTIVITY



6.2 ESTIMATING THE POPULATION AT RISK OF IMPAIRMENT

The treatment of age, gender and iodine status in the model is outlined in Table 6:1 — determined by data limitations and evidence.

TABLE 6:1 TREATMENT OF POPULATION VARIABLES IN MODELLING THE BENEFITS

Variable	Treatment
Age groups	Children aged 0-14 years benefit from iodine fortification. The model assumes that children must become iodine replete prior to age 15 and must remain replete until age 15.
Gender	The model treats males and females identically (except, in the Australian case, for the wages and rates of employment). The proportion of the population experiencing an increase in IQ, the size of the increase in IQ experienced, and the size of increase in productivity per extra IQ point is assumed to be the same for males and females.
Iodine status	The modelled benefits reflect a reduction in the proportion of the population whose iodine intake is below the EAR. More specifically, it is assumed that all those whose iodine intake was below the EAR before fortification (and who use iodised salt), will have an iodine intake above the EAR as a result of fortification.
Increase in IQ by age	Modelling is based on all age groups reacting to fortification in the same way — that is, the increase in IQ points is the same at every age.

There are limited data available on how many people in the population are likely to receive a benefit (in terms of increased intelligence) as a result of iodine fortification. Modelling by FSANZ provided an estimate of the proportion of the population whose iodine intake is below the EAR for both the baseline (do nothing) scenario and under the proposed iodine fortification policy. However for New Zealand, no data was available for the entire population (people aged 0-14) for which evidence in the literature supports an increase in IQ linked to increased iodine consumption.[8] It was necessary to make assumptions about who benefits from the policy based on what data was available.[9] Table 6:2 outlines the scenario that was modelled for each country.

TABLE 6:2: MODELLING SCENARIOS

	Australia	New Zealand
Beneficiaries	All people whose iodine intake moves from below the EAR to above the EAR as a result of fortification.	All people whose iodine intake moves from below the EAR to above the EAR as a result of fortification.
Population Share	0-4yrs 11 per cent 5-9yrs 11 per cent 10-14yrs 12 per cent (FSANZ modelling)	0-14yrs 10 per cent (FSANZ modelling for 15-18 year olds)

The values (based on the evidence discussed above) assigned to key variables determining the magnitude of the productivity benefit per person from mandatory fortification are summarised in Table 6:3.

TABLE 6:3: SIZE OF BENEFITS PER PERSON

	Unit	Distribution for sensitivity analysis	Distribution parameters
Size of IQ increase from mild deficiency to replete	IQ point	Lognormal	Mean = 0.8 point, standard deviation = 1 point, minimum = 0 points
Size of productivity increase per IQ point	Per cent increase in earnings	Lognormal	Most likely = 0.9% minimum = 0%, maximum = 3.5%
Size of total productivity increase per person	Calculated as the product of the above variables	Distribution parameters drawn from simulation using @Risk.	Mean = 0.48%, standard deviation = 1.06%, minimum = 0.0005%, maximum = 28.25% 90% CI = (0.01%,1.93%)

6.3 RESULTS

The estimated benefits arising from mandatory fortification are described in Table 6:4. The estimated mean productivity gain from the proposed fortification policy is A$1.85 billion for Australia and NZ$286 million for New Zealand. It is most likely that the size of productivity

[8] For Australia, no data was available for children aged 0 to 2 years.

[9] It was also necessary to apply estimate across different age groups to be consistent with the population projections.

gain resulting from mandatory fortification falls in the interval (A$44.9 million, A$7.23 billion) for Australia, and in the interval (NZ$6.56 million, NZ$1.14 billion) for New Zealand.

TABLE 6:4: DISTRIBUTION OF PRODUCTIVITY GAINS

	Australia (A$)	*New Zealand (NZ$)*
Minimum	2,125,429	289,031
Mean	1,850,000,000	286,000,000
Maximum	91,300,000,000	16,700,000,000
Std Dev	3,980,000,000	629,000,000
5th Percentile	44,900,940	6,560,331
95th Percentile	7,231,350,000	1,136,772,000

7. COSTS

7.1 CONSUMER CHOICE

Mandatory fortification aims to address the potential for under-consumption of iodine by women of childbearing age, children aged 0 to 3 years and the population in general. In a world of perfect information and foresight, where people knew of the potential social (and personal) costs of under-consumption of iodine in terms of an increased risk of cognitive and motor impairment, health and visual effects, they would alter their dietary habits. Public health information campaigns aside (not in scope here) and use of supplements aside (also not in scope), regulation in the form of voluntary or mandatory fortification of food could improve consumption outcomes by increasing iodine intake.

However, given the possible adverse effects of excess iodine intake, *mandatory* fortification prevents consumers from avoiding fortified products unless they make considerable changes to their dietary habits. This may result in significant costs in terms of consumer choice. A willingness-to-pay vehicle could be used to estimate this cost, but was not able to be undertaken for this project.

- While as part of the iodine fortification program in Tasmania, a survey was conducted amongst small to medium sized Tasmanian bakeries in 2003 with the aim of determining participation in the program. Bakeries indicated that the switch to use of iodized salt had no significant impact on consumer acceptance (Turnbull et al, 2004). However, given the survey was of bakeries rather than consumers, it is not clear whether consumers were fully aware of the impacts of iodine on healthy functioning.

As with folic acid (see Access Economics 2006), while costs will initially fall on industry, in a competitive industry such as processed cereal products, these costs will be largely (if not entirely) passed on to consumers. That is, while the legal incidence of fortification falls on industry, the economic incidence will be on the purchasers of processed cereal products. A cost benefit analysis is necessarily a partial analysis of the first round impacts of a policy change – it is beyond the scope of this analysis to estimate the second round effects as industry and consumers adjust to the increased costs of bread production. That said, we note that an across-the-board increase in the cost structure for an industry tends to be rapidly passed on to consumers. A possible exception to this is production being exported, where the scope to pass on cost increases may be less.

7.2 INDUSTRY

In summary, the impact of the proposal for industry would be as follows:

- **Salt suppliers** would need to alter production processes in order to produce more iodised salt for the food industry (and less non-iodised salt), and also reduce the iodine concentration in table salt.
- The significant number of firms that make up **the cereal processing industry** (more than 8000 manufacturers of bread and biscuits in 2003[10] alone) would need to swap to using iodised salt, instead of unfortified salt.

Method

[10] BRI (2003).

As Access Economics was able to obtain estimates of the costs of iodine fortification from close to a census of ANZ[11] salt suppliers, it was possible to estimate total costs to salt manufacturers simply by adding up the cost estimates from the data providers.

However, for cereal processing, cost estimates are based on data provided by a sample of companies. While the sample is small and not necessarily representative, both large and small firms from all three industry sectors provided data. Costs of iodine fortification for cereal processing were calculated by dividing total cost estimates from each company by the amount of salt input the company purchased, to obtain a cost per kilogram of salt. These unit costs were then multiplied by the total production of salt supplied to the processed cereal products industry to obtain total industry costs.

Estimates of salt production used by Australian cereal processing firms were in the range 20,000 tonnes per year to 30,000 tonnes per year. Salt production for cereal processing in New Zealand is around 2,900 tonnes.

7.2.1 Salt manufacturers

Major suppliers of salt to food processing businesses in Australia and New Zealand include Cheetham Salt Ltd (including Western Salt Refinery in WA and Dominion Salt in New Zealand) and Olsson's Pacific salt. The nature of the costs is outlined here, removing significant numerical detail to maintain confidentiality.

Machinery and equipment

In some cases, plant upgrades would be required to install a dry mixing system to enable increased production of iodised salt. In addition, where salt products are certified as an organic allowed input, firms need to ensure that there is no cross contamination, so a separate processing area would be required. The total cost of the machinery and equipment as well as installation costs have been included in the estimates. In Australia, around A$143,000 of additional machinery and equipment would be required (including installation costs). Associated (additional) maintenance costs for the extra machinery have been included in the projections of annual ongoing costs (around A$5000 per annum).

Labelling

In some cases, salt manufacturers indicated that changes to labelling would be necessary of a type to ensure that iodised and non-iodised salt are not confused. The costs incurred would be around $1000 per plate. One manufacturer advised that the costs of changing labels would be minimal. In Australia, upfront costs associated with changing labels would amount to around A$16,000, with no further costs modelled after the first year.

Iodine

Manufacturers indicated that an iodine compound would be added in a premix of fine salt. Costs were calculated on the basis of adding an average 30mg iodine per kilo salt (which equates to 51mg/kg potassium iodate), although as noted below, manufacturers noted the importance of establishing a 'working range' for concentration of iodine to compensate for normal process variation. Most indicated they would use potassium iodate which costs A$30-40 per kg in Australia and NZ$55-65 in New Zealand.

[11] Australian and New Zealand.

In principle, the cost benefit analysis should be based on estimates for the costs of *additional* iodine (i.e. iodine purchased specifically as a result of the fortification requirement — over and above that already purchased). The estimates here are based on the total costs of iodine added to salt for the whole cereal processing industry, even though some iodised salt is already provided to the industry (for example, for bakers in Tasmania). While this will overestimate the additional costs associated with iodine fortification, the current quantities of iodised salt already used in cereal processing are not known, and the impact on the estimate of net benefits should not be material given the small amounts likely to be involved.

Analytical testing

Responses on approaches to analytical testing differed, with the amount of product tested ranging between 6% and 20%. In Australia, estimates of test costs also differed depending on whether tests were carried out in-house or at a laboratory. Based on company estimates of test costs and the number of tests, costs of analytical testing in Australia for all salt manufacturers is $22,000 per year.

Other costs

- One manufacturer advised that additional ware-housing costs would be incurred to separately store multipurpose non-iodised salt with sector specific iodised salt.
- In addition, one salt manufacturer in Australia indicated that it would incur additional transport costs because it would expand its plant in one State but not in another, and would therefore need to transport salt from the expanded plant to customers in other states. These transport costs are relatively significant, comprising 72% of annual ongoing outlays associated with fortification.

Transition time

With the exception of one salt manufacturer, salt manufacturers in Australia and New Zealand advised that a transition period of six to 12 months would ameliorate the costs of stock in trade and allow preparation of plant and installation of machinery.

Technological issues

- Iodine will not disperse evenly in salts with large crystals or granules the way it does in finer salt. One salt manufacturer advised that a few food manufacturing companies use larger granules, although this is diminishing as larger granules require extended dough kneading times. Most companies are moving to use of smaller salt granules. Given the scope for this project, Access Economics was not able to pursue the significance of this potential problem for those using large granule salt in food manufacture although it would appear that the costs of changing recipes or processes is unlikely to be material.
- Manufacturers noted the importance of establishing a ‘working range’ to compensate for normal process variation in concentration of iodine (for example, to achieve an average of 30mg iodine per kg, the regulation might specify a range of 20-40mg iodine per kg salt).

Summary of costs of fortification to salt manufacturers

- In Australia, upfront costs would be around A$160,000 and total ongoing costs around A$490,000 per year. The net present value of the costs of fortification for salt manufacturers over a 15 year period would be A$5.9 million.

- In New Zealand, upfront costs would be around NZ$303,000 and total ongoing costs around NZ$18,170 per year. The net present value of the costs of fortification for salt manufacturers over a 15 year period in New Zealand would be NZ$508,000.

Given that costs for salt manufacturers were based on close to a census of firms, no sensitivity testing has been undertaken on these costs estimates.

7.2.2 CEREAL PROCESSING INDUSTRY

Manufacturers of processed cereal products affected by the proposed iodine fortification strategy would include makers of breakfast cereals, bread and bread products, and biscuits.

Breakfast cereals: major companies include Kellogg's, Sanitarium, Goodman Fielder and Nestle. Data from a Department of Agriculture, Forestry and Fishing survey of the processed food sector undertaken in 1998-99 and cited on a Victorian Government website[12] suggested national turnover of cereal food and baking mix manufacturing was about $2100 million. It is not clear what proportion of the $2100 million comprised breakfast cereals (as opposed to baking mixes). The modelling is based on 50%.

Bread manufacturing: major companies include Goodman Fielder, George Weston Foods, and a significant number of small firms including franchise bakers (such as Bakers Delight and Brumbies) and small bakeries and hot bread shops. Data from the survey mentioned above suggested 1998-99 national turnover of bread was about $1300 million.

Biscuit manufacturing: companies include Arnott's and George Weston Foods. Data from the survey mentioned above suggested 1998-99 national turnover of just over $1000 million.

In the absence of more recent information, it has been assumed that the three sectors (breakfast cereals, bread and bread products and biscuits) make up around one third each of total production of foods that would be affected by iodine fortification.

Cost centres affected by the fortification proposal include: additional costs of iodised salt, changes to labels, analytical testing and trade related costs. Potential costs associated with making the transition are also discussed in this section.

7.2.2.1 IODISED SALT

Iodised salt would cost cereal processing firms around 10% more than non-iodised salt. **However, the additional cost of iodised salt to cereal processing firms is taken into account in this analysis in the costs of fortification to salt manufacturers.**

7.2.2.2 LABELLING AND PACKAGING

If mandatory fortification were introduced, cereal processing firms would be obliged to redesign label templates to ensure compliance with labelling standards for food containing salt. The term 'iodised salt' would need to be added to the ingredients list, and in some cases possibly the nutritional panel would also need to be changed. The redesign may be more expensive for biscuits and breakfast cereal products than for bread products, as the first two tend to have a greater range of colours on their labels.

For **pre-packaged** products:

- Labelling standards require that ingredients must be declared in the statement of ingredients using a name that describes the true nature of the ingredient. To enable consumers to make informed choices and to protect public health and safety, there is a requirement that iodised salt be listed in the ingredients list. Thus labels will need to be changed to reflect this (pers. comm. FSANZ, 30 May 2006).

[12] http://www.business.vic.gov.au/BUSVIC/STANDARD/1001/PC_60183.html accessed 17 June 2006.

- Labelling standards also require that compound ingredients[13] (such as bread crumbs) be declared if the amount of the compound ingredient in the final food is 5% or more by weight. In other words, if mandatory fortification is introduced, labels on products with 5% or more of a compound ingredient containing iodised salt will need to be altered to reflect the inclusion of iodine in salt (pers. comm. FSANZ, 30 May 2006).

Estimates provided to Access Economics of the costs of label redesign for **pre-packaged** products were in the range:

- A$500 per stock keeping unit for simpler changes in Australia and NZ$500 in New Zealand, and around A$1000-2000 per stock keeping unit (or NZ$1000) for more complex changes.
- On a per kilogram of salt input basis, pre-packaged labelling estimates ranged from A$0.06 to A$0.33 to A$2 in Australia and on average NZ$0.11 in New Zealand.

If food is sold **unpackaged**, or made on the premises from which it is sold, or packed in the presence of the purchaser, no label is required. Enterprises producing unpackaged products generally provide information about ingredients via information manuals available for public perusal, label stickers, or cardboard inserts listing ingredients.

- Estimates of the costs of changing these items from companies producing unpackaged products were between 1 cent and 7 cents per kilogram salt input.

In Australia, labelling costs (pre-packaged and unpackaged together) were modelled in a range, with a mode of A$0.30 per kilogram of salt input and a mean of A$0.62, reflecting the clustering of costs (both pre-packaged and unpackaged) of A$0.33 and below, with some firms experiencing costs at the higher end (A$2 per kilogram of salt). In New Zealand, NZ$0.11 was used as the basis for modelling — reflecting that this estimate was provided by a firm with a very large proportion of the market. Based on these parameters, the upfront costs of labelling changes required if fortification was introduced would be around A$15.5 million in Australia and NZ$341,000 in New Zealand.

Sensitivity testing of the impact of these different estimates on the net present value of costs over 15 years for cereal processing firms was conducted and the results are detailed in the section on sensitivity testing (section 7.2.2.6).

7.2.2.3 ANALYTICAL TESTING

Around half of the cereal processing firms that contributed data for this analysis indicated that they would not undertake analytical testing and would instead rely on salt suppliers' guarantee that iodine concentration complied with the proposed fortification regulation. **However, the modelling here is based on all cereal processing firms affected by fortification undertaking analytical testing.** Three larger firms indicated that they would undertake testing and provided estimates of the associated costs. Cost estimates varied according to differences in approach. The highest projected cost estimate for testing was 3 cents per kilogram of salt purchased by that company, and the lowest was 0.3 cents per kilogram of salt. Taking an average of these (1.65 cents per kilo salt) and applying it to total salt used in cereal processing, ongoing costs per year of analytical testing would result in outlays of A$413,000 in Australia and NZ$51,000 in New Zealand. This estimate may or may not overestimate total expenditure per year on analytical testing because — while half the sample of firms indicated that they would not undertake any testing — it is not clear whether

[13] Compound ingredient means an ingredient of a food which is itself made from two or more ingredients.

these firms would be culpable if they used salt that did not have the iodine concentration required by the regulation.

Sensitivity testing of the impact of these different estimates on the net present value of costs over 15 years for cereal processing firms was conducted and the results are detailed in the section on sensitivity testing (section 7.2.2.6).

7.2.2.4 TRADE RELATED COSTS

A number of stakeholders indicated in submissions to FSANZ (for example, the New Zealand Food and Grocery Council) that iodine fortification would increase trade related costs because imports of foods fortified with iodine are proscribed in some countries. For example, Japan does not permit addition of iodine compounds in foods because the Japanese population is iodine sufficient. Thus, companies exporting to these countries need to maintain separate product lines, with the associated ongoing warehousing and label switching costs[14]. According to estimates from one company, these costs for affected companies could be significant. While industry estimates suggested ongoing costs of around A$36 per kg of salt used in exported products, not all of this would be attributable to iodine fortification alone. Some label switching would be necessary even without fortification to account for differences in language or other differences across export destinations. **Access Economics has therefore taken 25% of trade related costs as the *additional* costs due to iodine fortification.**

It is difficult to calculate trade related costs on an ANZ-wide basis for the cereal processing industry as a whole. However, Access Economics calculated ball park estimates of the trade related costs to the industry as a whole of iodine fortification on the following basis.

- **% processed cereal products exported:** Access Economics is not aware of the proportion of breakfast cereals made in ANZ that are exported. While less than one per cent of Australian bread turnover was exported in 2001-02, around 5% to 10% of Australian biscuits (by turnover) are exported (BRI 2003 p. 23 and company estimates). In the absence of other information, Access Economics has modelled the same proportions for New Zealand, and that the proportion of ANZ breakfast cereals exported is the same as that for ANZ biscuits.
- **% processed cereal products exported to countries where iodised products are proscribed:** Access Economics is not aware of the proportion of exports to countries in which iodine compounds in foods are proscribed. Over half of Australian biscuit exports were to NZ in 2001-02 (BRI 2003 p. 23). Other export destinations for Australian made biscuits (according to company websites) include Japan, the USA, Canada, United Kingdom, South East Asia and the Pacific. Since Canada has mandatory fortification of salt with iodine and the US allows voluntary iodisation of salt (FSANZ Initial Assessment Report), it is unlikely that these countries would proscribe imports of foods fortified with iodised salt. Access Economics conservatively modelled the proportion of exports to countries where addition of iodine compounds is proscribed with a uniform distribution between 10% and 30%.

In summary, in the base case:

- each element of the industry comprises a third of the output

[14] Man hours involved in switching labels for domestic good to labels for exported good for the same product line.

- bread and bread products are not exported (on the basis that less than 1% of bread turnover was exported in 2001-02 as noted above).
- 7.5% of output of biscuits and breakfast cereals are exported and between 10% and 30% of these are exported to countries where addition of iodine compounds to food is proscribed.

Based on these parameters, trade related costs would entail over A$2.3 million in ongoing outlays per year in Australia and more than NZ$280,000 in ongoing outlays per year in New Zealand. **Importantly, trade related costs comprise 85% of all ongoing costs to cereal processing firms per year associated with iodine fortification.**

Sensitivity testing of the impact of these different estimates on the net present value of costs over 15 years for cereal processing firms was conducted and the results are detailed in the section on sensitivity testing (section 7.2.2.6).

7.2.2.5 TRANSITIONAL ISSUES

Firms have requested a transition period of 12 months to four years to ameliorate labelling costs, and facilitate adjustments necessary to accommodate exports of unfortified products.

- If mandatory fortification is introduced at a time when labels are redesigned in the normal course of business, then the incremental labelling costs would be minimal.
- Further, simultaneous implementation of a number of regulatory changes would also reduce the associated cost of labelling changes to industry (for example, combining the implementation of proposals to fortify products with iodine and folic acid). Implementation of folic acid and iodine fortification simultaneously would lead to savings for firms that would be required to use both bread making flour and iodised salt — that is, those producing bread and bread products (English muffins, buns, bread rolls, fruit breads, pizza bases, crumbed products and stuffing's). This includes plant bakeries, franchise bakers, individual bakers and hot bread shops which could redesign labels to reflect the addition of folic acid and iodine at the same time. Based on labelling estimates for the folic acid cost benefit analysis (Access Economics 2006), **implementation of folic acid and iodine fortification together would save industry A$2.5million in Australia and NZ$220,000 in New Zealand compared with the separate implementation of these policies.**

A transition period would also moderate — although not eliminate — the problem of disposing of unused labels, or unfortified products.

- Firms preprint labels to make the most of economies of scale and unused pre-printed packaging would need to be thrown away[15]. At any given time, firms may hold millions of dollars worth of pre-printed packaging. NZIER suggested that, in order to gain economies of scale in purchase, manufacturers may purchase labels for up to two years in advance, but usually for shorter periods (NZIER 2005). One firm advised Access Economics that print runs usually last three to six months. At least two firms advised that, while it might take an individual firm six months to revise and store packaging ready for the implementation of folic acid fortification, given the potentially high number of stock keeping units affected industry wide, the large size of some print runs, and the competing demands of food companies for printers, a transition period of

[15] One firm noted that this would be inconsistent with policies aimed at reducing waste — for example, the National Packaging Covenant.

two to four years would be necessary to minimise labelling costs. This is based on experience with previous regulatory change affecting labels.

7.2.2.6 SUMMARY OF BASE CASE PARAMETERS DETERMINING COSTS OF FORTIFICATION FOR CEREAL PROCESSING FIRMS

Base case parameters	Australia	New Zealand
Salt production per year (kg)	25,000,000	2,900,000
Labelling cost per kilo salt($)	A$0.60 (mean) A$0.30 (mode)	NZ$0.11(mean)
Analytical testing cost per kilo salt ($)	A$0.0165	NZ$0.0165
Share processed cereal products exported (%)	7.5%	7.5%
Share exports to countries where iodine is proscribed (%)	20%	20%
Trade related costs — per kilo salt in exported products ($)	A$36.20	NZ$36.20
Share of trade related costs attributable to iodine fortification (%)	25%	25%
Biscuits & breakfast cereals as % of all cereal processing production	67%	67%

7.2.3 SENSITIVITY TESTING OF COSTS FOR CEREAL PROCESSING FIRMS

Sensitivity testing was undertaken on the estimates of the net present value over 15 years of costs to cereal processing firms because of the considerable uncertainty surrounding some of the estimates. No testing was undertaken on estimates from salt manufacturers (other than the estimate for the quantity of salt used in cereal processing in Australia) because the data were based on close to a census of firms.

Australia

Sensitivity testing was undertaken on the costs of iodine fortification for cereal processing firms in Australia to examine the impact on the net present value of costs over 15 years for these firms on modelling assumptions about the following variables, in order to account for the significant uncertainty around the estimates for these variables:

- Upfront labelling costs were modelled with a log normal distribution with a mean of 60 cents per kilogram of salt and a mode of 30 cents. The long right tail associated with this distribution means there was some probability allocated to costs being over $2 per kilogram of salt. Changes in this variable had the largest impact on the net present value of costs (Figure 4).
- The second largest impact was from varying the proportion of product exported to countries where the addition of iodine compounds to foods is proscribed. This was modelled with a uniform distribution with minimum 10% and maximum 30% (Figure 4).
- The quantity of salt used in cereal processing was modelled with a uniform distribution with a minimum of 20,000 tonnes used in the cereal processing industry per year and a maximum of 30,000 tonnes per year (Figure 4).
- The proportion of products exported was assumed to have a uniform distribution with minimum 5% exported and maximum 10% exported (Figure 4).
- Analytical testing costs were modelled with a normal distribution with a mean of 0.0165 cents per kilogram salt and a standard deviation of 0.0135 cents per kilogram salt (Figure 4).

With these distributions for these variables, the likely range for the costs of iodine fortification for cereal processing firms is outlined in Table 7:1. The mean of the NPV over 15 years of costs for cereal processing firms is A$38 million. The chart (Figure 3) shows that while the maximum possible NPV of costs could be A$245 million, it is most likely that costs will fall below A$64 million.

Table 7:1 Distribution of NPV of costs for cereal processing firms of fortification, Australia (A$)

NPV Minimum	10,300,000
NPV Mean	38,000,000
NPV Maximum	245,000,000
Standard deviation	15,000,000
5th percentile	20,000,000
95th percentile	64,000,000

Figure 3 Distribution of the NPV of costs for cereal processing firms

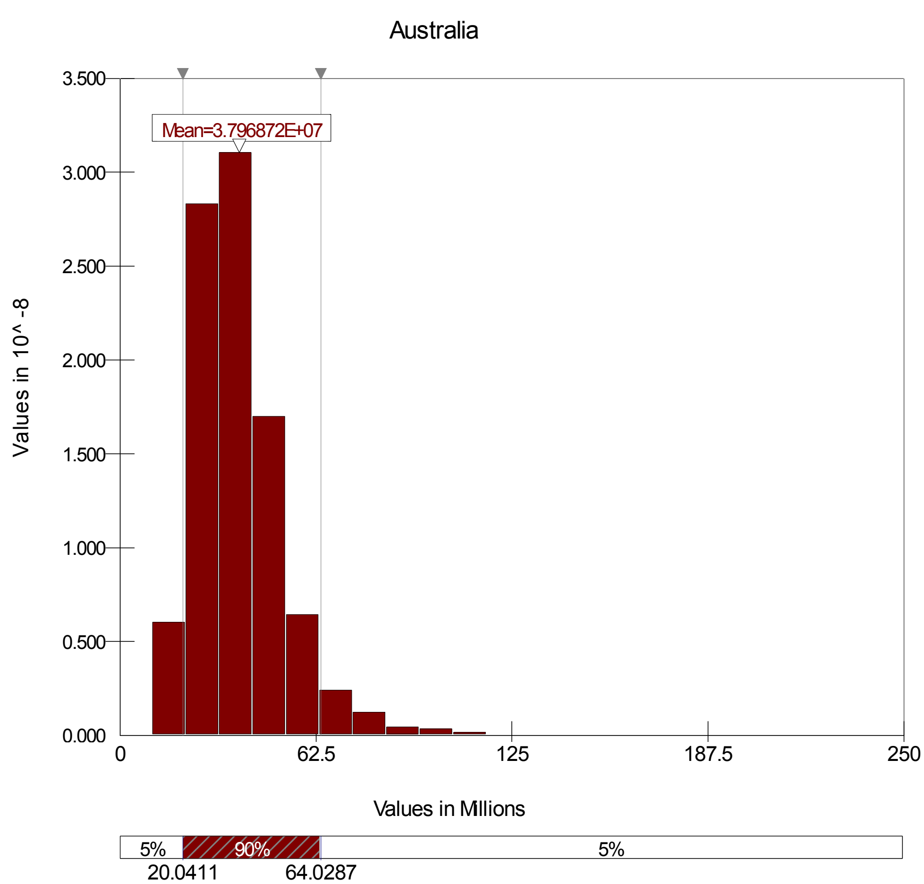
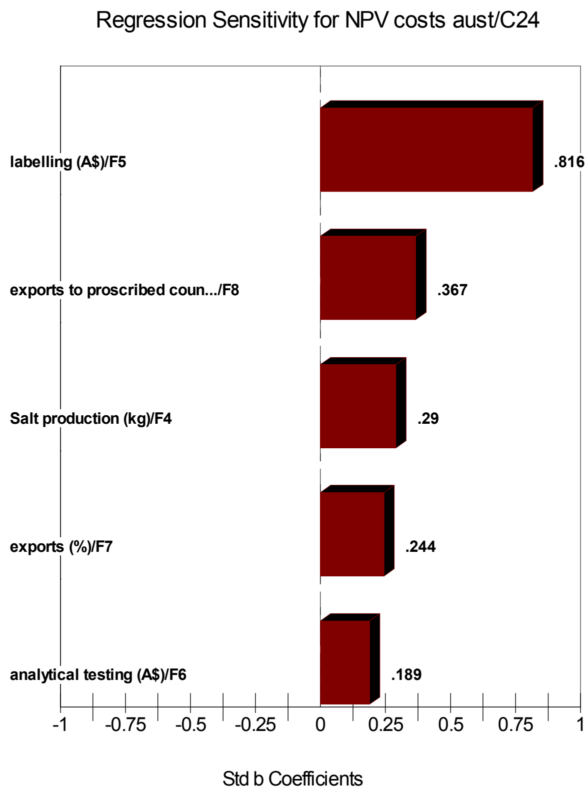


FIGURE 4 IMPACT OF KEY VARIABLES, AUSTRALIA



New Zealand

Sensitivity testing was also undertaken on the costs of iodine fortification for cereal processing firms in New Zealand to examine the impact on the net present value of costs over 15 years for these firms on assumptions about the following variables, in order to account for the significant uncertainty around the estimates for these variables:

- Analytical testing costs were assumed to have a normal distribution with a mean of 0.0165 cents per kilogram salt and a standard deviation of 0.0135 cents per kilogram salt (Figure 6).
- The proportion of products exported was assumed to have a uniform distribution with minimum 5% exported and maximum 10% exported (Figure 6).
- Similarly, the proportion of product exported to countries where the addition of iodine compounds to foods is proscribed was assumed to be uniform with minimum 10% and maximum 30% (Figure 6).

Based on these assumptions about the distribution of these variables, the likely range for the costs of iodine fortification for cereal processing firms is outlined in Table 7:2. The mean of the NPV of costs over 15 years for cereal processing firms is NZ$3 million. The chart (Figure 5) shows that while the maximum possible NPV of costs could be NZ$5.8 million, it is most likely that costs will fall below A$4.6 million.

Table 7:2 Distribution of NPV of costs for cereal processing firms of fortification, New Zealand (NZ$)

NPV Minimum	774,085
NPV Mean	3,055,744
NPV Maximum	5,841,971
Standard deviation	877,044
5th percentile	1,754,479
95th percentile	4,612,788

Figure 5 Distribution of the NPV of costs for cereal processing firms

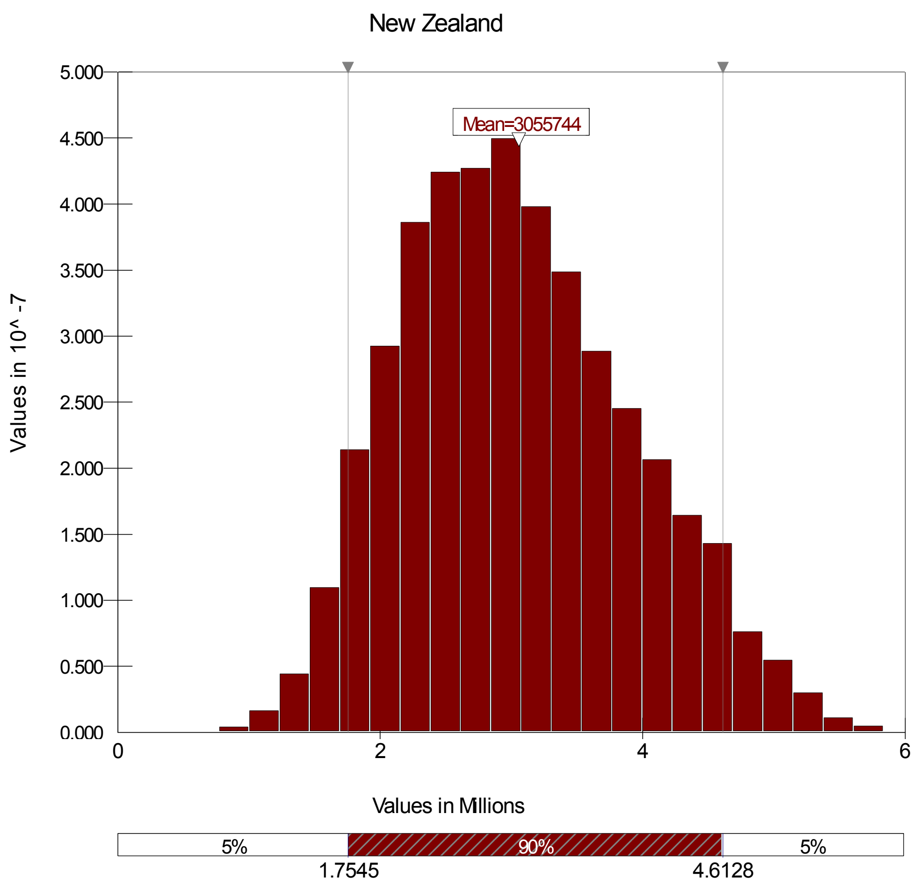
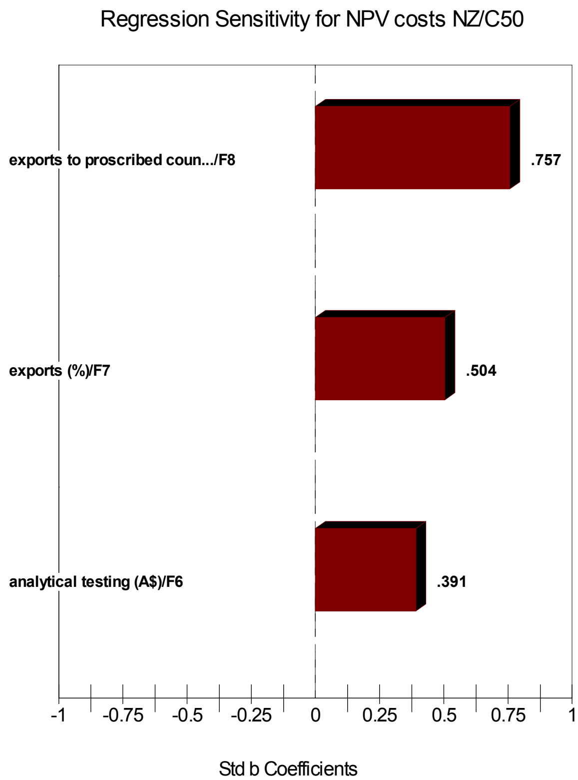


FIGURE 6 IMPACT OF KEY VARIABLES, NEW ZEALAND



7.3 GOVERNMENT

The cost estimates in this section reflect only the value of resources allocated to activities that would not otherwise be undertaken if mandatory fortification was not introduced, ignoring costs already sunk in developing the proposal thus far.

The costs outlined here draw on estimates provided by governments in Australia and New Zealand and have also been compared with the cost estimates from a previous project for governments to administer a proposal for mandatory fortification of bread making flour with folic acid (Access Economics 2006).

- The costs of administering the regulation in the case of iodine fortification are likely to be higher than those for administering folic acid fortification because the iodine requirement relates to cereal processing firms of which there are thousands (more than 8,000 firms in the baking industry in Australia (BRI 2003)[16]), whereas the folic acid fortification requirement relates to milling companies (less than 20).

The introduction of the two fortification requirements (folic acid and iodine) together may lead to some economies of scale for governments, for example, in training and awareness raising as firms in the baking industry are affected by both policy proposals, or in auditing (as indicated by the New Zealand Food Safety Authority).

16 This figure includes some companies that would not be affected by iodine fortification but excludes some companies making breakfast cereals (for example) that would be affected by iodine fortification.

7.3.1 AUSTRALIA

Administration and enforcement of mandatory fortification would be undertaken by the relevant section of the health or human services department in each State and Territory.

Given fixed regulatory resources, State and Territory governments need to balance the health risks associated with iodine intake against the other health and safety risks in their purview. As with folic acid fortification, iodine intake (in controlled concentrations such as that envisaged under the fortification proposal) may be allocated a lower priority than other food safety issues (for example, preparation of seafood). Furthermore, iodine fortification does not involve significant process change (except for a proportion of salt manufacturing plants).

Access Economics requested estimates of the costs of administering and enforcing the regulation from a number of jurisdictions. One small jurisdiction and one large jurisdiction provided estimates of their costs. The costs vary according to the type of monitoring model implemented, and the different characteristics of each jurisdiction (for example, greater distances to travel in NSW, Queensland, WA and the NT). **The total costs of administration and enforcement by all State and Territory governments Australia-wide were estimated by calculating the jurisdictional cost per head for those jurisdictions that provided cost estimates to Access Economics, and then applying these per capita costs to the entire Australian population (around 20.5 million people in 2005).**

Cost centres for governments include awareness raising and training, auditing (surveillance), administration and responding to complaints.

- As with folic acid fortification (Access Economics 2006), the costs of prosecutions have not been included in the analysis. FSANZ advised that prosecutions are rarely mounted on food standards compliance issues (pers. comm., FSANZ, 4 May 2006), with 'encouragement' being the preferred approach.
- While one state noted the importance of health monitoring (or monitoring of the fortification program on population iodine status), responsibility for the costs of monitoring may be the subject of some discussion between States/Territories and the Australian Government. Health monitoring costs are discussed in section 7.4.1.2.

Training and awareness raising

Proposed approaches to training and raising awareness of the fortification policy differed widely. One state indicated that it would distribute a letter to those companies affected by iodine fortification, whereas another jurisdiction suggested it would hold an information session for industry, and develop information manuals and a web page.

Based on indicative estimates from one jurisdiction, introducing iodine and folic acid fortification together would save approximately A$19,000 in training costs (Australia-wide).

Auditing

Cost estimates for an auditing program were provided by one jurisdiction, which indicated that each year, the products from a sample of around 20% of firms in that state would be tested for iodine concentration. Tests were estimated to cost $150. Collecting and analysing the samples would involve around one week of work. Wages per hour across jurisdictions that provided data were in the range A$35 to A$51 (including on-costs).

Unlike the proposed administration of folic acid fortification, no jurisdiction indicated that it would incur *additional* costs in checking labels.

Administration

One state suggested nil additional administration costs, whereas another state indicated that establishing administration systems for iodine fortification would involve around four weeks work, but that ongoing costs each year thereafter would be minimal.

Complaints

One jurisdiction estimated that each complaint would involve around four hours work, however, was uncertain about how many complaints would arise. Another jurisdiction estimated that dealing with complaints would involve around one week's work each year (at the hourly wage noted above).

An approximate range for total costs is presented in Table 7:3. Given the costs are based on data from only two jurisdictions and each suggested it would take a different approach, the estimates in Table 7:3 should be interpreted as an **indicative range**.

- The higher of the two estimates for upfront costs has been adopted for the net benefit calculations (A$138,182) on the basis that in a cost benefit analysis it is better to err on the side of overestimating rather than underestimating compliance costs.
- The average of the two estimates of ongoing costs in Table 7:3 (A$156,045 per year), has been used to calculate the overall net benefits of the fortification proposal. This figure is very similar to the ongoing costs of administering and enforcing the folic acid fortification proposal (Access Economics 2006).

The costs provided by the Tasmanian government above (see section 4) for its iodine fortification program are significantly higher than the estimates in Table 7:3, which the Tasmanian Government has indicated in the past may reflect the *voluntary* nature of the Tasmanian program.

TABLE 7:3 COSTS OF GOVERNMENT ADMINISTRATION OF REGULATION, AUSTRALIA (A$)

	Lower estimate	Upper estimate
Upfront	1,835	138,182
Ongoing per year	96,490	215,600

Source: based on estimates from two Australian state governments.

7.3.2 NEW ZEALAND

Administration and enforcement of mandatory fortification in New Zealand would be undertaken by the New Zealand Food Safety Authority (NZFSA). The NZFSA estimates of the associated costs are outlined in Table 7:4. The major cost centres include:

- The upfront costs of training and awareness raising, including 30 hours work at $NZ120 an hour and with around $NZ1200 in materials;
- Auditing, likely to be contracted out at $80,000 per year with $NZ600 upfront in setting up the contract;
- The cost of administration based on 20 hours in the first year and 11 hours per year thereafter;
- Dealing with complaints, based on 19 hours a year; and

- In the event that there are repeated infringements, the NZFSA might prosecute, but the chance of this happening is very small. One prosecution would cost $80,000.

If iodine and folic acid fortification were implemented together, the NZFSA indicated there would be economies of scale in auditing which would save $NZ400 in upfront costs and $NZ10,000 per year thereafter.

TABLE 7:4: COSTS OF GOVERNMENT ADMINISTRATION OF REGULATION, NEW ZEALAND (NZ$)

	Upfront	Ongoing cost per year
Training and Awareness raising	4,800	1,200
Auditing	600	80,000
Administration	2,400	1,320
Complaints		2,280
Cost of one prosecution (not likely so excluded)		80,000
Total	**7,800**	**84,800**

Source: NZFSA

7.4 OTHER COSTS OF FORTIFICATION

7.4.1.1 COSTS OF ADVERSE HEALTH EFFECTS

The health benefit-risk assessment commissioned by FSANZ concluded that there may be small health risks to identified vulnerable groups, but that any adverse effects would be extremely rare. **While potential adverse health effects should not be ignored, not least because of the potential impact on quality of life of those possibly affected, assessment of their costs is outside the designated scope of this particular project. Even so, there is a lack of data available to quantify the possible adverse effects. For these reasons, the associated costs are not included in the calculations here.**

Hypothyroidism

The FSANZ health benefit-risk assessment of the impact of the proposal for iodine fortification concluded that people with pre-existing thyroiditis may experience short term hypothyroidism (2 to 3 weeks) as a result of fortification and some may need therapy.

Iodine induced hyperthyroidism

An increased incidence of iodine induced hyperthyroidism (IIH) is reported to be the most common adverse effect encountered following the introduction of iodine fortification. It affects principally the elderly who are the population group most likely to have developed multinodular goitres as a result of long-standing ID. Small increases in incidence have also been documented in people under 40 years old due largely to Graves' disease.

Access economics was not able to source Australian studies of the prevalence or incidence of Graves disease or autonomous multinodular goitre, precluding estimation of the possible costs to society of the adverse health effects of fortification due to IIH.

The National Health Survey (Table 7:5) suggests that around 2.4% of Australians reported a thyroid gland disorder, however, these data do not include those who were undiagnosed and are not disaggregated by type of disorder. Stevens (2000) applied the results from what he claimed was the most reliable survey of thyroid disorders available (the Wickham Survey conducted in England over 20 years from 1972) to the Australian population for 1999 and found that around 7.5% of women and 1.5% of men could have spontaneous (i.e. not caused by treatment) hypothyroidism and hyperthyroidism.

TABLE 7:5 AUSTRALIANS WITH SELF REPORTED DISORDERS OF THE THYROID GLAND, 2004-05(a)

0-14	15-24	25-34	35-44	45-54	55-64	65-74	75 or over	Males	Females	Persons
Number people with Disorders of the thyroid gland ('000)										
**2.7	*9.4	32.3	76.2	93.4	105.8	76.0	72.8	61.6	406.9	468.5
Total population ('000)										
3920.6	2693.0	2813.6	2959.2	2734.8	2120.2	1353.7	1086.4	9788.4	9893.1	19681.5
Per cent of population (%)										
**	0.35	1.1	2.6	3.4	5.0	5.6	6.7	0.6	4.1	2.4

* estimate has a relative standard error of 25% to 50% and should be used with caution ** estimate has a relative standard error greater than 50% and is considered too unreliable for general use (a) Conditions which have lasted or are expected to last for 6 months or more.

Source: ABS, 2004–05, National Health Survey Summary of results, cat. no. 4364.0.

According to FSANZ, the best indicator of what might happen after fortification is the Swiss experience. After 18 years of mild deficiency, the mean iodine supply was increased from 90ug/day to 150ug/day. The impact of this was to change the population's iodine status to replete. A 27% rise in IIH was observed in the first year after the increase in iodine intake. Nearly 10 years later, the prevalence of iodine induced hyperthyroidism had fallen to 44% that of the decade before (FSANZ health risk assessment).

- A study of increased iodine intake due to supplementation policies in the 1960s in Tasmania suggested an even higher rise in the rate of IIH (cited in Hetzel 2004, p. 183) but it is not clear whether this is comparable with the current scenario.
- In his submission to FSANZ, Professor Cresswell Eastman noted:

  Most recent example of IIH occurred in Zimbabwe where iodine fortification of salt results in a rising incidence of hyperthyroidism from 2.8 per 100,000 in 1991 to 7.4 per 100,000 in 1995. It should be noted that iodine fortification was very variable in Zimbabwe at this time with many salt samples showing iodine content of over 100ppm[17]. Given this data, at worst we could expect an additional 4.5 cases of hyperthyroidism per 100,000 population per year.

While these estimates of the potential increase in IIH due to fortification provide the basis for analysis of the potential associated costs, it is difficult to find data indicating the extent to which IIH might occur in Australia or New Zealand as a result of the current fortification proposal.

Overall, in FSANZ's assessment, iodine deficiency in Australia and New Zealand has emerged only in the last 10 to 15 years, so the prevalence of autonomous multinodular goitre is expected to be small, and IIH due to fortification is likely to be rare. Those with Graves'

[17] Parts per million.

disease are likely to be under the care of a medical professional who will be able to respond appropriately.

7.4.1.2 COSTS OF COMPLEMENTARY POLICIES

The programs discussed below are necessary complements to iodine fortification and should be introduced in concert with the FSANZ proposal — even though they are not necessarily within the purview of FSANZ. The scope of this project did not include costing of the last two.

Monitoring of population nutrition and iodine status

Monitoring and policy evaluation represent best practice policy making, and in any case, COAG Guidelines for Standard Setting Bodies specify that regulations should be reviewed at intervals of less than 10 years (COAG June 2004). Monitoring of iodine fortification is particularly important because:

- There is a reduced margin of safety associated with the impact of fortification on the intakes for young children.
- There is potential for adverse effects from fortification on those susceptible eg. those with thyroid problems due to Graves' disease or multinodular goitre.
- There is uncertainty surrounding the intake of discretionary salt, and those on iodine supplements were not able to be included in the FSANZ projections of iodine intake.
- The FSANZ projections are based on nutritional/dietary intakes data from 1995 in Australia and 1997 in New Zealand (the most recent data available).
- In Australia, there was geographic diversity in iodine status which could not be taken into account in the projections of intake by FSANZ.

FSANZ (2004) stated:

> *Iodine intake can also produce adverse health effects at high levels and particular care is required where populations have had low intakes of iodine over time. Iodine induced hyperthyroidism is considered a possible side effect of iodine supplementation and has been reported in almost all supplementation programs. Any program to increase the iodine status of a population has to be implemented in a controlled manner and monitored carefully. (p. 7)*

Health monitoring could include both nutritional/dietary intake data, as well as urinary iodine concentration.

- The cost of nutritional surveys would not be attributable in full to iodine fortification as costs would be spread across all policy issues that would benefit from such survey information (for example, folic acid fortification, or other health policy issues such as obesity). FSANZ estimates (based on a nutritional survey that reported intakes of 36 nutrients and costing A$3.6 million for the whole survey including the development of a food composition survey database) suggest that the cost attributable to monitoring iodine intake would be approximately A$100,000 (and the same cost in New Zealand — about NZ$107,000) (pers. comm. FSANZ, 6 July 2006). An Australian children's nutrition survey and a New Zealand adult nutrition survey are both due in 2007. The analysis here therefore allocates outlays on nutritional surveys in 2007, and again 10 years later (in 2017).
- Monitoring of MUIC would need to occur two to three years after implementation of the policy (for the purposes of the analysis here, this is assumed to be 2010, and a follow

up survey is modelled in 2015). The cost of monitoring urinary iodine status has been based on the NINS. The NINS surveyed 1709 school students aged 8 to 10 years between July 2003 and December 2004, and monitored MUIC and thyroid volume in 5 states in Australia. The cost of the NINS was (ball park) $320,000 (pers. comm., Professor Mu Li, 14 June 2006). As noted earlier, the costs of monitoring in Tasmania are around A$100,000 per year — although this incorporates more activities than the NINS.

- In Australia, the cost estimates for monitoring have been derived on a per state basis to factor in travelling costs. The NINS cost around A$64,000 per State. A cost estimate for monitoring the iodine status of the Australian population as a whole based on the NINS approach might be A$320,000, plus 3 x $64,000 (to incorporate the NT (with high travelling costs), Tasmania (with moderate travelling costs) and the ACT (with low travelling costs). In total this is (ball park) A$512,000.
- In New Zealand, using the Australian NINS cost per child ($320,000/1709) as the basis for calculating a ball park monitoring cost, the cost would be the product of NZ$200 per child, and the number of children surveyed. (The last is based on the same proportion of the Australian population aged 8 to 10 years surveyed in the NINS which was 1709/775,493). The total cost for New Zealand is therefore around NZ$79,000.

A further cost of A$10,000 (NZ$10,700) has been allocated to the years in which the surveys are undertaken to cover administration costs within health departments.

Raising awareness amongst health professionals

Information needs to be provided to medical practitioners caring for, or likely to be approached by those potentially adversely affected by iodine fortification to ensure vigilance for adverse effects — for example, health professionals caring for patients with Graves' disease or caring for toddlers who may be affected by iodine intakes above the tolerable upper limit. This is outside the purview of FSANZ.

Supplementation of pregnant women and those considering pregnancy

Once again, while this is outside the purview of FSANZ, it is necessary given that fortification as proposed cannot deliver sufficient amounts of iodine to all pregnant and lactating women, yet this is the population which could most benefit from increased iodine intake to prevent irreversible brain damage in infants.

7.5 SUMMARY OF COSTS

Financial costs, incorporating the costs to salt manufacturers, cereal processing firms, government, and monitoring costs, but excluding the costs of other complementary policies outlined in section 7.4, are presented in Table 7:6 for Australia and New Zealand.

TABLE 7:6 SUMMARY OF COSTS OF FORTIFICATION (ROUNDED), AND COST PER HEAD

	Australia (A$)	New Zealand (NZ$)
Upfront costs		
Government - administration and enforcement of regulation	138,000	7,800
Salt industry (machines and labelling)	159,000	303,000
Cereal processing industry (labelling)	15,500,000	341,000
Total upfront	15,800,000	651,556
Ongoing costs (per year)		
Government - administration and enforcement of regulation	156,000	84,800
Salt industry (maintenance, iodine, analytical testing, transport and storage)	488,000	18,170
Cereal processing industry (analytical testing and trade related costs)	2,675,000	331,500
Total ongoing (per year)	3,319,000	434,000
Monitoring costs		
Monitoring (nutritional survey) (in 2007 and 2017)	110,000	117,000
Monitoring (MUIC) (in 2010 and 2015)	522,000	89,700
Discount rate	3.3%	3.8%
Net Present Value of costs (over 15 years)	55,600,000	5,882,000
Costs of iodine fortification per person		
Population	20,111,297	4,120,900
Upfront cost per head	A$0.79	NZ$0.16
Ongoing cost per head	A$0.17	NZ$0.11

Monitoring cost per head	A$0.03	NZ$0.05

8. NET BENEFITS

Net benefits are calculated on the basis that iodine fortification is implemented consistently over a 15 year period. This is the minimum period required for iodine fortification to benefit all children aged between 0 and 13 years at time period zero (see Figure 1). It is envisaged that monitoring and review would occur at intervals during this time period (consistent with COAG Guidelines that regulation should be reviewed at intervals of less than 10 years (COAG 2004)).

There is a high degree of uncertainty surrounding the underlying variables contributing to the modelling of net benefits, and the caveats discussed in sections 4, 5, 6 and 7 should be kept in mind. The main caveats are repeated in brief here.

- There is uncertainty associated with the FSANZ projections of iodine intake given significant gaps in the underlying data, including uncertainty surrounding the intake of discretionary salt, no data on consumption of iodine supplements, the nutritional/dietary intakes data on which the modelling is based are around 10 years old, and no ability to disaggregate projections by geographic region (particularly problematic given regional variation in iodine status). There will therefore be a large variation around the national average intakes projected by FSANZ, but very little indication of the extent of this variation, or which demographic groups or which geographic areas might be most affected — if fortification is implemented — by either continued deficiency or consumption above the upper limit.
- There is a paucity of data allowing quantification of the benefits of fortification. Randomised controlled trials of the effectiveness of iodine fortification are scarce and not necessarily comparable either with the situation in Australia and New Zealand, or with iodine fortification of the type proposed by FSANZ. There is evidence of health benefits arising from addressing iodine deficiency across a range of human capabilities — intelligence, hearing, concentration, reproduction, fertility and infant survival (for example). However, for the purpose of a cost benefit analysis, there is a dearth of the type of evidence required to enable the potential benefits to be quantified for Australia and New Zealand.
- While the key benefit of iodine fortification would be to prevent intellectual impairment of children suffering iodine deficiency up to age three years that can be **irreversible**, not all pregnant women will become iodine replete as a result of fortification and many will still need to take supplements. In addition, lack of data precluded estimation of potential improvements resulting from fortification in quality of life, and the health, education or other types of expenditure (for example on carers) avoided. The likely major health benefit from fortification — which is central to the analysis here — is the avoidance of any **reversible** decrease in cognitive function which may affect productivity (measured as loss of some proportion of lifetime earnings). However, an **empirical** relationship between iodine status and improvements in productivity and health has not been established. **It is therefore very difficult to quantify the benefits except within a large range to account for the high degree of uncertainty.** As a specific example, while there is evidence suggesting that some iodine deficiency related cognitive damage is reversible if iodine intakes increase, there is no data available indicating the extent of reversibility or the age ranges of people who might benefit.

  In addition, the implicit and probable economic assumption is that the numbers of people whose IQ increased as a result of fortification would not be of sufficient magnitude to substantially influence the overall clearing of the labour market, thus making a net addition to productive capacity. However, if the proportion of the population was large enough, a wholesale rise in the number of people with a certain IQ may affect the level of earnings at which the market clears — more specifically, in the long term, while average IQ may increase, earnings may not be affected. A full economic analysis examining the long-run situation where the impact of an increase in average IQ would be passed on to society through adjustments in wages and prices is not in scope here. However, considerable sensitivity analysis has been undertaken to account for the partial nature of this study.

- Lastly, some costs are not included in the analysis, namely, the costs of some complementary policies, the cost of restricting consumer choice, and of potential adverse health effects associated with iodine intake.

Indicative net benefit ranges are outlined in Table 8:1. The wide ranges reflect the significant uncertainty underlying the results.

- For Australia, the most likely outcome is that fortification as proposed will lead to net benefits of A$1.8 billion. While there is a chance that the proposal will result in a net cost of (A$162 million), it is more likely that net benefits will be in the range (–A$9.8 million) and A$7.3 billion. The probabilities associated with these results are depicted in Figure 7.
- For New Zealand, the likely outcome is that fortification as proposed will lead to net benefits of NZ$265 million. While there is a chance that the proposal will results in a net cost of (NZ$7.9 million), it is more likely that net benefits will be in the range NZ$910,000 to NZ$1.0 billion. The probabilities associated with these results are depicted in Figure 8.

TABLE 8:1 NET BENEFITS OF IODINE FORTIFICATION

	Australia (A$)	New Zealand (NZ$)
Minimum	-161,840,400	-7,885,350
Mean	1,759,772,000	265,180,900
Maximum	124,026,500,000	10,706,680,000
Standard Deviation	3,991,378,000	559,302,000
5th percentile	-9,835,839	909,763
10th percentile	27,649,490	6,078,189
50th percentile	571,817,400	89,968,930
85th percentile	2,986,907,000	471,879,400
90th percentile	4,168,812,000	664,897,800
95th percentile	7,329,940,000	1,044,035,000

Figure 7 Distribution of net benefits, Australia

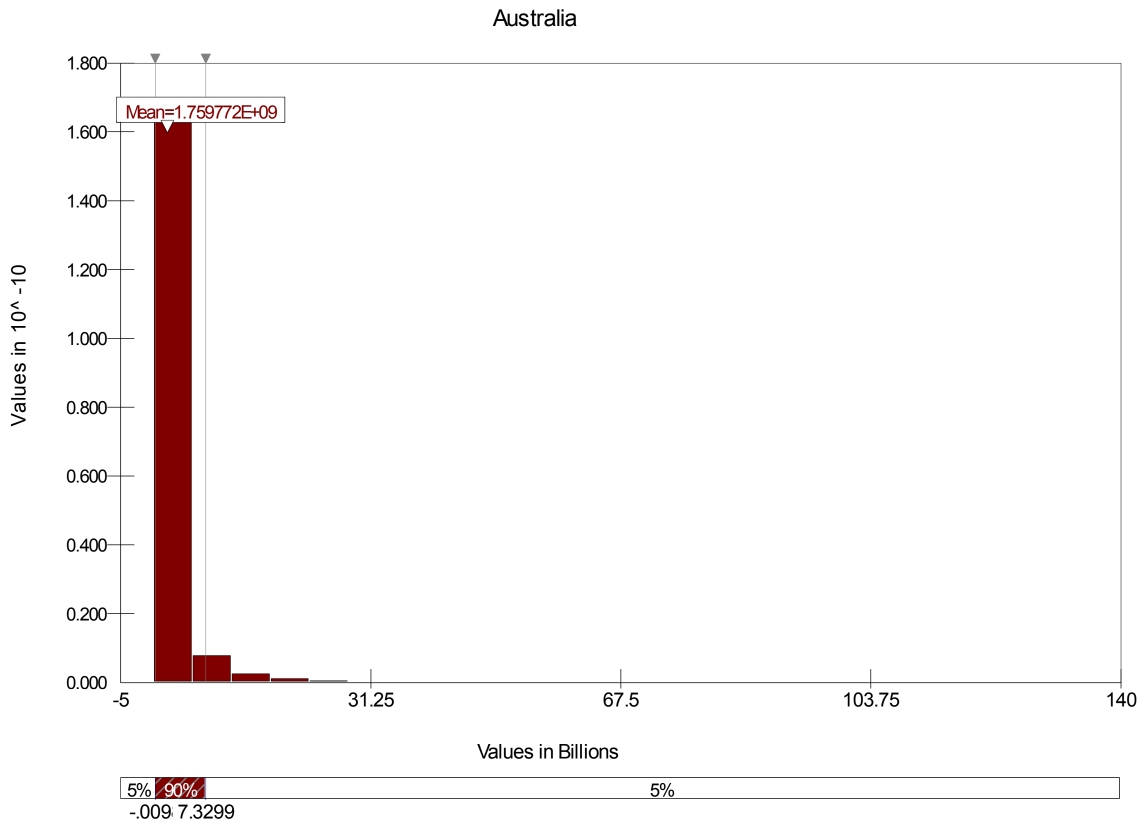
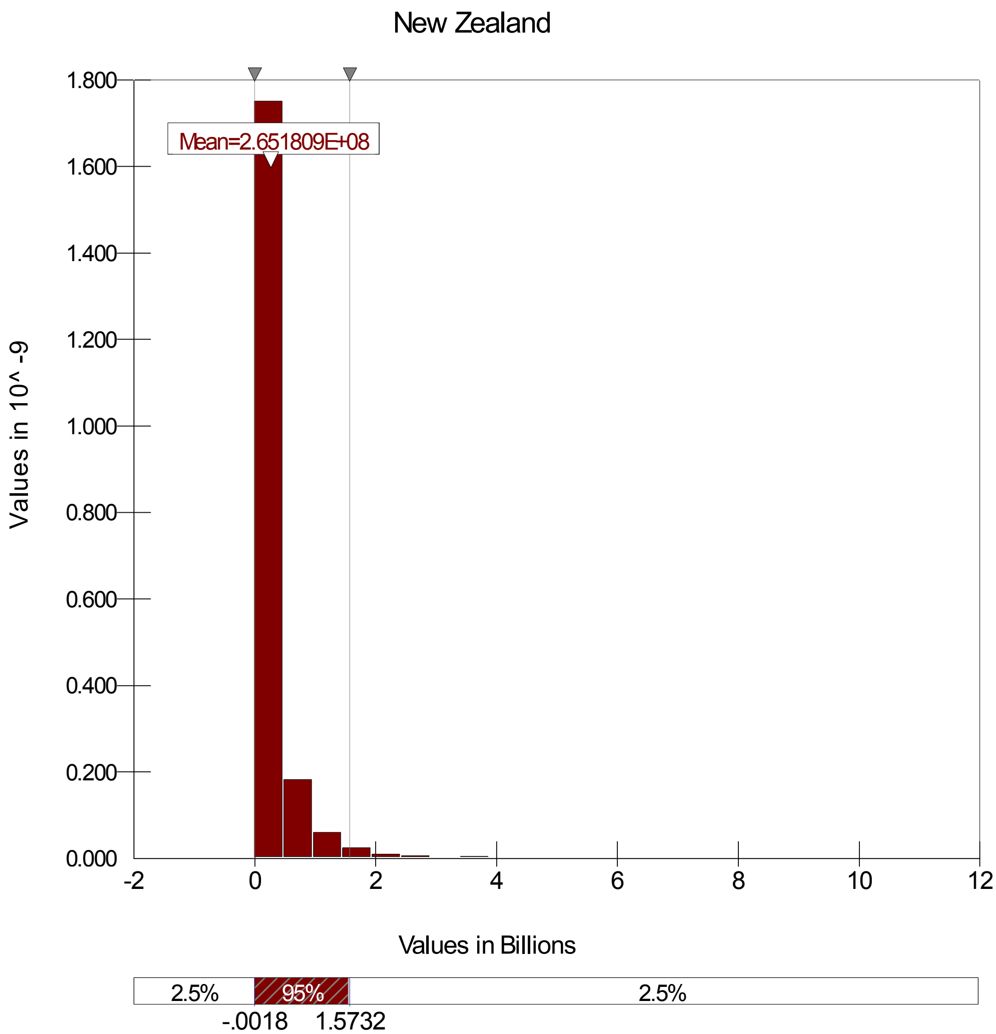


FIGURE 8 DISTRIBUTION OF NET BENEFITS, NEW ZEALAND



9. CONCLUSION

In conclusion, there is a large degree of uncertainty surrounding the calculation of net benefits for the FSANZ proposal. This high degree of uncertainty in the results reflects the lack of research of a nature which facilitates quantification of the links between iodine status, cognitive impairment and productivity.

It should be noted that

- the benefits as estimated do not include all potential benefits of the proposal. Lack of data precluded the estimation of other potential benefits of fortification — such as the potentially positive impact on improvement in quality of life for those with IDDs, and the benefits of reducing harm from lack of iodine on hearing ability, concentration, reproduction, fertility and infant survival.
- There are also some elements of costs that were not able to be covered by the analysis, including the costs of complementary policies such as supplementation of most pregnant and lactating women, and the costs associated with possible adverse health outcomes for those susceptible to IIH, or hypothyroidism.
- The basis for the modelling is that population iodine status will remain the same in future. However, iodine concentrations have not been tracked over time so from the information available, it is not possible to know whether iodine status is trending down over time, or whether current levels reflect a new steady state. Iodine status may conceivably fall in future or it may not. If iodine status continued to fall, the benefits of a fortification program would increase.

The current proposal does not capture all the benefits that may arise from assisting those who are currently iodine deficient to repletion, and it may therefore be worth exploring an alternative proposal that embraces all of the potential benefits. Further, another vehicle may be available which better targets those in need, including targeting those in geographic regions in Australia where iodine deficiency was identified.

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