School of Public Health

Assessment of iodine knowledge, beliefs and practices of pregnant women attending Western Australia's only tertiary women's and neonatal hospital

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DECLARATION

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Human Ethics: The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number #HR125/2012 and from the Western Australian Health Human Research Ethics Committee, Approval Number #2048/EW.

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Date: 11/3/16

ABSTRACT

Adequate iodine intake during pregnancy is vital for the developing foetus. Most of the Australian research over the last two decades suggests suboptimal iodine status in pregnant women, however, iodine-related behaviours and nutritional indices of iodine status of Western Australian pregnant women have not been assessed.

This study explored iodine intake, knowledge, beliefs, iodine supplement and iodised salt use in 425 pregnant women attending WA's only tertiary women's and neonatal hospital in 2012-13. In addition, the reliability of an existing food frequency questionnaire was assessed and a potential rapid iodine screening tool for use in this population was developed.

Participants completed a self-administered questionnaire (including a 41-item food frequency questionnaire). Median iodine intakes calculated using self-reported dietary iodine and total iodine data both met the EAR (160 ug/day). Median iodine intake from food alone (148 ug/day) approached the EAR. Approximately 66% of subjects used iodine-containing supplements during pregnancy and approximately 45% of subjects who could recall the type of salt they used were consuming iodised salt. Significant factors associated with iodine-containing supplement use during pregnancy were gestational stage and gravidity, with education level and ethnic group combination identified as significant factors associated with iodised salt use. Knowledge regarding food sources of iodine and health problems associated with inadequate iodine intake was low.

Findings indicate that the NHMRC recommendation for all pregnant women to take an iodine-containing supplement during pregnancy may not apply to all pregnant women in this state. Further research is needed to assess urinary indicators of iodine status of WA pregnant women and to validate the rapid screening tool. The latter will assist with identifying those pregnant women at risk of inadequate iodine intakes.

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LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
ACCIDD	Australian Centre for Control of Iodine Deficiency Disorders
ACT	Australian Capital Territory
ALSWH	Australian Longitudinal Study on Women's Health
ATA	American Thyroid Association
CAMI	Childbirth and mental illness
CH	congenital hypothyroidism
DIT	diiodotyrosine
EAR	estimated average requirement
EWC	East Wing Clinic
FFQ	food frequency questionnaire
FSANZ	Food Standards Australia New Zealand
FT3	free triiodothyronine
FT4	free thyroxine
FT4I	free thyroxine index
GFR	glomerular filtration rate
GP	general practitioner
hCG	human chorionic gonadotropin
I-	iodide
ICC	intraclass correlation coefficient
ICCIDD	International Council for Control of Iodine Deficiency Disorders
IDD	iodine deficiency disorders
IO3-	iodate
IQR	interquartile range
KEMH	King Edward Memorial Hospital
LC/MS/MS	liquid chromatography-tandem mass spectrometry
MIT	monoiodotyrosine
MITCH	maternal iodine supplementation and effects on thyroid function
MUIC	median urinary iodine concentration
Na+ - K+	sodium-potassium
NAPLAN	National Assessment Program-Literacy and Numeracy
NESB	non-English speaking backgrounds
NHMRC	National Health and Medical Research Council
NHMS	National Health Measures Survey
NINS	National Iodine Nutrition study
NIS	sodium-iodine symporter
NNS	National Nutrition Survey
NSW	New South Wales
NT	Northern Territory
NZ	New Zealand
NZ MoH	New Zealand Ministry of Health
NZTDS	New Zealand Total Diet Survey
PHC	primary health care
PHCATA	Public Health Committee of the American Thyroid Association
PIPS	Perth Iodine and Pregnancy Study

Qld	Queensland
RDI	recommended dietary intake
RHH	Royal Hobart Hospital
SA	South Australia
SAC	school-aged children
SARIS	Student Assessment and Reporting Information System
SD	standard deviation
SPSS	Statistical package for the social sciences
T3	3,5,3'-triiodothyronine
T4	3,5,3',5'-tetraiodothyronine (thyroxine)
Tas	Tasmania
TBG	thyroxine-binding globulin
Tg	thyroglobulin
TGR	total goitre rate
TH	Tammy Hine
TPO	thyroid peroxidase
TSH	thyroid stimulating hormone
TSI	Torres Strait Islander
TT4	total serum T4
TV	thyroid volume
UIC	urinary iodine concentration
UIE	urinary iodine excretion
UNICEF	United Nations International Children's Emergency Fund
USI	universal salt iodisation
Vic	Victoria
WA	Western Australia
WHO	World Health Organization

CHAPTER 1 : INTRODUCTION

1.1 Statement of the problem

It has been well-documented that severe deficiency of the essential trace element, iodine, results in maternal and foetal hypothyroidism. This, in turn, has been associated with a range of poor health outcomes such as stillbirth, miscarriage, birth defects and mental retardation of varying severity (World Health Organization United Nations Children's Emergency Fund and International Council for the Control of Iodine Deficiency Disorders 2007, (WHO/UNICEF/ICCIDD)). The most devastating, yet preventable, consequence of severe iodine deficiency is cretinism (Delange 2007; Hetzel 1983; Morreale de Escobar, Obregón, and del Rey 2007). Evidence of the effect that mild-to-moderate iodine deficiency during pregnancy has on foetal (and child) outcomes is less clear. Furthermore, evidence from quality randomised controlled trials is limited (Zhou et al. 2013) at this point in time.

The 2003-4 National Iodine Nutrition Survey (NINS) involving the mainland states of Australia classified the general Australian population as mildly iodine deficient based on a population weighted median urinary iodine concentration of school-aged children (Li et al. 2008). Although pregnant women were not represented in these studies, all research conducted on iodine status of pregnant women in Australia and New Zealand (NZ) from 1999-2010 reported iodine deficiency in study populations.

In October 2009, iodine fortification of all non-organic bread and bread products available in Australia was mandated. It was acknowledged that this strategy was not likely to meet the needs of pregnant women and breastfeeding women and after further review with an expert group, the National Health and Medical Research Council (NHMRC) released in 2010 a national blanket recommendation that all women who are considering pregnancy, pregnant or breastfeeding take a daily iodine supplement of 150 ug (Mackerras and Eastman 2012).

Seven to eight years later the results of the 2011-12 National Health Measures Survey (NHMS) reported improvements in general adult iodine status with median urinary iodine concentration (MUIC) indicating iodine sufficiency (Australian Bureau of Statistics 2013a). This improvement is likely to reflect the 2009 introduction of mandatory fortification of all bread and bread products (non-organic) with iodised salt and potentially the NHMRC iodine recommendation mentioned above.

Western Australia (WA) is in a unique position as reflected in the highest MUIC of the populations sampled in the NINS and NHMS with results indicating iodine sufficiency in 2003-4 and 2011-12. The reason for this difference in iodine status is multifactorial; not only is WA the largest state in Australia with a vast coastline and nutrient-rich soils (Australian Bureau of Statistics 2013b), it is also the most culturally diverse state with nearly one-third of the population born overseas, a higher proportion than any other Australian state or territory (Government of Western Australia 2013). The former reason is likely to impact on the native iodine content of local produce and water supplies. The latter is likely to influence dietary intake patterns, health beliefs and health behaviours in general (Chaturvedi 2001) and possibly influence the use of iodine-containing supplements, iodised salt and knowledge on the topic.

The review of literature regarding iodine intakes, knowledge and practices has been restricted to Australian and New Zealand studies due to the NHMRC recommendation referring to this population only. Up until now, there has been no investigation into iodine intakes, knowledge and practices of pregnant women in this state. Furthermore the urinary iodine concentrations (UIC) of pregnant women from WA were not included in projections used to estimate the national iodine supplementation recommendation (as no previous studies have measured UIC of WA pregnant women).

1.2 Benefits of the study

This research will be the first to investigate iodine knowledge, beliefs and practices (dietary intake, iodised salt use and iodine-containing supplement use) in WA pregnant women. The overall opinion was that mandatory fortification of bread and bread products alone was not enough to ensure adequate iodine intake in pregnant women (Australian Bureau of Statistics 2013b; Mackerras et al. 2011), hence the recommendation in 2010 for iodine supplementation during pregnancy.

Whether this applies to pregnant women in WA requires review. Results from this study will begin to address this gap in the literature. In addition to this, pregnancy is a time when women are bombarded with nutrition and health related messages and it is important to know whether this message is necessary. This study will also provide the opportunity to assess the possibility of pregnant women exceeding the upper level of intake (UL) for iodine.

1.3 Study aims and objectives

1.3.1 Primary aim and objectives

To explore the knowledge, beliefs and practices related to iodine nutrition in a sample of WA pregnant women.

- Estimate dietary intake of iodine in pregnant women in WA.
- Determine consumption of dietary sources of iodine, including iodised salt.
- Quantify the use of iodine supplementation before and during pregnancy.
- Assess knowledge of food sources of iodine and the need for iodine during pregnancy, as well as beliefs of pregnant women regarding iodine requirements.
- Identify sources of information regarding iodine that pregnant women have used.

1.3.2 Secondary aim and objectives

To develop a rapid iodine screening tool for use in WA pregnant women.

- Assess the reliability of an existing tool used to rank dietary iodine intake in WA pregnant women.
- Identify the key components from the existing tool to be included in a rapid iodine screening tool to determine the women whose individual usual intakes are not likely to meet the EAR for iodine.

CHAPTER 2 : LITERATURE REVIEW

The first section of this chapter provides an overview of iodine including iodine deficiency disorders, assessment of iodine status, adult nutrient reference values and iodine homeostasis during pregnancy, as well as a summary of key results from large scale nutrition and health surveys conducted in Australia and New Zealand. The second part of this chapter focuses on pregnancy-related iodine nutrition findings (including iodine-containing supplement use and iodised salt use) from studies conducted in Australia and New Zealand between 1 January 1980 to 24 October 2015 (date of literature search cessation). The following electronic databases were searched for relevant articles: PubMed, Science Direct, Informit, Medline and Google scholar using the key terms "iodine" or "iodine deficiency" and "pregnancy" or "pregnant women" and "Australia" or "New Zealand". Articles that were from veterinarian journals, related to thyroid cancer or referred to iodine use as an antiseptic were excluded.

2.1 Introduction

Iodine is an essential trace element necessary for the regulation of thyroid gland function and for the production of thyroid hormones triiodothyronine (3,5,3'-triiodothyronine or T3) and thyroxine (3,5,3',5'-tetraiodothyronine or T4). Consequently, a large proportion (70-80%) of the body's iodine is found in the thyroid gland under euthyroid (normal thyroid gland) conditions (Food Standards Australia New Zealand 2005; Gibson 2005).

The thyroid hormones are required for the regulation of the metabolism of the macronutrients carbohydrate, fat and protein, as well as vitamin and mineral metabolism (World Health Organization and Food and Agriculture Organisation of the United Nations 2001). These hormones are essential for early development of the central nervous system and most organs, in particular, the brain of the developing foetus during gestation (Hetzel 2012; National Health and Medical Research Council and New Zealand Ministry of Health 2006b), infancy and childhood (WHO/UNICEF/ICCIDD 2007).

The link between iodine and thyroid function began in the early 20th century when associations between goitre (an enlarged thyroid gland) and iodine deficiency were made. More importantly, it was discovered that iodine prophylaxis prevented goitre and by the 1920s salt iodisation began in Switzerland and the United States to address this issue. Before this discovery goitre was considered to be a cosmetic problem only (Zimmermann 2009). The relationship between iodine, thyroid hormones and brain development became apparent in the 1970s when Pharoah and Connolly (1987) confirmed that iodine supplementation played a role in the prevention of cretinism (Lazarus 2005), defined as; a condition that results in severe mental retardation and varying degrees of deaf-mutism, stunted linear growth and spasticity) (WHO/UNICEF/ICCIDD 2007). This became a key trial, providing strong evidence that the consequences of iodine deficiency were more widespread than goitre alone (Hetzel and Dunn 1989).

2.1.1 Iodine Deficiency Disorders (IDD)

In 1983, Hetzel suggested the use of the term "iodine deficiency disorders" (IDD) to encompass the spectrum of consequences (Figure 2.1) resulting from iodine deficiency that are preventable with adequate iodine intake (Hetzel 1983; WHO/UNICEF/ICCIDD 2007). One of the most serious consequences of iodine deficiency is cretinism (Section 2.1). This draws attention to the importance of ensuring adequate iodine intake during pregnancy and early childhood when the brain is most vulnerable to the effects of iodine deficiency. It is, however, worth noting that IDD can have negative effects in all life stages (Hetzel 1983; WHO/UNICEF/ICCIDD 2007).

Iodine deficiency (and the associated range of preventable disorders) continues to pose a major public health problem. Andersson, Karumbunathan, and Zimmermann (2012) estimated that in 2011, 1.88 billion people worldwide, including 240.9 million school-aged children had inadequate iodine intakes. It is important to note, however, that more recent data reveal that the number of countries with adequate iodine intakes has almost doubled in the last decade (from 67 to 111), with Australia being one of these countries (Australian Bureau of Statistics 2013a; Pearce, Andersson, and Zimmermann 2013).

This reflects global improvement in iodine status due to the successful implementation of universal salt iodisation (USI) in some countries around the globe, and, in the case of Australia, due to the 2009 introduction of mandatory fortification of non-organic bread and bread products with iodine.

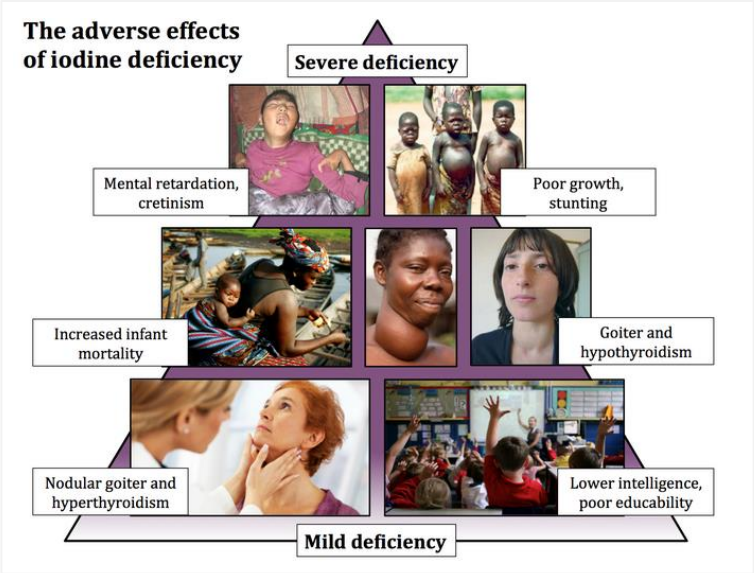

Figure 2.1 Iodine deficiency disorders
(Iodine Global Network n.d.) (formerly known as ICCIDD)

2.1.2 Iodine deficiency in Australia and New Zealand

From an historical viewpoint, recognition of iodine deficiency in Australia and New Zealand, as evidenced by endemic goitre, dates back to the early 1900s (Australian Population Health Development Principal Committee 2007). Populations in Tasmania (Tas), New South Wales (NSW), Victoria (Vic), Queensland (Qld), Australian Capital Territory (ACT), South Australia (SA) and NZ were subject to varying degrees of iodine deficiency with intervention strategies employed in different areas of Australia such as; the introduction of iodised household salt in the 1920s, iodine tablets in 1947 in the ACT and Tas and an initial trial of fortification of bread improvers with iodised salt between 1953 and the 1980s in both the ACT and Tas (Australian Population Health Development Principal Committee 2007; Food Standards Australia New Zealand 2008c).

In New Zealand, iodisation of table and cooking salt began in the 1920s with limited success on goitre rates, hence an increase in the concentration of iodine in table and cooking salt was initiated in the late 1930s (Australian Population Health Development Principal Committee 2007; Food Standards Australia New Zealand 2008c). The overall impact of these strategies in Australia and New Zealand has varied, some having limited success on improving iodine status, others being associated with high rates of iodine induced hyperthyroidism leading to their cessation (Connolly, Vidor, and Stewart 1970; Food Standards Australia New Zealand 2007).

It is believed that up until the 1990s, the trace contamination of milk (and dairy products) with iodine (from iodine-containing sterilising agents) inadvertently protected vast parts of the Australian and the New Zealand population from iodine deficiency (Li et al. 2006; Zimmermann 2010). The replacement and, or reduction of iodine containing sterilising agents in the dairy industry saw a reduction in the iodine concentration of milk and dairy products which has been linked to the recurrence of iodine deficiency in Australia and NZ reported from the late 1990s (Li et al. 2001). The trend towards a decreased consumption of discretionary salt for health related reasons and the increased consumption of food prepared outside of the home (iodised salt use in commercial food production was not common at the time) (Li et al. 2001), together with the abandonment of previous iodine intervention strategies have also been proposed as contributing factors (Australian Population Health Development Principal Committee 2007).

Further to this, all studies conducted on pregnant women in Australia between 1998 and 2009 (prior to the mandatory fortification of non-organic bread and bread products with iodised salt) reflected borderline iodine deficiency or mild iodine deficiency in NSW (Blumenthal, Byth, and Eastman 2012; Charlton et al. 2010; Gunton et al. 1999; Li et al. 2001; McElduff et al. 2002; Travers et al. 2006), Vic (Hamrosi, Wallace, and Riley 2005; Rahman et al. 2011), ACT (Nguyen et al. 2010), NT (Mackerras, Singh, and Eastman 2011) and Tas (Burgess et al. 2007; Stilwell et al. 2008).

The results of the 2011–12 NHMS (post-fortification of bread and bread products) show improvements in the overall Australian population iodine status, reflecting a shift from mild iodine deficiency in 2004 (based on urinary excretion in school-aged children (SAC) (Section 2.4) to iodine sufficiency in 2011-12 (in both SAC and adults) (Australian Bureau of Statistics 2013a). However, approximately 60% of women of childbearing age (16-44 years) (Australian Bureau of Statistics 2013a) remain at risk of iodine deficiency according to WHO/UNICEF/ICCIDD (2007) criteria for pregnant women.

2.1.3 Ecology and food sources of iodine

Iodine is found in varying concentrations in oceans, the atmosphere and soil, mainly as salts of the iodide ion (I-). Methyl iodide in the ocean is transformed (as is molecular iodine) to gaseous inorganic and particulate forms of iodine. These forms return to soil via precipitation or enter groundwater and surface water directly or via leaching (Agency for Toxic Substances and Disease Registry 2004; Zimmermann, Jooste, and Pandav 2008).

Interruptions to this cycle over time can result in iodine-deficient soils, groundwater, and crops. This progression through the food chain results in iodine-deficient animals and humans who consume or rely upon the local produce (Australian Population Health Development Principal Committee 2007; Zimmermann, Jooste, and Pandav 2008). Iodine deficiency was once thought to be a problem mostly affecting those living in developing countries and, or, certain geographical areas such as: mountainous regions, inland areas and areas that are prone to frequent flooding. (Food Standards Australia New Zealand 2008c; WHO/UNICEF/ICCIDD 2007). It is now known that iodine deficiency can and does occur in coastal areas, in developed countries (in this case, Australia and New Zealand) and in areas once thought to be iodine sufficient (WHO/UNICEF/ICCIDD 2007).

Within the ocean environment, bioaccumulation results in seafood and aquatic plants becoming concentrated sources of iodine (United States Department of the Interior 2007). Other than seafood and aquatic plants, terrestrial plants and animal products can be important sources of iodine depending on the local iodide content of the soil which can vary immensely (from 1 to 250 ug g -1) (Hess 2013) and the frequency of consumption of these products. In recent years, globalisation of the food supply has led to contributions from non-local sources.

Cow's milk (and dairy products) in their native forms are not rich sources of iodine, however, there has been a general consensus that up until the last twenty years, the trace contamination of milk (and dairy products) with iodine (from iodine containing sterilising agents) has protected parts of the Australian and NZ populations from iodine deficiency (Li et al. 2001; Li et al. 2006; Zimmermann 2010). Changes within the dairy industry as described in Section 2.1.3 have been linked to the recurrence of iodine deficiency in Australia and New Zealand (Li et al. 2001).

The introduction of foods fortified with iodine in Australia and NZ (iodised salt in general and non-organic bread and bread products containing iodised salt) are cost-efficient and feasible strategies currently being used to reintroduce iodine into the food chain, with the latter being mandated in October, 2009 in Australia and NZ to improve the population's iodine status (Food Standards Australia New Zealand 2008c; Zimmermann 2009). The Food Standards Australia New Zealand (2009, p.3) mandatory fortification definition of bread is:

> "…the product made by baking a yeast-leavened dough prepared from one or more cereal flours or meals and water and includes yeast-leavened bread made from all cereal flours (i.e. wheat, rye and gluten free bread), bread rolls, buns, English muffins, focaccia and fruit bread." (Food Standards Australia New Zealand 2009).

Yeast-free bread, purpose made breadcrumbs and bread mixes sold for domestic use are not required to meet the mandatory iodine fortification standards (Food Standards Australia New Zealand 2009).

Large scale (or national) nutrition and health surveys over the last 10 years have been important investigative and informative tools regarding iodine intake in Australia. Dietary intake data from the 1995 National Nutrition Survey (NNS) has been used to calculate estimated iodine intakes and to determine the major food contributors of iodine within population subgroups (Food Standards Australia New Zealand 2008a). The NNS has also been used to assist with the estimation of iodine supplementation levels and, in combination with the 2003 cohort of the Australian Longitudinal Study on Women's Health (ALSWH) to project the impact of mandatory iodisation of bread on dietary iodine intake of women (Mackerras et al. 2011; Mackerras and Eastman 2012). Nutrient data and health measures from more recent national surveys e.g. National Children's Survey (Commonwealth of Australia 2008) and the NHMS (Australian Bureau of Statistics 2013a) have provided valuable updated data regarding iodine intake and iodine status of Australians, respectively.

Table 2.1 Approximate iodine content of various foods
(Food Standards Australia New Zealand 2012).

Food	Iodine content (ug/100 g)	Iodine content (ug/serve)	Serve size
Oysters	160	144	6 oysters – 90 g
Sushi (containing seaweed)	92	92	1 sushi roll – 100 g
Bread (except organic bread)	46	28	2 slices bread -60 g
Steamed snapper	40	50	1 fillet – 125 g
Cheddar cheese	23	4	2.5 cm cube – 16 g
Eggs	22	19	2 eggs – 88 g
Ice cream	21	10	2 scoops – 48 g
Regular milk	23	57	1 large glass – 250 ml
Canned tuna	10	10	1 small tin – 95 g
Bread, organic	3	2	2 slices – 60 g
Beef, pork, lamb	<1.5	<1.5	2 loin lamb chops

2.2 Iodine absorption, metabolism and excretion

Iodine is typically ingested as iodate (IO3-) or iodide (I-) from iodine containing foods and supplements. The former is reduced to iodide in the gut and is rapidly absorbed in the duodenum (Hess, 2013). Iodide is actively taken up by several tissues in the body including the thyroid, lactating mammary gland and the placenta (Cavalieri 1997; Hess 2013; Nicola et al. 2009). The salivary glands and gastric mucosa also have the ability to take up iodide from the circulation, and iodide is released into saliva and gastric juice, enters the small intestine and is reabsorbed (Nicola et al. 2009). The physiological role of this enteric phase remains unclear (Hess 2013; Nicola et al. 2009).

Iodide is vital for the regulation of thyroid gland function and for the production of the thyroid hormones triiodothyronine (3,5,3'-triiodothyronine, T3) and thyroxine (3,5,3',5'-tetraiodothyronine, T4) (Figure 2.2) which are responsible for the regulation of basal metabolic rate and the growth, development and functioning of the central nervous system (Hess 2013). Under euthyroid conditions up to 10% of circulating iodide is taken up by the thyroid, however during prolonged iodine deficiency this can increase to 80% (Gibson 2005; Hess 2013). Circulating iodide is also cleared by the kidneys with approximately 90% of iodide eventually excreted by the kidneys (Gibson 2005; Zimmermann 2009).

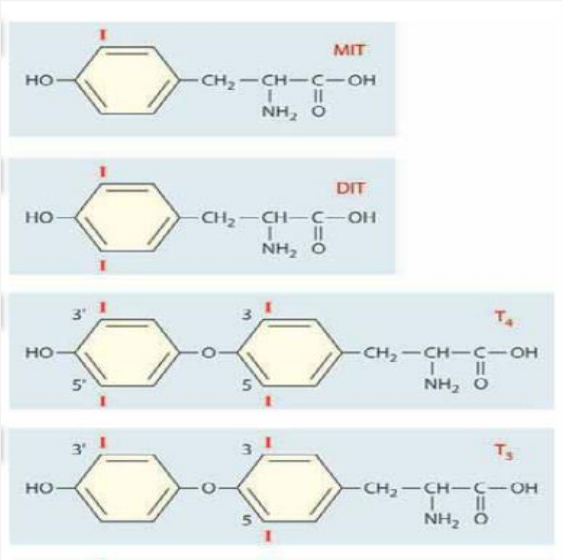

Figure 2.2 Chemical structure of the thyroid hormones
(Michael and Sabyasachi 2010)

The biosynthesis of thyroid hormones is complex and tightly regulated by TSH (thyroid stimulating hormone) secreted by the anterior pituitary (Michael and Sabyasachi 2010; Obregon, Escobar Del Rey, and Morreale de Escobar 2005). Iodide is actively transported into the thyroid cells across the basolateral membrane via the sodium-iodine symporter (NIS) which is driven by the Na+ - K+ ATPase pump (Bizhanova and Kopp 2009; Gibson 2005). It is transported through the cell and across the apical membrane into the colloid of the thyroid follicle via pendrin (Bizhanova and Kopp 2009; Zimmermann, Jooste, and Pandav 2008). The next step involves the rapid oxidation of iodide by thyroperoxidase (TPO) and hydrogen peroxide on the apical surface of the thyroid follicular cell, and is followed by the iodination of tyrosyl residues on thyroglobulin (Tg) (a glycoprotein found within the colloid) to produce the precursors of thyroid hormone–monoiodotyrosine (MIT) and diiodotyrosine (DIT) (Bizhanova and Kopp 2009; Gibson 2005; Zimmermann, Jooste, and Pandav 2008).

Under the influence of TPO, two residues of DIT are coupled within Tg to form thyroxine (T4), or one MIT and one DIT are coupled to form T3 (Gibson 2005; Hess 2013). These are stored within the follicular lumen until they are endocytosed and fused with lysosomes within the thyroid cell. Proteases degrade peptide linkages within Tg releasing T3 and T4 which then enter the circulation whilst iodide stored in MIT and DIT is cleaved and recycled within the thyroid gland (Hess 2013; Michael and Sabyasachi 2010) (Figure 2.3).

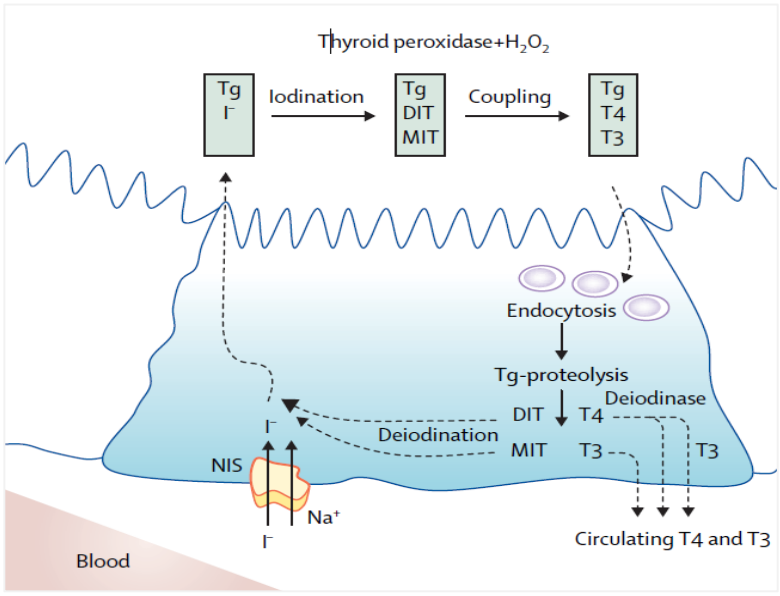

Figure 2.3 Iodine pathway in the thyroid cell
(Zimmermann, Jooste, and Pandav 2008)

Once in the circulation the majority of T3 and T4 attach to thyroxine-binding globulin (TBG), transthyretin and albumin (Hess 2013) and begins the journey to target tissues. T3 is the metabolically active form of these thyroid hormones and the deiodination of T4 to T3 is an important final step occurring in target tissues (Hess 2013; World Health Organization and Food and Agriculture Organisation of the United Nations 2001). T3 binds to its nuclear receptor in target tissue cells where the complex controls gene transcription and protein synthesis (World Health Organization and Food and Agriculture Organisation of the United Nations 2001). Removed iodide then re-enters the plasma iodide pool to return to the thyroid or is excreted by the kidney (more than 90%), with a small amount excreted in the faeces after entering the gastrointestinal tract (Hess 2013; Zimmermann, Jooste, and Pandav 2008).

There is the potential for dietary factors such as goitrogens (substances that block absorption and utilisation of iodine) (Gibson 2005) and deficiencies in other micronutrients such as iron, selenium and vitamin A, to interfere with the normal processes of absorption and metabolism. Vegetables from the Brassica family (including cabbage, kale, cabbage, broccoli, cauliflower), as well as, cassava, maize, sweet potatoes and lima beans contain goitrogenic substances (Hess 2013). Deficiencies in iron, selenium and vitamin A can have effects on a range of enzymes involved in thyroid hormone and TSH synthesis and, or metabolism (Gibson 2005; Hess 2013).

2.2.1 Changes in iodine homeostasis during pregnancy

Pregnancy induces physiological changes which bring about a greater demand for iodine, hence higher iodine requirements during this life stage. A rise in oestrogen concentration in early pregnancy leads to an increase in liver synthesis of TBG, and thus increased serum TBG levels. Higher serum TBG concentration ensures increased total circulating thyroid hormones during pregnancy. Maternal thyroid hormone production increases as a means to maintain adequate free (unbound) T3 (FT3) and T4 (FT4) concentrations, thereby providing the foetus with adequate maternal T4 for neuronal migration and proliferation in the period before the foetal thyroid gland is functional (Glinoer 2007; Williams 2008; Zimmermann 2009).

After this time, the hypothalamic-pituitary axis develops and the foetus begins producing its own thyroid hormone supply from maternal iodide. The foetus, however, remains dependent on maternal thyroid hormones throughout gestation (Morreale de Escobar, Obregón, and del Rey 2007; Williams 2008).

Placental human chorionic gonadotropin (hCG) concentration peaks late in the first trimester. The mild thyrotrophic effect of hCG causes an increase in maternal T4, leading to an initial decrease in serum TSH at this gestational stage (Delange 2001; Morreale de Escobar, Obregón, and del Rey 2007; Pearce, Andersson, and Zimmermann 2013). Again, this is a process thought to provide adequate T4 to the foetus (Morreale de Escobar, Obregón, and del Rey 2007). An increase in maternal TSH occurs at the end of the first trimester and concentrations remain higher during the second and third trimesters than in the first trimester (Delange 2001; Stagnaro-Green et al. 2011). The onset of foetal thyroid hormone production (foetal TSH) commences around the end of the first trimester (Williams 2008), however, the foetus remains reliant on maternal thyroid hormones until birth. During pregnancy there is an increase in glomerular filtration rate (GFR) (due to increased renal blood flow) which leads to increased iodine excretion. Whether urinary iodine excretion increases or decreases with advancing gestation is still a topic of debate, with many studies reporting conflicting results (Fuse et al. 2011; Stilwell et al. 2008). Maternal FT4 and FT3 concentrations progressively decrease in the second trimester onwards as foetal hormone production increases (Figure 2.4) (Morreale de Escobar, Obregón, and del Rey 2007).

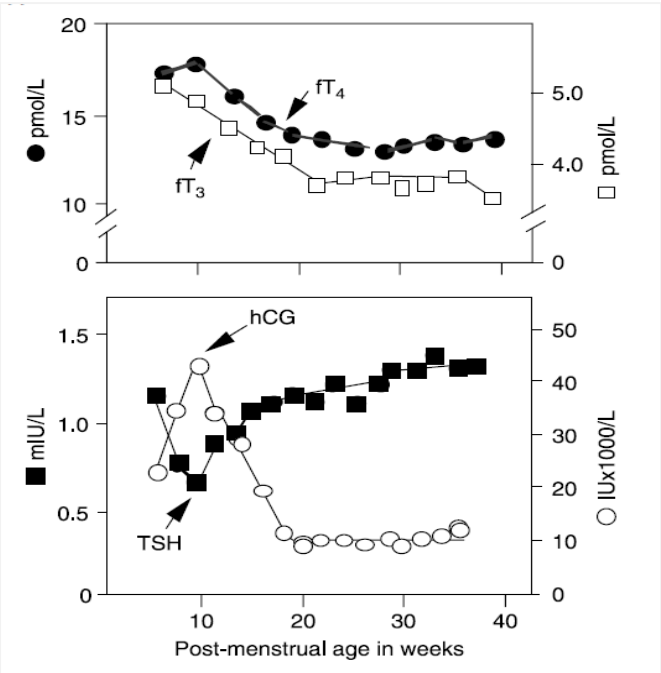

Figure 2.4 Maternal FT4 and FT3 concentrations during pregnancy
(Morreale de Escobar, Obregón, and del Rey 2007)

2.3 Biochemical and clinical assessment of iodine status in the general population

Four of the most commonly used methods to assess iodine status in various populations are as follows; 1) Urinary iodine concentration (ug/L) or 24-h collections (ug/L or ug/24 h), 2) Goitre rate assessed by palpation or ultrasound (%), 3) Serum TSH, 4) Serum Tg (Li and Eastman 2010; WHO/UNICEF/ICCIDD 2007), together with two methods that are not used as frequently 5) Free T4 and 6) Free thyroxine Index (FT4I) (Stagnaro-Green et al. 2011).

2.3.1 Urinary iodine concentration (UIC)

Approximately 90% of iodine absorbed by the body is eventually cleared by the kidneys (Gibson 2005). For this reason, UIC, indicative of recent dietary iodine intake, is a widely used index in population iodine studies (Gibson 2005; Li and Eastman 2010). Samples are either casual, also known as spot urine samples, or based on a 24-hour urine collection. The former method is more frequently used due to ease of collection (WHO/UNICEF/ICCIDD 2007).

Assessing the UIC of SAC (≥6 years of age) is currently the recommended method for determining the iodine status of populations (Eastman 2012; WHO/UNICEF/ICCIDD 2007) due to the traditional use of reference ranges in this age group (WHO/UNICEF/ICCIDD 2007). Whilst UIC is the most commonly used, practical and universally accepted method to determine iodine status it is not without its limitations. Firstly, the reliability of this biomarker as a population indicator of iodine status depends on representative populations or samples and the overall sample size (National Health and Medical Research Council 2009; WHO/UNICEF/ICCIDD 2007). WHO/UNICEF/ICCIDD (2007) guidelines recommend a minimum of 30 urine collections from the sampling group. Using a casual sample to measure individual iodine status, irrespective of life stage, is limited due to diurnal, seasonal and intra-individual variation (König et al. 2011), including hydration status (Brough et al. 2015; Nguyen et al. 2010).

2.3.2 Goitre assessed by palpation or ultrasound (%)

The thyroid gland is located in front of the larynx and upper trachea (Gibson 2005). Enlargement of the thyroid gland, also known as goitre, has historically been used as an indicator of iodine deficiency (WHO/UNICEF/ICCIDD 2007). Goitre formation can be triggered by various conditions. In the case of iodine deficiency, goitre formation in non-pregnant adults occurs due to inadequate iodine intake (usually at levels <50 ug/day, however this is variable) and/or significant levels of goitrogens in the diet and is potentially exacerbated by selenium, iron or vitamin A deficiencies (Gibson 2005; Hess 2013; Zimmermann 2009).

Iodine intakes less than 100 ug per day can cause a reduction in circulating T4 levels (Zimmermann 2009). Figure 2.5 represents the steps leading to goitre formation. In severe iodine deficiency a marked increase in the secretion of TSH from the pituitary occurs. This causes an increase in both iodine turnover (by acting on NIS gene transcription) and glandular uptake of iodide together with proliferation of thyroid cells releasing Tg (a thyroid specific protein). These combined effects result in increased thyroid volume (TV) and (potential) goitre formation (Gibson 2005; Glinoer 2007; Zimmermann 2009).

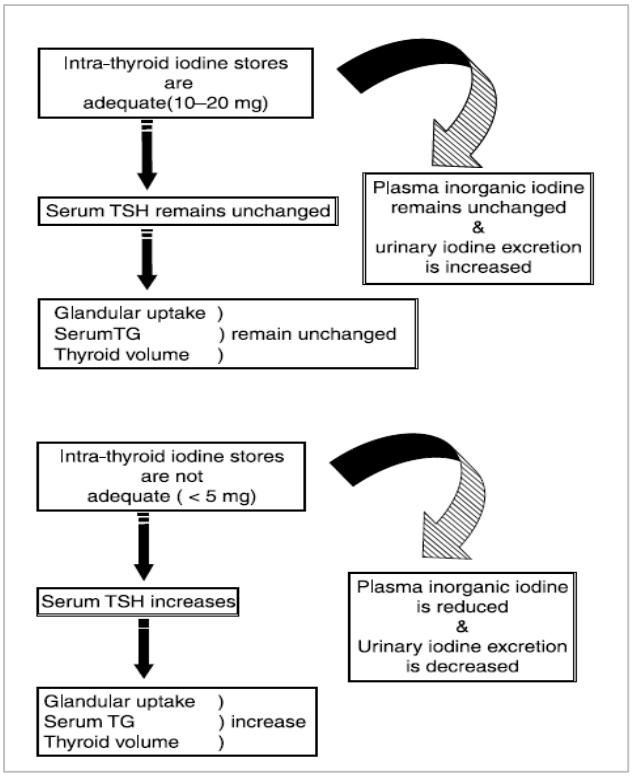

Figure 2.5 Thyroid function and goitre formation during pregnancy
(Glinoer 2007)

Thyroid size reflects the long-term iodine status of an individual or a population and can be measured by palpation (Grade 0, Grade 1 and Grade 2). A high inter-observer variation can lead to misclassification by this method (WHO/UNICEF/ICCIDD 2007). A second and more precise method of determining thyroid size is by ultrasonography. Gender-specific reference values for the upper limit of normal (p.97) thyroid volume of children between 6 and 12 years of age (or using body surface area) are referred to in the classification process (WHO/UNICEF/ICCIDD 2007). The prevalence of goitre, total goitre rate (TGR), is one method of determining the iodine status of populations in epidemiological studies. TGR is an indicator of long-term iodine status but has limited applicability when evaluating current prevalence or current iodine status of a population as it can take some months for the size of the thyroid gland to normalize following improvements in iodine status. TGR can still be used as a measure of iodine status trends (Andersson et al. 2005; WHO/UNICEF/ICCIDD 2007).

2.3.3 Serum TSH

In severe iodine deficiency, reduced circulating T4 levels can bring about a marked increase in the secretion of TSH from the pituitary (Gibson 2005; Glinoer 2007). In mild-to-moderate iodine deficiency, however, TSH levels are typically within the normal range (Gibson 2005; Skeaff 2012). Measurement of TSH levels in adults and school children is not recommended for assessment of iodine status of the adult and child populations (WHO/UNICEF/ICCIDD 2007) due to this lack of sensitivity, however, improvements in the assays over time have led to some improvements in the sensitivity of this measure (Eastman 2012).

2.3.4 Serum Tg

The thyroid protein, Tg, can be used as measure of thyroid activity (Eastman 2012; Gibson 2005; WHO/UNICEF/ICCIDD 2007). Stimulation of thyroid cells (which occurs when iodine intake is inadequate), can trigger thyroid hyperplasia leading to increases in serum Tg concentration (Gibson 2005; Hess 2013). In contrast to UIC which reflect shorter term iodine nutrition and goitre as an indicator of long-term iodine status, Tg can be used as a medium to long-term index as it reveals iodine status over months or years (Hess 2013).

2.3.5 Free thyroxine (FT4)

The majority of thyroxine (T4) in the blood is found bound to serum proteins such as TBG and albumin (Stagnaro-Green et al. 2011). Total serum T4 (TT4) concentration can be measured, however TT4 concentration alone does not give an indication of the T4 that is free (unbound). FT4 is a direct measure of the proportion of the serum TT4 that is unbound and available to be taken up by target tissues (Stagnaro-Green et al. 2011). Measuring FT4 concentration using modern techniques is more favourable to using indirect measures such as FT4I (described below).

2.3.6 Free thyroxine index (FT4I)

FT4I, historically known as adjusted total thyroxine (Stein and Price 1972), is calculated by multiplying TT4 by T3 resin uptake (TT4 x T3 resin uptake) or as a ratio of TT4 and TBG (Stagnaro-Green et al. 2011). FT4I is an indirect measure of free circulating T4 and takes into consideration the influence of TBG on FT4 concentration. This measure is not commonly used today, due to improvements in the direct analysis techniques of measures of free thyroid hormones (Stagnaro-Green et al. 2011).

2.4 Biochemical and clinical assessment of iodine status in pregnancy

2.4.1 Urinary iodine concentration

As mentioned in section 2.3.1 UIC reflects recent iodine intake (over preceding days) (WHO/UNICEF/ICCIDD 2007) and therefore is not an appropriate measure of long-term iodine status (Mackerras, Singh, and Eastman 2011). The use of a casual urine sample to measure individual iodine status, irrespective of life stage, is limited due to diurnal, seasonal and intra-individual variation (König et al. 2011). The latter results from variation in recent iodine intake (Andersen et al, 2014) as well as hydration status (Brough et al. 2015; Nguyen et al. 2010).

It has been recognised that the accuracy of using UIC to determine iodine status during pregnancy is impacted by three pregnancy-specific factors; a) increased GFR (Glinoer 2007), leading some to suggest that increased iodine excretion during early pregnancy may mask iodine deficiency (Mackerras et al. 2011; Stilwell et al. 2008); b) a lack of data available on the role of the placenta with regards to iodine storage (Delange 2007), as this value cannot be assessed by UIC; and c) UIC does not account for iodine transferred to the foetus (Mackerras and Eastman 2012). Andersen et al. (2014) also found that timing of consumption of iodine-containing supplements (if used) in relation to timing of urine sampling had a significant effect on the MUIC and UIE of a sample of Danish women (n=158). Furthermore, Skeaff (2012) points out a lack of validation relating to the pregnancy-specific cut-off value.

Recognition of the major differences between UIC in SAC and pregnant women is reflected in the separate recommendations for the interpretation of UIC in pregnant women (Andersson et al. 2007). It is worth noting in Table 2.2 and Table 2.3 that the MUIC between 100-199 ug/L is considered adequate in SAC and non-pregnant adults whilst the corresponding MUIC for pregnant women is set higher (150-249 ug/L).

Table 2.2 MUIC criteria for assessing iodine nutrition of SAC (≥6 years) and adults[a] (WHO/UNICEF/ICCIDD 2007).

MUIC (ug/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	Adequate iodine nutrition
200-299	Above requirements	May pose a slight risk of more than adequate intake in overall population
≥300	Excessive	Risk of adverse health consequences[b]

[a] Applies to adults but not to pregnant and lactating women.
[b] Such as iodine-induced hyperthyroidism, autoimmune thyroid disease.

Table 2.3 MUIC criteria for assessing iodine nutrition of pregnant women[a] (WHO/UNICEF/ICCIDD 2007).

MUIC (ug/L)	Iodine intake
<150	Insufficient
150-249	Adequate
250-499	Above requirements
≥500	Excessive[b]

[a] For lactating women and children <2 years of age a MUIC of 100 ug/L can be used to define adequate iodine intake, but no other categories of iodine intake are defined.
[b] "Excessive" means in excess of the amount required to prevent and control iodine deficiency.

The International Council for Control of Iodine Deficiency Disorders (ICCIDD) and the Public Health Committee of the American Thyroid Association (PHCATA) have since adopted the recommendations for pregnant women (Table 2.3) (Australian Population Health Development Principal Committee 2007). The current criteria do not give cut-off values which would allow determination of the severity of iodine deficiency, although it has been assumed that a greater degree of deficiency is reflected by lower UICs (Pettigrew-Porter et al. 2011).

A longitudinal study conducted on pregnant women in Sydney between 2007 and 2008 (n=367) by Blumenthal, Byth, and Eastman (2012) (Table 2.6) found that MUIC reflecting mild-to-moderate iodine deficiency did not correlate with abnormal thyroid function or abnormal thyroid hormone levels. Similar findings were reported in a New Zealand study conducted on 170 pregnant women in 2005 (Pettigrew-Porter et al. 2011) (Table 2.6). Up until recently, this cast doubt on whether mild-to-moderate iodine deficiency had negative impacts on the neurocognitive development of the foetus.

More evidence is mounting to negate this doubt, with findings from longitudinal studies conducted by (Hynes et al. 2013) in Tas and (Bath et al. 2013) in the United Kingdom suggesting that mild-to-moderate iodine deficiency during pregnancy negatively impacts foetal neurocognition. Results show impaired cognitive outcomes at 8-9 years of age in the children born to mothers with mild-to-moderate iodine deficiency during pregnancy using standardized assessment tools such as National Assessment Program-Literacy and Numeracy (NAPLAN), Student Assessment and Reporting Information System (SARIS) or Child IQ using an abbreviated form of Wechsler Intelligence Scale for Children (Bath et al. 2013; Hynes et al. 2013). Randomised controlled trials currently being conducted in Thailand and India (the MITCH studies) will provide further evidence relating birth outcomes from mild-to-moderate iodine deficiency in pregnancy (Melse-Boonstra et al. 2012).

2.4.2 Goitre assessed by palpation or ultrasound (%)

Skeaff (2012) acknowledges that the assessment of goitre rates in pregnancy is difficult due to a lack of published TV ranges for use in pregnancy, although it can be assumed that visible goitre in pregnant women reflects moderate-to-severe iodine deficiency. As mentioned previously, measurements of goitre rates or TV (size) are long–term measurements of iodine status and have limited applicability when evaluating current prevalence or current iodine status. In pregnancy it is not appropriate to rely on measures of TV, especially since other methods described in this section (e.g. UIC and TSH) can detect inadequate/insufficient iodine status prior to the sequelae that lead to increased TV and, or goitre formation, therefore allowing for earlier detection and correction.

2.4.3 Serum TSH

To interpret TSH levels during pregnancy, the major metabolic processes that initiate changes in the regulation of thyroid hormone production and usage need to be acknowledged (Eastman 2012; Morreale de Escobar, Obregón, and del Rey 2007; Stagnaro-Green et al. 2011). In particular, peak hCG levels late in the first trimester have a thyrotropic effect, causing an increase in maternal T4 and an initial decrease in maternal serum TSH (Gilbert et al. 2008; Morreale de Escobar, Obregón, and del Rey 2007; Williams 2008). This is followed by normalisation of levels in most pregnant women, as compensatory mechanisms to maintain a euthyroid state are triggered.

Gilbert et al. (2008), Eastman (2012) and Stagnaro-Green et al. (2011) have proposed the use of trimester-specific TSH thresholds to diagnose sub-clinical hypothyroidism during pregnancy. The PHCATA concludes that the maternal TSH reference range for pregnancy is lower than in non-pregnant women and (in the absence of laboratory trimester specific reference ranges) the upper limit for TSH in the first trimester is 2.5 mIU/L and 3.0 mIU/L for second and third trimesters (Stagnaro-Green et al. 2011) (Table 2.4).

The secretion of T4 in neonates is highly sensitive to iodine deficiency in the maternal circulation (due to low iodine stores in the neonatal thyroid) and results in increased TSH secretion in the neonate (Li and Eastman 2010; WHO/UNICEF/ICCIDD 2007). Hence neonatal TSH levels are used as an indirect method for assessing maternal iodine status (as well as population iodine status) and directly to screen for congenital hypothyroidism (CH) in the neonate (Li and Eastman 2010; Skeaff 2012; WHO/UNICEF/ICCIDD 2007). The WHO/UNICEF/ICCIDD (2007) criterion of an iodine sufficient population is one in which there is a < 3% frequency of neonatal TSH levels >5 mIU/L.

The use of neonatal TSH as a population monitoring tool for iodine deficiency has been a topic of debate for many years. Eastman (2012) stresses that the use of neonatal TSH for population iodine monitoring should only be used as an additional screening method. There are still many variables affecting the accuracy of neonatal TSH levels for example, factors such as stress during labour can increase neonatal TSH levels, as can exposure to iodine containing antiseptics during pregnancy and labour (Gibson 2005; WHO/UNICEF/ICCIDD 2007). The timing of blood samples (samples taken before 72 hours are likely to result in higher values due to the immediate rise in TSH in the neonate following birth and up to 72 hours after birth) and the choice of assay method used to measure TSH can also affect these values (Li and Eastman 2010; WHO/UNICEF/ICCIDD 2007).

Determination of maternal TSH concentration to assess maternal thyroid function is preferable and more logical than awaiting neonatal TSH levels. This allows for earlier detection and correction of thyroid dysfunction, in addition, maternal measures are less susceptible to interference by extraneous factors. However, it has been suggested that the use of maternal TSH levels to determine iodine status lacks sensitivity in those with mild-to-moderate iodine deficiency (Section 2.3.3) and is best used as an adjunct to other measurements of iodine status (e.g. UIC).

Table 2.4 Maternal TSH reference ranges (trimester-specific)
(Stagnaro-Green et al. 2011).

Trimester	Reference range (mIU/L)*
1	0.1-2.5
2	0.2-3.0
3	0.3-3.0

* If laboratory trimester-specific reference ranges are not available

2.4.4 Serum Tg

Use of Tg as an indicator of iodine status during pregnancy is currently limited. Reference cut-offs are not available for use in pregnancy (Skeaff 2012) and determination of these ranges is complicated by studies reporting that increased Tg during pregnancy can be due to greater thyroid secretory activity during this life-stage, in general (Laurberg et al. 2007). Ma and Skeaff (2014) suggested that further research using larger sample sizes including pregnant women of varying iodine status (adequate and inadequate) and studies measuring both Tg and UIC are required to investigate this indicator further.

2.4.5 Free thyroxine (FT4)

Free thyroxine (FT4) can be used to determine thyroid function in pregnant women (albeit as an adjunct to TSH concentration), however limitations do exist. Earlier immunoassay methods were prone to interference as a result of increased TBG and decreased serum albumin during pregnancy (Azizi et al. 2013; Stagnaro-Green et al. 2011). Issues relating to time, expense and availability of more advanced methods i.e. online solid phase extraction-liquid chromatography/tandem mass spectrometry (LC/MS/MS) (Stagnaro-Green et al. 2011), together with the absence of laboratory-specific reference ranges and gestation-specific reference ranges, have limited the use of FT4 alone in determining thyroid function in pregnant women (Eastman 2012).

2.4.6 Free thyroxine index (FT4I)

Improvements in the direct analysis of free thyroid hormones, together with the lack of widely accepted reference ranges for FT4I during pregnancy have limited the use and applicability of this measure in pregnant women. Whilst Azizi et al. (2013) derived trimester-specific reference ranges for FT4I in a small Iranian study on 152 healthy iodine sufficient pregnant women, the use of FT4I remains minimal and has not been used in any of the Australian or New Zealand studies.

2.5 Iodine requirements

Adult Nutrient Reference Values (NRV) for Australia and New Zealand released in 2006 are stated in Table 2.5.

The Recommended Dietary Intake (RDI) for iodine represents the daily dietary intake of iodine that is sufficient to meet the iodine needs of most (97-98%) healthy individuals in a certain gender and life stage group, however this value should not be used to assess intakes of groups (Food Standards Australia New Zealand 2008e; National Health and Medical Research Council and New Zealand Ministry of Health 2006b). The Estimated Average Requirement (EAR) for iodine is the daily level of iodine that meets the iodine requirements for half of the healthy individuals in a certain gender and life stage (National Health and Medical Research Council and New Zealand Ministry of Health 2006b) and it is applied to this research to estimate the prevalence of inadequate iodine intakes within the (study) population (Food Standards Australia New Zealand 2008e; National Health and Medical Research Council and New Zealand Ministry of Health 2006b). The Upper Level of Intake (UL) is briefly referred to in this study and relates to the highest average level of iodine likely not to cause adverse health effects to most individuals (National Health and Medical Research Council and New Zealand Ministry of Health 2006b). The potential for adverse effects increase as iodine levels increase above the UL and can be used to estimate the proportion of the population at risk of excessive iodine intake (National Health and Medical Research Council and New Zealand Ministry of Health 2006b).

Table 2.5 Iodine NRV for Adults
(National Health and Medical Research Council and New Zealand Ministry of Health 2006b)

	EAR (ug/day)	RDI (ug/day)	UL (ug/day)
Men 19 - >70 y	100	150	1100
Women 19 - > 70 y	100	150	1100
Pregnancy 14-50 y	160	220	1100
Lactation 14-50 y	190	270	1100

2.5.1 Adults

Iodine balance studies have indicated that urinary iodide concentrations of approximately 100 ug/L reflect intakes that meet adult physiological needs thus providing the background necessary for establishing an Estimated Average Requirement (EAR) of 100 ug/day for adults. A coefficient of variation of 20% was added to the EAR to determine the Recommended Dietary Intake (RDI) of 150 ug/day (National Health and Medical Research Council and New Zealand Ministry of Health 2006b) (Table 2.5).

2.5.2 Pregnancy

The higher iodine requirements during pregnancy are reflected in the EAR (160 ug/day) and RDI (220 ug/day) versus EAR (100 ug/day) and RDI (150 ug/day) for non-pregnant adults (Table 2.5). Requirements have been based on iodine thyroid content of newborns and iodine balance studies. A coefficient of variation of 20% was added to the EAR to determine the RDI for pregnant women (National Health and Medical Research Council and New Zealand Ministry of Health 2006b). As discussed in 2.2.1, these elevated requirements reflect a greater demand for iodine during pregnancy due to an increase in maternal thyroid hormone production and an increase in GFR leading to increased iodine excretion (Glinoer 2007; Zimmermann 2009).

2.6 Iodine status in the Australian and New Zealand population

Iodine deficiency was reported in the early 1900's in Tasmania and regions of Queensland, NSW, ACT and Victoria (Section 2.1.2) Various efforts were undertaken in some states to rectify the problem (Section 2.1.2) and in the early 1990's Australia's iodine status was deemed sufficient (Eastman 1993, cited in National Health and Medical Research Council 2009). During this time, surveillance and monitoring of the population's iodine status by the Australian Centre for Control of Iodine Deficiency Disorders (ACCIDD) was irregular (Eastman 1999), and over the following years the results from smaller surveys and studies raised concern about the declining urinary iodine excretion (UIE) of the population (Eastman 1999; Li et al. 2006).

This concerning trend led to the undertaking of a national iodine study of the mainland states of Australia. The results of the NINS conducted in 2004 on 1709 SAC in five mainland states of Australia classified the general Australian population as mildly iodine deficient as evidenced by a national population weighted median urinary iodine concentration (MUIC) of 98 ug/L (Australian Population Health Development Principal Committee 2007; Li et al. 2008; Li et al. 2006).

This confirmed the suggestion at the time that iodine deficiency had re-emerged in some parts of Australia. Western Australia and Qld were the only two states reported to have an optimal population iodine status in this study (Australian Population Health Development Principal Committee 2007; Li et al. 2008; Li et al. 2006). Tas, ACT and NT were not represented in this study, however, both Tas and ACT had historical evidence of inadequate iodine intake in their populations and were the first to implement the use of iodine containing bread improvers as a strategy to improve population iodine status (in 1966 and 1953, respectively), albeit unsuccessful in the initial attempt (Australian Population Health Development Principal Committee 2007).

More recently, the 2011–12 NHMS has shown improvements in the overall iodine intake in the Australian adult population 18 months post mandatory fortification of bread and bread products with iodine. Results reveal MUIC of 124.0 ug/L (with approximately 13% having MUIC less than 50 ug/L), indicating overall iodine sufficiency according to WHO criteria (Australian Bureau of Statistics 2013a; WHO/UNICEF/ICCIDD 2007). As can be seen in Figure 2.6, WA adults still have the highest MUIC (157.4 ug/L), followed by the NT, whilst the MUIC of Tasmanian adults remains the lowest (108.0 ug/L). This level still indicates iodine sufficiency for the general adult population (Australian Bureau of Statistics 2013a; WHO/UNICEF/ICCIDD 2007).

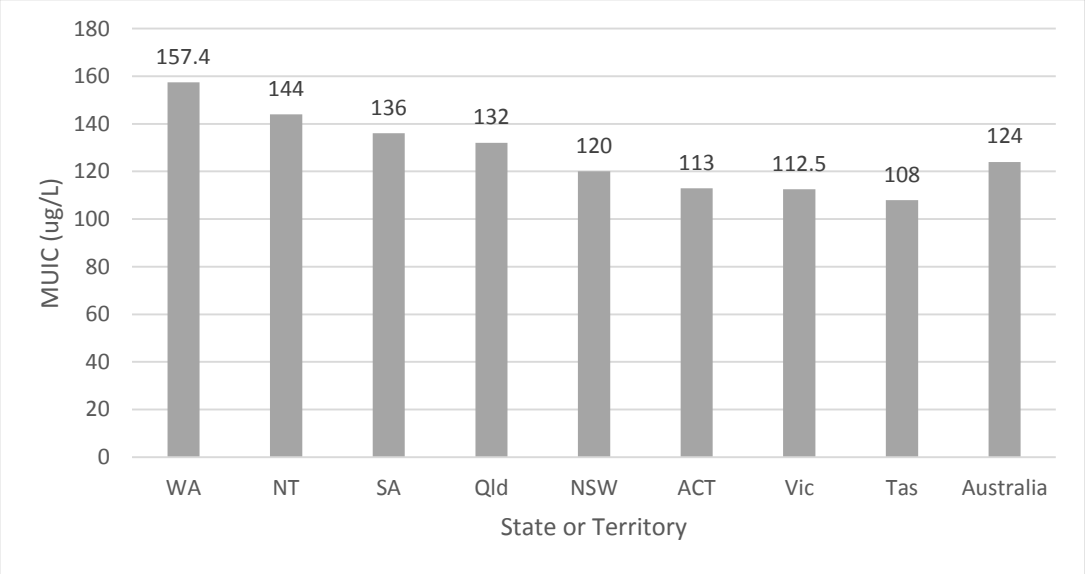

Figure 2.6 MUIC of persons aged 18 years and over by state and territory
(Australian Bureau of Statistics 2013a).

A review of the studies conducted on pregnant women in areas of Australia and NZ is discussed further in Section 2.9. To date, no studies have been conducted to assess MUIC in pregnant women in WA (or Qld) where the iodine status of SAC in 2004 and adults in 2012-2013 was considered adequate.

It has been suggested that MUIC of pregnant women in these states is likely to be equivalent to, if not lower, than the MUIC of school age children (Australian Population Health Development Principal Committee 2007; Mackerras and Eastman 2012), therefore reflecting insufficient iodine intake based on 2004 data.

MUIC results from the NHMS were obtained for Australian women of childbearing years (16-44 years). These women had MUIC of 121.0 ug/L and whilst this reflects sufficient iodine intake in non-pregnant adults, this level is considered insufficient for pregnant women. Furthermore, around 18.3% had MUIC less than 50 ug/L, lower than the national average and approximately 62% had MUIC less than 150 ug/L, levels that would raise some concern for pregnant women according to WHO/UNICEF/ICCIDD (2007) criteria (Australian Bureau of Statistics 2013a, 2013b).

Whilst the latest NHMS data looks promising with regards to overall improvement in iodine status following mandatory iodine fortification of bread and bread products in the Australian population, the study did not focus on pregnant women. The overall opinion is that mandatory fortification alone is not enough to ensure adequate iodine intake in pregnant women (Australian Bureau of Statistics 2013a; Mackerras et al. 2011), but whether this applies to all states and territories is yet to be fully explored.

It has been well-documented that NZ soils are low in iodine, with reports of endemic goitre dating back to the late 1800s (Thomson 2004). Many strategies to improve iodine status have been implemented over the years commencing with the iodisation of table and cooking salt in 1924 (Food Standards Australia New Zealand 2008d), followed by an increase in iodine concentration in cooking salt in 1938 that assisted with improving the population iodine status between 1960-1980 (adequate or more than adequate iodine status) (Australian Population Health Development Principal Committee 2007). However, studies in the late 1980s and early 1990s indicated that iodine deficiency in the NZ population had re-emerged (Australian Population Health Development Principal Committee 2007).

Various initiatives have been put in place since then including the mandatory iodine fortification of bread and bread products in 2009 and a government subsidised iodine supplementation program for all pregnant and breastfeeding women in 2010 (Brough et al. 2015). Authors of studies conducted after the mandatory iodine fortification of bread and bread products agree that improvements in UIC have occurred, however a level of concern remains regarding suboptimal iodine status of SAC (Skeaff and Lonsdale-Cooper 2013) and pregnant and breastfeeding women (Brough et al. 2015; Mallard and Houghton 2014). This has highlighted the need for further research in subgroups within the NZ population.

2.7 Estimation of dietary iodine consumption

Dietary assessment tools such as dietary records, 24-hour dietary recalls, weighed food records, and food frequency questionnaires (FFQ) are used in the field of nutrition as a means of estimating dietary intake (short-term to longer-term), as well as dietary habits and trends. National nutrition surveys and smaller scale studies often utilise FFQ, whereas 24-hour dietary recalls, dietary records, weighed food records, and FFQ can be used on an individual basis or for group level analysis (Thompson and Subar 2013).

Most of the iodine specific studies that have been conducted in pregnant women in Australia have used either 24-hour recalls or FFQ. These methods are easy to administer, of low participant burden and provide information on dietary habits and significant food sources of iodine (Biro 2002; Willett 2013). However, researchers rely on the accurate recall of foods consumed by the participants, as well as the correct interpretation of quantities, frequency of consumption and motivation of the participants to complete the FFQ (Babor 1987). Furthermore, it is not possible to collect information on all aspects of a person's diet such as all food eaten, contents of combination dishes and all cooking methods used (Thompson and Byers 1994).

It should be noted that dietary assessment methods such as 24-hour dietary recalls, dietary records or food frequency questionnaires are in general are subject to self-report bias (if self-administered), including social desirability bias (the subject's desire for approval) (Babor 1987; Subar et al. 2015) thus leading to over or underestimation of the key nutrient/s of interest. In addition to this, length of questionnaire may influence over or underestimation. Krebs-Smith et al. (1995) found that a high number of questions (related to fruit and vegetable consumption) had a tendency to overestimate intakes compared to a summary question. Some authors suggest FFQs overestimate iodine intake (Rasmussen et al. 2001), while others question underestimation in their FFQs due to the omission of iodine-rich food sources such as iodised salt (Condo et al. 2015). The act of quantifying the weight of iodised salt itself is problematic (often in grams or less), relies on individual accuracy in reporting minimal amounts such as "sprinkle", "shake" or "pinch" (Skeaff 2012) and allowances need to be made for cooking losses.

In addition to this, the calculation of iodine intake is dependent on food composition databases, some of which are incomplete (Charrondiere et al. 2011; Skeaff 2012). An element of uncertainty remains for specified values in food composition databases as to whether multiple sampling has captured seasonal, soil and natural variability, as well as variances in agricultural processes, cleaning procedures and storage (if direct methods are used) or whether values have been assigned using indirect methods (from literature or imputed data) and the accuracy of this data (Charrondiere et al. 2011).

It is recommended that FFQ should be validated against methods such as; duplicate portions, biological markers such as UIC and/or thyroid hormones (TSH, T4) or dietary records (Skeaff 2012). Each of these methods, however, contributes its associated limitations to the estimation. Tan et al. (2013) validated their short iodine-specific FFQ using a combination of the two above methods in a sample of older Australians living in NSW and results indicated a moderate correlation (r=0.377) between the FFQ and three 24-hour dietary recalls. A significant correlation (Spearman's correlation, r=0.265) was reported between UIC/creatinine ratio and estimated iodine intake measured by the FFQ (Tan et al. 2013). Condo et al. (2015) compared an iodine-specific FFQ with 4 day weighed food records of pregnant women in SA and assessed the correlation between iodine intake (FFQ) and urinary iodine as well as thyroid hormones. The authors reported a moderate correlation (r=0.349) between the iodine-specific FFQ and 4-day weighed food records, this increased when iodine-containing supplements were accounted for (r=0.876). The FFQ was associated with 24-hour UIE and 24-hour UIC however no association was found between the FFQ and thyroid hormones. Australian studies which have investigated the use of a FFQ to assess intake of this nutrient are generally positive.

Limitations aside, validated FFQs are considered useful for their ability to categorise or rank individuals into levels of intake (Block 1982; Erkkola et al. 2001; Thompson and Subar 2013) and for highlighting those who fall within the extremes (Erkkola et al. 2001). They are relatively inexpensive and practical research tools for estimating and ranking dietary iodine intake, especially when alternative indices are not available (e.g. biochemical, clinical or anthropometric data) (Skeaff 2012). Additionally, FFQ provide essential information relating to complex dietary patterns and behaviours, important information that biomarkers alone do not provide (Subar et al. 2015).

2.8 Iodine intake in the Australian and New Zealand population

As mentioned in Section 2.1.3, the richest food sources of iodine are animals and plants of marine origin (e.g. fish, shellfish and marine plants such as seaweed) (Gibson 2005). Iodine content of other plant and animal food sources varies markedly and is dependent on the local iodine content of soil and water, geographical location, agricultural and farming practices and seasonality (Gibson 2005; Laurberg et al. 2007). Other sources of dietary iodine, albeit in lesser quantities are; milk and dairy products, bread and bread products that have been fortified with iodine, eggs and iodised salt (Gibson 2005) and tap water (Food Standards Australia New Zealand 2008a).

Whether a food product is an important source of iodine depends not only on the concentration of iodine in that food, but the frequency of consumption of that food product. In order to present an overall picture of iodine intake in Australia and NZ over the last two decades, information from two large Australian surveys, together with one NZ survey, will be summarised here and briefly compared to relevant iodine intake findings of pregnancy-specific iodine studies conducted in these two countries.

Results from 13,858 participants (2 years of age and over) in the 1995 NNS revealed that dairy products contributed significantly to overall iodine intake in Australia with eggs, tap water and iodised salt noted as important contributors. Seafood consumption in these participants was low and did not make a significant contribution to iodine intake (Food Standards Australia New Zealand 2008a).

Although a large study, the present day applications of the results from the 1995 NNS are somewhat limited. The sample size of pregnant women (and in this case the population of interest), was relatively small (Mackerras et al. 2011). At the time of the survey, fortification of bread and bread products with iodine had not been mandated and this accounted for bread and bread products not being identified as major contributors to overall iodine intake (Food Standards Australia New Zealand 2008a). Further to this, Food Standards Australia and New Zealand (FSANZ) cautioned that the data obtained for discretionary iodised salt use were likely to be an underestimation due to incomplete participant responses (Food Standards Australia New Zealand 2008a).

More recently data from the 2003 cohort of the ALSWH study have provided information on dietary iodine intakes of women in Australia, in particular pregnant women. Iodine intake data were obtained via a FFQ developed by The Cancer Council of Victoria and contained key iodine-containing foods (Mackerras et al. 2011). Results from 665 pregnant women confirmed that milk and dairy products were major contributors to dietary iodine intake in this group, together with bread and bread products (adjusted for iodine fortification). The findings of low seafood consumption in the 1995 NNS are reinforced in this study with fish consumption contributing minimally to overall iodine intake (Mackerras et al. 2011).

Findings from the 2009 New Zealand Total Diet Survey (NZTDS) (Vannoort and Thomson 2011) suggested that dairy products were significant contributors to dietary iodine intake in 25+ year females (encompassing women of childbearing age). This survey was based on simulated diets and did not assess iodised salt use.

Australian and NZ studies on iodine nutrition and status of pregnant women confirm the above findings, namely that milk and dairy products together with bread and bread products containing iodised salt are significant contributors to overall iodine intake (Charlton et al. 2013; Lucas et al. 2014; Martin, Savige, and Mitchell 2014; Rahman et al. 2011), whilst fish and other seafood are consumed infrequently (Charlton et al. 2013; Lucas et al. 2014; Martin, Savige, and Mitchell 2014; Nguyen et al. 2010; Pettigrew-Porter et al. 2011; Rahman et al. 2011).

A total of 20 studies to measure iodine status and, or intake have been conducted on pregnant women in Australia and NZ since 1980 (Table 2.6). A study conducted by Nithiananthan, Carroll, and Krebs (2013) included pregnant women but their results cannot be distinguished from non-pregnant women so has been excluded. One other study was excluded due to a small sample size, that conducted by Thomson et al (2001) in NZ. Urinary iodine excretion was measured for a small number of the pregnant women supplemented with selenium (n=18) and those not supplemented (n=17).

Table 2.6 Studies related to iodine status and, or intakes of pregnant women in Australia and New Zealand (1980 to present)

Author (Publication Date) Date of study	State or Territory	Sample Size (n)	Gestation stage (wk)	MUIC (ug/L)	K/B/A	Diet I (ug)	Supp I (% use)	Salt I	TV	TSH (mIU/L)	Other
Gunton et al. (1999) *(Public)* 1998-1999 *(overlap with McElduff et al. 2002)*	NSW	81	Approx. 30	**104**						Maternal	I/Cr ratio FT4
McElduff et al. (2002) *(Public)* 1998-1999 1998-1999 2000	NSW	**84 (total)** (1316 Neo) (1457 Neo)	Approx. 30							Neo	
Li et al. (2001) *(Public)* 1998-1999	NSW	101	Full term	**88**							
Hamrosi et al. (2005) *(Public)* 1998-2001	Vic	**802 (total)** 277 (Cauc) 263 (Viet) 262 (In/SL)	14-20	 52 58 61							
Stilwell et al. (2008) *(Public)* 1999-2001	Tas	**686 (total)** 18 178 171 54 48 63 134 20	19.4 8.7 12.6 17.9 22.2 27.8 32.6 36.8 40.7	**75** 124 94 74 55 62 76 76 69							

Author (Publication Date) Date of study	State or Territory	Sample Size (n)	Gestation stage (wk)	MUIC (ug/L)	K/B/A	Diet I (ug)	Supp I (% use)	Salt I	TV	TSH (mIU/L)	Other
Travers et al. (2006) *(Public & Private)* 2004	NSW	**815 (total)** 691(public) 124 (private)	≥ 28	**85** 82 101						Neo	
Burgess et al. (2007) *(Public)* 2000-2001 pre iodine fort. (RHH) 2003-2006 post iodine fort*. (PHC) 2006-2006 post iodine fort*. (RHH)	Tas	**802 (total)** 285 288 229	All 1st trimester	**109** 76 81 86							
Mackerras et al. (2011) *(Public)* 2005-2008	NT	24	Not reported	**49**							
Pettigrew-Porter et al. (2011) *(Various)* 2005	NZ	170	All	**38**		48	23			Maternal	FT4
Blumenthal et al. (2012) *(Private)* 2007-2009	NSW	367	7-11	**81**		132 *Extrapolated*	32.5			Maternal	FT4
Charlton et al. (2010) *(Public)* 2008	NSW	139	All	**87.5**			20				
Nguyen et al. (2010) *(Public)* Feb – May 2009	ACT	100	Not reported	**62**			34				I/Cr ratio
Rahman et al. (2011) *(Public & Private)* 2009 pre iodine fort. 2009/2010 post iodine fort.	Vic	**86 (total)** 24 62	≥ 28	**96** 96 95.5			51 54 50				

Author (Publication Date) Date of study	State or Territory	Sample Size (n)	Gestation stage (wk)	MUIC (ug/L)	K/B/A	Diet I (ug)	Supp I (% use)	Salt I	TV	TSH (mIU/L)	Other
Clifton et al. (2013) *(Public)* Jan 2009 and July 2010	SA	196	 12 18 30 36	**82** 73 68 84 118			47				
Brough et al. (2015) *(Various)* July 2009 pre iodine fort. Jan-Sept 2011 post iodine fort	NZ	**57 (total)** 25 32	> 26	 47 85		 119 217 *Extrapolated*	70				Br milk Tg TgAB
Charlton et al. (2013) *(Public)* 2011 2012	NSW	 147 114	All	 145.5 166		 176 160	 60 66				
Mallard & Houghton (2014) *(Public & Private)* 2011	NZ	723	All**			 107 (Prior preg) 179 (Preg) *Baseline assignment*	 16 22-39				
Martin et al. (2014) *(Public & Private)* 2011-2012	Vic	200	≥ 28				62				

Author (Publication Date) Date of study	State or Territory	Sample Size (n)	Gestation stage (wk)	MUIC (ug/L)	K/B/A	Diet I (ug)	Supp I (% use)	Salt I	TV	TSH (mIU/L)	Other
Condo et al. (2015) *(Public)* 2011-2012	SA	96	< 20	178-212		144 (FFQ) 160 (4d WR)	75			Maternal	Tg FT3 FT4
El-Mani et al. (2014) *(Various)* 2012-2013	NSW	152	All				67.7				
Lucas et al. (2014) *(Public & Private)* 2012 and 2013	NSW	142	All			189	70				

MUIC = Median urinary iodine concentration
K/B/A = Knowledge/Beliefs/Attitudes
Diet I = Dietary Iodine
Salt I = Iodised salt use
Cauc = Caucasian
Neo = Neonatal
Public = recruitment from a public hospital/antenatal setting

* Fort = Fortification (voluntary)

TV = Thyroid volume
Br milk = Breast milk iodine content
Supp I = Iodine containing supplement use
Fort = Fortification (mandatory)
Viet = Vietnamese
Preg=Pregnancy/pregnant
Private = recruitment from a public hospital/antenatal setting

**Women surveyed postpartum

Salt I = Iodised salt use
RHH = Royal Hobart Hospital
PHC = Primary health care centre
In/SL = Indian/Sri Lankan
4d WR = 4 day weighed record
Various = recruitment from a variety of settings

2.9 Iodine status of pregnant women in Australia and New Zealand

2.9.1 Urinary iodine concentration (UIC)

Iodine deficiency (MUIC <150 ug/L) set by WHO/UNICEF/ICCIDD (2007) was reported in 14 out of the 16 studies which included MUIC measurements. The range in MUIC across these studies was 38-212 ug/L.

Studies conducted pre-fortification of bread and bread products

The iodine content of soils across Australia and NZ is variable and therefore the following results have been divided into states of Australia and NZ. These arbitrary boundaries also assist with reporting iodine status in different regions.

New South Wales

The earliest studies were conducted in 1998-1999 (Gunton et al. 1999; Li et al. 2001) in women at full-term from Westmead Hospital antenatal clinic and in those at 30 weeks from Royal North Shore Hospital, respectively (Table 2.6). The MUIC of both of these groups indicated iodine deficiency in the sample population (88 ug/L and 81 ug/L, respectively). Iodine deficiency was also reported in third trimester women in one of the largest iodine studies conducted on pregnant women in Australia and NZ prior to the mandatory iodine fortification of bread and bread products in 2004 (Travers et al. 2006) (MUIC=85 ug/L), as well as in a sample of first trimester women attending a private antenatal clinic in North Western Sydney in 2007-2009 (Blumenthal, Byth, and Eastman 2012) (MUIC=81 ug/L). Charlton et al. (2010) also reported iodine deficiency in participants attending a public antenatal clinic in the Illawarra region of NSW in 2008 (MUIC=87.5 ug/L) (Table 2.6).

These MUIC values covered a wide range of gestational ages and were remarkably similar. Women from non-English speaking backgrounds (NESB) were excluded from the Charlton et al. (2010) study and no other information was provided on ethnicity. The study conducted by Blumenthal, Byth, and Eastman (2012) comprised of women mainly with Australian backgrounds (79.3%), whilst it is likely that the majority of participants in Travers et al. (2006) were English speaking due to the information provided on those using the services where the study was conducted. No information was provided on ethnicity in the earliest studies NSW studies (Gunton et al. 1999; Li et al. 2001).

Victoria

Hamrosi, Wallace, and Riley (2005) focused on iodine status (UIC) in three ethnic subgroups rather than a random sample of pregnant women. Eight hundred and two pregnant women (14-20 weeks gestation) in Melbourne were recruited during 1998-2002 (Table 2.6). The MUIC values were significantly lower than those of the Sydney studies. MUIC of 227 Caucasian women was significantly lower (52 ug/L) and 48.4% had UIC < 50 ug/L than women from Vietnamese (n = 263; 58 ug/L and 38.4 % < 50 ug/L) and Indian/ Sri Lankan (n = 262; 61 ug/L and 40.8 % < 50 ug/L) backgrounds. It should be noted that the authors of this study found that samples stored for a greater length of time (greater than 3 years) had lower UIC than samples stored for less time. Inadequate storage of older samples, potential dietary changes over time leading to lower iodine intakes (hence lower UIC) in women whose samples were taken earlier in the study (and stored for longer), adsorption of iodine into the storage tube material or other unexplained loss of iodine over time were potential factors identified by the authors. This was the first study conducted in Australia to highlight that ethnic subgroups appeared to have different iodine status than pregnant women with Caucasian backgrounds.

Tasmania

The Stilwell et al. (2008) study conducted in 1999-2001 involved 686 women of all gestational stages. The authors stated that the sample was representative of the general population using the public health system in terms of socioeconomic status, education and ethnicity, however the ethnicity of the pregnant women in the study was not reported. Participants were found to be iodine deficient (MUIC=75 ug/L), as were those in a smaller pre-fortification study conducted by Burgess et al. (2007) in 2000-2001 (MUIC=76 ug/L) (Table 2.6). Thus the Tasmanian MUIC data were part-way between the NSW and Vic data.

Australian Capital Territory

Nguyen et al. (2010) investigated a sample of 100 pregnant women across all gestational stages attending the antenatal clinic at Canberra Hospital (MUIC=62 ug/L) (Table 2.6). This is the only study to date that has been conducted in ACT, and resulted in a MUIC considerably lower than the data from Sydney or even Tasmania. The ethnicity of the participants was not reported in this study.

Northern Territory

Studies conducted on pregnant women in the NT are limited, however one study conducted by Mackerras, Singh, and Eastman (2011) involved a small sample (n=24) of Indigenous teenagers in the Darwin Health Region. The MUIC in this study was the second lowest out of all the studies reviewed (49 ug/L) (Table 2.6). Whilst the sample size was small, it highlighted the need for further research into the iodine status of both Indigenous pregnant women and adolescents in general.

It is worth noting that geographical differences between states/territories (e.g. coastal versus inland) *within* Australia are likely to have had an impact on local soil content of iodine and therefore the iodine content of the local food supply. In addition, differences in ethnic backgrounds and thus food habits of the populations may have contributed to the variations in MUIC values observed.

New Zealand

Pettigrew-Porter et al. (2011) reported the lowest MUIC out of all of the studies (38 ug/L). Their study included 170 pregnant women, predominantly of New Zealand European and Other backgrounds, across all gestational stages residing in the North and South Island (Table 2.6). This was the only study to use a proportionate to population sampling method. The difference in geographical location with NZ traditionally having a lower iodine content of soil (Thomson et al. 2001) and therefore less iodine in the local food supply (Brough et al. 2015) was likely to have been a major contributing factor to the low MUIC reported in this study.

In the states and territories involved (NSW, Vic, Tas, ACT, NT) and in NZ, the overall finding was that the pregnant subjects were iodine deficient based on MUIC (prior to the mandatory fortification of bread and bread products with iodine). Hamrosi, Wallace, and Riley (2005) (Vic), Stilwell et al. (2008) (Tas), Burgess et al. (2007) (Tas), Nguyen et al. (2010) (ACT), Mackerras, Singh, and Eastman (2011) (NT) and Pettigrew-Porter et al. (2011) (NZ) all reported MUIC at less than half of the WHO/UNICEF/ICCIDD (2007) cut-off point for sufficiency in pregnant women (> 150 ug/L).

Studies conducted post-fortification of bread and bread products

Six studies in four Australian states and in NZ have investigated UIC since the fortification of bread and bread products. Two of the five studies that had pre-and post-fortification comparison groups reported that differences in MUIC in pregnant women pre- and post-iodine fortification were not significantly different (Burgess et al. 2007) (Tas) and (Rahman et al. 2011) (Vic), whilst (Brough et al. 2015) (NZ), (Charlton et al. 2013) (NSW) and (Clifton et al. 2013) (SA) reported some significant differences in iodine status between pre- and post-fortification groups.

Tasmania

Tasmania stood alone with regards to the early initiation of iodine fortification of bread and bread products. The Tasmanian government addressed iodine deficiency in the state's population by adopting a voluntary iodine fortification program in October 2001 whilst awaiting fortification on a national scale (implemented in October 2009). Burgess et al. (2007) recruited 517 Tasmanian pregnant women across two settings in 2003-2006 to compare with the MUIC data from the 2000-2001 sample. The participants who attended the Royal Hobart Hospital (RHH) antenatal clinic were of all gestational stages (as were 2000-2001 subjects); details on ethnicity were not provided. The increase in post-fortification MUIC was not significant (76 ug/L vs. 86 ug/L, p=0.237). The second subgroup (n=288) was recruited on the first trimester visit to a primary health care centre (PHC) in 2006. Again the MUIC was not significantly different (76 ug/L vs. 81 ug/L, p=0.809), indicating iodine insufficiency.

Supplement use and iodised salt use were not reported in the above study, however, it is unlikely that the majority of pregnancy multivitamin supplements contained iodine at the time. In addition, the contribution of iodine obtained from iodised salt was likely to have been low around this time, with Li et al. (2007) reporting that only 11% of Australian households purchased iodised salt (based on SALT Market Overview Homescan Data to July 2003). AZTEC data capturing iodised salt purchases between 2003-2006 indicated a 29% increase in iodised salt purchased by Australian households, potentially influenced by media coverage at the time (Li et al. 2007). Overall iodised salt use, however, was still likely to be low in 2006 (post-fortification subgroup), with less than 50% of Australian households purchasing iodised salt.

Victoria

The second study to report no significant difference in MUIC pre- and post-fortification of bread and bread products was a cross-sectional study conducted from January 2009 to February 2010 in regional Vic (Rahman et al. 2011) (Table 2.6). All women (at or over 28 weeks gestation) attending major antenatal clinics in all six local government areas in Gippsland were invited to participate in the study. The majority of women were of Caucasian backgrounds (93.5%) (Rahman et al. 2011). The MUIC of the participants pre-fortification was similar to the MUIC post-fortification (96.0 ug/L vs. 95.5 ug/L), indicating iodine insufficiency. Approximately half of the participants were consuming iodine containing supplements post-fortification although it should be noted that the sample sizes both pre- and post-fortification were relatively small (n=24 and n=62, respectively) and response rate was low (29%).

New South Wales

In contrast, the Illawarra (NSW) post-fortification study conducted by Charlton et al. (2013) was the only study (with a pre-and post-fortification comparison group) to report MUIC > 150 ug/L (MUIC=166 ug/L in the overall sample in 2012) (Table 2.6). MUIC indicated sufficiency in 2011 and 2012 in the women using iodine-containing supplements, whilst MUIC remained insufficient in post-fortification years in those not taking iodine containing supplements (2011:178 ug/L; 2012:202 µg/L versus 2011: 109 ug/L; 2012: 124 µg/L $p<0.05$), respectively. It should be noted that the (pre-fortification) iodine status of women in studies conducted in NSW was not as low as women in other states, territories and in NZ. This, together with higher reported iodine-containing supplement use (60-66%) than half of the studies that reported this data likely explains why a subset of these participants achieved iodine sufficiency (post-fortification).

The post-fortification study above was conducted more than 4 years after the Tasmanian post-fortification study (Burgess et al. 2007) and during a period of mandatory iodine fortification (versus voluntary fortification, as was the case in the Tasmanian study). Furthermore, time differences in the pre- and post-fortification findings between the Illawarra study and earlier studies will have impacted the results. Additional contributing factors over this time period include; a) the 2010 release of NHMRC recommendations stating that women who are pregnant, considering pregnancy or breastfeeding take an iodine supplement of 150 ug daily (National Health and Medical Research Council 2010) and b) reformulation of some pregnancy multivitamin preparations to include or increase iodine content. The possible flow-on effect of these factors needs to be considered when comparing more recent studies with studies conducted prior to 2010.

Although a smaller study, the factors mentioned above will have had an impact on the findings of the 2009-2010 Victorian study (Rahman et al. 2011) with 60% (2011) and 66% (2012) of participants in the Illawarra study (Charlton et al. 2013) having consumed iodine containing supplements compared to 51% in the earlier Gippsland study (Rahman et al. 2011).

South Australia

For the first time, the Adelaide study by Clifton et al. (2013) revealed a significant increase in the MUIC in participants not using iodine supplements pre- (n=84) and post-fortification (n=94) (68 ug/L vs. 84 ug/L, p=0.01), suggesting that bread fortification had a positive impact on iodine status in these pregnant women. Participants in this study however, remained iodine deficient with an overall MUIC=82 ug/L (Table 2.6).

Results from a second Adelaide study by Condo et al. (2015) (n=96) (post-fortification only) reported MUIC ranging from 178-212 ug/L indicating iodine sufficiency in pregnant women attending antenatal clinics in 2011-2012. The MUIC was the highest out of all of the studies and more than double the concentration of the previous Adelaide study. This difference, again, was likely to be due to the positive influence of bread fortification, however, this trend also coincided with the highest reported iodine containing supplement use (75%) amongst all studies. It is worth noting that sampling bias was likely in this population as women in the study were participants in another study regarding iodine and pregnancy.

New Zealand

Findings from the Palmerston North area of NZ (Brough et al. 2015) confirm a significant increase in the MUIC of pregnant women from pre- (n=25) to post-fortification (n=32) (47 ug/L vs.52 ug/L, $p < 0.001$), with 70% taking iodine supplements in 2011 (post-fortification). Despite this high prevalence of iodine supplement use, the overall study population remained iodine deficient post-fortification whereas the MUIC of pregnant women in the 2011 and 2012 subset in the Illawarra study (Charlton et al. 2013) with slightly lower percentages (60-66% iodine supplement use, respectively) indicated borderline sufficiency and sufficiency (MUIC=145.5 ug/L in 2011 and 166 ug/L in 2012) (Table 2.6). The pre-fortification iodine status of the Illawarra study population was not as low as that of the NZ participants and, as mentioned previously, is likely to be a contributing factor to this difference.

The small sample size of the NZ study (n=59), with subjects mostly of a Caucasian background, needs to be acknowledged, as well as the impact that differences in geographical location are likely to have on iodine status between participants in the Illawarra region of NSW and Palmerston North in NZ. Not only are there distinct differences in the iodine content of soil and the local food supply but government initiatives in NZ differ to those in Australia (Section 2.7). In addition, the health care system (including antenatal and postnatal care), population demographics, iodine content of iodine supplements, as well as prior knowledge of the general public on iodine nutrition topics are not similar.

Four out of five studies that had pre-and post-fortification comparison groups raise concern of ongoing inadequate iodine status for pregnant women in Tas, Vic, SA and NZ despite the implementation of iodine fortification strategies. The findings reinforce the importance of the NHMRC recommendations for pregnant women to take an iodine-containing supplement of 150 ug daily in the states, territories and countries where MUIC reflected inadequate iodine status.

Two of the more recent Australian studies (Charlton et al. 2013) (Illawarra) and (Clifton et al. 2013) (Adelaide) reveal a different trend to the majority of studies with iodine sufficiency reported in study subsets using iodine-containing supplements. The findings from the Illawarra study indicated borderline sufficiency in those taking iodine-containing supplements in 2011 and in 2012 (Table 2.6). Clifton et al. (2013) reported that a significant number of women taking iodine-containing supplements at two time points in the 3rd trimester (30 and 36 weeks) had UIC >150 ug/L when compared to those who were not taking iodine supplements ($p=0.022$ and $p=0.038$, respectively) at any gestational stage. In contrast, Condo et al. (2015) (Adelaide) reported MUIC indicating iodine sufficiency (178 (24 h UIC)-212 (spot MUIC) ug/L) with no significant difference in spot MUIC reported between iodine-containing supplement users or non-users.

The above findings differ to those of the smaller NZ and Gippsland studies (Brough et al. 2015; Rahman et al. 2011). The reason for this difference is multifactorial and can be explained, in part, by the higher baseline MUIC reported in subgroups within the Illawarra (Charlton et al. 2013) and Adelaide (Clifton et al. 2013) studies. Further explanations can be found, as indicated below.

Some clarification of the role of iodine supplementation in closing the gap between iodine deficiency and iodine sufficiency in pregnant women has been provided. In the studies that did not find significant changes in iodine status after the introduction of mandatory fortification of bread and bread products, iodine supplementation ranged from 50-70% (Table 2.6). Iodine status, post-fortification, was similar in the Gippsland study (Rahman et al. 2011) and improved in Palmerston North subjects (Brough et al. 2015), however, as mentioned previously, sample sizes in both studies were small.

One of the limitations of most of the studies in Table 2.6 was that they were cross-sectional and conducted on pregnant women during various stages of pregnancy. This is problematic from a comparison point of view due to variances in MUIC at different stages (Section 2.4.1). Two longitudinal studies have been conducted (Clifton et al. 2013; Stilwell et al. 2008) with Stilwell et al. (2008) reporting that GFR and iodine excretion in Hobart participants was higher in early gestation (prior to 22 weeks). This raised questions as to whether the current criterion for assessing UIC overestimated the adequacy of iodine nutrition, particularly before 22 weeks of gestation (Stilwell et al. 2008). It should be noted that information regarding iodine supplement use was not reported in this study, although use of iodine supplements was unlikely to be high in this era.

Clifton et al. (2013) (Adelaide) reported a significant increase in UIC with advancing gestation in the total sample despite an overall decrease in the number of women using iodine supplements as gestation progressed beyond 30 weeks (Table 2.6). This lack of adherence to iodine supplementation as pregnancy progressed, as well as the lack of consistency with the use of iodine supplementation at reported time points, limits the interpretation of the value of iodine supplementation. These factors are likely to have had an impact on all studies that investigated iodine supplement use.

The lack of clarity regarding changes in UIC with advancing pregnancy is a gap in the literature and highlights the need for further research to determine and standardise gestation-specific UIC reference intervals. Furthermore, sample size, socioeconomic and cultural differences of participants, study methodologies, prior iodine knowledge of participants, sampling bias and varied settings place limitations on comparisons between states/territories and between Australia and NZ. As mentioned previously, variance in local iodine content of soil and produce, government initiatives, health care and iodine content in popular pregnancy multivitamin preparations are additional factors that confound comparisons between these two countries.

2.9.2 Goitre and thyroid volume as indicators of iodine status

Studies conducted pre-fortification of bread and bread products

Only one study (Pettigrew-Porter et al. 2011) (Table 2.6) reported TV (measured by ultrasonography) in pregnant participants (n=170) in both the North and South Island of NZ. The majority were classified as iodine deficient based on MUIC (38 ug/L) but only 7% of the participants were classified as having goitre (TV>18 ml). It is important to mention that most participants had normal TSH and FT4 levels with only 2.6% classified as hypothyroidic based on maternal TSH and 15% with FT4 < 10.3 pmol/L. The limitations of using TV/goitre rates are described in Section 2.4.2, and apply when interpreting the results of this study. The sequelae of goitre formation only partially concur with the overall pattern shown in this study and therefore earlier detection of iodine deficiency using UIC in combination with TSH and FT4 to make a subclinical diagnosis is preferable given the limitations of using TV/goitre rates.

Given that 5 years have passed since the implementation of mandatory fortification, it would be appropriate to conduct a study to reassess all of these indicators in a similar population.

2.9.3 Serum TSH

As mentioned in Section 2.4.3, an iodine sufficient population is one in which there is <3% frequency of *neonatal* TSH levels >5 mIU/L (WHO/UNICEF/ICCIDD 2007). More recent research has led to the proposal of trimester-specific *maternal* TSH thresholds to diagnose subclinical hypothyroidism during pregnancy (Eastman 2012; Gilbert et al. 2008; Stagnaro-Green et al. 2011). In the absence of laboratory trimester-specific TSH thresholds, the recommendation for the upper limit for maternal TSH in the first trimester is 2.5 mIU/L, and 3.0 mIU/L for second and third trimesters (Stagnaro-Green et al. 2011) (Table 2.4).

Studies conducted pre-fortification of bread and bread products–maternal TSH

Four studies across two states and NZ investigated maternal TSH levels as an indicator of thyroid function in pregnant participants prior to iodine fortification of bread and bread products.

Maternal TSH levels of 70 consecutive participants (approximately 30 weeks gestation) in Northern Sydney (Gunton et al. 1999) were determined and compared to those who were classified as having normal iodine status, mild deficiency or moderate-to-severe deficiency based on WHO 1994 urinary excretion reference ranges. TSH levels across all iodine status subgroups in the pregnant participants did not exceed 1.67 ± 0.9 μIU/ml, were within the reference ranges recommended in the Guidelines of the ATA (Stagnaro-Green et al. 2011) and indicated that thyroid function (based on TSH) did not appear to be affected despite urinary measures suggesting iodine deficiency (of varying degrees) in the participants. This highlighted the insensitive nature of maternal serum TSH levels in determining iodine status of pregnant women as described in Sections 2.3.3 and 2.4.3.

A second Sydney study (North Western Sydney) conducted almost a decade later (Blumenthal, Byth, and Eastman 2012) (Table 2.6) found that 6.5% of the 367 first trimester participants had serum TSH > 2.5 mIU/L indicating gestational subclinical hypothyroidism in the first trimester according to the Guidelines of the ATA (Stagnaro-Green et al. 2011). The influence of time on the differing results needs to be acknowledged. It has been documented that the population iodine status in Australia changed from iodine sufficient in 1992 (Li et al. 2008) to mildly deficient by 2007-2009. The larger sample size in the second study and difference in gestational stage of the participants also needs to be taken into consideration.

A lower percentage (2.6%, n=4) of the 154 NZ participants (Pettigrew-Porter et al. 2011) were similarly hypothyroidic as assessed by TSH. It should be noted that the sample size of this study was smaller than the Sydney studies, women across all trimesters were sampled (Table 2.6) and the previously explained differences between Australian and NZ make comparisons difficult to interpret.

Although the aim of a 2006 WA study by Gilbert et al. (2008) was not specifically to study the iodine status of 2159 first trimester pregnant women, the results are worth noting given the paucity of information relating to the iodine status of pregnant women in this state. The reference group (n=1817) used to derive a first trimester reference range consisted of consecutive pregnant women from both regional and metropolitan areas (excluding those with thyroid autoimmunity) who attended their first trimester screening in Western Diagnostic pathology laboratories over a two month period.

The reported-derived reference range for maternal TSH in eligible women (n=1817) in their first trimester of pregnancy was 0.02-2.15 mIU/L, within the reference range of 5 out of 6 studies assessed in the Guidelines of the ATA (Stagnaro-Green et al. 2011) and the recommendation of first trimester reference range of 0.1-2.5 mIU/mL in the absence of laboratory specific values (Table 2.4). The median TSH concentration was 0.78 (0.03, 2.78) and within the reference range proposed by the ATA (Stagnaro-Green et al. 2011) indicating adequate iodine status (based on TSH) for first trimester pregnant women in WA compared to the findings from the Sydney study indicating subclinical hypothyroidism in their study population (Blumenthal, Byth, and Eastman 2012).

Studies conducted post-fortification of bread and bread products–maternal TSH

Condo et al. (2015) measured maternal TSH following the fortification of bread with iodine in 96 subjects at 28 weeks gestation in a SA study conducted in 2011-2012. Mean maternal TSH level was 1.53 (± 0.10) mIU/L , within the manufacturer's non-pregnant reference ranges as well as the third trimester-specific reference range of 0.3-3 mIU/L (Stagnaro-Green et al. 2011). These findings indicated adequate iodine status in participants (based on mean TSH level).

Studies conducted pre-fortification of bread and bread products–neonatal TSH

McElduff et al. (2002) reported a prevalence of 8.1% (n=1316) and 5.4 % (n=1457) of neonates with TSH >5 mIU/L in two population samples in Northern Sydney during 1998 and 1999, indicative of an iodine deficient population. A different conclusion was drawn from a 2004 study conducted by Travers et al. (2006) in the Central coast area of NSW that found that only 2.2% of neonates (n=824) had TSH levels >5 mIU/L. Differences in sample size, study methodology, year of study, sample demographics, time of heel-prick samples and assay methods in neonates is likely to account for at least some of the differences in findings between these NSW studies.

Private or public hospital status of neonates born to mothers attending Royal North Shore hospital in Sydney was not reported in the study conducted by McElduff et al. (2002). The authors acknowledged that although some neonatal blood samples were drawn on day 3, this could have been before 72 hours in some babies born in the morning, hence overestimating neonatal TSH levels. Travers et al. (2006) sampled neonates born to mothers attending both public and private antenatal clinics (including NESB women) and similarly, timing of neonatal blood samples was problematic. Time of birth was only ascertained for neonates born in the public hospital and most of those samples were collected before 72 hours of birth.

All of the studies investigating neonatal and maternal TSH levels were conducted prior to the mandatory fortification of bread and bread products with iodine. The findings from the McElduff et al. (2002) (Sydney) show >3% frequency of neonatal TSH levels >5 mIU/L, indicating iodine insufficiency in the study population, whilst a study conducted in the NSW central coast area 5-6 years later reflected iodine sufficiency (<3% frequency of neonatal TSH levels >5 mIU/L) (Travers et al. 2006). Possible reasons for the differing results are mentioned above, in addition, these studies highlight that iodine status of populations within regions of the same state (two coastal regions) can vary.

It is interesting to note that the maternal TSH levels of participants at approximately 30 weeks gestation in the Gunton et al. (1999) study did not reflect iodine insufficiency of the group (MUIC reflected iodine deficiency) whilst neonatal TSH levels over a similar time period, in the same location (Northern Sydney), indicated iodine insufficiency. Moreover, an unexpected weak positive relationship ($r=0.26$, $p=0.02$) was reported by McElduff et al. (2002) when neonatal TSH levels of 84 participants were correlated to the maternal UIC (paired) from the study conducted by Gunton et al. (1999). Given the sample size and the problems associated with using UIC as an individual marker of iodine status, the correlation remains questionable until reproduced on a larger sample.

Studies assessing maternal TSH levels showed mixed results with 6.5% of the participants in the 2007-2009 North Western Sydney study (Blumenthal, Byth, and Eastman 2012) and 2.6% of pregnant women in the 2005 New Zealand study (Pettigrew-Porter et al. 2011) diagnosed with gestational subclinical hypothyroidism. The findings from two Northern Sydney studies (Gunton et al. 1999; McElduff et al. 2002) reported maternal TSH levels within normal ranges, despite UIC and neonatal TSH indicating iodine deficiency.

Maternal TSH results from a WA study (Gilbert et al. 2008) suggested that participants in this study were iodine sufficient (in the absence of UIC). Further studies assessing neonatal and maternal TSH following the mandatory fortification of bread with iodine would assist with population and regional monitoring and comparisons (pre- and post-fortification), given that all current studies assessing these measures were conducted pre-fortification.

2.9.4 Serum Tg

Studies conducted post-fortification of bread and bread products

Only two studies measured serum Tg (and anti-thyroglobulin antibodies), both were post-fortification. Brough et al. (2015) measured serum Tg (and anti-thyroglobulin antibodies) in a self-selecting sample of pregnant and breastfeeding women living in Palmerston North (NZ) (Table 2.6). A small sample of pregnant women post-fortification (n=34) had a median Tg of 15.9 ug/L, however similar levels were reported in euthyroid women in the United States (Mitchell et al cited in Brough et al. 2015) with no correlation between Tg concentration and UIC or iodine supplement use. Condo et al. (2015) reported mean serum Tg within non-pregnant reference ranges for pregnant women in a 2011-2012 SA study (17.9 ± 1.4 ng/ml) (reference range=0-59 ng/ml). The use of serum Tg as a sole indicator of iodine status, as mentioned previously, is limited, as described in Section 2.4.4.

2.9.5 Free thyroxine (FT4)

Five studies conducted in NSW, WA, SA and NZ measured FT4 concentrations.

Studies conducted pre-fortification of bread and bread products

Gunton et al. (1999) (Northern Sydney) reported TSH and FT4 concentrations in 70 pregnant women classified by iodine status subgroup according to urinary excretion. Those with severe-to-moderate iodine deficiency had the lowest FT4 concentration (12.9 ± 3.70 pmol/L) compared to the mildly iodine deficient group (12.5 ± 3.00 pmol/L) and those with normal iodine status (12.1 ± 2.25 pmol/L) (Table 2.6) although the findings were not significant.

Similarly, a North Western Sydney study (Blumenthal, Byth, and Eastman 2012) found no significant association between FT4 and UIC in their sample of first trimester pregnant women, even when those with UIC < 50 ug/L were compared with participants who had UIC > 100 ug/L. TSH concentration and FT4 levels were found to be inversely associated ($r=-0.490$, $p < 0.001$) which is to be expected given the thyrotropic effect of high concentrations of hCG in the first trimester (leading to an increase in maternal FT4) that, in turn, leads to a transient depression of maternal TSH (Morreale de Escobar, Obregón, and del Rey 2007; Skeaff 2011). The mean FT4 concentration reported in this study was 15.4 (± 2.7) pmol/L and was well within the trimester-specific references range for the first trimester (7.4-18.9 pmol/L) (Soldin 2006).

Pettigrew-Porter et al. (2011) (NZ) reported a median FT4 concentration of 14.2 pmol/L (within the normal reference range). It is worth noting that 15% of women in their third trimester were reported to have low FT4 concentration (<10.3 pmol/L) when kit-specific reference ranges were applied. The authors acknowledged the limitations of FT4 and the likelihood of overestimation of low FT4 concentrations of those in their second and third trimesters.

In the WA study conducted by Gilbert et al. (2008), reference ranges were derived for thyroid hormones in pregnant women in their first trimester. The mean FT4 concentration was 13.5 pmol/L (2.1) which was part-way between the NSW and NZ concentrations reported in studies by Gunton et al. (1999) (NSW), Blumenthal, Byth, and Eastman (2012) (NSW) and Pettigrew-Porter et al. (2011) (NZ). The reference range (10.4-17.8 pmol/L) ascertained in this WA study did not differ substantially from the laboratory-specific reference range of 9-19 pmol/L.

Studies conducted post-fortification of bread and bread products

One study assessed FT4 concentration in a sample of 96 pregnant women in SA (Condo et al. 2015). The mean FT4 concentration at 28 weeks gestation (11.95 ± 0.14 pmol/L) was within non-pregnant normal reference ranges reported in the study. The mean FT4 value was also within the reference range for third trimester (8.3–15.6 pmol/L) (Soldin 2006), which was not unexpected given that the MUIC was the highest out of all of the studies.

In summary, FT4 was not used as a single measure of thyroid function in any of the studies above, presumably due to the limitations described in Section 2.4.5. The use of different reference ranges (i.e. kit-specific or laboratory) makes it difficult to compare the above studies, as does differing assay methods, sample sizes and gestational stages of participants.

Comparing the results to Soldin's reference ranges; 3.7–23.4 pmol/L for the first trimester, 7.4–18.9 pmol/L for the second trimester, 8.3–15.6 pmol/L for the third trimester, it is unlikely that even those with moderate-to-severe iodine deficiency (assessed by UIC) in the above studies would have been identified as being at risk of iodine deficiency based on abnormal FT4 levels alone. This reinforces the fact that FT4 is not a reliable indicator of iodine status in isolation.

2.10 Maternal iodine knowledge and beliefs

Little is known about the iodine related knowledge and beliefs of pregnant women living in Australia and NZ, with only 8 studies identified between 1980 and 2014 (Brough et al. 2015; Charlton et al. 2012; Charlton et al. 2010; El-mani, Charlton, et al. 2014; Lucas et al. 2014; Mallard and Houghton 2014; Martin, Savige, and Mitchell 2014; Rahman et al. 2011).

2.10.1 Knowledge of iodine-related topics

Australia

A pre-fortification study conducted in the Illawarra region of NSW in 2008 (Charlton et al. 2010) provided useful insight into the knowledge of pregnant women across all trimesters with regards to iodine. Less than a third of the participants (n=139) attending a public antenatal clinic were able to identify the correct health effects as a result of insufficient iodine. Comparative results from the post-fortification study, conducted on 147 pregnant participants attending a public antenatal clinic in the same region in 2011-2012 (Charlton et al. 2012) found that the majority of correct responses on the same topics decreased or remained the same, indicating that overall, there was no significant increase in knowledge relating to iodine and pregnancy adverse effects in women before and after fortification. Factors such as age, number of pregnancies and education did not significantly affect iodine knowledge in the pre-fortification study (Charlton et al. 2010).

El-mani, Charlton, et al. (2014) (Table 2.6) conducted a study in the same region (including women attending private obstetrician's clinics) and reported similar results with less than a third of the participants able to select the correct answers regarding health effects and iodine deficiency. Unlike the previous studies, the authors found that those with higher education levels and with greater household incomes had better knowledge (relating to the question). More recently, Lucas et al. (2014) also reported poor iodine knowledge in pregnant women in the Illawarra region (Table 2.6) despite a higher percentage who were able to identify malformations in pregnancy (46%), goitre (39 %) and impaired physical development (32%) (approximately), when compared to the pre-fortification study (Charlton et al. 2010).

A Victorian cross-sectional study of 200 women in their third trimester also indicated limited knowledge (Martin, Savige, and Mitchell 2014). Approximately 45% of women were unaware of the need for increasing their intake of iodine and one-third (32.5%) of subjects were unaware of good food sources of iodine.

The 2008 and 2011-2012 Illawarra studies (Charlton et al. 2012; Charlton et al. 2010), 2012-2013 study (El-mani, Charlton, et al. 2014), 2012-2013 study (Lucas et al. 2014) and 2011-2012 study (Martin, Savige, and Mitchell 2014) were the only studies that investigated the participants' knowledge of iodine-rich food sources, which was found to be inadequate pre- and post-fortification. Whilst fish and seafood are considered to be rich sources of iodine, only around 26-60% of participants in these studies correctly identified these foods. Half of the participants in the Illawarra studies (51%) pre- and post-fortification identified salt as a good source of iodine (Charlton et al. 2012; Charlton et al. 2010), similar percentages were reported in studies conducted by Lucas et al. (2014) and Martin, Savige, and Mitchell (2014). Approximately one quarter of participants (pre- and post-fortification) selected milk as a good source of iodine (Charlton et al. 2012; Charlton et al. 2010), comparable to the latest study by (Lucas et al. 2014). Eggs were correctly identified by between 23%-31% (Charlton et al. 2012; Charlton et al. 2010; El-mani, Charlton, et al. 2014; Lucas et al. 2014).

Charlton et al. (2012), Lucas et al. (2014) and El-mani, Charlton, et al. (2014) reported that less than a third of participants identified bread in their post-fortification studies. Furthermore, approximately 16% of subjects in the SA study (Martin, Savige, and Mitchell 2014) were aware of the mandatory iodine fortification of bread, followed by 11.5% in NSW (El-mani, Charlton, et al. 2014) and 5% of the participants in the NSW study by Charlton et al. (2012).

New Zealand

Brough et al. (2015) reported low knowledge of iodine deficiency and recommendations for iodine supplement use in their NZ (Palmerston North) study of breastfeeding and pregnant women of ≥28 weeks gestation- pre-fortification (2009) and post-fortification (2011) (Table 2.6). Sixty eight percent of the 2009 sample identified that iodine deficiency was a problem compared to 41% in 2011. The awareness of NZ government initiatives to address iodine deficiency (the mandatory iodine fortification of bread in 2009 and a government subsidised iodine supplement program for pregnant and breastfeeding women from July 2010) was low. Approximately half of the pregnant women in 2011 were aware of the subsidised iodine supplement initiative, whilst 5 pregnant women (15%) in the post fortification sample were aware of the mandatory bread fortification (Brough et al. 2015).

One of the major limitations of this study relates to the small sample sizes of pregnant women in both 2009 and 2011. Comparisons between studies from Australia and NZ need to be made with caution due to various geographical factors (as described in Section 2.9.1) that are likely to contribute to differing knowledge, beliefs and status of participants in these countries. Despite this, the overall findings of low knowledge in this NZ study concur with the results of other Australian studies (Charlton et al. 2012; Charlton et al. 2010; El-mani, Charlton, et al. 2014; Lucas et al. 2014; Martin, Savige, and Mitchell 2014; Rahman et al. 2011).

2.10.2 Beliefs and sources of information regarding iodine-related topics

Australia

Only 17% of women in the 2008 pre-fortification study (Charlton et al. 2010) believed that they had received enough information to make informed decisions regarding iodine versus 80% for iron and 72% for folate. A significant improvement occurred post-fortification whereby 34 and 32% of the participants in the 2011 and 2012 post-fortification studies believed that they had received enough information regarding iodine (Charlton et al. 2013). Interestingly, the percentage who felt that they had received enough information almost doubled (61.1%) in another NSW study post-fortification study (El-mani, Charlton, et al. 2014), three-fold the pre-fortification results in the study conducted by Charlton et al. (2013), suggesting an improvement in the participant's perception of having obtained enough information despite overall poor knowledge on the topic.

Approximately 49% of women in the 2011-2012 Illawarra studies (Charlton et al. 2012) reported that they had received information on iodine related topics. Similarly, unpublished results from the study conducted by Lucas et al. (2014) suggest that 46% of women had received information on iodine related topics.

These results raise three immediate concerns; 1) an ongoing lack of awareness by health professionals of the need to educate women on the importance of iodine during pregnancy, as well as 2) an ongoing lack of public health education (Charlton et al. 2013) in areas where iodine deficiency during pregnancy has been shown to be prevalent, and 3) the discordance between women receiving information on iodine related topics and their belief that they have received enough information to make informed decisions regarding iodine. These three factors are likely to influence iodine related behaviours (e.g. use of iodine-containing supplements, iodised salt use and intake of iodine-rich foods).

Of the women participating in the 2008 Illawarra study, approximately 16% obtained written nutrition information regarding iodine from a healthcare professional, with approximately 7% obtaining information verbally (Charlton et al. 2010). Approximately 12% of participants in the 2011 Illawarra study obtained nutrition information regarding iodine via written communication from a healthcare professional versus approximately 37% who received this information verbally from a health professional (Charlton et al. 2012). Possible explanations for the increasing trend in verbal communication on iodine related topics could be due to; increased knowledge of health professionals with regards to the importance of iodine in pregnancy and, or improvements in opportunities to provide verbal education.

Most participants (74%) in the Charlton et al. (2010) pre-fortification study did not know if their diet provided enough iodine. In the 2012 post-fortification study it was reported that 74% of participants did not know if their diet provided enough iodine for their own needs and 80% did not know if their diet provided enough iodine for their unborn child's needs (Charlton et al. 2013). The percentage of women who did not know if their diet provided enough iodine for their own needs (53%), or for their unborn child's needs (58%) decreased in the study conducted by Lucas et al. (2014). Again, suggesting an improvement in the participant's perception (of meeting their iodine requirements).

These studies were cross-sectional convenience samples and women from NESB were excluded. The studies were region specific, limiting the generalizability of the results to other states or other regions within the same state. The validated survey instrument was kept consistent between studies (Charlton et al. 2012; Charlton et al. 2013; Lucas et al. 2014), however, as with all self-reported questionnaires, participant responses were subject to self-report bias (Charlton et al. 2012). This knowledge and awareness perspective requires further investigation in other states, preferably in studies with larger sample sizes and the inclusion of NESB participants.

A smaller Victorian post fortification study (Rahman et al. 2011) (Table 2.6) found that only a third of pregnant women reported hearing about the importance of iodine and a similar number of participants had received advice from doctors about taking iodine containing supplements. This study, also a cross-sectional study, had the advantage of including both hospital antenatal clinic participants and those from private obstetrician clinics in Gippsland. It should be noted that all participants were ≥28 weeks gestation, therefore the majority of these women had proceeded to their third trimester without knowing about the importance of iodine, and without any formal communication regarding iodine supplementation from a doctor.

A cross-sectional study conducted in Gippsland (Martin, Savige, and Mitchell 2014) on 200 pregnant women in their third trimester reported that around 40% of participants did not believe it necessary to take an iodine-containing supplement if they had a healthy diet during pregnancy. A similar percentage (34.3%) had received iodine information from a medical practitioner, with the media, midwives, family and friends named as other common sources of information.

There is a clear consensus from the authors of the studies conducted in regions of NSW (Charlton et al. 2012; Charlton et al. 2010; Charlton et al. 2013; El-mani, Charlton, et al. 2014; Lucas et al. 2014); Vic (Martin, Savige, and Mitchell 2014; Rahman et al. 2011) and NZ (Brough et al. 2015) that knowledge and awareness of the importance of iodine during pregnancy and of the initiatives to address the problem of iodine deficiency is lacking in pregnant women. Whilst some improvements have occurred post-fortification, it is apparent that these improvements do not translate to better overall knowledge especially when compared to other nutrition-related topics (Charlton et al. 2012) such as iron and folate. More recent publications (El-mani, Charlton, et al. 2014; Lucas et al. 2014) have focused on the lack of awareness of health professionals and the importance of their role in the provision of education and advice on iodine related topics to women as part of their antenatal care. These findings highlight that consideration of the complexities of addressing improvements in knowledge are not only needed for pregnant women.

2.11 Dietary iodine consumption and iodised salt use

2.11.1 Dietary iodine consumption

Australia

Ten studies assessed dietary iodine intake (Blumenthal, Byth, and Eastman 2012; Brough et al. 2015; Charlton et al. 2012; Charlton et al. 2013; Condo et al. 2015; Lucas et al. 2014; Mallard and Houghton 2014; Martin, Savige, and Mitchell 2014; Nguyen et al. 2010; Pettigrew-Porter et al. 2011; Rahman et al. 2011) with seven of these studies estimating participant daily iodine intake (ug) (Blumenthal, Byth, and Eastman 2012; Brough et al. 2015; Charlton et al. 2013; Condo et al. 2015; Lucas et al. 2014; Mallard and Houghton 2014; Pettigrew-Porter et al. 2011) (Table 2.7).

Blumenthal, Byth, and Eastman (2012) (NSW) estimated the mean daily iodine intake of pregnant women (n=367) (pre-fortification) using a method of extrapolation from UIE. The derived estimate of daily iodine intake was 132 ug/day, which was below the EAR for pregnant women (160 ug/day). This study also utilised a FFQ, limited to milk, dairy and fish consumption to determine associations between the consumption of these three iodine food sources and UIC. Out of these food sources, only milk was reported to significantly increase UIC (p=0.035) when UIC subgroups were tested for homogeneity across categorical milk consumption data.

Two to three years post-fortification in another NSW study (Illawarra), Charlton et al. (2013) reported mean daily iodine intake of 176 (92) ug/day (2011) and 160 (80) ug/day (2012) using an iodine-specific, validated, self-administered FFQ to calculate mean dietary intake. Estimated intakes after additional adjustments were made for the inclusion of iodine in bread were 211 (98) ug/day (2011) and 193 (86) ug/day (2012). The results were in accordance with the 2003 ALSWH food frequency data projected onto the 1995 NNS for total iodine intake for pregnant women (167 ug/day) (Mackerras et al. 2011). Major contributors to iodine intake in the 2012 NSW study (Charlton et al. 2013) were milk and dairy foods (58%), cereals including bread (20%), tap water (8%), with seafood and eggs only contributing 3% to estimated daily iodine intake.

Table 2.7 Studies reporting dietary iodine intakes of pregnant women in Australia and New Zealand (1980 to present)

Author (Date of publication) Date of study	State or Territory	Sample Size (n)	Gestational stage (wk)	Diet I (ug)
Pettigrew-Porter et al. (2011) 2005	NZ	170	All	48 (FFQ)
Blumenthal et al. (2012) 2007-2009	NSW	367	7-11	132 *Extrapolated*
Brough et al. (2013) July 2009 pre iodine fort. Jan-Sept 2011 post iodine fort	NZ	57 25 32	> 26	119 217 *Extrapolated*
Charlton et al. (2013) 2011 2012	NSW	147 114	All	211 (FFQ) 193 (FFQ)
Mallard & Houghton (2013) 2011	NZ	723	All	107 (Prior preg) 179 (Preg) *Baseline assignment*
Condo et al. (2015) 2011-2012	SA	96	< 20	144 (FFQ) 160 (4d WR)
Lucas et al. (2014) 2012 and 2013	NSW	142	All	189 (FFQ)

Lucas et al. (2014) (Table 2.7) used the same iodine-specific, validated, self-administered FFQ to calculate median dietary intake of participants in the Illawarra region. They reported the highest estimated dietary iodine of 189 (129-260) ug/day, however 38% of participants did not meet the EAR. Dairy foods and bread and cereals contributed the most to overall iodine intake of the participants (52% and 18%), respectively, with minimal contribution from fish and seafood (7%).

In 2011-2012 (Condo et al. 2015) assessed iodine intake of study participants using a validated iodine-specific FFQ (at two time points) and a four day weighed food record. The mean iodine intakes were 144 (52) ug/day and 160 (54) ug/day, respectively, indicating borderline sufficiency/adequacy. It should be noted that iodine from iodised salt was not quantified and therefore not included in these figures.

The two remaining Australian studies did not quantify daily iodine intake but reported on the consumption of various iodine food sources. Rahman et al. (2011) found that 95% of participants in the Gippsland study reported consuming milk, milk products and bread fortified with iodine regularly. Seafood, seaweed, sushi contributed minimal amounts to overall dietary iodine intake with only 9% of participants consuming these foods. The second study conducted in Canberra gave limited information relating to dietary intake, however findings from previous studies were confirmed with regards to the low dietary intake of fish and sushi (Nguyen et al. 2010).

New Zealand

A study conducted in NZ in 2005 on 170 pregnant women (pre-fortification) (Pettigrew-Porter et al. 2011) (Table 2.7) assessed dietary intake via an iodine-specific, semi-quantitative, self-administered FFQ. The reported mean daily iodine intake was 48 (23) ug/day, well below the EAR for pregnant women (160 ug/day). Fish and seafood consumption was low with only 38% of participants consuming fish once a week and 77% never consuming other types of seafood.

Mallard and Houghton (2014) reported findings from a postpartum survey conducted across eleven maternity wards and hospitals in NZ in 2011 (n=723). Unlike other studies, iodine from food was determined by the baseline assignment of 60 ug/day (based on 2003-2004 NZTDS) to all subjects, with a further 48 ug/day of iodine assigned to those who used iodised salt. The mean iodine intake prior to pregnancy was estimated to be 107 ug/day and 179 ug/day during pregnancy, figures that were well above the 2005 NZ study (Pettigrew-Porter et al. 2011) and indicated adequate iodine intake during pregnancy in this population. The results for pregnant women (post-fortification) were part-way between the 2005 NZ study and findings from the study conducted by Brough et al. (2015).

Brough et al. (2015) (Palmerston North) reported that the mean estimated daily iodine intake based on extrapolation from 24-h urinary excretion was below the EAR in 2009 (pre-fortification) in their 2011 study. The majority of women (73%) achieved the EAR post-fortification (2009: 119 ug/day (77) vs. 2011: 217 ug/day (87)), a significantly higher value than the pre-fortification estimated iodine intake ($p<0.001$). The pre-fortification result was higher than the estimated iodine intake reported in the 2005 NZ study (Pettigrew-Porter et al. 2011), possibly due to sample size differences (Table 2.7), different methods of estimating iodine intake (estimation from FFQ versus extrapolation from urinary excretion), timing of studies, location within NZ and socio-demographic variances, in addition to possible increases in non-local food supply between 2005-2009 and changing dietary trends.

2.11.2 Iodised salt use

Eleven studies reported the percentage of iodised salt use in pregnant women (Blumenthal, Byth, and Eastman 2012; Brough et al. 2015; Charlton et al. 2012; Charlton et al. 2010; Charlton et al. 2013; Condo et al. 2015; El-mani, Charlton, et al. 2014; Lucas et al. 2014; Martin, Savige, and Mitchell 2014; Nguyen et al. 2010; Pettigrew-Porter et al. 2011; Rahman et al. 2011) (Table 2.6).

Data capturing iodised salt sales in Australia indicated that 11% of households purchased iodised salt in 2003, followed by a 29% increase between 2003 and 2006 (Li et al. 2007) due to media coverage. The majority of studies that investigated iodised salt use confirmed that 50% or less of the participants consumed iodised salt; 21% pre-fortification (Blumenthal, Byth, and Eastman 2012) (NSW), 40% pre-fortification vs. 49% post-fortification (Charlton et al. 2012; Charlton et al. 2010) (NSW), <34% pre-fortification (Nguyen et al. 2010) (ACT), 50% pre-fortification vs. 32% post-fortification (Rahman et al. 2011) (Vic), 38% post-fortification (Brough et al. 2015) (NZ), 47% post-fortification (Condo et al. 2015) (SA); 19.5% post-fortification (Martin, Savige, and Mitchell 2014) (Vic) 45.6% post-fortification (El-mani, Charlton, et al. 2014) (NSW) and 50% post-fortification (Lucas et al. 2014) (NSW). It was difficult to establish if the percentages reported related to daily iodised salt use, which limits further interpretation.

A NZ study (Pettigrew-Porter et al. 2011) provided further detail, reporting iodised salt consumption at the table (60%) and in cooking (73%) separately, however only a quarter of participants used iodised salt at least once a day. The most recent study from the Palmerston North, NZ (Brough et al. 2015) found that although 88% and 79% of participants had access to iodised salt at home (pre- and post-fortification, respectively), only 38% exclusively used iodised salt. These findings highlighted that iodised salt use amongst this population can be sporadic and not exclusive, even when readily available.

Many factors influence the accuracy of these results and limit comparisons between studies. The depth of questioning on the topic varied (i.e. frequency of consumption, general use, discretionary use, use in cooking, quantities and exclusive use). Equally as important to acknowledge is that iodised salt use will naturally vary between countries and states (and within states) due to differences in geographical location, public education strategies, traditions, iodised salt availability, individual perceived risk, education levels and other socioeconomic factors.

Summary of estimates of iodine intake

The method used to estimate intake (i.e. extrapolation based on UIE, baseline assignment of iodine or values obtained from food frequency data) limits the generalisability of these findings to other populations. In addition, the FFQ used varied between most of these studies, with the exception of Charlton et al. (2012); Charlton et al. (2013); Lucas et al. (2014). Despite being based on the same nutrient, (i.e. iodine), differing food lists and quantities places limitations on comparisons between populations (i.e. states in Australia and NZ).

In summary, the estimated mean daily iodine intake was found to be inadequate (based on EAR for pregnant women=160 ug/day) in 2 pre-fortification studies (Pettigrew-Porter et al. 2011) (North and South Island, NZ), (Blumenthal, Byth, and Eastman 2012) (North Western Sydney, NSW), in the pre-fortification subset in the study conducted by Brough et al. (2015) (Palmerston North, NZ) and in the value determined via FFQ only in the post-fortification study by Condo et al. (2015) (Adelaide, SA). The majority of post-fortification estimated daily iodine intake results indicated adequacy (Table 2.7).

Whilst it is difficult to establish whether these improvements were due to mandatory fortification of bread and bread products, increased iodine supplement use, iodised salt use or a combination of factors, there is a general shift from insufficient iodine intake toward adequate iodine intake in NSW, NZ and SA. Dietary consumption of iodine-containing foods and iodised salt use has not been reported in pregnant women in recent years in Tas or NT and to the author's knowledge, not reported at all in pregnant women in Qld or WA. Further investigation in these states would prove useful from a monitoring and surveillance perspective (and to provide initial data regarding dietary intake and iodised salt use in Qld and WA, the two states that have traditionally been reported as iodine sufficient).

2.12 Iodine-containing supplement use

The 2010 NHMRC recommendation that women who are pregnant, considering pregnancy or breastfeeding take an iodine supplement of 150 ug daily (National Health and Medical Research Council 2010) was based on national studies conducted on pregnant women in south eastern Australia, results of the 2004 NINS, FSANZ 1995 Total Diet Survey results and international findings (Food Standards Australia New Zealand 2008c). Similar recommendations by WHO, ICCIDD and ATA were already established in other countries around the world.

Consistent with the recommendation, use of dietary modelling by Mackerras and Eastman (2012) estimated a gap of 100-150 ug iodine intake in Australian women aged 19-44 years, even after the introduction of mandatory fortification of bread and bread products with iodine. It should be noted that pregnant women in WA and Qld were not represented (Mackerras and Eastman 2012) in one of two phases of dietary modelling due to a lack of studies on iodine status in pregnant women in these states at the time.

Iodine-containing supplement use in pregnant women was investigated in 13 out of 20 of the studies (Table 2.6). Iodine supplement use in these studies (conducted during 2005-2013) ranged from 20% to 75%.

Four of these studies (Blumenthal, Byth, and Eastman 2012; Charlton et al. 2010; Nguyen et al. 2010; Pettigrew-Porter et al. 2011) were conducted prior to the mandatory fortification of bread and bread products with iodised salt and prior to the release of the NHMRC recommendation for Iodine Supplementation During Pregnancy in Australia. These studies reflected a lower percentage of iodine supplement use in their participants (32.5%, 20%, 34% and 23%, respectively) than in the more recent post-fortification studies conducted by Brough et al. (2015), Charlton et al. (2013), Clifton et al. (2013), Condo et al. (2015); El-mani, Charlton, et al. (2014); Lucas et al. (2014); Mallard and Houghton (2014); Martin, Savige, and Mitchell (2014); and (Rahman et al. 2011) (70%, 60-66%, 47%, 75%, 67.7%, 70%, 22-39%; 62% and 51-54%), respectively.

Studies conducted pre-fortification of bread and bread products

The NSW study conducted by Blumenthal, Byth, and Eastman (2012) had the largest sample size (n=367), however had limited generalisability due to the recruitment of the sample from one private obstetric clinic in North Western Sydney. Nearly half (48%) of the women taking part in the study had a tertiary education, thus it was assumed that most were well-educated and able to afford private obstetric care (Blumenthal, Byth, and Eastman 2012).

Approximately 72% of the subjects were taking a pregnancy vitamin supplement, however only 32.5% of these supplements contained iodine. The findings suggest firstly, that most pregnancy vitamin supplements at the time did not contain iodine and secondly, that pregnant women with a tertiary education and those likely able to afford daily iodine supplements were unaware of the importance of taking iodine containing supplements during pregnancy. This lack of awareness was to be expected, given that these studies were conducted prior to the mandatory fortification of bread and bread products with iodine and the release of the NHMRC recommendation for iodine supplementation.

The pre-fortification study conducted in NZ in 2005 (n=170) reflected a similar trend. The majority of women (79%) had either tertiary or postgraduate qualifications and 74% of responding subjects had a total household income > $50 000 (New Zealand Dollars) however, only 23% used an iodine supplement during pregnancy (Pettigrew-Porter et al. 2011). The overall generalisability of these findings was limited due to the underrepresentation of women with lower education levels, lower incomes and Maori/Pacific Island ethnic backgrounds. The study was also prone to self-selection bias due to the recruitment strategy used.

Two of the remaining pre-fortification studies (Charlton et al. 2010; Nguyen et al. 2010) were on smaller samples sizes than the previous studies. Nguyen et al. (2010) reported that 34% of pregnant women in the study (n=100) (Canberra) consumed iodine supplements. Broader application of these findings is limited due to the small sample size. The Illawarra study conducted on 139 pregnant women attending a public antenatal clinic (Charlton et al. 2010) reported the lowest iodine supplement use out of all pre-fortification studies (20%) (Table 2.6).

Overall, iodine supplement use amongst participants in the pre-fortification studies (attending both private and public health care facilities) was low (<50%). Charlton et al. (2010) provided some evidence for higher supplement use among those with tertiary education ($p=0.049$) and in those who were pregnant for the first time ($p<0.005$).

Studies conducted post-fortification of bread and bread products

Iodine supplement use (post-fortification) was reported in 9 out of 20 studies (Brough et al. 2015; Charlton et al. 2012; Clifton et al. 2013; Condo et al. 2015; El-mani, Charlton, et al. 2014; Lucas et al. 2014; Mallard and Houghton 2014; Martin, Savige, and Mitchell 2014; Rahman et al. 2011). Iodine supplement use was only reported in both pre-fortification and post-fortification groups by Rahman et al. (2011) and Charlton et al. (2013).

The study conducted in the Illawarra region of NSW in 2011-2012 (Charlton et al. 2013) (n=130) revealed an increase in iodine supplement use from 20% pre-fortification (in 2008) to 60% (in 2011) and 66% (in 2012). This study reported the second highest iodine supplement use out of all studies in this review and was one of two studies to report a MUIC > 150 ug/L (MUIC=166 ug/L for pregnant women sampled in 2012, n=95), indicating iodine sufficiency in the participants using iodine supplements post-fortification (2012 subset).

Findings from a later Illawarra study (El-mani, Charlton, et al. 2014) reflect that the majority of the participants were using supplements containing both iodine and folate (67.7%). The use of iodine supplements was very similar to the 2012 subset in the Charlton et al. (2013) study (66%). It should be noted that women attending private obstetrician's clinics and various other locations in the region were invited to participate in the study conducted by El-mani, Charlton, et al. (2014) whereas those in the Charlton et al. (2013) study were recruited from a single public antenatal clinic, suggesting similarities in iodine supplement use in participants regardless of the utilisation of public or private antenatal services, at least in this region.

The most recent NSW study in the same region as those above (Lucas et al. 2014) reported the joint second highest percentages of iodine supplement use (70%). The majority of participants were recruited from a public antenatal facility. Lucas et al. (2014) declared that this figure may have been over-reported due to the assumptions made when assigning iodine contents to supplements for which brand names were not specified by the participants. In contrast to the pre- versus post-fortification trend reported by Charlton et al. (2013), Rahman et al. (2011) found lower iodine supplement use in 62 Gippsland participants post-fortification (50%) versus pre-fortification (54%). The small sample size and the fact that this study was conducted in the 9 months leading up to fortification (January-September 2009) and immediately post-fortification (October 2009–February 2010) needs to be taken into consideration when interpreting these results. Results from a 2011-2012 study conducted in the same region on 200 pregnant women (Martin, Savige, and Mitchell 2014) indicated higher iodine-containing supplement use (62%).

Forty seven percent of pregnant women in an Adelaide study (Clifton et al. 2013) used iodine supplements, however it was not possible to differentiate between supplement use pre- and post-fortification. A second Adelaide study (Condo et al. 2015) reported the highest percentage of iodine supplement use (75%) however supplement use may have been influenced by the recruitment of women already involved in a study related to iodine.

Brough et al. (2015) reported that 70% of participants used iodine-containing supplements in 2011 (Table 2.6). Recruitment was via local newspapers, flyers, posters and a university website therefore the study was prone to self-selection bias, and therefore interpretation of the results needs to be made with caution, especially in light of lower reports in the NZ study conducted in the same year (22-39%) across 12 sites (Mallard and Houghton 2014).

At the present time, studies on iodine supplement use during pregnancy in women residing in WA and Qld (where the population iodine status is considered optimal) are limited. In 2002-2004 it was reported that none of the lactating participants in the Perth Infant Feeding Study II (n=587) reported taking iodine-containing supplements during pregnancy (Lee et al. 2012). It is worth noting that this study was designed for endpoints other than the assessment of iodine supplement use in pregnant women. Data collection occurred post-partum, with participants answering questions regarding iodine supplement use (during pregnancy) in retrospect during an era when iodine was not topical (and presumably not easily recalled). It can, however, be assumed that adequate iodine supplementation during pregnancy in this study population (pre-fortification) was minimal as pregnancy multivitamin supplements would not have contained the recommended amounts of iodine (Lee et al. 2012), if any iodine at all.

It is difficult to ascertain when iodine inclusion in pregnancy multivitamin supplements began. Gallego, Goodall, and Eastman (2010) reported that in July 2009 there were 18 pregnancy multivitamin preparations, of which 85% contained iodine of varying concentrations (38–250 ug/day). More recently with the results of their audit of five Australian based online pharmacies in early 2013, El-mani, Mullan, et al. (2014) discovered that only 18 out of 23 pregnancy specific multivitamin preparations contained iodine. Iodine content varied across the brands, ranging from 25-299 ug per capsule, tablet or vita gummy.

With the release of the 2010 NHMRC recommendation for iodine supplementation (150 ug/day) for women who are pregnant, planning a pregnancy or breastfeeding, it is likely that most manufacturers have, or plan to increase the iodine content of their pregnancy multivitamins to align with this recommendation. This is a feasible explanation for the increase in iodine-containing supplement use reported in the post-fortification studies, especially as the knowledge and awareness of the importance of iodine during pregnancy remains minimal amongst pregnant women in Australia and NZ.

As mentioned previously, three of the more recent Australian studies reporting iodine sufficiency in study subgroups (based on MUIC) (Charlton et al. 2013; Clifton et al. 2013; Condo et al. 2015) also report higher iodine containing supplement use. It is likely that this trend reflects a shift in pharmaceutical manufacturers including iodine or increasing the iodine content of their pregnancy formulations and for the latter study may have also been due to sampling bias as mentioned in Section 2.9.1.

Gallego, Goodall, and Eastman (2010) highlighted factors such as the cost of supplements together with a lack of understanding of the importance of iodine during pregnancy as barriers to their use. Whilst not related specifically to iodine supplementation, it is worth noting that Barbour et al. (2012) (United Kingdom) identified factors such as supplement associated with morning sickness, forgetting to take the supplement, less perceived risk due to previous normal pregnancy, other health priorities and scepticism of the benefits of supplements as reasons for non-compliance with folic acid supplementation. A large Norwegian study based on the Norwegian Mother and Child Cohort Study (MoBa) found that pregnant dietary supplement users were more likely to be older, primigravid, non-smokers, of normal body weight and those with higher education levels (Haugen et al. 2008). It is not unreasonable to expect that these factors may also apply to iodine supplementation use (or non-use).

El-mani, Charlton, et al. (2014) reported a higher percentage iodine (and folate) supplement use in women with the highest household income versus the lowest ($p=0.001$) and although Mallard and Houghton (2014) did not confirm the specific sociodemographic indictors used, they reported that women who were less likely to take supplements as recommended were those who were the least advantaged. Results from the study conducted by Charlton et al. (2010) suggested significantly higher supplement use among those with tertiary education ($p=0.049$), as well as in women during their first pregnancy ($p<0.005$). Predictors of iodine supplement use reported by Martin, Savige, and Mitchell (2014) were twofold; general supplement use and knowledge (those who did not think that they consumed adequate iodine in their diet). Comparing the Australian results to a recent Danish study in which a higher level of maternal education was identified as a significant predictor of iodine-containing supplement use (Andersen et al. 2013) together with the results from the Norwegian MoBa study confirms similarities between Australian and some of the Nordic countries.

Whilst it appears that the use of iodine supplements has improved in NSW, Vic, SA and NZ, pre-fortification data is limited and little attempt has been made to obtain post-fortification data in other states. The post-fortification studies suggest that at least 50–75% of participants used iodine supplements, however, only three studies reported MUIC >150 ug/L in subgroups of their populations (Charlton et al. 2013; Clifton et al. 2013; Condo et al. 2015). Brough et al. (2015) (NZ), Condo et al. (2015) (SA) and Lucas et al. (2014) (NSW) reported the highest iodine supplement use out of the Australian studies, with Condo et al. (2015) reflecting the highest MUIC out of all of the studies.

2.13 Summary

Studies conducted in Australia and NZ over the last 15 years confirm that iodine deficiency in pregnant women is prevalent in regions of NT, ACT (pre-fortification of bread and bread products with iodine and the introduction of recommendations for iodine supplementation for pregnant and breastfeeding women and those planning a pregnancy) and in NSW, Vic, Tas, SA and NZ after the commencement of these initiatives. Only three authors reported iodine sufficiency (MUIC >150 ug/L) in women using iodine-containing supplements in their study samples (Charlton et al. 2013; Clifton et al. 2013; Condo et al. 2015).

Studies investigating iodine intake, knowledge and beliefs of pregnant women in Australia and NZ are limited in quantity, by number of participants and by incomplete coverage of all states and territories of Australia and areas of NZ. Eight studies have investigated iodine knowledge and beliefs of the study participants, and knowledge of iodine nutrition issues was found to be minimal (Brough et al. 2015; Charlton et al. 2012; Charlton et al. 2010; El-mani, Charlton, et al. 2014; Lucas et al. 2014; Mallard and Houghton 2014; Martin, Savige, and Mitchell 2014; Rahman et al. 2011).

The use of iodine-containing supplements varied substantially in the studies reviewed (20% to 75%). Minimal iodine supplement use during pregnancy is of concern in states with evidence of ongoing iodine deficiency in pregnant populations despite the introduction of bread and bread product fortification. Currently, it is not known if iodine supplementation is required by pregnant women living in WA and Qld (where the population iodine status is considered optimal).

It is clear from the literature that there is a paucity of research on iodine status, iodine intake, iodine-containing supplement use and iodine nutrition knowledge and beliefs of pregnant women in WA and Qld. This research project aims to begin to address this gap in the literature in pregnant women in WA.

CHAPTER 3 : METHODS

3.1 Overview of aims of the study

The primary aims of this study were to determine the knowledge of iodine nutrition (health effects, iodine-rich food sources); beliefs regarding iodine nutrition (participant-perceived consumption); use of an iodine-containing supplement (prior to and during pregnancy) and iodised salt use; as well as to estimate dietary intake of iodine of pregnant women in WA.

The secondary aims were to assess the reliability of an existing tool used to rank dietary iodine intake in pregnant women and to identify the potential of developing a rapid iodine screening tool to determine the women whose individual usual intakes are not likely to meet the EAR for iodine.

3.2 Study design

The study's aforementioned aims were addressed through the use of an observational, cross-sectional study design which involved subjects completing a 68-item self-administered paper-based questionnaire which included a 49-item FFQ (Section 3.4). A retest subgroup from the original sample repeated the FFQ section of the questionnaire (on a separate occasion) in order to address the reliability of the existing tool.

The study was approved by Curtin University Human Research Ethics Committee (Approval number HR125/2012) and the Women and Newborn Health Service Human Research Ethics Committee (Registration number 2048/EW).

3.3 Subjects

3.3.1 Recruitment of subjects

The recruitment of subjects was conducted by TH in King Edward Memorial Hospital (KEMH) East Wing Clinic (EWC) from 29 December 2012 to 16 July 2013. The antenatal clinics sampled were weekly medical-run clinics servicing WA women with medium to high risk pregnancies (referred by their General Practitioner (GP)) and included women attending a weekly Childbirth and Mental Illness clinic (women were referred by their GPs and other health organisations).

A pilot study to assess administration methods and time taken to complete the questionnaire was conducted in the EWC on 18 December 2012. Twenty eight questionnaires were returned during the 4-hour clinic and most subjects took less than 10 minutes to complete. Response rate was difficult to ascertain as the planned recruitment method (every woman receiving a questionnaire when checking in at the clinic desk) did not occur and therefore quantifying the number of women who declined or did not pick up a questionnaire was not possible. It was determined from this pilot that the recruitment strategy would be refined so that only TH would disseminate questionnaires and approach as many women as possible during the clinic (see process below).

Pregnant women attending the EWC from 29 December 2012 to 16 July 2013 were approached via face-to-face introduction and explanation of the research by TH. Information regarding the study (Appendix A) was provided to all women who were approached and they were given time to read the information, ask questions and sign the consent form if they agreed to participate (Appendix A). It was explained that participation was voluntary and subjects could withdraw from the study at any time.

Pregnant women at any gestational stage over the age of 18, of any nationality and/or linguistic background were eligible for inclusion in the study. Interpreters, translators or family members were asked to explain the study and to complete the questionnaire in consultation with consenting non-English speaking subjects. Food flashcard images from the Food for New Arrivals program (Association for Services to Torture and Trauma Survivors Incorportated n.d.) were adapted and available for use by TH and interpreters, translators and family members to help women identify foods that may not be recognised or commonly used in their culture.

Initially women who had diabetes (or history of diabetes/gestational diabetes) or active thyroid disease (or history of thyroid disease) were excluded. This was based on exclusion criteria of similar studies conducted in Australia (Clifton et al. 2013; Tan et al. 2013). However, despite screening questions being asked prior to questionnaire administration, some women answered yes to "*Have you ever been told by a doctor that you have thyroid disease/diabetes?"* in the questionnaire. After discussion with supervisors, it was decided that only those women who had active thyroid disease (taking medication for the disease) were to be excluded from the present study.

Subjects completing the initial questionnaire (FFQ1) (Appendix B) were asked if they would be willing to participate in the retest questionnaire (FFQ section only) (FFQ2) (Appendix C) at a different antenatal visit. Those who agreed were given a card stating their study identification number and the date and this card was presented at their next appointment for administration of the retest questionnaire. Women who did not have time to finish the questionnaire in the clinic were given a pre-paid envelope to return the completed questionnaire via post.

A resource entitled "Iodine in Pregnancy" prepared by KEMH Dietitians was provided on completion of the questionnaire to any women who had any concerns or questions regarding iodine.

3.3.2 Sample size

The final sample size for the initial administration of the questionnaire was determined primarily to provide sufficient statistical power to undertake test-retest analysis of the tool. The sample size for determining the number of test-retest subjects was estimated to be 46-86 to detect the difference between test and retest intraclass correlation coefficient (ICC) by 10-20% at a 5% significance level with 80% power. Recruitment was stopped when 69 subjects had completed the test-retest questionnaire because of time constraints for recruitment.

Sixty nine subjects completed the FFQ section of the questionnaire twice (retest group). Subjects agreeing to undertake the retest questionnaire approached TH with their study card (containing ID number and date of first questionnaire administration) and were given the retest questionnaire to complete. Three subjects were willing to complete the retest questionnaire but had lost their study cards, therefore they provided their date of birth and date of their last appointment to allow the matching up of birth dates and initial questionnaire to the retest questionnaire. Subjects could indicate on the retest questionnaire whether they thought that their intake had changed since they last completed the questionnaire and if so, they were requested to specify the reason for the change.

3.4 Data collection tool

This study utilised a 68-item questionnaire comprising of a 41-item iodine-specific FFQ (adapted from a tool validated by Tan et al. (2013) in the elderly). The questionnaire was a combination of work developed and used previously by Charlton et al. (2013) (NSW) and Edmonds (2013) (NZ) and was based on foods considered to have a relatively high level of iodine per 100g (using the NZ food composition database) or foods that had been previously identified as good sources of iodine in the NZ diet. The FFQ was tailored for the purpose of the study aims and the study population (see Table 3.1 for full documentation of adaptations and justification). Additions that improved the accuracy of reporting in this study were the options “I do not know” and “I do not know what iodine is” (Table 3.1).

The data collection tool was used to estimate dietary iodine intake (including iodised salt use), to identify frequency of consumption of important sources of iodine including cow's milk, bread and bread products, eggs, fish, shellfish and iodised salt over the previous two months, to assess iodine knowledge and iodine-containing supplement use (before and during pregnancy). Versions of this questionnaire have been used in iodine studies on pregnant women in NZ and NSW (Charlton et al. 2013; Edmonds 2013; Lucas et al. 2014).

Table 3.1 Modifications to original questionnaire from Charlton et al. (2013) and Edmonds (2013) for Perth Iodine and Pregnancy Study (PIPS)

Original item	Modification for present study	Justification
Are you planning on breastfeeding?	Item deleted	Not a primary aim of the study
How often in the last 2 months have you had fruit (fresh, canned or dried)?	Item deleted	Not a major source of iodine
Do you feel that your own diet provides enough iodine for your body's needs (i.e. when you are not pregnant)?	Addition of the option "I do not know what iodine is"	To encourage accurate reporting for those who did not know what iodine was
Do you feel that your own diet provides enough iodine for your body's needs (i.e. when you are pregnant)?	Addition of the option "I do not know what iodine is"	To encourage accurate reporting for those who did not know what iodine was
What type of salt do you mostly use at home?	Addition of the option "I do not know"	To encourage accurate reporting for those who did not know
How often do you add iodised salt during cooking?	Addition of the option "I do not know"	To encourage accurate reporting for those who did not know and to acknowledge that not all women would be responsible for cooking/ additions to cooking
How often in the last 2 months have you had a snack bar (muesli or fruit bar)?	Term "snack bar" replaced with the term "muesli or protein bar"	Muesli or protein bar likely to be a term that is more widely recognised in this population
If you eat chocolate, what is your usual serving size (i.e. compared to a Moro bar)?	"Moro bar" replaced with "Mars bar"	Mars bar likely to be a term that is more widely recognised in this population

Original item	Modification for present study	Justification
What ethnic group do you belong to? European, Chinese, Indian, Other (Dutch, Japanese, Tokelauan)	Main ethnic groups changed to Australian, Australian Aboriginal, Torres Strait Islander, Indian, Chinese, British	To reflect the Australian Standard Classification of Cultural and Ethnic Groups *
None	Addition of the item "Are there any foods that you have given up or stopped eating since you became pregnant?"	Investigation of the omission of rich iodine sources (e.g. fish and seafood)
None	Addition of the item "How often in the last 2 months have you eaten a dish or meal that has used packaged breadcrumbs"? + "If you add packaged breadcrumbs what would be the usual amount added per serve of the meal?"	To capture some data on breadcrumb consumption (potentially influenced by mandatory fortification of breadcrumbs manufactured from returned bread)

*(Australian Bureau of Statistics 2011)

The FFQ consisted of eight consumption options per food item:

- Never
- Less than one a month
- 1-3 times a month
- Once a week
- 2-4 times per week
- 5-6 times per week
- Once a day
- 2 or more times a day

Serve sizes were specific to each food item and generally, three options were allocated per food (e.g. 1 small egg, 1 medium egg, 1 large egg or ¼ cup, ½ cup, ¾ cup). In the instance that women ticked a serve size that was not an option (in-between, "more" or "less" than amounts allocated) an additional code was used to record the quantity (e.g. if women stated "less than" the minimum serve size a code was assigned that related to half of the minimum serve of that particular food item).

Items relating to age, obstetric history, current breastfeeding status, income, education level and health status regarding diabetes and thyroid function formed part of the questionnaire. In addition, women were asked to list current medications so as to identify and exclude women with active thyroid disease using thyroid medications such as thyroxine, or any other medications containing iodine.

3.5 Data entry and calculations

Questionnaire items were coded and data were entered into Statistical Package for the Social Sciences (SPSS) (IBM Corporation 2013) for data analysis. Information obtained from the FFQs was entered into FoodWorks (Xyris Software Pty Ltd 2009) based on AUSNUT 2007 (Food Standards Australia New Zealand 2008b), the Australian food reference database containing the most complete iodine data at the time. Each subject's estimated daily iodine intake (ug) was calculated separately, as described below:

- Gram weights per day were calculated per food item consumed (based on corresponding serve size multiplied by frequency of consumption per day) (Table 3.2)
- The resulting amount (in grams) was entered into FoodWorks for each subject per food item consumed and iodine values based on AUSNUT 2007 were automatically assigned
- Estimated food iodine intake (ug) was automatically summated in FoodWorks and was manually entered into SPSS
- Users of iodised salt, either in cooking or added at the table were distinguished from those who didn't use iodised salt or any type of salt and women who didn't know if the salt they used was iodised or not (Figure 4.3).
- Gram weights (for iodised salt use) per day were calculated based on the corresponding serve size multiplied by frequency of consumption per day.
- Estimated iodine values from iodised salt were entered into FoodWorks and amounts were separated when the subject used iodised salt both in cooking and at the table
- Iodine values from discretionary iodised salt use were entered as a combined value (iodine from food alone + discretionary iodised salt = dietary iodine intake) and as a separate value (discretionary iodised salt only) in SPSS (for iodised salt users)

- Iodine contribution from non-iodised or regular salt is minimal (0.2 ug/g) therefore salt was not entered unless it was iodised (approx. 44 ug per/g)
- A manual recipe for "Bread fortified with iodine" was established in FoodWorks using values automatically assigned for "bread, fresh, nfs (no further specifications)" combined with a manual override entry of 46 ug iodine per 100 g, as per FSANZ information for fortified bread (Food Standards Australia New Zealand 2012). This manual recipe was used to calculate the iodine content of all bread and bread products listed in question 41 (except for organic bread). One slice of bread (one small roll, one small pita) was equivalent to 32 g in weight (as per assigned weight in FoodWorks for one slice of "bread, fresh, nfs".
- The recipe calculation for "Bread fortified with iodine" was used to correct for iodine content for the women who consumed the greatest quantity of breadcrumbs (n=8). Grams of breadcrumbs were considered equivalent to grams of bread.
- Dietary supplements were further categorised into those containing iodine (based on the subject consuming at least one brand of supplement containing iodine), whilst the remainder of subjects were categorised as not using iodine-containing supplements (prior to and during pregnancy)
- Iodine contribution from supplements was added to daily dietary iodine intake (ug) under a new variable and will be referred to as *total iodine intake.* This applied to subjects who had entered enough information for the daily iodine value of the supplement to be ascertained (e.g. brand name, dose + term "daily" or used the term "once' if supplement was a once daily formulation)
- Women who stated that they took supplements regularly (more than once a week) formed part of the subgroup above, with the assumption being that these women took the supplement daily
- Dosage amounts were confirmed on manufacturer's websites in October and November 2014 and cross checked with a recent publication reporting on iodine supplementation (El-mani, Mullan, et al. 2014)
- Estimated iodine intakes were not normally distributed, therefore median (IQR) values have been reported and non-parametric tests have been used to conduct analyses. Mean (SD) values have also been reported in some instances to allow comparison with other studies
- FoodWorks data were later imported into Excel spreadsheets

Table 3.2 Conversion of frequency options (into daily amount)

Frequency option	Conversion
2 or more times a day	Multiply by 3
Once a day	Multiply by 1
5-6 times per week	Multiply by (5.5/7=0.785)
2-4 times per week	Multiply by (3/7=0.428)
Once a week	Multiply by (1/7=0.143)
1-3 times a month	Divide by 14
Less than one a month	Divide by 35

Table 3.3 Food descriptions from FoodWorks used for data entry
(Food Standards Australia New Zealand 2012)

Food
Milk,cow,fluid,regular fat (~3.5%)
Cheese,colby style
Ice cream,regular fat,vanilla & other non-chocolate flavours
Sausage,beef,grilled
Chicken,breast,lean,baked
Beef,blade steak,lean,grilled
Tofu (soy bean curd),firm,as purchased
Egg,chicken,whole,cooked,nfs
Fish,finfish,raw,nfs
Oyster,raw
Sushi,California roll,restaurant style
Bread fortified iodine
Spinach,English,boiled,drained
Breadcrumbs,white,commercial
Cake,plain/buttercake,uniced,homemade from basic ingredients
Muffin,cake/American style,plain,homemade
Bar,muesli,with added nuts
Nuts,mixed (peanut,cashew,hazelnut,brazil nut)
Chocolate,milk & white chocolate (e.g. Top Deck)
Salt,table,iodised

Percentage contribution to dietary iodine intake (cow's milk and bread)

Studies conducted in Australia and NZ have identified that cow's milk and bread products are significant contributors to the iodine intake of women of child-bearing age and pregnant women. In the present study, the contribution of these food sources were determined by dividing each subject's estimated daily iodine intake from each source by her total estimated daily dietary iodine intake for all food items expressed as a percentage.

Iodised salt users as 3 separate subgroups

Only some subjects knew if they used iodised salt. The above calculation was used to estimate the percentage contribution of discretionary iodised salt for all subjects (assigning 0% for those who did not use iodised salt or did not know what type of salt they used) and for women who only answered yes or no to the iodised salt questions (excluding the subjects who did not know what type of salt they used) (Table 4.5). The differences in percentage contribution of iodised salt for iodised salt users only was also determined (Table 4.6).

For those who used iodised salt, the iodised salt contribution to dietary iodine intake (ug/d) was factored into the numerator and denominator as below:

- 1: Estimated iodine (ug) from iodised salt calculated using FoodWorks (based on subject's estimation of iodised salt use).
- 2: Estimated iodine (ug) from iodised salt calculated by correcting (halving) iodised salt used in cooking for primigravid women. This was based on the assumption that the majority of subjects who were pregnant for the first time were cooking for two people (subject and partner).
- 3: Estimated iodine (ug) from iodised salt calculated using an adjusted standard figure of 48 ug (approximately equivalent to 1 g of iodised salt) (Charlton et al. 2013; Mallard and Houghton 2014).

Example for 1: Iodised salt contribution to dietary iodine intake (ug/d) (ID 005):

> 1: Estimated iodine (ug) from iodised salt calculated using FoodWorks (based on subject's estimation of iodised salt use)/total estimated daily dietary iodine intake * 100 = 66.4/401.8*100 = 16.5%

This above approach was also applied to cow's milk and bread percentage contribution calculations (iodised salt included in the denominator for users of iodised salt). The difference in percentage iodine contribution of cow's milk and bread for those who did not use iodised salt was also determined (Table 4.5).

3.6 Data preparation

It was necessary to recode a number of variables into categorical variables to assist with data analysis (Table 3.4)

Table 3.4 Categorisation of variables used in the analyses

Variable	Definition and categorisation
Age (y)	Subject's age categorised into three levels (18-24, 25-34, 35-44)
Estimated food iodine intake (ug)	Subject's estimated food iodine intake categorised into two levels (Meets EAR, Does not meet EAR)
Estimated food iodine intake (ug)	Subject's estimated food iodine intake categorised into three levels (tertiles-for subjects completing FFQ1 and FFQ2)
Ethnic group	Subject's categorisation of her ethnic group collapsed into three combinations of ethnic groupings (Australian/Australian Aboriginal/TSI, New Zealand/Polynesian, Asian/African/Other)
Iodised salt use	Subject's use of iodised salt initially categorised into three groups (yes, no, I do not know), then into two levels (yes, no-omitting those who did not know).
Estimated iodine intake from cow's milk (ug)	Subject's estimated intake from cow's milk categorised into three levels (tertiles-for subjects completing FFQ1 and FFQ2)
Estimated iodine intake from bread and bread products (ug)	Subject's estimated intake from bread and bread products categorised into three levels (tertiles-for subjects completing FFQ1 and FFQ2)
Consumption frequency (bread and bread products)	The lowest levels of consumption (1-3 times a month, < once a month and never) were categorised into a new group (< once a week)
Dietary supplement use	Subject's use of dietary supplements categorised into two groups (iodine-containing or non-iodine containing)
Foods no longer consumed	Subject's descriptions of foods avoided during pregnancy categorised into seven groups (fish/shellfish/seafood, soft cheese and unpasteurised dairy, deli meat/pre-prepared and reheated foods, raw fish/raw seafood/raw meat, eggs, soft drinks/sugary foods, other)
Foods required by law to have iodine added to them	Subject's responses categorised into seven groups (bread, salt, breakfast cereal/cereal, food that is too salty, chips, seafood, milk/dairy)

New variables were created to record iodine content (ug) of reported supplement use for those who gave enough information to be able to quantify a daily iodine dose amount. It was assumed that non-specific descriptions of multivitamins that were preparations for "women" or "pregnancy" formulations contained iodine thus were coded as iodine-containing. Additional variables were created to record estimated iodine content (ug) of reported iodised salt use (separate from food intake in the FFQ). All p values < 0.05 were considered statistically significant.

Data analysis

Data were entered and analysed using IBM SPSS Statistics for Windows, version 23. Descriptive statistics were obtained for variables of interest. For continuous variables, median (interquartile range (IQR) were used for skewed data, mean ± standard deviation (SD) were used to allow for comparisons with other studies. Frequencies and relative percentages were obtained for categorical variables and chi-square tests were conducted to assess associations between two categorical variables of interest (e.g. iodine supplement use and level of education, income, ethnicity and previous pregnancies).

Test-retest reliability

Test-retest reliability between FFQ1 and FFQ2 was assessed using ICC for continuous variables and Cohen's kappa for categorical variables. For sound reliability, an ICC of >0.6 and kappa values of >0.7 are recommended (Table 3.6 and Table 3.7). More specifically, two-way random effects model (ICC) of food iodine intake (ug) from FFQ1 and FFQ2 based on two-way random effects model was calculated for assessing the agreement between the questionnaires, as well as between items contributing the most to overall food iodine intake (ug) of the study population (cow's milk and bread products).

Table 3.5 Statistical tests to determine reliability for continuous data

Variable	Statistical test	Application
Food iodine intake (ug) FFQ1 & FFQ2	($ICC_{agreement}$)	To determine inter-rater reliability
Cow's milk (iodine content ug) FFQ1 & FFQ2	($ICC_{agreement}$)	To determine inter-rater reliability
Bread products (iodine content ug) FFQ1 & FFQ2	($ICC_{agreement}$)	To determine inter-rater reliability

Table 3.6 Strength of agreement relating to ICC value

ICC value[a]	Strength of agreement
0.41-0.60	Moderate agreement
0.61-0.80	Good agreement
>0.80	Very good agreement

[a] (Altman 1999, cited inSchneider 2007)

In recognition of the fact that the iodine quantities (ug) were derived from the FFQ, food iodine intake (ug) data from FFQ1 and FFQ2 were further categorised into tertiles to investigate the ranking ability of the questionnaire upon repeated administrations. The kappa statistic and the percentage of observed agreement were computed (Appendix D).

Tertile values for food iodine intake (ug/d) data from FFQ1 and FFQ2 were categorised as follows:

- Tertile 1= lowest intake (0 through 104.96 ug/d)
- Tertile 2= medium intake (104.97 through 196.71 ug/d)*
  * The EAR for iodine (160 ug/d) is correctly captured in tertile 2
- Tertile 3= highest intake (196.72 through highest amount)

Table 3.7 Interpretation of Kappa

Kappa value	Strength of agreement Interpretation 1[a]	Kappa value	Strength of agreement Interpretation 2[b]
		<0	Poor agreement
		0.01-0.20	Slight agreement
		0.21-0.40	Fair agreement
0.41-0.60	Moderate agreement	0.41-0.60	Moderate agreement
0.61-0.80	Good agreement	0.61-0.80	Substantial agreement
>0.80	Very good agreement	0.81-0.99	Almost perfect agreement

[a] (Altman 1999, cited inSchneider 2007)
[b] (Viera and Garrett 2005)

Additionally, Wilcoxon signed rank test was applied to assess the difference in mean between two repeated variables (test and retest) from FFQ1 and FFQ2. Marginal homogeneity test was also used to assess the marginal homogeneity between two categorised variables of interest (Appendix D).

Separate analyses were carried out excluding the group who had reported that they thought their dietary intake had changed between FFQ administrations given the potential for changes in iodine intake. Analyses were run firstly with, and secondly, without these subjects. This process was also followed for women who were provided with the KEMH iodine brochure after completion of their first questionnaire due to the questions they asked regarding iodine upon initial administration, women who completed FFQ2 within 14 days or after 14 days and for women in two different stages of pregnancy (≤28 weeks gestation and ≥29 weeks gestation)

Development of a rapid screening tool

The development of a rapid screening tool to assess pregnant women's likelihood of meeting the EAR for iodine involved the reduction of the 41-item iodine-specific FFQ to five key questions (Section 4.7).

The purpose of the first question was to identify women with thyroid disease and to recommend that iodine requirements are discussed with their Doctor/Obstetrician. The remaining questions were based on the major contributors to iodine intake in this population (Figure 4.9):

- iodine-containing supplements
- iodised salt
- cow's milk
- bread and bread products (mandatory fortification vehicle)

The rapid screening tool associates the consumption of the above-mentioned items to the percentage likelihood of meeting the EAR using the total iodine data for the iodine-containing supplement question, the dietary iodine data for the question relating to iodised salt consumption and the food iodine data for the cow's milk and bread and bread products questions (Section 3.5). Chi-square tests were conducted to ascertain these percentages and to assess significant association between the consumption of major contributors to iodine in the study population and attainment of the EAR.

CHAPTER 4 : RESULTS

4.1 Subjects

Pregnant women were recruited from antenatal clinics operating from Western Australia's only tertiary women's and neonatal hospital (29 December 2012 to 16 July 2013). Sixty five women screened via the introductory questions were not recruited to the study due to thyroid disease, history of thyroid disease, diabetes and history of diabetes or suspicion of diabetes (awaiting results of their oral glucose tolerance test). One hundred and twenty women declined to participate in the study including four women who would have required an interpreter. Data were collected and analysed for 425 subjects, with 455 questionnaires disseminated and 433 questionnaires returned (Figure 4.1). Eight questionnaires were excluded: three due to subjects' age <18 years, three due to incomplete responses (>1/2 of the questionnaires were incomplete) and two because of active thyroid disease. Six women completed the questionnaire with translation and interpretation from a family member and one woman had the assistance of a translator/interpreter within the clinic. The overall response rate of those eligible was 71%.

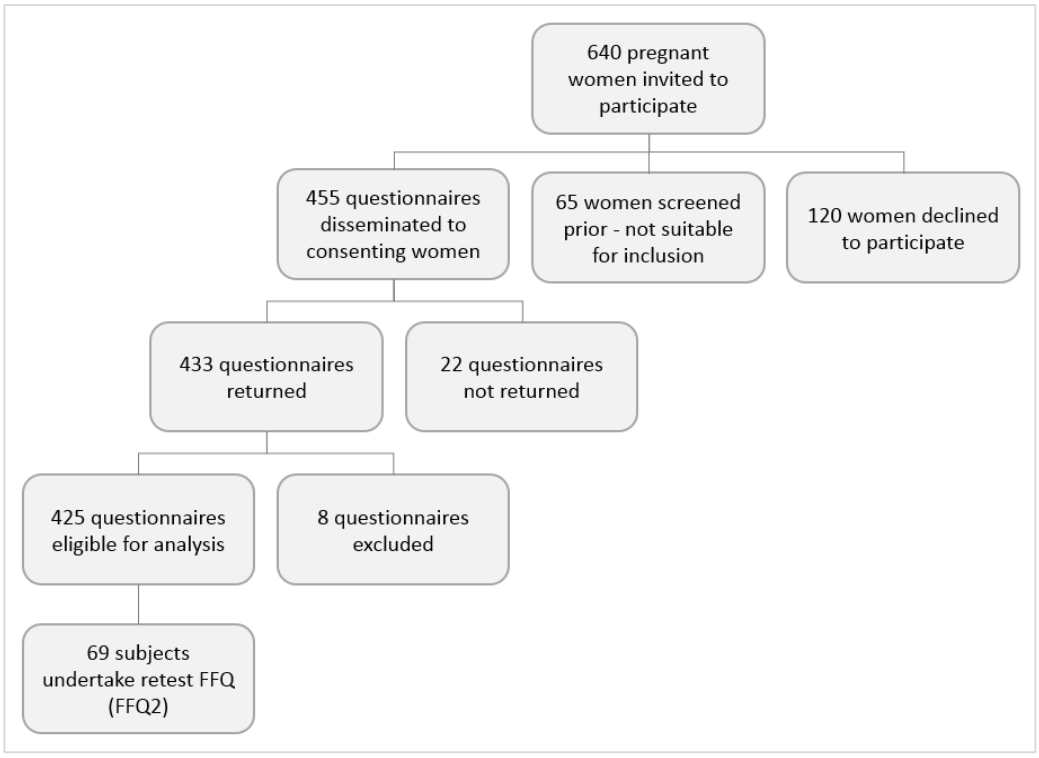

Figure 4.1 Recruitment for PIPS

4.1.1 Demographic characteristics

The demographic information of the subjects is summarised in Table 4.1. The mean age was 29.4 (5.5) years (range 18-44 years), with more than a third of these women (38%) in their first pregnancy. Over half (58%) were ≥ 29 weeks gestation, and 42% of subjects were 13-28 weeks pregnant. Only 3 women were less than 13 weeks pregnant (<1%).

Due to low subject numbers in some groups, ethnicity was recoded into three combinations of ethnic groups (see Appendix E for all ethnic groups indicated by subjects), with over half (53%) from Australian/Australian Aboriginal/Torres Strait Islander (TSI) backgrounds, of which a low number were Australian Aboriginal and TSI women (n=10 and n=0), respectively. Approximately 40% of subjects were of Asian/African/Other ethnicities. New Zealand/Polynesian subjects made up less than 10% of the total sample. The largest subgroup based on education had tertiary or professional qualifications (42%), followed by women who had completed secondary school only (33%) and women with a diploma, trade or technical certificate (25%).

Due to the sensitive nature of income related questions, women were given the option not to answer the question on self-reported individual income in the twelve months prior to completing the questionnaire, and 17% chose not to. Of those who answered, over half of the subjects (54%) earned less than $50 000, almost one quarter (24%) earned $50 000-$100 000 and 5% earned more than $100 000.

Despite the screening questions designed to exclude those with diabetes/gestational diabetes, history of diabetes or thyroid disease, 9 women (2%) reported a history of thyroid disease (diagnosed by a doctor) and 18 women (4%) had been told by a doctor that they have/had diabetes. Seven women (2%) were breastfeeding at the time of administration of the first questionnaire. Based on exclusion criteria, a further two questionnaires indicating active thyroid disease were excluded.

Table 4.1 Subject characteristics

Subject Variable	n	%
Age (y) (n=422)		
Mean (SD)	29.4 (5.5)	
Range	18-44	
Missing data	3	
Age (group) (n=422)		
18-24	89	21
25-34	253	60
35-44	80	19
Excluded <18	3	
Gravidity (n=425)		
Primigravid	163	38
Multigravid	262	62
Gestation (wk) (n=425)		
<13	3	<1
13-28 (inclusive)	177	42
≥29	245	58
Combinations of ethnic groups (n=424)		
Australian/Australian	223	53
Aboriginal/TSI		
New Zealand/Polynesian	33	8
Asian/African/Other	168	39
Missing data	1	
Highest level of education (n=420)		
Tertiary or professional qualification	176	42
Diploma, trade or technical certificate	106	25
Secondary school qualification	138	33
Missing data	5	
Individual reported income ($) (n=417)		
<$50 000	227	54
$50 000-100 000	99	24
>$100 000	19	5
Do not wish to answer	72	17
Missing data	8	

4.2 Iodine-containing supplement use

4.2.1 Prior to pregnancy

Two hundred and fifty three subjects reported that they did not use any dietary supplements in the year prior to becoming pregnant whilst a total of 169 selected either yes (occasionally, less than once a week) (n=34), yes (regularly, more than once a week) (n=132) or yes (without further description) (n=3). Three subjects did not answer this question.

In total, 78 different brands, and/or dosages of brands of dietary supplements were identified and these ranged from pregnancy-specific multivitamin preparations, folate, calcium ± vitamin D and iron, to weight loss and "detox" products. The highest percentage use per subject was iron (all brands) (21%), followed by Elevit (19.2%) (contains 220 ug iodine) and folate (all brands) (19.2%).

The results in Figure 4.2 demonstrate that approximately one-quarter of subjects (n=102) used an iodine-containing supplement in the year prior to pregnancy, the majority of women did not. Age was significantly associated with iodine-containing supplement use in the year before pregnancy (χ^2=10.855, df=2, p=0.004) (Table 4.2). A higher proportion of women in the highest age category (35-44 years) used iodine-containing supplements in the year before pregnancy (36.7%) compared to 24.2% in the 25-34 year age category and 14.8% in the youngest age category (18-24 years) (Appendix F).

There was a significant association between iodine-containing supplement use and gestational stage groups (χ^2=5.376, df=1, p=0.020). A greater proportion of women in the earlier stage of pregnancy at the time the questionnaire was completed (up to and including 28 weeks) (30.1%) reported using an iodine-containing supplement in the year before pregnancy compared to those who were in the later stage of pregnancy (29 weeks or more) (20.2%) (Table 4.2) (Appendix F).

Income category was significantly associated with iodine-containing supplement use in the year prior to pregnancy (χ2=6.923, df=2, p=0.031). A higher proportion of women from the highest income category (52.6%, n=10) reported using iodine-containing supplements in the year prior to pregnancy, followed by 26.5% (n=26) in the middle income category and 24.8% (n=55) in the lowest income category (Table 4.2) (Appendix F). Education level, however, was not significantly associated with iodine-containing supplement use prior to pregnancy (Appendix F).

4.2.2 During pregnancy

More than twice the number of subjects reported using dietary supplements during pregnancy compared to pre-pregnancy (n=362, n=169), respectively. Only sixty subjects reported that they did not use any dietary supplements whilst the majority of subjects used dietary supplements. A total of 362 women stated either yes (occasionally, less than once a week) (n=34), yes (regularly, more than once a week) (n=301) or yes (without further description) (n=27). Three subject responses to this question were missing.

Subject responses revealed that 82 different brands, and/or dosages of brands of dietary supplements were used during pregnancy. The same types of products were used before and after pregnancy apart from weight loss or "detox" products. The highest percentage use per subject was Elevit (43.4%) (contains 220 ug iodine), followed by iron (all brands) (31.8%), vitamin D (all brands) (19.4%) and folate (all brands) (19.2%).

Figure 4.2 illustrates that more than half of the subjects (65.7%) used an iodine-containing supplement during pregnancy. Three women did not respond to the question and eight women did not give enough information to ascertain whether the supplement contained iodine or not therefore were excluded from the percentage calculation.

Only three subjects (3.2%) taking quantifiable iodine-containing supplements did not meet the EAR cut-off of 160 ug/day. The most likely explanation for this relates to supplement dosing assumptions with all three women taking a pregnancy supplement that required a dose of two capsules per day. Two women did not specify that they took two capsules as a dose and therefore it was assumed that they only consumed one capsule daily, with the third woman specifying consumption of the supplement three times a week. In addition, these women only consumed cow's milk a maximum 2-4 times a week and were not iodised salt users.

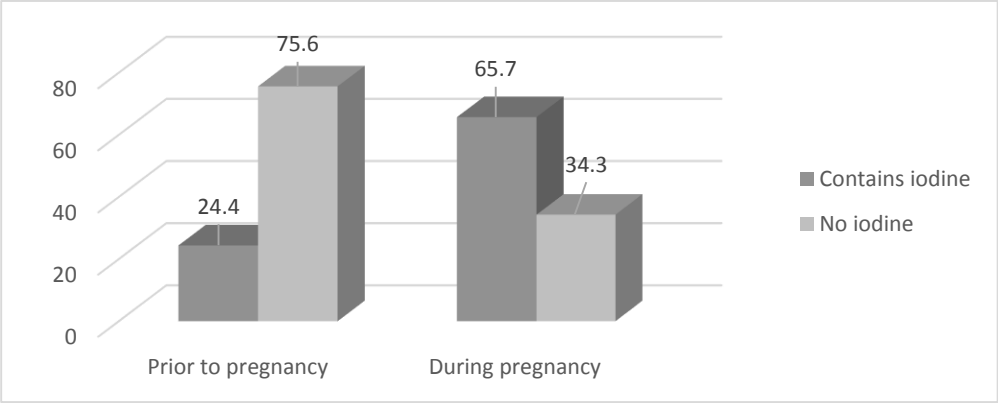

Figure 4.2 Percentage of subjects using iodine-containing supplements
Versus either no supplements or non-iodine containing supplements prior to pregnancy (n=418) and during pregnancy (n=414).

As mentioned in Section 3.5 iodine content in supplements was quantified for 95 subjects. The mean iodine content of these supplements was approximately 186 ug (median=220 ug) (range 38 ug to 500 ug). Over half of these subjects (n=49) (52%) consumed a supplement containing 220 ug iodine (above the NHMRC recommendation of 150 ug), with 17 women (18%) taking a supplement that contained less iodine than the NHMRC recommendation.

Gestational stage was significantly associated with iodine-containing supplement use during pregnancy (χ^2=11.279, df=1, p=0.001). A higher proportion of women who were in the earlier stage of pregnancy (at or before 28 weeks gestation) at the time of completing the questionnaire reported using iodine-containing supplements (74.9%, n=131) compared to women in the later stage of pregnancy (29 weeks or more) (59%, n=141) (Table 4.2) (Appendix F).

A higher proportion of women who were pregnant for the first time reported using iodine-containing supplements (73.8%, n=118) compared to 60.6% (n=154) of women who had been pregnant previously (χ^2=7.498, df=1, p=0.006) (Table 4.2) (Appendix F). Unlike the findings prior to pregnancy, age and income were not significantly associated with the use of iodine-containing supplements during pregnancy. Similar to the results prior to pregnancy, education level was not significantly associated with iodine-containing supplement use (Appendix F).

Table 4.2 Demographic comparison – iodine-containing supplement use

	Prior to pregnancy		**During pregnancy**	
Subject Characteristics	n (%)	P value Chi-square	n (%)	P value Chi-square
Age (group)				
n	102	p=0.004	271	p=0.216
18-24	13 (14.8)		52 (59.1)	
25-34	60 (24.2)		163 (66.5)	
35-44	29 (36.7)		56 (71.8)	
First pregnancy				
n	102	p=0.807	272	p=0.006
Yes	38 (23.8)		118 (73.8)	
No	64 (24.8)		154 (60.6)	
Gestation (wk)				
n	102	p=0.020	272	P=0.001
Up to-28 (inclusive)	53 (30.1)		131 (74.9)	
≥29	49 (20.2)		141 (59.0)	
Individual income				
n	91	p=0.031	230	p=0.508
<$50 000	55 (24.8)		145 (65.9)	
$50 000-100 000	26 (26.5)		71 (71.7)	
>$100 000	10 (52.6)		14 (73.7)	

4.3 Estimated iodine intake (ug/d)

Estimated daily iodine intake was determined from the subjects' selected serve sizes and frequencies of consumption of the food items within the FFQ (Section 3.5). Users of iodised salt, either in cooking or added at the table were distinguished from those who didn't use iodised salt or any type of salt and women who didn't know if the salt they used was iodised or not (Figure 4.3).

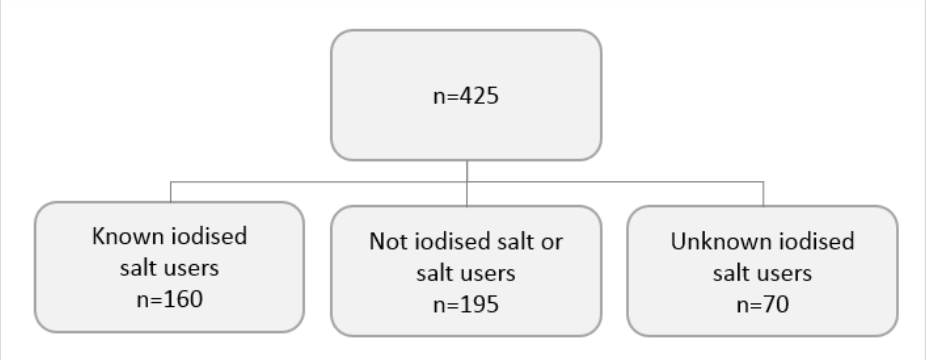

Figure 4.3 Categorisation of subjects' use of iodised salt

Estimates of iodine intake are reported via three different methods:

1. Food iodine (n=425) (iodine intake from food alone)
2. Dietary iodine (n=425) (iodine intake from + iodised salt for those who used iodised salt)
3. Total iodine (n=95) (iodine intake from food + iodised salt for those who used iodised salt + iodine in supplement for those who provided brand and dosage amounts) (Table 4.3).

The median iodine intake estimated from food was 148 ug/day, slightly less than the EAR for pregnancy (160 ug/day). Median iodine intakes calculated with the dietary iodine data and with the total iodine data were 196 ug/day and 358 ug/day, respectively, meeting the EAR for pregnancy (Table 4.3). Although the intake data were not normally distributed, the means have been calculated for comparison with other studies and are also included in Table 4.3.

Table 4.3 Estimated iodine intake according to three different methods.

Iodine intake	Mean (ug/day)	Median (IQR) (ug/day)	Min-Max (ug/day)	Meets EAR (≥160 ug/day)
FOOD IODINE (food alone) *n=425*	170 ±98.6	148 (100.2-228.0)	8.3-669.9	Yes (Mean) No (Median)
DIETARY IODINE (food ± iodised salt) *n=425*	234 ±172.1	196 (120.3-298.2)	8.3-1163.9	Yes (Mean) Yes (Median)
TOTAL IODINE (food ± iodised salt + iodine supplements) * *n=95*	415 ±211.7	358 (292.8-485.7)	109.9-1383.9	Yes (Mean) Yes (Median)

* The subjects who used iodine containing supplements and provided brand and dosage allowing for quantification.

Approximately 3% and 8% of the subjects who consumed quantifiable iodine supplements (n=95) did not achieve the EAR and RDI for pregnant women, respectively (Figure 4.4) (Table 4.4). This is compared to over one-third (39.3%) of the subjects in the dietary iodine group who did not meet the EAR, whilst more than half (53.4%) did not achieve the EAR in the food iodine group. Less than 5% of those in the total iodine group did not meet the EAR (Table 4.4).

Table 4.4 Proportion of women who did not achieve the EAR, who met the EAR, met the RDI and who exceeded the UL for iodine.

Iodine intake	Did not meet EAR (<160 ug/day) (%)	Meets EAR (≥160 ug/day) (%)	Meets RDI (≥220 ug/day) (%)	Exceeds UL (>1100 ug/day) (%)
FOOD IODINE (food alone) *n=425*	53.4	46.6	27.5	0
DIETARY IODINE (food ± iodised salt) *n=425*	39.3	60.7	42.6	0.2
TOTAL IODINE (food ± iodised salt + iodine supplements) * *n=95*	3.2	96.8	91.6	3.1

* The subjects who used iodine containing supplements and provided brand and dosage allowing for quantification.

Nearly 40% of the sample were primigravid. There was a significant association between meeting the EAR and gravidity (χ^2=6.695, df=1, p=0.010) when assessing food iodine data. A higher proportion (51.5%, n=135) of women who had been pregnant previously achieved the EAR compared to those who were primigravid (38.7%, n=63). A similar trend was apparent when comparing EAR and gravidity using food + iodised salt data for women who had been pregnant previously (63.7%, n=167) compared to primigravid women (55.8% n=91), however this association was not statistically significant (χ^2=2.637, df=1, p=0.104).

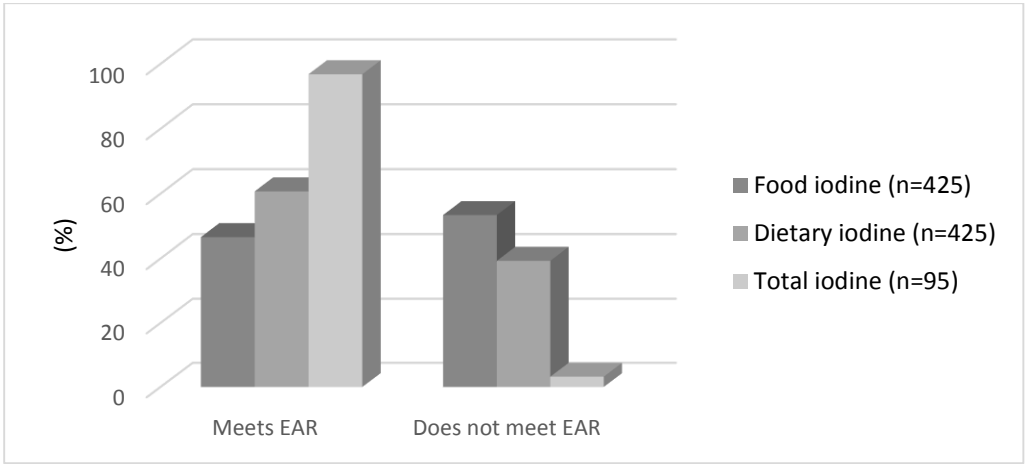

Figure 4.4 Percentage of subjects achieving the EAR for iodine
According to food iodine (iodine intake from food alone), dietary iodine (iodine intake from + iodised salt for those who used iodised salt) and total iodine (iodine intake from food + iodised salt for those who used iodised salt + iodine in supplement for those who provided brand and dosage amounts).

4.3.1 Important contributors to dietary iodine intake

The mean percentage contributions of the three major sources of dietary iodine intake for the study subjects was calculated as described in Section 3.5 and are summarised in Table 4.5 and Figure 4.5. The contribution of discretionary iodised salt was calculated by;

1. Estimated iodine from iodised salt calculated using FoodWorks (based on subject's estimation of iodised salt use)
2. Estimated iodine (ug) from iodised salt calculated by correcting (halving) iodised salt used in cooking for primigravid women (subject and partner)
3. Estimated iodine (ug) from iodised salt calculated using an adjusted standard figure of 48 ug (approximately equivalent to 1 g of iodised salt).

In addition, the percentage iodine contribution from cow's milk and bread and bread products for those who did not use iodised salt was calculated. Over one-third (38-41%) of dietary iodine intake came from cow's milk across these calculations with the contribution to those who were not using discretionary iodised salt (n=265) being closer to half (45%). Bread products (fortified with iodine) provided approximately 18-20% of total iodine. Iodised salt contributed 10-16% of the total or 12-19% when those subjects who did not know what type of salt they used were removed (n=70). In women who provided an estimate of serve size of iodised salt (n=156), contributions ranged from 27-44% (Table 4.5). The differences in percentage contribution of iodised salt for iodised salt users only are reported in Table 4.6.

Table 4.5 Mean percentage contribution of bread and bread products, cow's milk and iodised salt

	Bread	Cow's milk	Iodised salt	Iodised salt (only yes or no responses)
All subjects FoodWorks[1]	18.5 n=425	38.4 n=424*	16.1 n=425	19.3 n=355
All subjects Corrected[2]	18.8 n=425	39.1 n=424*	14.7 n=425	17.6 n=355
All subjects Adjusted 48 ug[3]	19.9 n=425	41.3 n=424*	10.0 n=425	12.0 n=355
Subjects NOT using iodised salt	21.5 n=265	45.0 n=265		

*1 subject response missing

[1]Total iodine intake of iodised salt users calculated using FoodWorks (based on subject's estimation of iodised salt)

[2]Total iodine intake of iodised salt users calculated by correcting (halving) iodised salt (cooking) for primigravid pregnant women

[3]Total iodine intake of iodised salt users calculated using an adjusted standard figure of 48 ug for iodised salt in all iodised salt users

Table 4.6 Mean percentage contribution of iodised salt (iodised salt users only)

	Iodised salt
Iodised salt users FoodWorks[1]	43.6 n=156
Iodised salt users Corrected[2]	40.1 n=156
Iodised salt users Adjusted 48 ug[3]	27.3 n=156

[1]Total iodine intake of iodised salt users calculated using FoodWorks (based on subjects estimation of iodised salt)

[2]Total iodine intake of iodised salt users calculated by correcting (halving) iodised salt (table) for primigravid pregnant women

[3]Total iodine intake of iodised salt users calculated using an adjusted standard figure of 48 ug for iodised salt in all iodised salt users

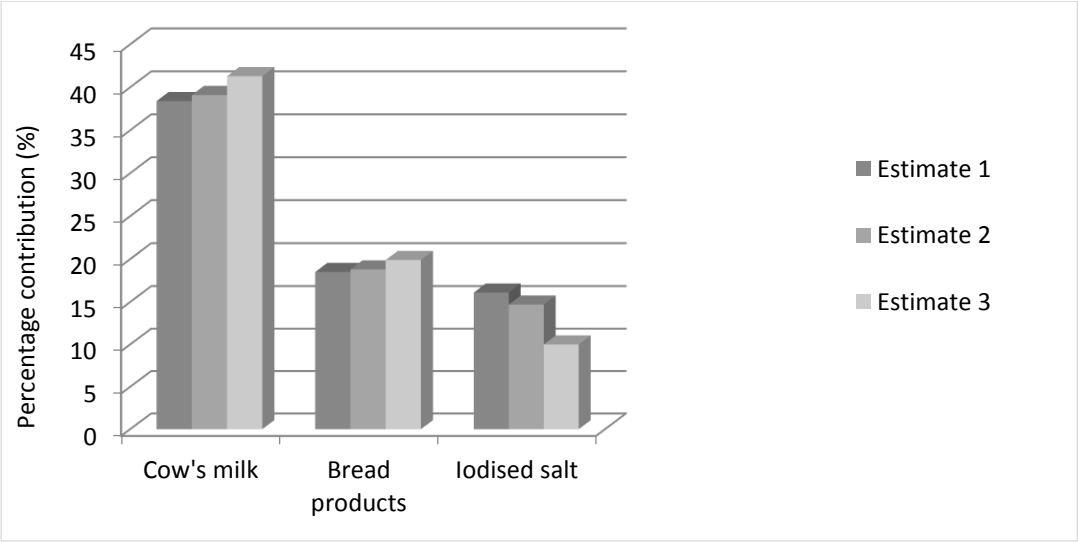

Figure 4.5 Comparison of the mean percentage contribution
Food items contributing the most to iodine intake of subjects using Iodine (ug) from iodised salt estimate 1 (calculated using FoodWorks (based on subject's estimation of iodised salt use)), estimate 2 (calculated by correcting (halving) iodised salt used in cooking for primigravid women) and estimate 3 (calculated using an adjusted standard figure of 48 ug (approximately equivalent to 1 g of iodised salt)).

4.3.2 Frequency of consumption

All but two women responded to the cow's milk questions in FFQ1, with 19 women indicating that they had not consumed cow's milk in the last two months. In addition, one subject indicated "nil" relating to serve size and another subject's serve size was missing. Frequency of consumption of cow's milk was found to be significantly associated with achieving the EAR (χ^2=205.865, df=7, p<0.001) using food iodine data. Of those who consumed cow's milk two or more times a day, the majority (91.2%, n=145) achieved the EAR. In comparison, only 23.3% (n=35) in the adjacent consumption category (once a day) and 15.8% (n=3) of those who never consumed cow's milk met the EAR (Table 4.7).

The relationship between the frequency of consuming cow's milk and meeting the EAR was also evident when analysing the dietary iodine data for the extreme categories (two or more times a day and never) (91.8%, n=146 and 15.8%, n=3) (χ^2=118.005, df=7, p<0.001).

Table 4.7 Proportions of women meeting the EAR in each cow's milk consumption category (using food iodine intake and dietary iodine intake)

Consumption frequency	n (within consumption category)	% meeting EAR (within consumption category)	
		Food iodine intake (Food alone)	Dietary iodine intake (Food ± iodised salt)
≥2 times a day	159	91.2 (n=145)	91.8 (n=146)
Once a day	150	23.3 (n=35)	51.3 (n=77)
5-6 times a week	23	30.4 (n=7)	43.5 (n=10)
2-4 times a week	37	10.8 (n=4)	35.1 (n=13)
Once a week	11	9.1 (n=1)	18.2 (n=2)
1-3 times a month	19	10.5 (n=2)	31.6 (n=6)
<once a month	5	20.0 (n=1)	20.0 (n=1)
Never	19	15.8 (n=3)	15.8 (n=3)
Missing	2		
P value (Chi-square)		<0.001	<0.001

Two women did not respond to the bread and bread products questions in FFQ1 with four subjects reporting that they had not consumed any bread or bread products in the last two months. Due to low subject numbers the lowest three categories were collapsed into a single category "less than once a week" to assist with statistical analysis. Frequency of consumption of bread products fortified with iodine (collapsed into 6 categories) was also significantly associated with achieving the EAR (χ2=85.309, df=5, p<0.001) based on food iodine data (method 1). Of the women who consumed bread products two or more times a day, more than three-quarters (82.8%, n=77) achieved the EAR (based on food iodine data), compared to 48.4% (n=78) of subjects who consumed bread products once a day (n=161). There were no subjects who reported never consuming these items in the group who met the EAR.

Based on the dietary iodine estimation (method 2), the association remained significant (χ2=65.447, df=5, p<0.001). Of those who had eaten bread products two or more times a day, the majority (91.4%, n=85) achieved the EAR compared to those who consumed bread products once a day (62.1%, n=100) or did not have bread products (25%, n=1) (Table 4.8).

Table 4.8 Proportions of women meeting the EAR in each bread consumption category - original categories
(using food iodine intake and dietary iodine intake)

Consumption frequency	n (within consumption category)	% meeting EAR (within consumption category)	
		Food iodine intake (Food alone)	Dietary iodine intake (Food ± iodised salt)
≥2 times a day	93	82.8 (n=77)	91.4 (n=85)
Once a day	161	48.4 (n=78)	62.1 (n=100)
5-6 times a week	47	14.9 (n=7)	34.0 (n=16)
2-4 times a week	76	25.0 (n=19)	42.1 (n=32)
Once a week	22	45.5 (n=10)	59.1 (n=13)
1-3 times a month	9	33.3 (n=3)	44.4 (n=4)
< once a month	11	36.4 (n=4)	45.5 (n=5)
Never	4	0.0	25.0 (n=1)
Missing	2		
P value (Chi-square)		<0.001	<0.001

Limitations of the FFQ:

1. Whilst not part of the bread and bread products question, 8 subjects in this study consumed breadcrumbs more than once a week. The maximum estimated quantity consumed by 5 of these women was approximately 26 g of breadcrumbs per day (approximately 12 ug of iodine when corrected for increased iodine due to fortification). This was determined by applying the "Bread fortified with iodine" calculation (46 ug iodine per 100g). These corrections did not have an impact on whether subjects did or did not meet the EAR for iodine.
2. One subject reported using rock salt with a strip of nori (edible seaweed) added to the salt grinder. Estimation of iodine quantity for this item was difficult based on limitations in measuring minimal amounts. The subject reported the quantity as "a sprinkle a day" and based on a FoodWorks estimation of 1 strip = 8.92 ug iodine, the amount of iodine would be negligible (e.g. 100 days to use up the strip weighing 0.5 g in total equates to 0.005 g of nori per day = 0.089 ug iodine).

4.4 Iodised salt use

The use of iodised salt in cooking and use at the table were two separate questions with different serve sizes allocated for each (1/4 teaspoon, 1/2 teaspoon, 1 teaspoon for addition to cooking and just a sprinkle, 1/8 teaspoon, 1/4 teaspoon for addition at the table) (see Appendix B).

The frequency categories for iodised salt use were; never, less than one a month, 1-3 times a month, once a week, 2-4 times per week, 5-6 times per week, once a day and 2 or more times a day, with the option of I don't know.

The initial analysis of iodised salt use categorised respondents as; *yes* (uses iodised salt, either in cooking or at the table), *no* (does not use iodised salt, either in cooking or at the table), or *I do not know* (for those who were uncertain of the type of salt they used). As shown in Figure 4.6, just under half of the subjects (45.9%) (n=195) did not use iodised salt, followed by 37.6% who reported using iodised salt (n=160). Approximately 16% (n=70) of the women did not know what type of salt they used.

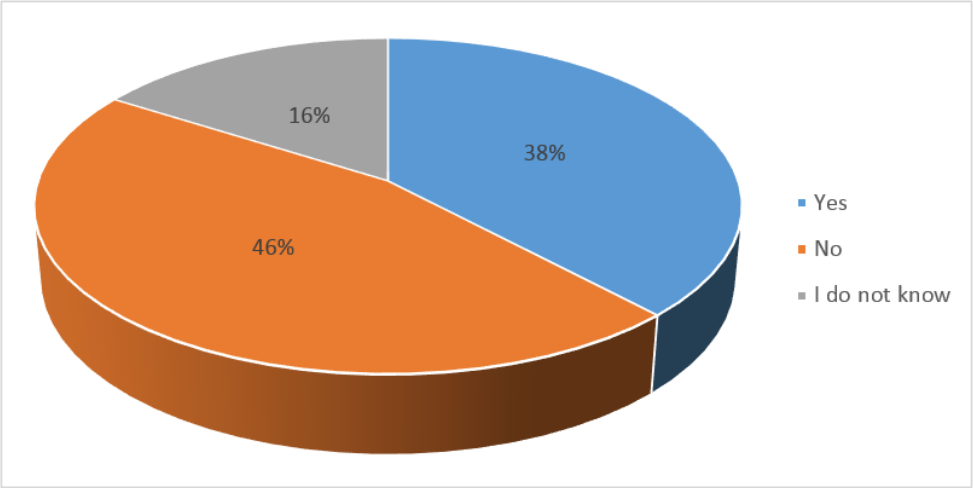

Figure 4.6 Iodised salt use in cooking and/or at the table

When those who didn't know whether they used iodised salt or not were excluded (n=70) 54.9% reported that they did not use iodised salt and 45.1% of subjects reported using iodised salt. Further analysis to determine the percentage of subjects who met the EAR and demographic characteristics associated with iodised salt use only used these binary data.

Over half of those who responded to the question relating to iodised salt use in cooking (n=158) used it at least once a day (62%, n=98) (Table 4.9). Comparative figures for iodised salt use at the table were much lower, with 39.2% (n=62) consuming iodised salt at the table at least once a day (Table 4.9).

Cross-tabulation and chi-square analysis indicated a significant association between iodised salt use and achievement of the EAR (χ^2=47.089, df=1, p<0.001). The majority of those who used iodised salt attained the EAR (82.5%, n=132) whilst only 47.2% of those who did not use iodised salt achieved the EAR (Appendix F).

There was a significant association between iodised salt use (for subjects who knew what type of salt they used) (n=352) and education level (χ^2=7.522, df=1, p=0.023). A greater proportion of women who had tertiary or professional qualifications (53.7%) reported using iodised salt compared to 39.8% of those who had secondary school qualifications and 38.5% of those with a diploma, trade or technical certificate (Appendix F).

Combination of ethnic group was also significantly associated with iodised salt use (χ^2=18.056, df=2, p<0.001). The highest proportion of women from Asian/African/Other ethnic groups backgrounds (59.1%) used iodised salt, compared to 46.7% of women from New Zealand/Polynesian backgrounds. The lowest proportion of women using iodised salt were those of Australian/Australian Aboriginal/TSI backgrounds (35.2%) (Appendix F).

Table 4.9 Frequency and percentage of iodised salt use in cooking and at the table.

	Use in cooking		**Use at the table**	
Consumption frequency	Frequency (n)	Percent	Frequency (n)	Percent
2 or more times a day	42	26.6	13	8.2
Once a day	56	35.4	49	31.0
5-6 times per week	15	9.5	4	2.5
2-4 Times per week	19	12.0	16	10.1
Once a week	11	7.0	18	11.4
1-3 times a month	5	3.2	9	5.7
Less than once a month	3	1.9	13	8.2
Never	4	2.5	36	22.8
I do not know	3	1.9	0	0.0
Total	158	100.0	158	100.0
Missing	2		2	

4.5 Knowledge and beliefs-food sources, health problems associated with inadequate iodine intakes and iodine information sources

4.5.1 Food sources

Salt was selected as a good source of iodine in the Australian diet by 46.9% of subjects (Question 13). Less than half of the subjects correctly selected seafood, eggs and bread. Over one-quarter of subjects incorrectly identified meat and vegetables as a good source of iodine, with 12.6% incorrectly selected fruit. Approximately one-quarter of women selected *"I do not know"* when asked to nominate which of the eight food items were good sources of iodine in the Australian diet (subjects could select as many food items as they wanted) (Table 4.10). Five subjects did not answer this question.

Table 4.10 Percentage of pregnant women nominating specific foods as being good sources of iodine.

Food source	% of subjects *(n=420)*	% of responses *(Responses=986)*
Salt[a*]	46.9	20.0
Seafood[a]	35.2	15.0
Eggs[a]	19.8	8.4
Milk[a]	17.4	7.4
Bread[a*]	15.5	6.6
Vegetables	34.3	14.6
Meat	26.2	11.2
Fruit	12.6	5.4
I do not know	26.9	11.5

[a]Correct answer
[a]*Correct answer – only if iodised.

Education level was significantly associated with the selection of the option *"I do not know"* for the above question (χ^2=9.188, df=2, p=0.010). A lower proportion of those with tertiary or professional qualifications selected "I do not know" (18.8%) compared to 32.1% and 31.9% of those with a diploma, trade or technical certificate and secondary education, respectively (Appendix F).

Upon assessment of demographic variables and the number of correct responses from women for the food items seafood (n=148), eggs (n=83) milk (n=73) and bread (n=65), it was found that education was significantly associated with the correct selection of seafood as a good source of iodine (χ^2=13.380, df=2, p=0.001). Proportionally more women who had tertiary or professional qualifications correctly selected seafood (43.8%), followed by 34.9% with a diploma, trade or technical certificate and 23.9% of those with secondary school qualifications (Appendix F). All other demographic factors were not significantly associated with correct responses for this question. Salt was not included in this assessment due to the assumptions surrounding its selection, namely that it was assumed that those who selected this option were referring to iodised salt.

In response to the question *"Do you know if there are any foods in Australia that are required by law to have iodine added to them?"* the majority of women did not know (74.7%), 17.3% stated *"no"*, whilst 8% responded *"yes"* to the question. The second part of the question was open ended allowing women to specify the food if they nominated *"yes"*.

The responses were categorised as follows; bread, salt, breakfast cereal/cereal, any food that is too salty, chips, seafood, milk and dairy. Only 20 women correctly identified bread as the mandatory fortification vehicle (4.7% of total sample).

4.5.2 Health problems

Over half of the study subjects (55.8%) selected *"I do not know*" in relation to the list of health problems which may or may not be associated with a lack of iodine in the diet (Question 14). Approximately one-quarter of subjects selected the correct responses goitre and mental retardation (combined) (Table 4.11).

Table 4.11 Selected answers for health problems associated with a lack of iodine intake.

Health Problem	% of subjects *(n=414)*	% of responses *(Responses=591)*
Goitre[a]	17.1	12.0
Mental retardation[a]	8.9	6.3
Tiredness	21.3	14.9
Neural tube defects	15.9	11.2
Weak bones and teeth	9.2	6.4
Depression	7.5	5.2
Arthritis	3.6	2.5
Blindness	3.4	2.4
I do not know	55.8	39.1

[a]Correct answer

Demographic characteristics indicating significant associations are presented in Table 4.12. Age was significantly associated with the correct selection of the health problem goitre (χ^2=6.017, df=2, p=0.049). A higher proportion of women in the 35-44 year age group (25%, n=20) correctly selected goitre, followed by 14.6% (n=37) of those in the 25-34 year age group and 12.4% (n=11) of those in the 18-24 year age category. While only 36 women correctly selected mental retardation, the same trend occurred with the greatest proportion of correct responses (18.8%, n=15) from those in the highest age group, 6.3% (n=16) of those in the middle age group and 5.6% (n=5) in the 18-24 year age category (Table 4.12) (Appendix F).

Education level was significantly associated with the selection of the option *"I do not know"* regarding the health problems associated with poor iodine intake (χ^2=12.022, df=2, p=0.002). A lower proportion of those with tertiary or professional qualifications selected "I do not know" (44.9%, n=79) compared to 58.5% (n=62) and 63.8% (n=88) of those with a diploma, trade or technical certificate and secondary education, respectively (Appendix F). Education level was also significantly associated with the correct selection of goitre as an adverse health outcome due to poor iodine intake (χ^2=32.308, df=2, p<0.001) with the greatest proportion of women responding affirmatively being those in the higher education group (28.4%, n=50) compared to subsequent categories. A similar trend was evident between education category and the correct selection of mental retardation (χ^2=7.603, df=2, p=0.022) (Appendix F).

Combination of ethnic groups was significantly associated with the selection of *"I do not know"* (χ^2=9.732, df=2, p=0.008). The highest proportion of women from New Zealand/Polynesian backgrounds selected this response (63.6%, n=21), followed by 60.1% (n=134) of those from the Australian/Australian Aboriginal/TSI ethnic combination group (Appendix F). Proportionally more women from Asian/African/Other backgrounds (29.2%, n=49) correctly selected goitre, followed by 9.1% (n=3) from the New Zealand/Polynesian group and 8.5% (n=19) of those from the Australian/Australian Aboriginal/TSI ethnic combination group (χ^2=30.801, df=2, p<0.001). Similarly, the greatest proportion of women from Asian/African/Other backgrounds correctly selected mental retardation as an adverse health outcome (13.1%, n=22), followed by 6.3% (n=14) of those from the Australian/Australian Aboriginal/TSI ethnic combination group and 3% (n=1) from the New Zealand/Polynesian group (χ^2=7.048, df=2, p=0.029) (Table 4.12) (Appendix F).

Stage of pregnancy was significantly associated with the correct selection of goitre (χ^2=6.828, df=1, p=0.009). A higher proportion of women in the earlier stage of pregnancy (up to and including 28 weeks) (22.2%, n=40) selected goitre compared to 12.7% (n=31) of those in the later stage of pregnancy.

Table 4.12 Demographic characteristics for selected answers for health problems associated with a lack of iodine intake.

	I do not know		Goitre		Mental retardation	
Subject Characteristics	n (%)	P value Chi-square	n (%)	P-value Chi-square	n (%)	P value Chi square
Age (group)						
n	231	p=0.351	68	P=0.049	36	p=0.001
18-24	50 (56.2)		11 (12.4)		5 (5.6)	
25-34	143 (56.5)		37 (14.6)		16 (6.3)	
35-44	38 (47.5)		20 (25.0)		15 (18.8)	
Combinations of ethnic groups						
n	231	p=0.008	71	P<0.001	37	p=0.029
Aust/Australian Aboriginal/TSI	134 (60.1)		19 (8.5)		14 (6.3)	
NZ/ Polynesian	21 (63.6)		3 (9.1)		1 (3.0)	
Asian/Afr/Other	76 (45.2)		49 (29.2)		22 (13.1)	

	I do not know		Goitre		Mental retardation	
Gestation (wk)						
n	231	p=0.123	71	p=0.009	37	P=0.063
Up to-28 (inclusive)	90 (50.0)		40 (22.2)		21 (11.7)	
≥29	141 (57.6)		31 (12.7)		16 (6.5)	
Highest level of education						
n	229	p=0.002	70	P<0.001	37	p=0.022
Tertiary or professional	79 (44.9)		50 (28.4)		23 (13.1)	
Diploma, trade or technical	62 (58.5)		13 (12.3)		8 (7.5)	
Secondary school	88 (63.8)		7 (5.1)		6 (4.3)	

4.5.3 Sources of dietary information

Exploration of the sources of dietary information for the study subjects revealed that more than half of the women received their dietary information from a doctor, followed by a midwife and the internet. Women could select as many options as applied to them. It can be concluded from Figure 4.7 that women received less information on iodine and other topics compared to folate and iron. In addition, more women were unsure if they received information on iodine, or from who they received this information, than the other dietary topics.

Figure 4.7 Comparison of sources of dietary information

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In response to the question *"If you needed, do you feel that you can receive enough dietary information to make informed decisions about the following topics during pregnancy?"* the majority of subjects felt that they could obtain enough dietary information to make informed decisions on iron, calcium, folate, vitamin D, listeria and healthy eating during pregnancy (Figure 4.8). More women stated they could not receive enough information on iodine than any of these other dietary topics (Figure 4.8).

Over 10% of women reported that they did not know what iodine was (in relation to whether they felt that their diet provided enough iodine for their body's needs when pregnant, and when not pregnant). More than half of the subjects did not know if their diet provided enough iodine when pregnant and when not pregnant (58.2% and 57.5%), respectively. Approximately one-quarter were confident that their diet provided enough iodine when pregnant (25.9%) and when not pregnant (23.5%). Less than eight percent (7.4%) did not believe that their diets contained adequate iodine for pregnancy, whilst 4.8% thought their diets contained inadequate iodine (when not pregnant).

There was a significant association between the subjects' belief that their diet met their iodine needs and consumption of iodine-containing supplements (χ^2=16.817, df=3, p=0.001). A high proportion of women in all response categories for the question *"Do you feel that your own diet provides enough iodine for your body's needs i.e. when you are pregnant?"* reported taking iodine-containing supplements (at least 64%) except for those choosing *"I do not know what iodine is"* (40%, n=18). A higher proportion of women who selected *"No, I do not think my diet provides enough iodine"* reported using iodine-containing supplements (72.4%, n=21), compared to 70.9% (n=168) of those who did not know if their diets provided enough iodine. Women who were confident that their diets provided enough iodine reported lower iodine-containing supplement use than the aforementioned categories (63.6%, n=63) (Appendix F).

There was also a significant association between the subjects' belief that their diet met their iodine needs and consumption of iodised salt (χ^2=7.955, df=3, p=0.047). A higher proportion of women who were confident that their diet provided enough iodine reported using iodised salt (54.5%, n=48) compared to those who chose the option *"No, I do not think my diet provides enough iodine"* or *"I do not know if my diet provides enough iodine"* (44.8%, n=13 and 44.5%, n=89, respectively). Only 26.5% (n=9) of women who did not know what iodine was used iodised salt (Appendix F).

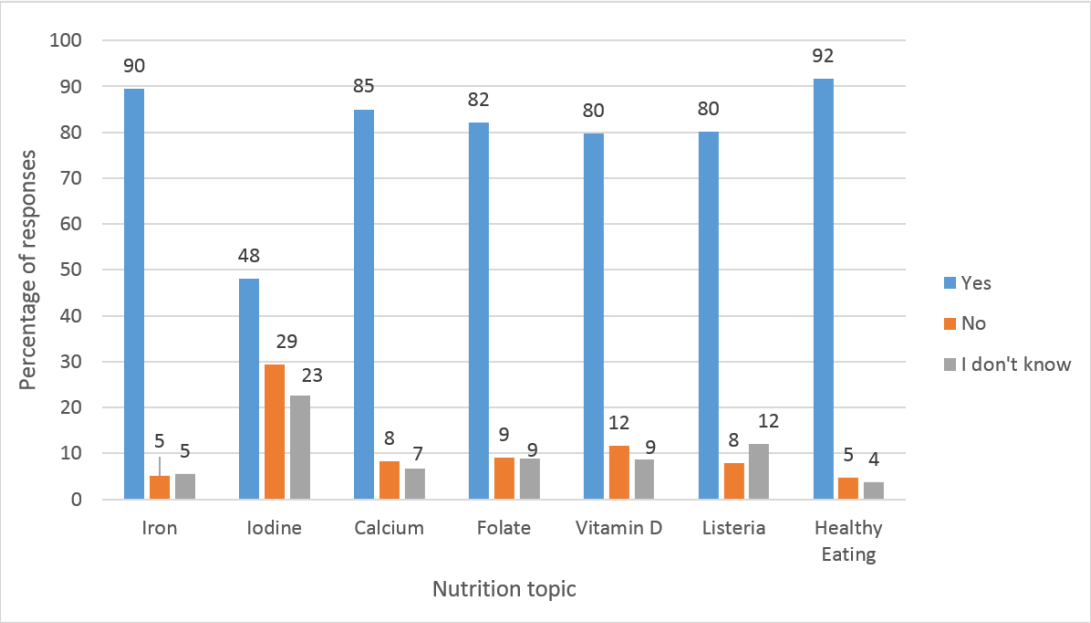

Figure 4.8 Responses regarding availability of dietary information during pregnancy
Comparison of responses from women who felt they could obtain dietary information on various nutrition related topics during pregnancy.

When asked *"Are there any foods that you have given up or stopped eating since you became pregnant?"* approximately 63% (n=267) of subjects stated *"yes"*. More than one-quarter of responses indicated that subjects had given up deli meat, pre-prepared and reheated foods totalling the highest response (26.7%), followed by soft cheeses, unpasteurised dairy (24.9%) (Table 4.13). This relates to the high percentage of women who reported they felt they could obtain enough information on listeria (80%) (Figure 4.8). The category "Other" included foods such as; mushrooms, acidic foods, onion, red meat, alcohol, artificial sweetener, milk and yoghurt.

Table 4.13 Foods no longer consumed once pregnant

Foods avoided once pregnant	Number of responses*	% of responses
Deli meat, pre-prepared and reheated foods	194	26.7
Soft cheeses, unpasteurised dairy	181	24.9
Fish, shellfish (seafood)	56	7.7
Raw fish, raw seafood, raw meat	121	16.7
Soft drinks, sugary foods	29	4.0
Eggs	23	3.2
Other	123	16.9

*Total responses = 727

In response to the question relating to how often the subjects chose low or reduced salt food items, more than half (61.5%) stated *"rarely or never*", 32.4% selected the option *"sometimes"* whilst 26.2% either stated *"often or always"*.

4.6 Reliability of the FFQ

Overall the FFQ exhibited moderate reliability based on the results presented in Table 4.14 through to Table 4.18.

Median values of the estimated food iodine intakes for the 69 subjects who completed the first FFQ (FFQ1) and the retest FFQ (FFQ2) were 152 ug/day and 144 ug/day, respectively. The difference between the population medians assessed by Wilcoxon signed rank tests was not significant (p=0.979) (Table 4.14).

Table 4.14 Comparison of means (SD) and medians (IQR) for FFQ1 and FFQ2

	Mean ± SD (ug/day)	Median (IQR) (ug/day)
Estimated food iodine FFQ1 *n=69*	160 ±85.5	152 (95.0-231.1)
Estimated food iodine FFQ2 *n=69*	161 ±89.0	144 (85.34-224.2)

ICC were calculated and ranged from 0.48 for bread (moderate agreement), to 0.60 (substantial agreement) for cow's milk and 0.67 (substantial agreement) for estimated food iodine intake (ug) between FFQ1 and FFQ 2 (See Table 4.15).

Additionally, Wilcoxon signed ranks test revealed that the differences in median values between each pair of test and retest variables (food iodine intake, bread and bread products and cow's milk) as well as all subgroups were not statistically significant. Food iodine intake, bread and bread products and cow's milk were further recoded into tertiles for both test and retest observations. Kappa statistic was then used to assess the reliability between FFQ1 and FFQ2. The kappa value (κ=0.48) indicated moderate agreement for food iodine intake of the subjects. Cow's milk (ranked into tertiles) also showed a moderate agreement between administrations of the FFQ (κ=0.58), with bread and bread products (fortified) achieving a kappa value of 0.38 (fair agreement) (Table 4.16). More than half of the subjects were correctly classified into the same tertile upon repeat administration of the FFQ (Table 4.16).

Table 4.15 Intraclass correlation coefficients for FFQ1 and FFQ2
Food iodine intake (ug), cow's milk (ug) and bread and bread products (ug).
Comparisons with different subgroups.

	ICC	Intake change YES*[a]	Intake change NO*[a]	≤ 28 wks (inclusive) gestation*[b]	> 29 wks gestation*[c]	≤14 days*[d]	>14 days*[e]	Excluding n=4 (pamphlet)*[f]
Food iodine intake FFQ1 and FFQ2 (ug)	**0.67**	0.62	0.72	0.68	0.79	0.83	0.62	0.71
Bread and bread products FFQ1 and FFQ2 (ug)	**0.48**	0.66	0.37	0.49	0.34	0.11	0.63	0.48
Cow's milk FFQ1 and FFQ2 (ug)	**0.60**	0.57	0.63	0.61	0.76	0.78	0.55	0.68

[a]Subjects stated that their dietary intake had/had not changed since first administration of the FFQ (FFQ1)
[b]Subjects who completed FFQ1 up to 28 weeks (inclusive) gestation
[c]Subjects who completed FFQ1 from 29 weeks gestation
[d] FFQ2 completed ≤14 days from FFQ1
[e] FFQ2 completed >14 days from FFQ1
[f] Analysis run excluding 4 subjects who received iodine brochure upon completion of FFQ1

In addition to this, marginal homogeneity tests indicated there was no significant difference in marginal proportions between each pair of test and retest variable of interest (food iodine intake, bread and bread products and cow's milk), suggesting agreement between FFQ1 and FFQ2.

Kappa was also determined for individual food items (as ordered categorical variables relating to frequencies of consumption only) for FFQ1 and FFQ2. Results for food items with kappa > 0.5 (and bread/bread products) are given in Table 4.18. Although tofu, shellfish and sushi had kappa values ranging from 0.39 to 0.76 (fair to substantial agreement) for some subgroups, these food items were not consumed frequently by the majority of subjects and were not considered major contributors to iodine intake.

The kappa statistics for cow's milk, one of the top contributors to iodine intake, across the subgroups was consistently above 0.40 (up to 0.66), indicating moderate to substantial agreement. Bread and bread products demonstrated fair agreement (κ=0.20-0.38).

Differences in ICC/kappa associated with the subjects' perceived change of intake between administrations of FFQ1 and FFQ2 was investigated. Some of the reasons for reported change of dietary intake had the potential to affect iodine intake such as; drinking more milk, being more aware of the nutritional requirements for pregnancy and using iodised salt. Other reasons provided by subjects included eating more or less (generally), different cravings, feeling full quickly, more nausea, end of religious fast, being on holidays or travelling.

4.6.1 Comparisons with different subgroups

Time differences between completion of FFQ1 and FFQ2 were explored, as well as differences in gestational stage at time of FFQ1. It should also be noted that four subjects in the retest group were provided with the KEMH iodine brochure after completion of their first questionnaire due to the questions they asked regarding iodine upon initial administration. Two subjects stated that they thought their intake had changed upon administration of FFQ2 (eating more in general, eating more meat) and two stated that intake had not changed. As with time differences and gestational stage, ICC and kappa tests were run twice with this group, including and separately excluding all 4 subjects (see Table 4.17 and Table 4.18).

Table 4.16 Kappa statistic and percentage classification of subjects for FFQ1 and FFQ2
Into same tertile, adjacent tertiles (1 and 2, 2 and 1, 2 and 3 or 3 and 2) and opposite tertiles (1 and 3 or 3 and 1).

	Kappa	Same tertile (%)	Adjacent tertile (%)	Opposite Tertile (%)	P Value Kappa
Kappa-tertiles FFQ1 and FFQ2*	0.48	65.2	31.9	2.9	<0.001
Kappa-tertiles Bread and bread products FFQ1 and FFQ2*	0.38	59.4	34.8	5.8	<0.001
Kappa-tertiles Cow's milk FFQ1 and FFQ2*	0.58	72.5	24.6	2.9	<0.001

*Marginal homogeneity p>0.05

Table 4.17 Kappa statistic for FFQ1 and FFQ2
Food iodine intake (tertiles), cow's milk (tertiles) and bread and bread products (tertiles). Comparisons with different subgroups.

	Kappa	Intake change YES*[a]	Intake change NO*[a]	≤ 28 wks (inclusive) gestation*[b]	> 29 wks gestation*[c]	≤14 days*[d]	>14 days*[e]	Excluding n=4 (pamphlet)*[f]
Food iodine intake FFQ1 and FFQ2*	**0.48**	0.45	0.50	0.54	0.40	0.37	0.51	0.49
Bread and bread products FFQ1 and FFQ2*	**0.38**	0.49	0.29	0.42	0.26	0.09	0.47	0.39
Cow's milk FFQ1 and FFQ2*	**0.58**	0.65	0.52	0.58	0.60	0.71	0.53	0.62

*Marginal homogeneity p>0.05

[a]Subjects stated that their dietary intake had/had not changed since first administration of the FFQ (FFQ1)

[b]Subjects who completed FFQ1 up to 28 weeks (inclusive) gestation

[c]Subjects who completed FFQ1 from 29 weeks gestation

[d] FFQ2 completed ≤14 days from FFQ1

[e] FFQ2 completed >14 days from FFQ1

[f] Analysis run excluding 4 subjects who received iodine brochure upon completion of FFQ1

Table 4.18 Kappa > 0.5 for food items for FFQ1 and FFQ2
Categorised according to frequency of consumption (including bread and bread products). Comparisons with different subgroups.

	Kappa	Intake change YES*[a]	Intake change NO*[a]	≤ 28 wks (inclusive) gestation*[b]	> 29 wks gestation*[c]	≤14 days*[d]	>14 days*[e]	Excluding n=4 (pamphlet)*[f]
Kappa-frequency Cow's milk FFQ1 and FFQ2*	**0.52**	0.66	0.41	0.56	0.49	0.62	0.49	0.54
Kappa-frequency Tofu FFQ1 and FFQ2*	**0.60**	0.62	0.56	0.64	0.58	0.73	0.50	0.56
Kappa-frequency Shellfish FFQ1 and FFQ2*	**0.53**	0.56	0.47	0.41	0.70	0.76	0.39	0.55
Kappa-frequency Sushi FFQ1 and FFQ2*	**0.50**	0.43	0.56	0.46	0.51	0.70	0.41	0.49
Kappa-frequency Bread and bread products FFQ1 and FFQ2*	**0.23**	0.32	0.24	0.27	0.20	N/A	0.38	0.26

[*] Marginal homogeneity p>0.05

[a] Subjects stated that their dietary intake had/had not changed since first administration of the FFQ (FFQ1)

[b] Subjects who completed FFQ1 up to 28 weeks (inclusive) gestation

[c] Subjects who completed FFQ1 from 29 weeks gestation

[d] FFQ2 completed ≤14 days from FFQ1

[e] FFQ2 completed >14 days from FFQ1

[f] Analysis run excluding 4 subjects who received iodine brochure upon completion of FFQ1

[N/A] Limited number of subjects in this category (n=16) completed FFQ2 ≤14 days from FFQ1

4.7 Development of a rapid screening tool

The findings in Figure 4.9 were used to develop a rapid screening tool designed to assess the likelihood of pregnant women meeting the EAR for iodine. Each question and result were independent of each other. As can be seen in Figure 4.9 nearly all women (97%) who used an iodine-containing supplement (regardless of iodine content) (n=95) attained the EAR using total iodine data. Women who were consuming iodised salt (n=160) had an 83% chance of meeting the EAR using dietary iodine data (based on findings that over half of the subjects used iodised salt in cooking daily).

The last two components of the screening tool related to the likelihood of attaining the EAR for iodine if relying on food sources of iodine. Women who consumed cow's milk at least twice a day (minimum 1 cup per day) demonstrated a high likelihood of attainment (91%) of the EAR using food iodine data, reinforced by moderate to substantial agreement upon reliability testing (Section 4.6). Those consuming bread or bread products at least twice a day (minimum 2 slices per day) were assessed to have a slightly lower chance of meeting the EAR using food iodine data (83%), with reliability testing demonstrating fair agreement.

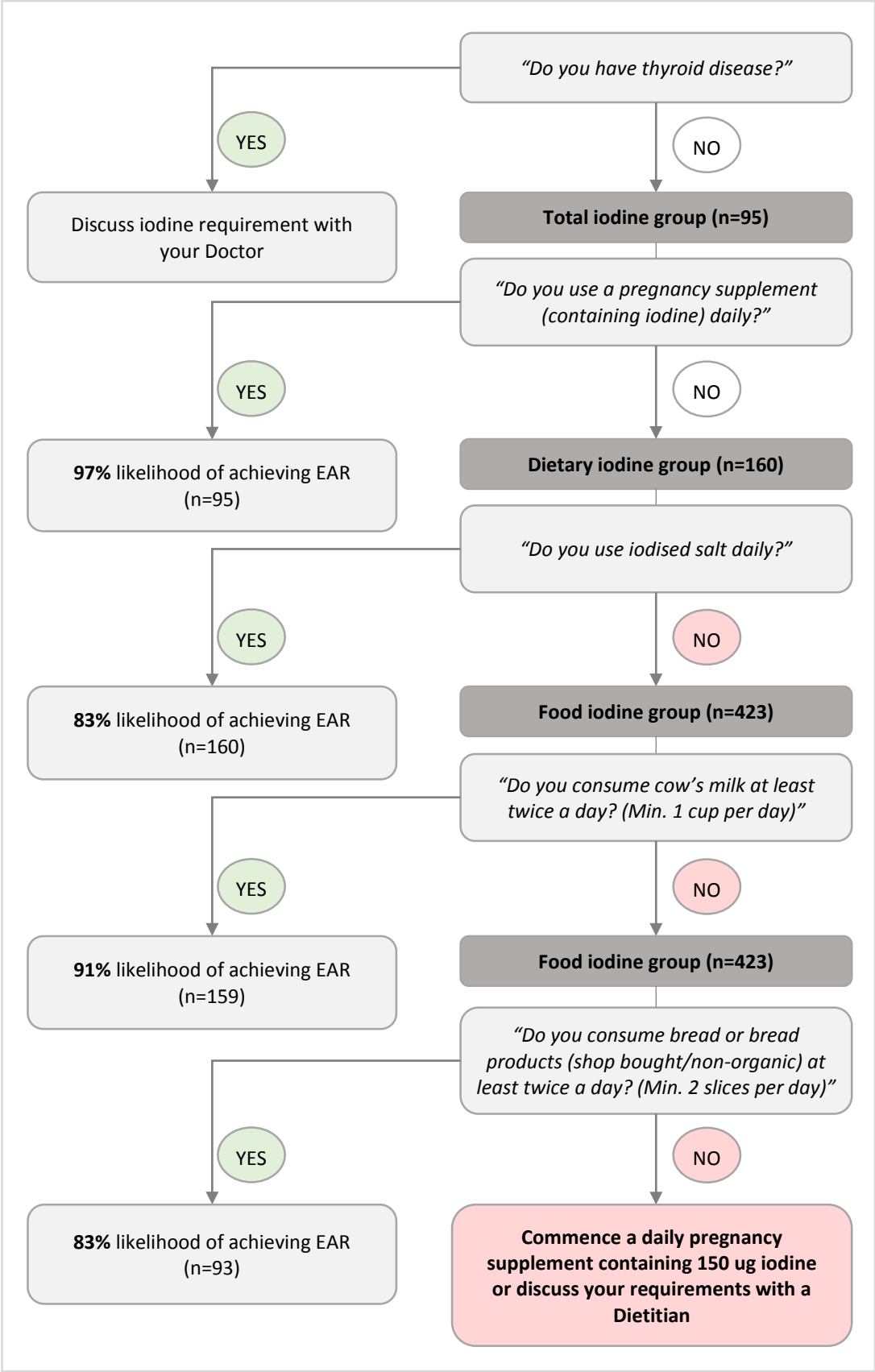

Figure 4.9 Decision tree used to develop a rapid screening tool
(based on subjects achieving EAR (%) for major contributors to iodine intake)

4.8 Summary

Estimated iodine intake:

- Median iodine intakes calculated using the dietary iodine data and the total iodine method met the EAR for pregnancy, whilst median intake of the food iodine data was slightly less than the EAR.
- Cow's milk contributed approximately 38-41% of dietary iodine intake, followed by bread and bread products (fortified with iodine) (18-20%) and iodised salt (10-16%).
- Over one-third of the subjects did not meet the EAR (calculated using dietary iodine data), whilst more than half did not achieve the EAR (calculated using the food iodine data).
- Higher frequency of consumption of cow's milk (at least twice a day) was significantly associated with achieving the EAR from both dietary iodine and food iodine.
- Higher frequency of consumption of bread and bread products (fortified with iodine) (at least twice a day) was significantly associated with achieving the EAR from both dietary iodine and food iodine.

Iodised salt use:

- Approximately 45% of subjects used iodised salt (after excluding women who did not know whether they used iodised salt or not).
- Education level was significantly associated with iodised salt use. Proportionally more women who had tertiary or professional qualifications reported using iodised salt compared to those in the other education categories.
- Ethnic combination group was significantly associated with iodised salt use. Proportionally more women from Asian/African/Other ethnic backgrounds reported using iodised salt, followed by women from New Zealand/Polynesian backgrounds. Australian/Australian Aboriginal/TSI women reported the lowest iodised salt usage.
- Iodised salt use was significantly associated with achieving the EAR.

Iodine-containing supplement use

- Approximately one-quarter of subjects used an iodine-containing supplement in the year prior to pregnancy.
- Age was significantly associated with iodine-containing supplement use in the year prior to pregnancy. A higher proportion of women in the highest age category used an iodine-containing supplement prior to pregnancy compared to women in the middle and lowest age category.
- Gestational stage was significantly associated with iodine-containing supplement use in the year prior to pregnancy. A higher proportion of women in the earlier stage of pregnancy reported using an iodine-containing supplement prior to pregnancy compared to women in the later stage of pregnancy.
- Income was significantly associated with iodine-containing supplement use in the year prior to pregnancy. A higher proportion of women in the highest income category used an iodine-containing supplement prior to pregnancy compared to women in the middle and lower income category.
- Two-thirds of subjects used an iodine-containing supplement during pregnancy with the majority of subjects (97%) who consumed quantifiable iodine supplements (n=95) achieving the EAR for pregnant women.
- Gestational stage was significantly associated with iodine-containing supplement use during pregnancy. A higher proportion of women who completed the questionnaire at or before 28 weeks gestation used iodine-containing supplements compared to women who were in the later stage of pregnancy (29 weeks or more).
- Gravidity was also significantly associated with iodine-containing supplement use during pregnancy. A higher proportion of women who were pregnant for the first time used iodine-containing supplements compared to those who had been pregnant previously.

Knowledge and beliefs

- Knowledge regarding food sources of iodine and health problems associated with a lack of iodine in the diet was low compared to other issues.

- There was a significant association between education level and knowledge regarding food sources of iodine. Proportionally more women who had secondary school qualifications only selected "I do not know" while the lowest proportion was found in the highest education category. The greatest proportion of women from the highest education category correctly selected seafood as a good source of iodine.
- Education was significantly associated with the knowledge of health problems potentially related to a lack of iodine in the diet. Proportionally more women who had secondary school qualifications only selected "I do not know" while women from the highest education category represented the lowest proportion. Conversely, the greatest proportion of women from the highest education category correctly selected goitre and mental retardation.
- Age was significantly associated with the correct selection of goitre and mental retardation with the greatest proportion of women from the highest age category (35-44 years) correctly choosing these conditions.
- Ethnicity was significantly associated with knowledge regarding health problems related to inadequate iodine intakes. A greater proportion of women within the Asian/African/Other ethnic combination group correctly selected goitre and mental retardation, with proportions of less than 10% coming from those in each of the other ethnic combination groups. Proportionally more women from the New Zealand/Polynesian ethnic combination group selected "I do not know" in relation to health problems, followed by those from the Australian/Australian Aboriginal/TSI group while women from the Asian/African/Other ethnic combination group represented a considerably lower proportion.
- Gestational stage was significantly associated with the correct selection of goitre as a health problem. A higher proportion of women in the earlier stage of pregnancy correctly selected goitre.
- Approximately 45-55% of women across all categories relating to their belief that their diet met their iodine needs whilst pregnant reported using iodised salt. Women who were confident that their diet provided enough iodine for their needs were more likely to use iodised salt compared to those who did not know what iodine was.

- Approximately 60-75% of women across all categories relating to their belief that their diet met their iodine needs whilst pregnant reported using iodine-containing supplements. Women who did not think that their diet provided enough iodine for their needs were more likely to use iodine-containing supplements compared to those who did not know what iodine was.
- The most popular sources of dietary information were a doctor, followed by a midwife and the internet.
- Women received less information on iodine and other diet-related topics compared to folate and iron, with more women indicating they could not receive enough information on iodine than for any of the other dietary topics.

Reliability and rapid screening tool

- The FFQ demonstrated moderate reliability, allowing for the development of a rapid iodine screening tool that incorporated iodine-containing supplement use, iodised salt use, consumption of cow's milk and bread or bread products to determine the percentage likelihood of subjects meeting the EAR from total iodine, dietary iodine and food iodine, respectively.
- Women answering *"yes"* to the use of a pregnancy multivitamin (containing iodine) or the cow's milk consumption question were highly likely to achieve the EAR (97% likelihood using total iodine data) and (91% likelihood using food iodine data), respectively.

CHAPTER 5 : DISCUSSION

This study was designed to investigate the dietary iodine intake (including iodised salt and iodine-containing supplement use) of pregnant women attending KEMH, Western Australia's only women's and neonatal hospital, as well as to determine their knowledge and beliefs on iodine-related topics. The secondary aims were to assess the reliability of an existing tool used to rank dietary iodine intake in pregnant women in order to identify the potential of developing a rapid iodine screening tool to determine the women whose individual usual intake are not likely to meet the EAR for iodine.

This is the first study to investigate iodine knowledge, beliefs and practices of pregnant women in WA. The literature over the last 15 years reveals that there is a lack of data regarding iodine status, iodine intake or the more recent interests of iodine, iodine-containing supplement use and iodine nutrition knowledge and beliefs of pregnant women in WA.

5.1 Estimated iodine intake

The median iodine intake values calculated for dietary iodine (iodine from food + iodised salt) and for the total iodine data (iodine from food + iodised salt + iodine-containing supplements) met the EAR for pregnancy (196 ug/day and 358 ug/day), respectively, whilst median intake relating to the food iodine data was slightly less than the EAR at 148 ug/day. These findings are consistent with two of the more recently published studies with Condo et al. (2015) (SA) reporting similar estimated iodine intake values for food iodine data (borderline sufficient/sufficient) and Lucas et al. (2014) (NSW) reporting a median iodine intake value that exceeded the EAR for dietary iodine data and total iodine intake data. Brough et al. (2015) (NZ), Charlton et al. (2013) (NSW) and Mallard and Houghton (2014) (NZ) also report estimated population iodine intake values above the EAR post-fortification of bread and bread products, whereas pre-fortification studies estimating iodine intake indicated insufficiency.

Whilst not a focus of this study, it is noteworthy that three of the 95 women whose estimated *total* iodine intake (range 1142-1384 ug/day) exceeded the UL for iodine (1100 ug/day) set by the NHMRC (2006b). These women used iodised salt (estimated iodine content approximately 800 ug/day with the majority added to cooking) iodine-containing supplements (iodine content of supplements approximately 220 ug/day), in addition to consuming cow's milk daily, with two women using bread and bread products at least twice a day. Iodised salt was clearly contributing the most toward excessive iodine intakes in these subjects, highlighting a potential issue with women using the equivalent of 1 tsp of iodised salt at least twice a day (in addition to daily iodine-containing supplements). Overestimation of the amount of salt used by these women is a possibility given the limitations of estimating iodine contribution from iodised salt (Section 2.7). It has also been assumed that iodine-containing supplements are taken every day.

Comparisons between estimates of intake are complicated by different dietary assessment methods, sample sizes, research methodologies, sample demographics, timing of study (pre- or post-fortification), and associated dietary habits, however the trend of iodine intakes approaching and achieving the EAR in study populations in WA, SA, NSW and NZ is promising on a population level.

The food items contributing the most to iodine intake of subjects using iodine (ug) from iodised salt (Section 4.3.1) were calculated using estimate 1 (calculated in FoodWorks (based on the subject's estimation of iodised salt)), estimate 2 (calculated by correcting (halving) iodised salt used in cooking for primigravid women (assuming the cooking was for two people-subject and partner)) and estimate 3 (calculated using an adjusted standard figure of 48 ug (approximately equivalent to 1 g of iodised salt)), the latter method has been used in other studies (Charlton et al. 2013; Mallard and Houghton 2014). The top three sources of iodine in the study population (n=425) were cow's milk, bread and bread products (fortified with iodine) and iodised salt, contributing 38-41%, 18-20% and 10-16%, respectively (Table 4.5).

These results concur with findings from the 2003 cohort of the ALSWH study indicating that milk/dairy products and bread and bread products (adjusted for iodine fortification) were major contributors to dietary iodine intake in 665 pregnant women (Mackerras et al. 2011). The 1995 NNS provided evidence that dairy products contributed significantly to overall iodine intake in Australia on a larger scale (Food Standards Australia New Zealand 2008a), however it was around this time that iodine-containing sterilising agents used in milk production were being replaced by non-iodine containing agents, rendering dairy products as less reliable sources of iodine. In addition, the 1995 NNS was conducted prior to fortification of bread and bread products with iodine, discretionary iodised salt data was reported to be incomplete and only a small number of pregnant women were sampled.

The percentage contribution of iodised salt to dietary iodine intake in this study (10-16%) is higher than those reported by Lucas et al. (2014) and Charlton et al. (2013) (10 and 4.5-8%), respectively. Comparisons are limited as both studies used a maximum cut-off of 1g of iodised salt per day, differences are compounded further by the problems that exist for quantifying iodised salt intake (Section 2.7).

Since bread fortification, studies conducted in Australia and NZ confirm that milk and dairy products together with bread, bread products (iodine fortified) or breads and cereals are significant contributors to overall iodine intake (Charlton et al. 2013; Lucas et al. 2014; Martin, Savige, and Mitchell 2014; Rahman et al. 2011). Direct comparisons of percentage contribution of these major food sources could not be made, as specific categories of foods were not the same as those in the current study.

All studies (including this research) indicate low intakes of fish and other seafood (Charlton et al. 2013; Lucas et al. 2014; Martin, Savige, and Mitchell 2014; Nguyen et al. 2010; Pettigrew-Porter et al. 2011; Rahman et al. 2011), a trend that has repercussions not only on iodine intakes but also on other important dietary constituents such as omega-3 fatty acids and vitamin D.

5.2 Data collection tool and assessment of dietary iodine intake

This study utilised a 68-item questionnaire comprising of a 41-item iodine-specific FFQ (adapted from a tool validated by Tan et al. (2013) in the elderly) (Section 3.4).

Food frequency questionnaires are a well-accepted method of dietary data collection (long-term) allowing for the investigation into food and nutrient intake, behaviours and habits as well as eating patterns (Subar et al. 2015). This particular FFQ recorded subjects' self-reported dietary intake over the last two months which lent itself to capturing more "usual" estimated iodine intake data, thus reducing random error in a population where nausea and taste changes vary from one day to the next. The FFQ was a practical assessment and ranking tool of low subject burden and also provided a means of investigating consumption patterns of food items (e.g. once a day, once a week, never) as well as collecting some data on alcohol (beer) intake in this study sample.

Attempts were made to minimise systematic error associated with the collection of dietary intake data including; the use of a FFQ based on a previously validated tool demonstrating moderate test-retest reliability. This was the largest study out of all Australian studies in the literature review that had investigated iodine knowledge, beliefs and iodine intake. Furthermore, a standardised approach to data entry in Foodworks was carried out by TH, together with the assessment of the reproducibility of the FFQ upon repeat administration. In addition to this, TH was available to answer questions and to provide photographs of food items to assist with questionnaire completion during the data collection phase.

Methods used to determine estimated iodine intake in Australian and NZ studies varied with most using FFQs (Charlton et al. 2013; Lucas et al. 2014; Pettigrew-Porter et al. 2011), one study used a FFQ and a 4-day weighed food record (Condo et al. 2015), with Mallard and Houghton (2014) assigning 60 ug/day from food as a baseline assignment for all subjects and 48 ug iodine from iodised salt for those who used iodised salt. Two studies used a method of extrapolation from urinary iodine excretion to estimate dietary iodine intake (Blumenthal, Byth, and Eastman 2012; Brough et al. 2015). These methods have associated limitations and these will be discussed further in Section 5.9.

5.3 Iodised salt use

Approximately 45% of subjects used iodised salt (after excluding women who did not know whether they used iodised salt or not). More than half of the iodised salt users added it in cooking at least once a day (62%) and approximately 40% used iodised salt at the table at least once a day (Table 4.9). Gathering and comparing data regarding iodised salt use from the literature proved difficult as not all information was related to daily use or distinguished between iodised salt used in cooking or at the table. Most of the Australian and New Zealand studies that reported any iodised salt use described ranges between approximately 20% to 50% (Blumenthal, Byth, and Eastman 2012; Brough et al. 2015; Charlton et al. 2012; Charlton et al. 2010; Charlton et al. 2013; Condo et al. 2015; El-mani, Charlton, et al. 2014; Lucas et al. 2014; Martin, Savige, and Mitchell 2014; Nguyen et al. 2010; Pettigrew-Porter et al. 2011; Rahman et al. 2011). The results from this study are consistent with these findings.

Education level and knowledge regarding iodine were significantly associated with iodised salt use in the subjects who knew whether they used iodised salt or did not use iodised salt (excluding those who did not know what type of salt they used). A higher proportion of women who had tertiary or professional qualifications reported using iodised salt. Although the numbers are low, subjects who did not know what iodine was (n=36) in response to the woman's belief that her diet provided enough iodine for her body's needs when pregnant) were less likely to be using iodised salt (73.5%).

The subjects in this study were sampled from a public hospital whereas a number of other Australian studies have recruited from private hospitals or both private and public hospital sites. The mean age of subjects in this study was 29.4 (5.5) years with over half (60%) in the 25-34 age category. More than a third were primigravid and over half were $\geq$ 29 weeks gestation. Of those who responded to the question on earnings, more than half (54%) earned less than $50 000 in the previous 12 months.

Combination of ethnic groups was significantly associated with iodised salt use in the subjects who knew what type of salt they used. Women in the Asian/African/Other ethnic combination group were more likely to use iodised salt (59.1%) followed by 46.7% of women from New Zealand/Polynesian backgrounds. Women from the Australian/Australian Aboriginal/TSI grouping (Australian Aboriginal (n=6), TSI (n=0) used iodised salt and represented the lowest proportion of iodised salt use out of all groups (35.2%).

The representation of women of diverse ethnic backgrounds in this study has demonstrated differing dietary practices and knowledge relating to iodine. Given that USI exists in many areas of Asia, Africa and "Other" regions such as India, it is possible that habitual use and/or greater awareness of women from these ethnic groups explained the higher rates of consumption.

5.4 Iodine-containing supplement use

In 2010 the NHMRC released a national recommendation stating that all women who are considering pregnancy, who are pregnant or breastfeeding take a daily iodine supplement of 150 ug (National Health and Medical Research Council 2010). Despite this, the present study demonstrated a distinct difference in iodine-containing supplement use prior to pregnancy and during pregnancy.

Approximately one-quarter of subjects who answered the question used an iodine-containing supplement in the year prior to pregnancy versus more than half who indicated using iodine-containing supplements during pregnancy (Figure 4.2).

Age, income and gestational stage were significantly associated with iodine-containing supplement use in the year prior to pregnancy. Results indicated that the proportionate use of iodine containing supplements prior to pregnancy increased with the age category of the subjects. Whilst results indicate that more than half of those who used iodine-containing supplements in the year prior to pregnancy were from the lowest income category, a greater proportion of women from the highest income category (52.6%, n=10) used these supplements. As discussed further in Section 5.9, only the subject's income over the last 12 months was requested, potentially underestimating household income or earning potential of the subject (if currently on a career break). In addition, age and income are related and therefore may have led to confounding. A higher proportion of women who were 28 weeks gestation or less at the time of completing the questionnaire reported using iodine-containing supplements compared to those who undertook the questionnaire from 29 weeks.

Three assumptions can be made based on this data; 1) that women in the youngest age category may not have been planning to become pregnant and therefore were not taking an iodine-containing supplement or 2) were not aware of the recommendation to use these supplements (if planning to become pregnant or during pregnancy) or 3) iodine-containing supplement use was higher pre-pregnancy in those who were more likely to be able to afford these supplements. Memory recall over time may have affected the women's ability to retrospectively report their use of supplements used as their pregnancy progressed, potentially explaining the reason for the significant decrease of reported iodine-containing supplement use prior to pregnancy in women completing the questionnaire in the later stage of pregnancy (29 weeks or more).

In contrast, age and income were not significantly associated with iodine-containing supplement use during pregnancy. Gestational stage and gravidity were significantly associated with iodine-containing supplement use with a higher proportion of women who completed the questionnaire at or before 28 weeks gestation reporting use of iodine-containing supplements compared to those who undertook the questionnaire from 29 weeks. This trend of non-compliance with iodine supplement use in the later stage of pregnancy may be similar to factors identified in a United Kingdom study on folic acid supplementation use (Barbour et al. 2012) and include; forgetting to take the supplement, morning sickness, less perceived risk due to previous normal pregnancy (or in this case, possibly once assured that pregnancy is progressing without complications), other health priorities and doubt relating to benefits of supplementation.

A greater proportion of primigravid women reported iodine-containing supplement use compared to those who had been pregnant previously (73.8% and 60.6%), respectively. The lower use of these supplements by women who had been pregnant before was likely to have been due to less perceived risk (in those who had experienced a previous normal pregnancy). It was also found that women who did not know what iodine was were significantly less likely to be using iodine-containing supplements compared to women in the same category who were using them.

Previous studies conducted in Australia and NZ have reported similar factors associated with iodine-containing supplement use. Charlton et al. (2010) provided evidence for higher iodine supplement use in those who were pregnant for the first time, and Martin, Savige, and Mitchell (2014) similarly identified that women who did not think their diet contained enough iodine were more likely to take iodine-containing supplements than women who did not know or who thought a healthy diet was adequate. Mallard and Houghton (2014) reported that women who were less likely to take supplements as recommended were those who were the least advantaged (i.e. from lower income and education groups) although the results from the current study did not concur with the latter findings in those who used iodine-containing supplements prior to or during pregnancy. In contrast to the current study, El-mani, Charlton, et al. (2014) indicated higher percentage use of iodine (and folate) supplements in pregnant women from the highest income category and based on a related theme, Bower et al. (1997) reported that pregnant women with less education were less likely to take folate supplements prior to, and in early pregnancy compared to women with a tertiary education.

Differences in findings may have been due, in part, to the difference in overall sample sizes and locations within Australia and New Zealand. The proportion of multigravid women in the WA study was more than that of the Gippsland study (62%, n=262 versus 42%, n=83, respectively) with the current study indicating that amongst this group fewer women used iodine-containing supplements (compared to primigravid iodine-containing supplement users). Furthermore, varying results between studies may also have been due to the complexities related to the measurement of socioeconomic status, including the overlap between occupation, income and education (Adler et al. 1994). The use of individual income has limitations (Section 5.9), nonetheless, it was worth exploring this SES variable (in addition to education level) in this diverse study population.

The confirmed findings from this study are valuable as they highlight subgroups of the population at a higher risk of inadequate iodine intakes (e.g. younger women, those with less education and those from lower income groups). The fact that there was less supplement use from 29 weeks pregnancy than before in the present study raises concerns regarding continued supplement use during breastfeeding.

The prevalence of iodine-containing supplement use during pregnancy in the present study (66%) falls within the range found in post-fortification studies in NSW, Vic, SA and NZ (50-75%), adding to the body of evidence that iodine-containing supplement use post-fortification in 2009 is greater than pre-fortification (less than 50%). As mentioned previously, this trend, for the most part, is likely due to the reformulation of pregnancy multivitamins (over the last five or six years) to align with recommendations regarding iodine-containing supplement use of national and international health organisations such as NHMRC (2010), NZ MoH (2010) and ATA (2006). Interestingly, the dietary supplement with the highest percentage use in this study was Elevit (43.4%) with each dose containing 220 ug iodine which is greater than the recommended amount (150 ug).

5.5 Reliability and development of a rapid screening tool

Overall, the FFQ demonstrated moderate test-retest reliability based on repeat administration of the FFQ (for 69 subjects). The development of a rapid iodine screening tool incorporated key components found in this study (iodine-containing supplement use, iodised salt use, frequency of consumption of cow's milk and bread or bread products fortified with iodine) to determine the percentage likelihood of subjects meeting the EAR for each component (Figure 4.9).

The initial question in the screening tool acknowledges the requirement for women with thyroid disease or a history of thyroid disease to seek individual medical advice. The remaining 4-items relate to oral consumption with yes and no options for each. Women who answer two or more of the shaded "no" sections should consider taking an iodine-containing supplement (150 ug/day) or should discuss their individual requirements with a dietitian (as it may be possible to increase dietary intake to meet requirements without the need for iodine-containing supplements in this population).

Ninety-seven percent of women who reported using (quantifiable) iodine-containing supplements in this study (n=95) achieved the EAR based on the total iodine data (food + iodised salt + iodine from supplement). The percentage is likely to have been higher however the assumption was made that two out of the three women who did not meet the EAR only consumed one capsule (not two, as per manufacturer's instructions) of their pregnancy (iodine-containing) supplement per day. One woman only reported consuming her pregnancy supplement (iodine-containing) three times a week (Section 4.2.2). All of these women were not iodised salt users, nor did they consume cow's milk daily.

Following on from this, iodised salt use was significantly associated with meeting the EAR with women who used iodised salt having an 83% chance of meeting the EAR based on dietary iodine data (food + iodised salt).

An essential question for those not consuming iodine-containing pregnancy multivitamins or iodised salt was related to the consumption of cow's milk at least twice a day. This component demonstrated a high percentage likelihood of achieving the EAR (91%) using food iodine data, was significant and demonstrated moderate to substantial agreement upon reliability testing (Section 4.6).

Following on from this, the consumption of bread and bread products at least twice a day was also significantly associated with achieving the EAR with those who consumed a minimum of 2 slices of bread per day having an 83% likelihood of meeting the EAR based on food iodine data. Reliability assessment indicated fair agreement for this item.

There is scope for the trialling and subsequent validation of this newly developed 5-item screening tool in pregnant women in WA (Figure 4.9). Whilst there is no "gold-standard" to apply, it is likely that a combination of validation methods such as; weighed food records, UIE, UIC and thyroid function tests as used by Condo et al (2015) in their study (described below) on a larger sample size will enhance the usability of this tool and provide further data on this unique population.

Findings from other Australian and NZ studies identify similar key components and associations. To the author's knowledge only one other study in the Australian literature has validated a 44-item iodine-specific FFQ specifically in pregnant women (Condo et al. 2015) (SA) (using 4-day weighed food records, UIE, 24-h UIC, spot UIC and thyroid function tests) and have proposed its use as an iodine screening tool for pregnant women. However, factors such as the exclusion of iodine contribution from iodised salt and a final sample size of less than 100 subjects limits the applicability of the final results. It was also difficult to determine from the study if women from different ethnic backgrounds and NESB were excluded therefore limiting generalisability of the findings towards culturally and ethnically diverse populations if so.

5.6 Knowledge, beliefs and sources of iodine information

The study results indicate that the subjects' knowledge regarding iodine nutrition was limited, confirming the findings of previous literature on this topic (Brough et al. 2015; Charlton et al. 2012; Charlton et al. 2010; Charlton et al. 2013; El-mani, Charlton, et al. 2014; Lucas et al. 2014; Martin, Savige, and Mitchell 2014).

Less than half of the subjects in this study were able to correctly identify a good food source of iodine, salt being the most frequently selected option (46.9%). Given that nearly one-third of all women used iodised salt, it was assumed that those who selected this option were referring to iodised salt being a good source of iodine. Less than 5% of all subjects identified bread as the mandatory fortification vehicle whilst approximately one-quarter of women incorrectly identified food items such as meat and vegetables as good sources of iodine and a quarter chose the option "I do not know".

Over half of the women selected *"I do not know"* in response to a list of health problems that may or may not be associated with not having enough iodine in the diet with less than 20 and 10% of subjects correctly choosing goitre and mental retardation, respectively.

As explained in Section 4.5.3, subjects who did not know what iodine was (in response to the woman's belief that her diet provided enough iodine for her body's needs when pregnant) reported the lowest proportion of iodised salt and iodine-containing supplement use amongst respondents, providing some justification for increased iodine awareness/education strategies in areas where iodine deficiency is prevalent.

Interestingly, women who felt confident that their diet provided enough iodine were more likely to be using iodised salt however those who did not think that their diet provided enough iodine were more likely to be using iodine-containing supplements. This may reflect that those who were using iodised salt had made a conscious decision to use it and felt confident that this improved their diet whereas women using iodine-containing supplements may have been unaware of the recommendations to use them and/or were unsure as to whether their supplement contained iodine. There is also the possibility that these women perceived their diets (food only) to be inadequate and were deliberately using iodine-containing supplements (or pregnancy supplements) to increase iodine intake (or overall dietary adequacy).

In the current study education and age were significantly associated with knowledge regarding iodine. A greater proportion of women who had secondary school qualifications only selected *"I do not know"* for questions relating to good food sources of iodine and health problems. Women from the highest education group were more likely to correctly select goitre and mental retardation as health problems related to inadequate iodine intake (Table 4.12) and a higher proportion of women from this education group correctly chose seafood as a good food source. El-mani, Charlton, et al. (2014) also found a significant relationship between higher education levels and better knowledge regarding health problems associated with a lack of iodine in the diet. There was a significant association between age and the correct selection of the health problems goitre and mental retardation, with the highest proportion of women who chose these conditions being from the highest age group.

Younger age and less education have also been associated with other pregnancy-related health behaviours in Australian women such as smoking (Mohsin and Bauman 2005) and high-risk alcohol consumption after the first trimester (Cameron et al. 2013). This reinforces the need for targeted strategies to raise awareness and provide support for young pregnant women and those with lower education levels.

To the author's knowledge, this is the first time that iodine knowledge has been investigated in terms of ethnic differences, yielding important results. Combinations of ethnic groups was significantly associated with the selection of *"I do not know"* relating to health problems with greater proportions of women from the New Zealand/Polynesian and Australian/Australian Aboriginal/TSI ethnic combination groups selecting this option compared to those of Asian/African/Other backgrounds. Although the numbers were lower, a similar trend in relation to knowledge was shown with a higher proportion of women from the Asian/African/Other ethnic combination group correctly choosing goitre and mental retardation compared to women from the other two groupings (Table 4.12). As mentioned in relation to iodised salt use (Section 5.3) and equally as relevant here, it is possible that women from the Asian/African/Other combination group may have greater awareness due to USI in areas of Asia, Africa and "Other" regions such as India. This in turn would influence dietary habits, practices, patterns and knowledge.

A significantly higher proportion of women in the earlier stage of pregnancy correctly identified goitre as a health problem. This may have been related to age, education level and/or ethnic combination group, given the findings above.

A greater proportion of women who had been pregnant previously achieved the EAR from food alone compared to women who were pregnant for the first time. The reasons for this significant finding are unclear. One possibility could be that women who have been pregnant before may have incidentally gained more knowledge on healthy eating and pregnancy through previous antenatal care and/or mothers' groups and this has had a positive influence on iodine intake.

Given that cow's milk has been identified in this study as the single most important food contributor to iodine intake it was interesting to note that only 17.4% of subjects identified it as a good source of iodine, with approximately one-quarter of participants in NSW studies by Charlton et al. (2012); (2010) and Lucas et al. (2014) identifying the same. Similarly, lower percentages of women in the present study identified bread as a good source of iodine (18, 27 and 26%, respectively vs 16%). It is difficult to suggest a reason for this difference in knowledge of good food sources between the two states as it may simply reflect sample size differences (with the WA study sample being approximately three times the size of the NSW studies) or varied sample demographics. In addition to this, these findings suggest there may be less antenatal education provided on iodine in WA, however comparison with Charlton et al. (2013) (NSW) findings does not support this suggestion. The percentage of women attending a public antenatal clinic in Wollongong in 2008 and 2011 who reported that had received enough dietary information on iodine to make informed decisions was lower than the findings from this WA study (17, 34 and 48%), respectively.

Women in the present study received less information on iodine and other diet-related topics compared to folate and iron, with more women indicating they could not receive enough information on iodine than for any of the other dietary topics (Figure 4.8), this trend was also reported in NSW (Charlton et al. 2012; Charlton et al. 2013). Findings reveal that GPs and midwives were identified as the most popular sources of dietary information (followed by the internet) and therefore play an important role in providing this information. Similarly Charlton et al. (2012) report healthcare professionals, followed by the internet as the most common sources of dietary information.

5.7 Impact of pregnancy on food choices

Pregnancy is a time when many women experience taste changes, taste aversions and nausea. In addition to this women are advised to adapt food choices to minimise the risk of listeria infection, to minimise intake of fish that accumulate methylmercury and to abstain from alcohol consumption (National Health and Medical Research Council 2013). Over 60% of women in this study reported having eliminated food/foods during pregnancy with more than 50% (combined) no longer consuming deli meat, pre-prepared and reheated food and unpasteurised dairy/soft cheeses. This appears to be in keeping with a high percentage of women who felt they could access information on listeria topics.

It is difficult to ascertain from the data the reason why approximately 8% of women were no longer consuming fish, shellfish (seafood) (not raw) (Table 4.13). However, it is likely that the following factors have influenced the decreased consumption of this rich source of iodine; 1) taste changes, aversions and nausea, 2) confusion regarding mercury recommendations and fish intake, 3) women being focused (and potentially confused) about foods to avoid to minimise listeria infections. To illustrate the last point, results from focus groups conducted on WA women of child-bearing age to identify barriers to good nutrient intakes during pregnancy indicated that listeria was the most commonly discussed nutrition-related theme with the potential to have implications on food choices and therefore nutrient intake (Begley 2002).

There appears to be a clear case for improved education strategies on mercury and avoidance of listeria infection. Whether the form of such education requires review is worth considering in light of a recent article that investigated the complexities surrounding the uptake of health and nutrition-related practices of NSW mothers (Maher and Lowe 2015). An important finding of relevance to this study was the identification by mothers of the challenges related to following all of the recommended guidelines, as well as the difficulties of translating and implementing these recommendations in their day-to-day lives (Maher and Lowe 2015).

5.8 Strengths of this study

The doubling of sample size over the previous Australian studies that assessed iodine intake together with knowledge, attitudes and beliefs assisted with minimising sampling errors and increased the statistical power of other analysis.

Women from across the state were included in this study including women from varying cultural backgrounds and NESB (n=7). Representation of these women was appropriate given the cultural diversity of the WA population. Their inclusion has led to interesting findings suggesting that women from Asian/African/Other ethnic combination groups have better knowledge regarding potential health effects of inadequate iodine and are more frequent users of iodised salt, therefore may be less likely to have inadequate iodine intakes This study did not measure urinary iodine but such measures by Hamrosi, Wallace, and Riley (2005) on three different ethnic groups in Melbourne indicated that UIC for Caucasian women was significantly lower than Indian/Sri Lankan women and Vietnamese women. Indeed, it is likely that different education strategies are required for Australian women of Caucasian background and Aboriginal or TSI backgrounds and for Polynesian women.

The age of women in this study could be considered reasonably representative of national figures for women who had given birth in 2013 (29.4 versus 30.1 years, respectively). Primigravid women in this study were under-represented (38%) compared to 43.7% of women, nationally, who had given birth to their first baby in 2013. These differences could have been due, in part, to vastly different sample sizes (n=425 versus n= 304777) (Australian Institute of Health and Welfare 2013).

The FFQ used in this study enabled investigation into dietary habits and patterns, knowledge and beliefs. The addition of the options *"I do not know what iodine is"* in relation to the questions *"Do you feel that your own diet provides enough iodine for your body's needs (i.e. when you are pregnant)"* and *"... (when you are not pregnant?)"* was used to encourage accurate reporting relating to these questions, allowing subjects to feel that not knowing the answer was acceptable (Krosnick and Presser 2010). Furthermore, these options allowed exploration of factors related to knowledge, or lack thereof. This research provided evidence that women who selected *"I do not know what iodine is"* were less likely to use iodine-containing supplements and iodised salt, linking a lack of knowledge to their non-use.

5.9 Limitations of this study

The present cross-sectional study was based on a convenience sample of pregnant women at one public hospital site which limits the generalisability of the findings. In addition to this, one data collection day every week coincided with a Childbirth and Mental Illness clinic and therefore women with serious mental illness were likely to have been over-represented. Postcode information was not obtained from study subjects. Inclusion in future studies would prove useful for distinguishing between urban and rural responses.

Australian Aboriginal and TSI pregnant women comprised approximately 2.4% of the study population which is lower than the state and national percentage of Australian Aboriginal and TSI women reported to have given birth in 2013 (5.1% and 4.1%, respectively) (Australian Institute of Health and Welfare 2015). The small number of women this equates to (n=10) also limits the applicability and generalisability of these findings.

According to 2013 National Perinatal data 69% of women giving birth in Australia in 2013 were born in Australia (Australian Institute of Health and Welfare 2015) compared to 50% in this study sample (excluding Australian Aboriginal and TSI women). Nationally, 3.1% of women giving birth in 2013 were born in New Zealand (Australian Institute of Health and Welfare 2013). Thus the demographic profile of this study suggests an over-representation of these women in the study population with approximately 7% (n=30) of subjects including NZ and/or Maori backgrounds in their ethnic group description (Appendix E). It was difficult to ascertain WA information for the representation of the African/Asian/Other ethnic combination group due to the broad description of this category. In addition, the question *"What ethnic group do you belong to?"* could have been interpreted as country of birth or ancestry, further adding to the difficulty of determining representativeness of the sample.

The item relating to income is likely to have underestimated associations due to requesting the earnings of the subject only. Information on household income over the last 12 months would have given more of a complete picture on earnings and would have been more relevant given that some women from the highest education group in this population may have had career breaks due to undertaking unpaid work within the household, placing them in the lowest income category on their income alone. Changes should be made to the questionnaire in future to allow the determination of household income. An attempt was made to determine patterns relating to income and education however the aforementioned trend was not apparent in this study. The greatest proportion of those who correctly identified with these selections were in the highest education category.

As with any research that involves measuring self-reported dietary intake data, consideration needs to be given to the likelihood of measurement error. It is well-known that pregnant women experience taste changes, aversions and often nausea throughout pregnancy and attempts were made to identify inconsistent dietary intake in women who repeated the FFQ. Upon second administration of the FFQ subjects were asked to specify if their diet had changed since first administration and to state a reason. This allowed for reliability data to be looked at separately for these women.

Seasonal changes over the duration of the data collection period (December to July) may have affected dietary consumption patterns, a possibility that exists in many studies conducted across seasons. In the present study, if women completed the FFQ in late autumn when Perth's weather becomes considerably cooler, and with >14 days between administrations, seasonal changes may have influenced dietary intake. Separate reliability assessments were also conducted to determine differences related to time-frame between administration of the FFQ (≤14 days or >14 days between questionnaire completion), stage of pregnancy (≤28 weeks gestation and ≥29 weeks gestation) and the women who received written information on iodine after completing FFQ1.

The limitations associated with the use of food composition databases to determine dietary iodine intake are important to note. These databases only provide an estimated iodine value and are often based on an average figure determined via analysis, imputed data and/or borrowed data from a wide variety of food types or single foods that are grown and stored in different conditions and seasons (Sobolewski, Cunningham, and Mackerras 2010). The iodine content of soil varies across Australia therefore assigning one iodine value to a specific food that could have a substantial range in iodine content is problematic, especially given that WA is recognised for having nutrient-rich soil (Australian Bureau of Statistics 2013b) it may be possible that the iodine content of our local produce falls at the upper end of the iodine values assigned in food composition databases.

As described in Section 2.7 accurate estimation of dietary consumption is influenced by subject recall of foods, self-report bias, misinterpretation of quantities and lack of motivation to complete the FFQ (Babor 1987). In addition, the estimation of iodine contribution from iodised salt has been problematic in all studies that have attempted to do this. As a consequence, percentage iodine contribution from iodised salt in this study is presented as a range (based on three calculations). Whilst not ideal it is believed that providing a range based on three calculations is more likely to cover the true contribution than using one standard value. Further adjustments to account for cooking losses and women/partners/family members cooking multiple meals should be considered in future studies. Questions to address these issues need to be added to the FFQ to be answered by those who added iodised salt during cooking.

In addition to this, it is also important to acknowledge that the iodine levels of cow's milk (the most important contributor to food iodine intake in this population) is likely to be highly variable because of soil differences (milk sourced for the Perth market comes from WA and other states) and several different processing plants with different cleaning procedures (Section 2.7). Thus for all of the reasons discussed above, the values for dietary iodine intake presented here are at best estimated intakes. In the absence of urinary data, the FFQ has proven useful in categorising subjects into levels of intake suggesting likelihood of achieving the EAR, in ranking subjects into tertiles to assess the reliability of the FFQ and in determining key foods contributing to iodine intake.

There are conflicting reports on the contribution of tap water to iodine intake (Charlton et al. 2013; Food Standards Australia New Zealand 2008a; Rahman et al. 2010). Tap water was not an item in the FFQ and should be included in future studies. It is highly likely, however, that regional and seasonal variations in tap water source(s) and the use of rain water on some rural or remote properties in this vast state could make for inaccurate estimations and conclusions. It would be ideal to use iodine content data from a number of statewide locations and water sources in the future if including tap (and possibly rain water) as an item in FFQs. It is difficult to ascertain whether the FFQ over or underestimated iodine intake in this population as there were no comparison methods such as food records or biochemical indices. Estimated iodine intakes would have been higher if tap water was included in the FFQ, however estimated iodine intakes relating to iodised salt use would have been lower if losses of iodine through cooking and division of dishes to produce multiple meals had been undertaken.

The assumption that women who selected the option "*Yes, regularly (more than once a week*" used an iodine-containing supplement daily is a limitation of this study. The author acknowledges that the results presented represent a best-case scenario and adapting the wording of such a question in the future to specify "daily use" would be useful. It is worth noting that studies that have attempted to measure and verify pill/supplement usage via pill counts report limitations in these alternative methods such as subjects saving unused supplements and/or discarding unused supplements prior to collection due to social desirability (Jasti et al. 2005).

It is possible that the number of women who correctly selected iodised salt as a good source of iodine has been overestimated based on the assumption that subjects who selected "salt" for question 13 were referring to iodised salt. This is a limitation of the questionnaire, however, iodised salt is readily available on supermarket shelves in Western Australia and nearly one-third of all women reported using iodised salt therefore were likely to be aware that salt can be iodised. It would be useful to investigate an alternative approach in stating this option more clearly in future studies. Using the term "iodised salt" is problematic due to the option itself revealing the correct answer, thereby giving a false representation of the subjects' knowledge on the topic.

This research did not measure biomarkers such as UIC, a measure commonly used to determine iodine status of groups of pregnant women. Future studies could be strengthened by including a range of biomarkers such as UIC, UIE and thyroid hormones to offset limitations related to the use of UIC alone (Sections 2.4.1 and 2.9.1).

5.10 Summary

The median iodine intake values calculated for dietary iodine (iodine from food + iodised salt) and for the total iodine data (iodine from food + iodised salt + iodine-containing supplements) met the EAR for pregnancy (196 ug/day and 358 ug/day), respectively, indicating that the majority of the subjects had sufficient iodine intakes. The median iodine intake relating to the food iodine data was slightly less than the EAR at 148 ug/day. These findings are consistent with two of the more recently published studies with Condo et al. (2015) (SA) reporting similar estimated iodine intake values for food iodine data (borderline sufficient/sufficient) and Lucas et al. (2014) (NSW) reporting a median iodine intake value that met the EAR for dietary iodine data and total iodine intake data. Brough et al. (2015) (NZ), Charlton et al. (2013) (NSW) and Mallard and Houghton (2014) (NZ) also report estimated population iodine intake values that met the EAR post-fortification of bread and bread products, whereas pre-fortification studies estimating iodine intake indicated insufficiency.

Over one-third of women were using iodised salt, whilst two-thirds were using iodine-containing supplements, the latter being similar to other post-fortification studies conducted in Australia and NZ. Cow's milk, bread and bread products and iodised salt are major contributors to dietary iodine intake in this population. Results also suggest that iodine knowledge is limited, furthermore, sociodemographic factors involved with iodine knowledge, intake and practices are complex.

Whilst not a focus of this study, it is noteworthy that three of the 95 women whose *total* iodine intake was estimated (range 1142-1384 ug/day) appeared to have exceeded the UL for iodine (1100 ug/day) set by the NHMRC (2006b). These women used iodised salt (estimated iodine content approximately 800 ug/day) and iodine-containing supplements (iodine content of supplements approximately 220 ug/day), in addition to consuming cow's milk daily, with two women using bread and bread products at least twice a day. Iodised salt was clearly contributing the most toward excessive iodine intakes in these subjects, highlighting a potential issue with women using the equivalent of 1 tsp of iodised salt at least twice a day (in addition to daily iodine-containing supplements containing iodine at levels higher than that recommended).

Approximately 97% and 92% of the subjects who consumed quantifiable iodine supplements (n=95) achieved the EAR and RDI for pregnant women, respectively (Figure 4.4) (Table 4.4). Over one-third (39.3%) of the subjects in the dietary iodine group did not meet the EAR, whilst more than half (53.4%) did not achieve the EAR in the food iodine group.

This study was conducted on a convenience sample of pregnant women attending one hospital in Perth, thus generalisability of the findings is limited. Attempts to minimise measurement error associated with self-report dietary intake data were made including the adaptation of a previously validated tool and by assessing the reliability of the current tool. In addition, daily iodine intakes are reported as estimated values. To recognise this fact, the reliability assessment investigated the ranking ability of the questionnaire (tertiles) as well as estimated iodine values.

CHAPTER 6 : CONCLUSIONS AND RECOMMENDATIONS

This was the first WA study to investigate iodine knowledge, beliefs and practices of pregnant women attending the state's only tertiary women's and neonatal hospital (KEMH), thereby providing initial data on pregnant women residing in the largest state of Australia.

Based on the median iodine intake (calculated from self-reported dietary intake data) it is apparent that in 2012-2013 the population in this study achieved the EAR for pregnancy when iodised salt and iodine from supplements (for consumers of iodised salt and/or iodine-containing supplements) together with iodine from food was accounted for. Thus indicating that the majority of participants had sufficient iodine intakes. Furthermore, the median iodine intake based on food iodine alone was only slightly less than the EAR. This corresponds to Australian Bureau of Statistics (ABS) data indicating that WA adults and school children had the highest MUIC out of all Australian states and territories (Australian Bureau of Statistics 2013a).

There will always be subgroups within any pregnant population that have a higher risk of inadequate iodine intake and this study identified associations through dietary intake and demographic data. In the absence of urinary excretion data approximately 39% of subjects did not appear to meet the EAR (using estimated dietary iodine data) and therefore were unlikely to be meeting their requirement for iodine. Further exploration indicated four key components significantly associated with subjects attainment of the EAR:

1. Iodine-containing supplement use (resulting in an overall 97% likelihood of achieving the EAR) was lower in the 12 months prior to becoming pregnant (24.4%) compared to use during pregnancy (65.7%). Notably, younger women were less likely to take iodine-containing supplements prior to pregnancy and a lower proportion of women from the lowest income categories were using these supplements prior to pregnancy. Proportionally less women in the later stage of pregnancy (from 29 weeks) reported using iodine-containing supplements prior to pregnancy compared to those in the earlier stage of pregnancy. A lower proportion of multigravid women and of those in later pregnancy (from 29 weeks) used iodine-containing supplement during their pregnancy. Women who did not know what iodine was were less likely to use these supplements during their pregnancy.
2. Iodised salt use (resulting in an overall 83% likelihood of achieving the EAR) was proportionally less in women whose highest level of education was secondary, diploma or a trade/technical certificate compared to those with tertiary or professional qualifications and in women of Australian/Australian Aboriginal/TSI.
3. Cow's milk consumption was a major contributor to iodine intake in the study population despite being identified as a good source of iodine by less than one-quarter of subjects. Women who consumed cow's milk at least twice a day had a 91% chance of achieving the EAR.
4. Bread and bread products (fortified with iodine) were the second top contributor to iodine intake, again, subject knowledge of this item being a good source of iodine was low. The findings indicated that women who consumed these products at least twice a day had an 83% chance of achieving the EAR.

This information, together with reliability testing supported the development of a decision tree (Figure 4.9), leading to the development of a potential rapid iodine screening tool to identify women at risk of inadequate iodine intakes.

Subject knowledge regarding iodine topics was limited reflected in the findings that less women in this study indicated that they could receive enough information on the topic of iodine than on any other dietary topics. Conversely, a high percentage of women felt they could obtain enough information on listeria, however assessment of foods avoided during pregnancy raised concerns regarding confusion on this topic. This ultimately has flow-on effects to fish and seafood consumption and therefore iodine intake.

Whilst nation-wide recommendations exist for the use of iodine-containing supplements in pregnant women, the results from this study provide initial evidence that this may not be the case for WA pregnant women in general. This research, in particular, begins to challenge the notion of blanket iodine supplementation recommendation in a state that traditionally and recently has reported optimal iodine status of the adult population and SAC.

This study highlights areas for further investigation and several recommendations are proposed:

1. Assessment of the iodine status of WA pregnant women using biochemical measures such as UIC, UIE and thyroid hormones.
2. Use of the rapid screening tool on a larger, randomised sample of WA pregnant women (in both private and public antenatal settings) including validation against biochemical markers such as UIC, UIE and thyroid hormones.
3. Consider using the screening tool (once validated) with subgroups identified in this study as being at risk of not meeting the EAR for iodine (e.g. younger women, those with less education and those from lower income groups).
4. Promotion of dairy products and bread and bread products (fortified with iodine) to all pregnant women.
5. Clarification and promotion of safe fish and seafood intake to all pregnant women.
6. Prioritising and targeting education for subgroups identified in this study (e.g. younger women, those with less education and those from lower income groups). Given the findings from this research, women who do not consume bread or bread products (fortified with iodine) at least twice a day or those who do not consume cow's milk at least twice a day are at risk of inadequate iodine intakes if they are not using iodine-containing supplements or iodised salt.

7. Australian women of Caucasian background and Aboriginal or TSI backgrounds and Polynesian backgrounds may require different education strategies to improve iodine knowledge.
8. Strategies to increase the awareness on the importance of adequate iodine during pregnancy in health professionals are required, especially for doctors and midwives (identified as the top sources of information).
9. Promotion of reputable websites for dietary information on iodine.
10. Promotion of dietitians (as university trained nutrition experts) to provide tailored dietary advice on meeting iodine requirements.
11. Monitoring of pregnant women who are at risk of exceeding the UL for iodine needs to be considered in WA, especially women using more than 1 teaspoon of iodised salt and iodine containing supplements daily, in addition to consuming cow's milk and bread and bread products daily. Alternatively, discouraging the over-consumption of iodised salt and encouraging manufacturers of pregnancy supplements to add the recommended amount of iodine to supplements (150 ug) (range in this study was 38 ug to 500 ug iodine) should be considered as two options to limit women exceeding the UL.

In conclusion, this research indicates that the majority (65.7%) of women reported taking iodine-containing supplements (iodine range 38-500 ug) during pregnancy, and that taking an iodine-containing supplement was associated with a high likelihood of achieving the EAR (96.8%). This estimate is based on the assumption that iodine-containing supplements were taken every day. The population sampled here was a convenience sample rather than a truly representative sample (Section 5.9) and the subgroup for which data on total iodine (food, +/- iodised salt and supplements) was comprised of 95 subjects, thus it cannot be stated with certainty that this high level of likelihood of attaining the EAR can be applied to all the pregnant women who take iodine-containing supplements in WA. Nonetheless, 91.6% achieved the RDI which suggests that most pregnant women in this population are able to meet their requirements by taking an iodine-containing supplement.

The current study highlights that more than five years after the release of the NHMRC recommendation, at least one-quarter of this particular population were not using iodine-containing supplements. Interestingly, 43% of women were able to achieve the RDI without supplementation. Given that the RDI is the amount of iodine required to cover the needs of 97-98% of the needs of healthy pregnant women, this indicates a high likelihood of these women all meeting their individual requirement. However, the dietary hallmarks of these women were the daily use of iodised salt and the consumption of cow's milk and/or bread products at least twice a day. Thus the NHMRC recommendation for all pregnant women to take an iodine-containing supplement during pregnancy may not apply to all pregnant women in WA, but this needs to be balanced with the NHMRC suggested dietary target (sodium) to reduce chronic disease of 1600 mg (National Health and Medical Research Council and New Zealand Ministry of Health 2006a).

The investigation into an alternative approach such as a rapid screening tool to identify women at risk of inadequate iodine intakes is substantiated. Blanket recommendations regarding iodine supplementation may avoid confusion in the target population however it is also known that there are subgroups in the population who are less likely to use iodine-containing supplements. The need for such a screening tool may be of more use in the subgroups identified in this and similar studies (e.g. younger women, those with less education and those from lower income groups).

The future successful validation of the rapid screening tool detailed in this study is likely to enhance the ability of healthcare professionals to identify pregnant women at risk of inadequate iodine intakes. There are restricted opportunities for these groups to see an antenatal health professional in the early stages of pregnancy thus exposure to the screening tool may need to be through avenues such as doctor and hospital clinics, popular pregnancy websites and pharmacies.

An important next step in extending the investigation into the iodine status of pregnant women in WA would be to assess the median urinary iodine level of a sample of these women and to determine the sensitivity and specificity of the rapid screening tool.

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APPENDIX A : INFORMATION SHEET AND CONSENT FORM

A.1 Participant Information Sheet

Government of **Western Australia**
Department of **Health**
North Metropolitan Area Health Service
Women and Newborn Health Service

Curtin University

PARTICIPANT INFORMATION SHEET

Perth Iodine and Pregnancy Study (PIPS): Current knowledge, beliefs and practices relating to iodine nutrition and iodine supplement use of pregnant women living in Perth

Purpose of Research: My name is Tammy Hine. I am currently conducting research for my Master of Philosophy degree at Curtin University. I am investigating what is known about iodine and use of supplements containing iodine in pregnant women in Perth. The results of this study will be compared to similar studies carried out in other parts of Australia and New Zealand.

Benefits of the Study: Information gathered as part of this study is likely to benefit pregnant women and their babies in the future. It will help to guide future resource development on the topic. It is the first study of its kind in Perth.

Your Involvement: Your involvement in the research is entirely voluntary. You have the right to withdraw from the study at any stage, without it affecting your routine care. The results of this study may be published, however participant names will not be used

What do I need to do: If you agree to take part in the study, I will ask you to sign a consent form and to fill out a questionnaire (it is likely to take 20-30 minutes to complete yourself). You will be provided with a PIPS study identification (ID) number and **no** other identifying details (e.g. name, address, phone number) will be asked for on the questionnaire. Signed consent forms and completed questionnaires will be filed and kept securely and only myself, my supervisor and co-investigators will have access to these. These will be stored for a minimum of five years.

If you would like any more information about this study, please do not hesitate to contact one of the members of the research team. They are very happy to answer your questions.

Tammy Hine – Research Dietitian and Masters student
tammy.hine@postgrad.curtin.edu.au

Associate Professor Jill Sherriff – Supervisor
j.sherriff@curtin.edu.au (08) 9266 7948

Ethics Approval: This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number HR 125/2012). The Committee is comprised of members of the public, academics, lawyers, doctors and pastoral carers. If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/-Office of Research and Development, Curtin University, GPO Box U1987, Perth 6845 or by telephoning (08) 9266 9223 or by emailing hrec@curtin.edu.au.

Research questions or concerns: You can contact the Human Research Ethics Committee (Secretary) by telephoning (08) 9266 2784, emailing hrec@curtin.edu.au or in writing C/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth WA 6845. Alternatively, you can contact the Director of Medical Services at KEMH by telephoning (08) 9340 2222. WNHS Ethics Committee registration number is 2048/EW. Your concerns will be drawn to the attention of the Ethics Committee who are monitoring the study.

If you would like to take part in this research, please read and sign the consent form provided.

THANK YOU FOR YOUR TIME

A.2 Consent Form

Government of **Western Australia**
Department of **Health**
North Metropolitan Area Health Service
Women and Newborn Health Service

Curtin University

CONSENT FORM

PLEASE NOTE THAT PARTICIPATION IN RESEARCH STUDIES IS VOLUNTARY AND SUBJECTS CAN WITHDRAW AT ANY TIME WITH NO IMPACT ON CURRENT OR FUTURE CARE.

I ..... have read
Given Names Surname

the participant information explaining the study :

Perth Iodine and Pregnancy Study (PIPS): Current knowledge, beliefs and practices relating to iodine nutrition and iodine supplement use of pregnant women living in Perth.

- I have read and understood the information given to me. Any questions I have asked have been answered to my satisfaction.
- I understand I may withdraw from the study at any stage and withdrawal will not interfere with routine care.
- I agree that research data gathered from the results of this study may be published, provided that names are not used.
- I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.
- I understand that the procedure itself may not benefit me.
- I agree to participate in the study outlined to me.

Name :.....

Signature :.....

Date :.....

I, Tammy Hine. have explained the above to the signatory who stated that she understood the same.

Signature :.....

Date :.....

APPENDIX B : PIPS QUESTIONNAIRE 1 (FFQ1)

B.1 Cover Page

Government of **Western Australia**
Department of **Health**
North Metropolitan Area Health Service
Women and Newborn Health Service

Perth Iodine and Pregnancy Study (PIPS)

Current knowledge, beliefs and practices relating to iodine nutrition and iodine supplement use of pregnant women living in Perth

Chief Investigator : Tammy Hine
Research Dietitian & Master of Philosophy student
BSc (Nutr & Food Science); PostgradDip (Health Prom); GradDip (Dietetics); Accredited Practising Dietitian

Supervisor : Associate Professor Jill Sherriff

B.2 Questionnaire

Perth Iodine and Pregnancy Study (PIPS)

1. Please enter your PIPS study ID number.
If you are unsure please speak with a member of our study team.

ID number:

2. When were you born?

Date of birth DD / MM / YYYY

3. How many weeks pregnant are you?

- Less than 13 weeks
- 13-28 weeks
- 29 weeks or more

4. Is this your first pregnancy?

- Yes
- No

5. Are you currently breastfeeding?

- Yes
- No

6. Have you ever been told by a doctor that you have thyroid disease?

- Yes
- No

7. Have you ever been told by a doctor that you have diabetes?

- Yes
- No

8. Please list any medicine(s) you are currently taking and as much information as you know about them
Example: Antihistamines, 'Zetop', two pills daily for hay fever, 10mg a pill.

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Perth Iodine and Pregnancy Study (PIPS)

9. Are there any foods that you have given up or stopped eating since you became pregnant?

- Yes
- No

If yes, please write down the food(s):

10. Do you feel that your own diet provides enough iodine for your body's needs (i.e. when you are not pregnant)?

- I do not know what Iodine is.
- Yes, I am confident that my diet provides enough Iodine.
- I do not know if my diet provides enough Iodine.
- No, I do not think my diet provides enough Iodine.

11. Do you feel that your own diet provides enough iodine for you and your baby's needs (i.e. when you are pregnant)?

- I do not know what Iodine is.
- Yes, I am confident that my diet provides enough Iodine.
- I do not know if my diet provides enough Iodine.
- No, I do not think my diet provides enough Iodine.

12. Do you know if there are any foods in Australia that are required by law to have iodine added to them?

- I do not know
- Yes
- No

If yes, please write down the food(s):

Perth Iodine and Pregnancy Study (PIPS)

13. Which of the following foods do you think are good sources of iodine in the Australian diet (you can choose more than one food)?

- ☐ Meat
- ☐ Milk
- ☐ Bread
- ☐ Seafood
- ☐ Fruit
- ☐ Vegetables
- ☐ Eggs
- ☐ Salt
- ☐ I do not know

14. What health problems are associated with not enough iodine in the diet (you can choose more than one answer)?

- ☐ Arthritis
- ☐ Blindness
- ☐ Goitre
- ☐ Weak bones and teeth
- ☐ Mental retardation
- ☐ Tiredness
- ☐ Depression
- ☐ Neural Tube Defects (eg spina bifida)
- ☐ I do not know

15. If you needed, do you feel that you can receive enough dietary information to make informed decisions about the following topics during pregnancy?

	Yes	No	Don't Know
Iron	☐	☐	☐
Iodine	☐	☐	☐
Calcium	☐	☐	☐
Folate	☐	☐	☐
Vitamin D	☐	☐	☐
Listeria	☐	☐	☐
Healthy Eating	☐	☐	☐

16. If you did receive dietary information on any of these topics, who did you receive information from?

	Iron	Iodine	Calcium	Folate	Vitamin D	Listeria	Healthy Eating
Doctor	☐	☐	☐	☐	☐	☐	☐
Nurse	☐	☐	☐	☐	☐	☐	☐
Midwife	☐	☐	☐	☐	☐	☐	☐
Dietitian	☐	☐	☐	☐	☐	☐	☐
Pamphlet	☐	☐	☐	☐	☐	☐	☐
Newspaper	☐	☐	☐	☐	☐	☐	☐
Magazine	☐	☐	☐	☐	☐	☐	☐
Television	☐	☐	☐	☐	☐	☐	☐
Radio	☐	☐	☐	☐	☐	☐	☐
Internet	☐	☐	☐	☐	☐	☐	☐
Family	☐	☐	☐	☐	☐	☐	☐
Friends	☐	☐	☐	☐	☐	☐	☐
Not sure	☐	☐	☐	☐	☐	☐	☐

17. How often in the last 2 months have you had cow's milk?

- ○ 2 or more times a day
- ○ Once a day
- ○ 5-6 times per week
- ○ 2-4 times per week
- ○ Once a week
- ○ 1-3 times a month
- ○ Less than one a month
- ○ Never

18. If you have cow's milk, what is your usual serving size?

- ○ Small (1/2 cup)
- ○ Medium (1 cup)
- ○ Large (1 and 1/2 cups)

19. How often in the last 2 months have you had soy milk?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

20. If you drink soy milk, what is your usual serving size?

- Small (1/2 cup)
- Medium (1 cup)
- Large (1 and 1/2 cups)

21. How often in the last 2 months have you had cheese?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

22. If you eat cheese, what is your usual serving size?

- 1 slice off the end of a block of cheese
- 2 slices off the end of a block of cheese
- 3 slices off the end of a block of cheese

23. How often in the last 2 months have you had ice cream or yoghurt?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

24. If you eat ice cream or yoghurt, what is your usual serving size?

- 1 scoop of ice cream or half a tub/pot of yoghurt
- 2 scoops of ice cream or a tub/pot of yoghurt
- 3 scoops of ice cream or 1 and 1/2 half tub/pot of yoghurt

25. How often in the last 2 months have you eaten sausages, saveloys or frankfurters?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

26. If you eat sausages, saveloys or frankfurters, what is your usual serving size?

- 1/2 sausage
- 1 sausage
- 2 sausages

27. How often in the last 2 months have you eaten poultry (i.e. chicken, turkey or duck)?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

28. If you eat poultry, what is your usual serving size?

- 1/2 breast or 1 drumstick
- 1 breast or 2 drumsticks
- 1 and 1/2 breasts or 3 drumsticks

29. How often in the last 2 months have you eaten other meat (i.e. beef, lamb, pork)?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

30. If you eat other meat, what is your usual serving size?

- 1/2 the size of the palm of your hand
- the same size as the palm of your hand
- 1 and 1/2 times the size of the palm of your hand

31. How often in the last 2 months have you eaten tofu?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

32. If you eat tofu, what is your usual serving size?

- 1/2 the size of the palm of your hand
- the same size as the palm of your hand
- 1 and 1/2 times the size of the palm of your hand

33. How often in the last 2 months have you had eggs (including in cooked foods like quiche)?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

34. If you eat eggs, what is your usual serving size?

- 1 small egg
- 1 medium egg
- 1 large egg

35. How often in the last 2 months have you eaten fish?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

36. If you eat fish, what is your usual serving size?

- 1/2 fillet
- 1 fillet
- 1 and 1/2 fillets

37. How often in the last 2 months have you had shellfish (mussels, oysters, etc)?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

38. If you eat shellfish, what is your usual serving size?

- 3 oysters or mussels
- 6 (i.e. half a dozen) oysters or mussels
- 12 (i.e. dozen) oysters or mussels

39. How often in the last 2 months have you had sushi?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

40. If you eat sushi, what is your usual serving size?

- 4 pieces
- 6 pieces
- 8 pieces

41. How often in the last 2 months have you had bread and bread products (eg rolls, pita breads, pizza bases, bagels, English muffins, sticky buns etc)?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

42. If you eat bread or bread products, what is your usual serving size?

- 1 slice of bread, 1 small roll, or 1 small pita
- 2 slices of bread, 1 medium roll, or 2 pita
- 3 slices of bread, 1 large roll, or 3 pita

43. How often in the last 2 months have you had dark green leafy vegetables (eg spinach, silverbeet, bok choy, etc)?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

44. If you eat these vegetables, what is your usual serving size?

- 1/4 cup cooked
- 1/2 cup cooked
- 1 cup cooked

45. How often in the last two months have you eaten a dish or meal that has used packaged breadcrumbs?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

46. If you add packaged breadcrumbs what would be the usual amount added per serve of the meal?

- 1/4 cup
- 1/2 cup
- 3/4 cup

47. How often in the last 2 months have you had cake?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

48. If you eat cake, what is your usual serving size?

- 1 small slice
- 1 medium slice
- 1 large slice

49. How often in the last 2 months have you had muffins?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

50. If you eat muffins, what is your usual serving size?

- 1 small muffin
- 1 medium muffin
- 1 large muffin

51. How often in the last 2 months have you had a muesli or protein bar?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

52. How often in the last 2 months have you had a nuts or seeds (eg sunflower, almonds, peanuts etc)?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

53. If you eat nuts and seeds, what is your usual serving size?

- 1/8 cup
- 1/4 cup
- 1/2 cup

54. How often in the last 2 months have you had chocolate?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

55. If you eat chocolate, what is your usual serving size (i.e. compared to a Mars bar)?

- 1/2 bar
- 1 bar
- 2 bars

56. How often in the last 2 months have you had beer?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

57. If you drink beer, what is your usual serving size?

- half a can or bottle
- 1 can or bottle
- 2 cans or bottles

58. Did you take any dietary supplements in the year BEFORE you became pregnant?

- Yes, regularly (more than once a week)
- Yes, occasionally (less than once a week)
- No

Please list any supplements you have taken in last 12 months. Include as much information as you can remember. Example: Multivitamin 'Blackmores' once daily

59. Have you taken any dietary supplements SINCE you knew you were pregnant?

- Yes, regularly (more than once a week)
- Yes, occasionally (less than once a week)
- No

Please list any supplements you have taken in last 2 months. Include as much information as you can remember. Example: Multivitamin 'Blackmores' once daily

60. What type of salt do you mostly use at home?

- I do not know
- Iodised Salt
- Non-Iodised Salt
- Flakey Salt
- Rock Salt
- I do not use any salt

61. How often do you add iodised salt during cooking?

- I do not know
- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

62. If you use iodised salt in cooking, what is your usual serving size?

- 1/4 of a teaspoon
- 1/2 of a teaspoon
- 1 teaspoon

63. How often do you add iodised salt to your food at the table?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

64. If you use iodised salt at the table, what is your usual serving size?

- Just a sprinkle
- 1/8 of a teaspoon
- 1/4 of a teaspoon

65. How often do you choose low or reduced salt food items instead of the standard variety?

- Never
- Rarely
- Sometimes
- Often
- Always

66. What ethnic group do you belong to?

- Australian
- Australian Aboriginal
- Torres Strait Islander
- Indian
- Chinese
- British

Other (eg. Dutch, Japanese, Tokelauan)

67. In the last 12 months what did YOU (only you) earn BEFORE tax was removed?

- Less than $50,000
- $50,000 - $100,000
- More than $100,000
- Do not wish to answer this question

68. What is your HIGHEST level of education?

- Secondary School Qualification
- Bachelors degree (eg BA, BSc)
- Post-graduate University degree (eg MA, MSc, PhD)
- Professional Qualification (eg Dentist, Teacher, Nurse)
- Diploma
- Trade or Technical Certificate

Please return this completed questionnaire to Tammy Hine, or the staff at the clinic reception desk (if Tammy is unavailable).

If you have not had a chance to complete the questionnaire, please see Tammy and you will receive a reply-paid envelope that can be used to return your questionnaire by post within the next two weeks.

THANK YOU FOR YOUR CONTRIBUTION TO THIS RESEARCH.

APPENDIX C : PIPS QUESTIONNAIRE RETEST (FFQ2)

C.1 Cover Page

Government of **Western Australia**
Department of **Health**
North Metropolitan Area Health Service
Women and Newborn Health Service

Curtin University

THANK YOU FOR AGREEING TO REPEAT PART OF THIS QUESTIONNAIRE.
IT SHOULD ONLY TAKE 5-10 MINUTES TO COMPLETE.

- Before you begin, please answer the following question:

Has your diet/food and drink intake changed since you last completed this questionnaire?

Yes / No (please circle)

If you answered yes, please state the reason for your change in diet or food intake (eg. I am eating more - not feeling nauseous anymore)

_____

_____

PLEASE NOTE THAT PARTICIPATION IN RESEARCH STUDIES IS VOLUNTARY AND SUBJECTS CAN WITHDRAW AT ANY TIME WITH NO IMPACT ON CURRENT OR FUTURE CARE.

THANK YOU.

Study ID Number

Date 1
Date 2

C.2 Questionnaire (Questions 17-57)

Perth Iodine and Pregnancy Study (PIPS)

17. How often in the last 2 months have you had cow's milk?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

18. If you have cow's milk, what is your usual serving size?

- Small (1/2 cup)
- Medium (1 cup)
- Large (1 and 1/2 cups)

19. How often in the last 2 months have you had soy milk?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

20. If you drink soy milk, what is your usual serving size?

- Small (1/2 cup)
- Medium (1 cup)
- Large (1 and 1/2 cups)

21. How often in the last 2 months have you had cheese?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

22. If you eat cheese, what is your usual serving size?

- 1 slice off the end of a block of cheese
- 2 slices off the end of a block of cheese
- 3 slices off the end of a block of cheese

23. How often in the last 2 months have you had ice cream or yoghurt?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

24. If you eat ice cream or yoghurt, what is your usual serving size?

- 1 scoop of ice cream or half a tub/pot of yoghurt
- 2 scoops of ice cream or a tub/pot of yoghurt
- 3 scoops of ice cream or 1 and 1/2 half tub/pot of yoghurt

25. How often in the last 2 months have you eaten sausages, saveloys or frankfurters?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

26. If you eat sausages, saveloys or frankfurters, what is your usual serving size?

- 1/2 sausage
- 1 sausage
- 2 sausages

27. How often in the last 2 months have you eaten poultry (i.e. chicken, turkey or duck)?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

28. If you eat poultry, what is your usual serving size?

- 1/2 breast or 1 drumstick
- 1 breast or 2 drumsticks
- 1 and 1/2 breasts or 3 drumsticks

29. How often in the last 2 months have you eaten other meat (i.e. beef, lamb, pork)?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

30. If you eat other meat, what is your usual serving size?

- 1/2 the size of the palm of your hand
- the same size as the palm of your hand
- 1 and 1/2 times the size of the palm of your hand

31. How often in the last 2 months have you eaten tofu?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

32. If you eat tofu, what is your usual serving size?

- 1/2 the size of the palm of your hand
- the same size as the palm of your hand
- 1 and 1/2 times the size of the palm of your hand

33. How often in the last 2 months have you had eggs (including in cooked foods like quiche)?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

34. If you eat eggs, what is your usual serving size?

- 1 small egg
- 1 medium egg
- 1 large egg

35. How often in the last 2 months have you eaten fish?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

36. If you eat fish, what is your usual serving size?

- 1/2 fillet
- 1 fillet
- 1 and 1/2 fillets

37. How often in the last 2 months have you had shellfish (mussels, oysters, etc)?

- ○ 2 or more times a day
- ○ Once a day
- ○ 5-6 times per week
- ○ 2-4 times per week
- ○ Once a week
- ○ 1-3 times a month
- ○ Less than one a month
- ○ Never

38. If you eat shellfish, what is your usual serving size?

- ○ 3 oysters or mussels
- ○ 6 (i.e. half a dozen) oysters or mussels
- ○ 12 (i.e. dozen) oysters or mussels

39. How often in the last 2 months have you had sushi?

- ○ 2 or more times a day
- ○ Once a day
- ○ 5-6 times per week
- ○ 2-4 times per week
- ○ Once a week
- ○ 1-3 times a month
- ○ Less than one a month
- ○ Never

40. If you eat sushi, what is your usual serving size?

- ☐ 4 pieces
- ☐ 6 pieces
- ☐ 8 pieces

41. How often in the last 2 months have you had bread and bread products (eg rolls, pita breads, pizza bases, bagels, English muffins, sticky buns etc)?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

42. If you eat bread or bread products, what is your usual serving size?

- 1 slice of bread, 1 small roll, or 1 small pita
- 2 slices of bread, 1 medium roll, or 2 pita
- 3 slices of bread, 1 large roll, or 3 pita

43. How often in the last 2 months have you had dark green leafy vegetables (eg spinach, silverbeet, bok choy, etc)?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

44. If you eat these vegetables, what is your usual serving size?

- 1/4 cup cooked
- 1/2 cup cooked
- 1 cup cooked

45. How often in the last two months have you eaten a dish or meal that has used packaged breadcrumbs?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

46. If you add packaged breadcrumbs what would be the usual amount added per serve of the meal?

- 1/4 cup
- 1/2 cup
- 3/4 cup

47. How often in the last 2 months have you had cake?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

48. If you eat cake, what is your usual serving size?

- 1 small slice
- 1 medium slice
- 1 large slice

49. How often in the last 2 months have you had muffins?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

50. If you eat muffins, what is your usual serving size?

- 1 small muffin
- 1 medium muffin
- 1 large muffin

51. How often in the last 2 months have you had a muesli or protein bar?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

52. How often in the last 2 months have you had a nuts or seeds (eg sunflower, almonds, peanuts etc)?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

53. If you eat nuts and seeds, what is your usual serving size?

- 1/8 cup
- 1/4 cup
- 1/2 cup

54. How often in the last 2 months have you had chocolate?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

55. If you eat chocolate, what is your usual serving size (i.e. compared to a Mars bar)?

- 1/2 bar
- 1 bar
- 2 bars

56. How often in the last 2 months have you had beer?

- 2 or more times a day
- Once a day
- 5-6 times per week
- 2-4 times per week
- Once a week
- 1-3 times a month
- Less than one a month
- Never

57. If you drink beer, what is your usual serving size?

- half a can or bottle
- 1 can or bottle
- 2 cans or bottles

APPENDIX D : STATISTICAL TESTS TO DETERMINE RELIABILITY FOR CATEGORICAL DATA.

Variable	Statistical test	Application
Food iodine intake (tertiles) FFQ1 & FFQ2	1. Kappa and percentage agreement	1. To investigate ranking ability of FFQ upon repeat administration
Absolute iodine contribution-cow's milk (tertiles) FFQ1 & FFQ2	1. Kappa and percentage agreement 2. Wilcoxon signed rank test 3. Marginal homogeneity	1. To investigate ranking ability of FFQ upon repeat administration 2. To determine if differences in medians of FFQ1 and FFQ2 were statistically significant 3. To examine if changes between FFQ1 and FFQ2 were statistically significant
Absolute iodine contribution-bread and bread products (tertiles) FFQ1 & FFQ2	1. Kappa and percentage agreement 2. Wilcoxon signed rank test 3. Marginal homogeneity	1. To investigate ranking ability of FFQ upon repeat administration 2. To determine if differences in medians of FFQ1 and FFQ2 were statistically significant 3. To examine if changes between FFQ1 and FFQ2 were statistically significant
Frequency of consumption (8 categories) – selected food items* FFQ1 & FFQ2	1. Kappa and percentage agreement 2. Wilcoxon signed rank test 3. Marginal homogeneity	1. To investigate ranking ability of FFQ upon repeat administration 2. To determine if differences in medians of FFQ1 and FFQ2 were statistically significant 3. To examine if changes between FFQ1 and FFQ2 were statistically significant

* Food items with Kappa value >0.5 + bread and bread products

APPENDIX E : ORIGINAL ETHNIC GROUP RESPONSES

	Ethnic Group	Frequency (n)	Percent (%)
	Australian	207	48.8
	Australian Aboriginal	10	2.4
	Indian	27	6.4
	Chinese	14	3.3
	British	25	5.9
	Persian	2	.5
	Filipino	8	1.9
	African	16	3.8
	Canadian	3	.7
	Sri Lankan	2	.5
	Bangladeshi	1	.2
	New Zealand European	1	.2
	Thai	2	.5
	Libyan	2	.5
	Greek	1	.2
	Arabic	2	.5
	Maori NZ	12	2.8
	Vietnamese	4	.9
	Other	1	.2
	Serbian	1	.2
	Afghani	1	.2
	Iraqi	1	.2
	Maori/English	1	.2
	NZ/Samoan	2	.5
	Australian/British	4	.9
	American	1	.2
	Mongolian	1	.2
	Malay	1	.2
	Egyptian	1	.2
	South African	5	1.2
	NZ	14	3.3
	Australian/Indian/British	1	.2
	Polish	2	.5
	Pakistani	3	.7

	Ethnic Group	Frequency (n)	Percent (%)
	Middle Eastern	2	.5
	Irish	6	1.4
	Samoan	2	.5
	Australian Aboriginal/British	1	.2
	Fijian	1	.2
	South American/Chilean	1	.2
	Swiss	1	.2
	Italian	3	.7
	Bosnian	1	.2
	Indonesian	2	.5
	Papua New Guinean	1	.2
	Korean	2	.5
	Latin/Brazilian	2	.5
	Japanese	2	.5
	Indian/British	1	.2
	Albanian	1	.2
	Algerian	1	.2
	Dutch	3	.7
	Latina	1	.2
	Thai	1	.2
	Turkish	1	.2
	Nepalese	1	.2
	Australian/German	1	.2
	Bhutanese	1	.2
	Sudanese	1	.2
	Malay/English	1	.2
	Dutch/German/Irish	1	.2
	Iranian	1	.2
	Asian	1	.2
	Lebanese	1	.2
	Total	*424*	*100.0*
Missing		1	
Total		**425**	

APPENDIX F : SELECTED CROSS TABULATIONS AND CHI SQUARE TESTS

F.1 Iodine in supplement taken before becoming pregnant * Age Categorical

Cross Tabulation

			Age Categorical			Total
			18-24	25-34	35+	
Iodine in supplement taken before becoming pregnant	No iodine	Count	75	188	50	313
		% within Iodine in supplement taken before becoming pregnant	24.0%	60.1%	16.0%	100.0%
		% within Age Categorical	85.2%	75.8%	63.3%	75.4%
		% of Total	18.1%	45.3%	12.0%	75.4%
	Contains iodine	Count	13	60	29	102
		% within Iodine in supplement taken before becoming pregnant	12.7%	58.8%	28.4%	100.0%
		% within Age Categorical	14.8%	24.2%	36.7%	24.6%
		% of Total	3.1%	14.5%	7.0%	24.6%
Total		Count	88	248	79	415
		% within Iodine in supplement taken before becoming pregnant	21.2%	59.8%	19.0%	100.0%
		% within Age Categorical	100.0%	100.0%	100.0%	100.0%
		% of Total	21.2%	59.8%	19.0%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	10.855[a]	2	.004
Likelihood Ratio	10.850	2	.004
Linear-by-Linear Association	10.701	1	.001
N of Valid Cases	415		

[a] 0 cells (0.0%) have expected count less than 5. The minimum expected count is 19.42.

F.2 Iodine in supplement taken before becoming pregnant * Weeks pregnant recoded into BINARY

Cross Tabulation

			Weeks pregnant recoded into BINARY		Total
			Up to (including) 28 weeks	29 weeks or more	
Iodine in supplement taken before becoming pregnant	No iodine	Count	123	193	316
		% within Iodine in supplement taken before becoming pregnant	38.9%	61.1%	100.0%
		% within Weeks pregnant recoded into BINARY	69.9%	79.8%	75.6%
		% of Total	29.4%	46.2%	75.6%
	Contains iodine	Count	53	49	102
		% within Iodine in supplement taken before becoming pregnant	52.0%	48.0%	100.0%
		% within Weeks pregnant recoded into BINARY	30.1%	20.2%	24.4%
		% of Total	12.7%	11.7%	24.4%
Total		Count	176	242	418
		% within Iodine in supplement taken before becoming pregnant	42.1%	57.9%	100.0%
		% within Weeks pregnant recoded into BINARY	100.0%	100.0%	100.0%
		% of Total	42.1%	57.9%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.376[a]	1	.020		
Continuity Correction[b]	4.855	1	.028		
Likelihood Ratio	5.328	1	.021		
Fisher's Exact Test				.022	.014
Linear-by-Linear Association	5.363	1	.021		
N of Valid Cases	418				

[a] 0 cells (0.0%) have expected count less than 5. The minimum expected count is 42.95.

[b] Computed only for a 2x2 table

F.3 Iodine in supplement taken before becoming pregnant * Income 3 categories minus no response

Cross Tabulation

			Income 3 categories minus no response			Total
			Less than $50 000	$50 000-$100 000	More than $100 000	
Iodine in supplement taken before becoming pregnant	No iodine	Count	167	72	9	248
		% within Iodine in supplement taken before becoming pregnant	67.3%	29.0%	3.6%	100.0%
		% within Income 3 categories minus no response	75.2%	73.5%	47.4%	73.2%
		% of Total	49.3%	21.2%	2.7%	73.2%
	Contains iodine	Count	55	26	10	91
		% within Iodine in supplement taken before becoming pregnant	60.4%	28.6%	11.0%	100.0%
		% within Income 3 categories minus no response	24.8%	26.5%	52.6%	26.8%
		% of Total	16.2%	7.7%	2.9%	26.8%
Total		Count	222	98	19	339
		% within Iodine in supplement taken before becoming pregnant	65.5%	28.9%	5.6%	100.0%
		% within Income 3 categories minus no response	100.0%	100.0%	100.0%	100.0%
		% of Total	65.5%	28.9%	5.6%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.923[a]	2	.031
Likelihood Ratio	6.139	2	.046
Linear-by-Linear Association	3.830	1	.050
N of Valid Cases	339		

[a] 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.10.

F.4 Iodine in supplement taken since becoming pregnant * Weeks pregnant recoded into BINARY

Cross Tabulation

			Weeks pregnant recoded into BINARY		Total
			Up to (including) 28 weeks	29 weeks or more	
Iodine in supplement taken since becoming pregnant	No iodine	Count	44	98	142
		% within Iodine in supplement taken since becoming pregnant	31.0%	69.0%	100.0%
		% within Weeks pregnant recoded into BINARY	25.1%	41.0%	34.3%
		% of Total	10.6%	23.7%	34.3%
	Contains iodine	Count	131	141	272
		% within Iodine in supplement taken since becoming pregnant	48.2%	51.8%	100.0%
		% within Weeks pregnant recoded into BINARY	74.9%	59.0%	65.7%
		% of Total	31.6%	34.1%	65.7%
Total		Count	175	239	414
		% within Iodine in supplement taken since becoming pregnant	42.3%	57.7%	100.0%
		% within Weeks pregnant recoded into BINARY	100.0%	100.0%	100.0%
		% of Total	42.3%	57.7%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	11.279[a]	1	.001		
Continuity Correction[b]	10.586	1	.001		
Likelihood Ratio	11.495	1	.001		
Fisher's Exact Test				.001	.001
Linear-by-Linear Association	11.251	1	.001		
N of Valid Cases	414				

[a] 0 cells (0.0%) have expected count less than 5. The minimum expected count is 60.02.

[b] Computed only for a 2x2 table

F.5 Iodine in supplement taken since becoming pregnant * Is this your first pregnancy?

Cross Tabulation

			Is this your first pregnancy?		Total
			No	Yes	
Iodine in supplement taken since becoming pregnant	No iodine	Count	100	42	142
		% within Iodine in supplement taken since becoming pregnant	70.4%	29.6%	100.0%
		% within Is this your first pregnancy?	39.4%	26.3%	34.3%
		% of Total	24.2%	10.1%	34.3%
	Contains iodine	Count	154	118	272
		% within Iodine in supplement taken since becoming pregnant	56.6%	43.4%	100.0%
		% within Is this your first pregnancy?	60.6%	73.8%	65.7%
		% of Total	37.2%	28.5%	65.7%
Total		Count	254	160	414
		% within Iodine in supplement taken since becoming pregnant	61.4%	38.6%	100.0%
		% within Is this your first pregnancy?	100.0%	100.0%	100.0%
		% of Total	61.4%	38.6%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	7.498[a]	1	.006		
Continuity Correction[b]	6.928	1	.008		
Likelihood Ratio	7.646	1	.006		
Fisher's Exact Test				.008	.004
Linear-by-Linear Association	7.480	1	.006		
N of Valid Cases	414				

[a] 0 cells (0.0%) have expected count less than 5. The minimum expected count is 54.88.

[b] Computed only for a 2x2 table

F.6 Iodine in supplement taken since becoming pregnant * Education categorical

Cross Tabulation

			Education categorical			Total
			Secondary school	Diploma, trade or technical certificate	Tertiary or professional qualification	
Iodine in supplement taken since becoming pregnant	No iodine	Count	55	34	50	139
		% within Iodine in supplement taken since becoming pregnant	39.6%	24.5%	36.0%	100.0%
		% within Education categorical	41.4%	33.7%	28.6%	34.0%
		% of Total	13.4%	8.3%	12.2%	34.0%
	Contains iodine	Count	78	67	125	270
		% within Iodine in supplement taken since becoming pregnant	28.9%	24.8%	46.3%	100.0%
		% within Education categorical	58.6%	66.3%	71.4%	66.0%
		% of Total	19.1%	16.4%	30.6%	66.0%
Total		Count	133	101	175	409
		% within Iodine in supplement taken since becoming pregnant	32.5%	24.7%	42.8%	100.0%
		% within Education categorical	100.0%	100.0%	100.0%	100.0%
		% of Total	32.5%	24.7%	42.8%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.509[a]	2	.064
Likelihood Ratio	5.480	2	.065
Linear-by-Linear Association	5.439	1	.020
N of Valid Cases	409		

[a] 0 cells (0.0%) have expected count less than 5. The minimum expected count is 34.33.

F.7 Iodine in supplement taken before becoming pregnant * Education categorical

Cross Tabulation

			Education categorical			Total
			Secondary school	Diploma, trade or technical certificate	Tertiary or professional qualification	
Iodine in supplement taken before becoming pregnant	No iodine	Count	107[a]	81[a]	124[a]	312
		Expected Count	103.2	76.9	131.9	312.0
		% within Iodine in supplement taken before becoming pregnant	34.3%	26.0%	39.7%	100.0%
		% within Education categorical	78.1%	79.4%	70.9%	75.4%
		% of Total	25.8%	19.6%	30.0%	75.4%
	Contains iodine	Count	30[a]	21[a]	51[a]	102
		Expected Count	33.8	25.1	43.1	102.0
		% within Iodine in supplement taken before becoming pregnant	29.4%	20.6%	50.0%	100.0%
		% within Education categorical	21.9%	20.6%	29.1%	24.6%
		% of Total	7.2%	5.1%	12.3%	24.6%
Total		Count	137	102	175	414
		Expected Count	137.0	102.0	175.0	414.0
		% within Iodine in supplement taken before becoming pregnant	33.1%	24.6%	42.3%	100.0%
		% within Education categorical	100.0%	100.0%	100.0%	100.0%
		% of Total	33.1%	24.6%	42.3%	100.0%

Each subscript letter denotes a subset of Education categorical categories whose column proportions do not differ significantly from each other at the .05 level.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.368[a]	2	.186
Likelihood Ratio	3.348	2	.187
Linear-by-Linear Association	2.359	1	.125
N of Valid Cases	414		

[a] 0 cells (.0%) have expected count less than 5. The minimum expected count is 25.13.

F.8 FFQ1 Does or does not meet EAR Diet only * Is this your first pregnancy?

Cross Tabulation

			Is this your first pregnancy?		Total
			No	Yes	
FFQ1 Does or does not meet EAR Diet only	Meets EAR	Count	135	63	198
		% within FFQ1 Does or does not meet EAR Diet only	68.2%	31.8%	100.0%
		% within Is this your first pregnancy?	51.5%	38.7%	46.6%
		% of Total	31.8%	14.8%	46.6%
	Does not meet EAR	Count	127	100	227
		% within FFQ1 Does or does not meet EAR Diet only	55.9%	44.1%	100.0%
		% within Is this your first pregnancy?	48.5%	61.3%	53.4%
		% of Total	29.9%	23.5%	53.4%
Total		Count	262	163	425
		% within FFQ1 Does or does not meet EAR Diet only	61.6%	38.4%	100.0%
		% within Is this your first pregnancy?	100.0%	100.0%	100.0%
		% of Total	61.6%	38.4%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.695[a]	1	.010		
Continuity Correction[b]	6.188	1	.013		
Likelihood Ratio	6.736	1	.009		
Fisher's Exact Test				.012	.006
Linear-by-Linear Association	6.680	1	.010		
N of Valid Cases	425				

[a] 0 cells (0.0%) have expected count less than 5. The minimum expected count is 75.94.

[b] Computed only for a 2x2 table

F.9 FFQ1 Does or does not meet EAR Diet only

* How often in the last 2 months have you had cow's milk?

Cross Tabulation

			How often in the last 2 months have you had cow's milk?								
			2 or more times a day	once a day	5-6 times per week	2-4 times per week	once a week	1-3 times a month	less than once a month	never	Total
FFQ1 Does or does not meet EAR Diet only	Meets EAR	Count	145	35	7	4	1	2	1	3	198
		% within FFQ1 Does or does not meet EAR Diet only	73.2%	17.7%	3.5%	2.0%	0.5%	1.0%	0.5%	1.5%	100.0%
		% within How often in the last 2 months have you had cow's milk?	91.2%	23.3%	30.4%	10.8%	9.1%	10.5%	20.0%	15.8%	46.8%
		% of Total	34.3%	8.3%	1.7%	0.9%	0.2%	0.5%	0.2%	0.7%	46.8%
	Does not meet EAR	Count	14	115	16	33	10	17	4	16	225
		% within FFQ1 Does or does not meet EAR Diet only	6.2%	51.1%	7.1%	14.7%	4.4%	7.6%	1.8%	7.1%	100.0%
		% within How often in the last 2 months have you had cow's milk?	8.8%	76.7%	69.6%	89.2%	90.9%	89.5%	80.0%	84.2%	53.2%
		% of Total	3.3%	27.2%	3.8%	7.8%	2.4%	4.0%	0.9%	3.8%	53.2%
Total		Count	159	150	23	37	11	19	5	19	423
		% within FFQ1 Does or does not meet EAR Diet only	37.6%	35.5%	5.4%	8.7%	2.6%	4.5%	1.2%	4.5%	100.0%
		% within How often in the last 2 months have you had cow's milk?	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	37.6%	35.5%	5.4%	8.7%	2.6%	4.5%	1.2%	4.5%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	205.865[a]	7	.000
Likelihood Ratio	232.249	7	.000
Linear-by-Linear Association	91.959	1	.000
N of Valid Cases	423		

[a] 2 cells (12.5%) have expected count less than 5. The minimum expected count is 2.34.

F.10 Total diet intake + salt categorical

* How often in the last 2 months have you had cow's milk?

Cross Tabulation

			How often in the last 2 months have you had cow's milk?								
			2 or more times a day	once a day	5-6 times per week	2-4 times per week	once a week	1-3 times a month	less than once a month	never	Total
Total diet intake + salt categ-orical	Meets EAR	Count	146	77	10	13	2	6	1	3	258
		% within Total diet intake + salt categorical	56.6%	29.8%	3.9%	5.0%	0.8%	2.3%	0.4%	1.2%	100.0%
		% within How often in the last 2 months have you had cow's milk?	91.8%	51.3%	43.5%	35.1%	18.2%	31.6%	20.0%	15.8%	61.0%
		% of Total	34.5%	18.2%	2.4%	3.1%	0.5%	1.4%	0.2%	0.7%	61.0%
	Does not meet EAR	Count	13	73	13	24	9	13	4	16	165
		% within Total diet intake + salt categorical	7.9%	44.2%	7.9%	14.5%	5.5%	7.9%	2.4%	9.7%	100.0%
		% within How often in the last 2 months have you had cow's milk?	8.2%	48.7%	56.5%	64.9%	81.8%	68.4%	80.0%	84.2%	39.0%
		% of Total	3.1%	17.3%	3.1%	5.7%	2.1%	3.1%	0.9%	3.8%	39.0%
Total		Count	159	150	23	37	11	19	5	19	423
		% within Total diet intake + salt categorical	37.6%	35.5%	5.4%	8.7%	2.6%	4.5%	1.2%	4.5%	100.0%
		% within How often in the last 2 months have you had cow's milk?	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	37.6%	35.5%	5.4%	8.7%	2.6%	4.5%	1.2%	4.5%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	118.005[a]	7	.000
Likelihood Ratio	132.767	7	.000
Linear-by-Linear Association	83.428	1	.000
N of Valid Cases	423		

[a] 3 cells (18.8%) have expected count less than 5. The minimum expected count is 1.95.

F.11 FFQ1 Does or does not meet EAR Diet only

* How often in the last 2 months have you had bread and bread products eg rolls, pita breads, pizza bases, bagels, English muffins, sticky buns?

Cross Tabulation

			How often in the last 2 months have you had bread and bread products (eg rolls, pita breads, pizza bases, bagels, english muffins, sticky buns etc)?								Total
			2 or more times a day	once a day	5-6 times per week	2-4 times per week	once a week	1-3 times a month	less than once a month	never	
FFQ1 Does or does not meet EAR Diet only	Meets EAR	Count	77	78	7	19	10	3	4	0	198
		% within FFQ1 Does or does not meet EAR Diet only	38.9%	39.4%	3.5%	9.6%	5.1%	1.5%	2.0%	0.0%	100.0%
		% within How often in the last 2 months have you had bread and bread products (eg rolls, pita breads, pizza bases, bagels, english muffins, sticky buns etc)?	82.8%	48.4%	14.9%	25.0%	45.5%	33.3%	36.4%	0.0%	46.8%
		% of Total	18.2%	18.4%	1.7%	4.5%	2.4%	0.7%	0.9%	0.0%	46.8%
	Does not meet EAR	Count	16	83	40	57	12	6	7	4	225
		% within FFQ1 Does or does not meet EAR Diet only	7.1%	36.9%	17.8%	25.3%	5.3%	2.7%	3.1%	1.8%	100.0%
		% within How often in the last 2 months have you had bread and bread products (eg rolls, pita breads, pizza bases, bagels, english muffins, sticky buns etc)?	17.2%	51.6%	85.1%	75.0%	54.5%	66.7%	63.6%	100.0%	53.2%
		% of Total	3.8%	19.6%	9.5%	13.5%	2.8%	1.4%	1.7%	0.9%	53.2%
Total		Count	93	161	47	76	22	9	11	4	423
		% within FFQ1 Does or does not meet EAR Diet only	22.0%	38.1%	11.1%	18.0%	5.2%	2.1%	2.6%	0.9%	100.0%
		% within How often in the last 2 months have you had bread and bread products (eg rolls, pita breads, pizza bases, bagels, english muffins, sticky buns etc)?	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	22.0%	38.1%	11.1%	18.0%	5.2%	2.1%	2.6%	0.9%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	86.967[a]	7	.000
Likelihood Ratio	95.015	7	.000
Linear-by-Linear Association	43.179	1	.000
N of Valid Cases	423		

[a] 4 cells (25.0%) have expected count less than 5. The minimum expected count is 1.87.

F.12 Total diet intake + salt categorical

*** How often in the last 2 months have you had bread and bread products eg rolls, pita breads, pizza bases, bagels, English muffins, sticky buns?**

Cross Tabulation

			How often in the last 2 months have you had bread and bread products (eg rolls, pita breads, pizza bases, bagels, English muffins, sticky buns etc)?							Total
			2 or more times a day	once a day	5-6 times per week	2-4 times per week	once a week	1-3 times a month	less than once a month	never	
Total diet intake + salt categorical	Meets EAR	Count	85	100	16	32	13	4	5	1	256
		% within Total diet intake + salt categorical	33.2%	39.1%	6.3%	12.5%	5.1%	1.6%	2.0%	0.4%	100.0%
		% within How often in the last 2 months have you had bread and bread products (eg rolls, pita breads, pizza bases, bagels, English muffins, sticky buns etc)?	91.4%	62.1%	34.0%	42.1%	59.1%	44.4%	45.5%	25.0%	60.5%
		% of Total	20.1%	23.6%	3.8%	7.6%	3.1%	0.9%	1.2%	0.2%	60.5%
	Does not meet EAR	Count	8	61	31	44	9	5	6	3	167
		% within Total diet intake + salt categorical	4.8%	36.5%	18.6%	26.3%	5.4%	3.0%	3.6%	1.8%	100.0%
		% within How often in the last 2 months have you had bread and bread products (eg rolls, pita breads, pizza bases, bagels, English muffins, sticky buns etc)?	8.6%	37.9%	66.0%	57.9%	40.9%	55.6%	54.5%	75.0%	39.5%
		% of Total	1.9%	14.4%	7.3%	10.4%	2.1%	1.2%	1.4%	0.7%	39.5%
Total		Count	93	161	47	76	22	9	11	4	423
		% within Total diet intake + salt categorical	22.0%	38.1%	11.1%	18.0%	5.2%	2.1%	2.6%	0.9%	100.0%
		% within How often in the last 2 months have you had bread and bread products (eg rolls, pita breads, pizza bases, bagels, English muffins, sticky buns etc)?	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	22.0%	38.1%	11.1%	18.0%	5.2%	2.1%	2.6%	0.9%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	66.007[a]	7	.000
Likelihood Ratio	73.814	7	.000
Linear-by-Linear Association	35.510	1	.000
N of Valid Cases	423		

[a] 4 cells (25.0%) have expected count less than 5. The minimum expected count is 1.58.

F.13 Total diet intake + salt categorical

* Iodised salt use BINARY minus I do not know

Cross Tabulation

			Iodised salt use BINARY minus I do not know		Total
			No	Yes	
Total diet intake + salt categorical	Meets EAR	Count	92	132	224
		Expected Count	123.0	101.0	224.0
		% within Total diet intake + salt categorical	41.1%	58.9%	100.0%
		% within Iodised salt use BINARY minus I do not know	47.2%	82.5%	63.1%
		% of Total	25.9%	37.2%	63.1%
	Does not meet EAR	Count	103	28	131
		Expected Count	72.0	59.0	131.0
		% within Total diet intake + salt categorical	78.6%	21.4%	100.0%
		% within Iodised salt use BINARY minus I do not know	52.8%	17.5%	36.9%
		% of Total	29.0%	7.9%	36.9%
Total		Count	195	160	355
		Expected Count	195.0	160.0	355.0
		% within Total diet intake + salt categorical	54.9%	45.1%	100.0%
		% within Iodised salt use BINARY minus I do not know	100.0%	100.0%	100.0%
		% of Total	54.9%	45.1%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	47.089[a]	1	.000		
Continuity Correction[b]	45.584	1	.000		
Likelihood Ratio	49.385	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	46.956	1	.000		
N of Valid Cases	355				

[a] 0 cells (.0%) have expected count less than 5. The minimum expected count is 59.04.

[b] Computed only for a 2x2 table

F.14 Iodised salt use BINARY minus I do not know * Education categorical Crosstabulation

Cross Tabulation

I			Education categorical			Total
			Secondary school	Diploma, trade or technical certificate	Tertiary or professional qualification	
Iodised salt use BINARY minus I do not know	No	Count	72	53	68	193
		% within Iodised salt use BINARY minus I do not know	37.3%	27.5%	35.2%	100.0%
		% within Education categorical	61.5%	60.2%	46.3%	54.8%
		% of Total	20.5%	15.1%	19.3%	54.8%
	Yes	Count	45	35	79	159
		% within Iodised salt use BINARY minus I do not know	28.3%	22.0%	49.7%	100.0%
		% within Education categorical	38.5%	39.8%	53.7%	45.2%
		% of Total	12.8%	9.9%	22.4%	45.2%
Total		Count	117	88	147	352
		% within Iodised salt use BINARY minus I do not know	33.2%	25.0%	41.8%	100.0%
		% within Education categorical	100.0%	100.0%	100.0%	100.0%
		% of Total	33.2%	25.0%	41.8%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.522[a]	2	.023
Likelihood Ratio	7.530	2	.023
Linear-by-Linear Association	6.440	1	.011
N of Valid Cases	352		

[a] 0 cells (0.0%) have expected count less than 5. The minimum expected count is 39.75.

F.15 Iodised salt use BINARY minus I do not know
* NEW Ethnicity 3 cat

Cross Tabulation

			NEW Ethnicity 3 cat			Total
			Aust / Aust Aboriginal / TSI	New Zealand / Polynesian	Asian / African / Other	
Iodised salt use BINARY minus I do not know	No	Count	125	16	54	195
		% within Iodised salt use BINARY minus I do not know	64.1%	8.2%	27.7%	100.0%
		% within NEW Ethnicity 3 cat	64.8%	53.3%	40.9%	54.9%
		% of Total	35.2%	4.5%	15.2%	54.9%
	Yes	Count	68	14	78	160
		% within Iodised salt use BINARY minus I do not know	42.5%	8.8%	48.8%	100.0%
		% within NEW Ethnicity 3 cat	35.2%	46.7%	59.1%	45.1%
		% of Total	19.2%	3.9%	22.0%	45.1%
Total		Count	193	30	132	355
		% within Iodised salt use BINARY minus I do not know	54.4%	8.5%	37.2%	100.0%
		% within NEW Ethnicity 3 cat	100.0%	100.0%	100.0%	100.0%
		% of Total	54.4%	8.5%	37.2%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	18.056[a]	2	.000
Likelihood Ratio	18.153	2	.000
Linear-by-Linear Association	18.002	1	.000
N of Valid Cases	355		

[a] 0 cells (0.0%) have expected count less than 5. The minimum expected count is 13.52.

F.16 Food source of I I do not know * Education categorical

Cross Tabulation

			Education categorical			Total
			Secondary school	Diploma, trade or technical certificate	Tertiary or professional qualification	
Food source of I I do not know	No	Count	94	72	143	309
		Expected Count	101.5	78.0	129.5	309.0
		% within Food source of I I do not know	30.4%	23.3%	46.3%	100.0%
		% within Education categorical	68.1%	67.9%	81.3%	73.6%
		% of Total	22.4%	17.1%	34.0%	73.6%
	Yes	Count	44	34	33	111
		Expected Count	36.5	28.0	46.5	111.0
		% within Food source of I I do not know	39.6%	30.6%	29.7%	100.0%
		% within Education categorical	31.9%	32.1%	18.8%	26.4%
		% of Total	10.5%	8.1%	7.9%	26.4%
Total		Count	138	106	176	420
		Expected Count	138.0	106.0	176.0	420.0
		% within Food source of I I do not know	32.9%	25.2%	41.9%	100.0%
		% within Education categorical	100.0%	100.0%	100.0%	100.0%
		% of Total	32.9%	25.2%	41.9%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	**9.188[a]**	**2**	**.010**
Likelihood Ratio	**9.435**	**2**	**.009**
Linear-by-Linear Association	**7.315**	**1**	**.007**
N of Valid Cases	**420**		

[a] 0 cells (.0%) have expected count less than 5. The minimum expected count is 28.01.

F.17 Food source of I Seafood * Education categorical

Cross Tabulation

			Education categorical			Total
			Secondary school	Diploma, trade or technical certificate	Tertiary or professional qualification	
Food source of I Seafood	No	Count	105	69	99	273
		Expected Count	89.7	68.9	114.4	273.0
		% within Food source of I Seafood	38.5%	25.3%	36.3%	100.0%
		% within Education categorical	76.1%	65.1%	56.3%	65.0%
		% of Total	25.0%	16.4%	23.6%	65.0%
	Yes	Count	33	37	77	147
		Expected Count	48.3	37.1	61.6	147.0
		% within Food source of I Seafood	22.4%	25.2%	52.4%	100.0%
		% within Education categorical	23.9%	34.9%	43.8%	35.0%
		% of Total	7.9%	8.8%	18.3%	35.0%
Total		Count	138	106	176	420
		Expected Count	138.0	106.0	176.0	420.0
		% within Food source of I Seafood	32.9%	25.2%	41.9%	100.0%
		% within Education categorical	100.0%	100.0%	100.0%	100.0%
		% of Total	32.9%	25.2%	41.9%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	**13.380[a]**	**2**	**.001**
Likelihood Ratio	**13.669**	**2**	**.001**
Linear-by-Linear Association	**13.308**	**1**	**.000**
N of Valid Cases	**420**		

[a] 0 cells (.0%) have expected count less than 5. The minimum expected count is 37.10.

F.18 Health problem Goitre * Age Categorical

Cross Tabulation

			Age Categorical			Total
			18-24	25-34	35+	
Health problem Goitre	No	Count	78	216	60	354
		Expected Count	74.7	212.2	67.1	354.0
		% within Health problem Goitre	22.0%	61.0%	16.9%	100.0%
		% within Age Categorical	87.6%	85.4%	75.0%	83.9%
		% of Total	18.5%	51.2%	14.2%	83.9%
	Yes	Count	11	37	20	68
		Expected Count	14.3	40.8	12.9	68.0
		% within Health problem Goitre	16.2%	54.4%	29.4%	100.0%
		% within Age Categorical	12.4%	14.6%	25.0%	16.1%
		% of Total	2.6%	8.8%	4.7%	16.1%
Total		Count	89	253	80	422
		Expected Count	89.0	253.0	80.0	422.0
		% within Health problem Goitre	21.1%	60.0%	19.0%	100.0%
		% within Age Categorical	100.0%	100.0%	100.0%	100.0%
		% of Total	21.1%	60.0%	19.0%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.017[a]	2	.049
Likelihood Ratio	5.552	2	.062
Linear-by-Linear Association	4.775	1	.029
N of Valid Cases	422		

[a] 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.89.

F.19 Health problem I do not know * Education categorical

Cross Tabulation

			Education categorical			
			Secondary school	Diploma, trade or technical certificate	Tertiary or professional qualification	Total
Health problem I do not know	No	Count	50	44	97	191
		Expected Count	62.8	48.2	80.0	191.0
		% within Health problem I do not know	26.2%	23.0%	50.8%	100.0%
		% within Education categorical	36.2%	41.5%	55.1%	45.5%
		% of Total	11.9%	10.5%	23.1%	45.5%
	Yes	Count	88	62	79	229
		Expected Count	75.2	57.8	96.0	229.0
		% within Health problem I do not know	38.4%	27.1%	34.5%	100.0%
		% within Education categorical	63.8%	58.5%	44.9%	54.5%
		% of Total	21.0%	14.8%	18.8%	54.5%
Total		Count	138	106	176	420
		Expected Count	138.0	106.0	176.0	420.0
		% within Health problem I do not know	32.9%	25.2%	41.9%	100.0%
		% within Education categorical	100.0%	100.0%	100.0%	100.0%
		% of Total	32.9%	25.2%	41.9%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	12.022[a]	2	.002
Likelihood Ratio	12.073	2	.002
Linear-by-Linear Association	11.442	1	.001
N of Valid Cases	420		

[a] 0 cells (.0%) have expected count less than 5. The minimum expected count is 48.20.

F.20 Health problem Goitre

* Education categorical

Cross Tabulation

			Education categorical			Total
			Secondary school	Diploma, trade or technical certificate	Tertiary or professional qualification	
Health problem Goitre	No	Count	131	93	126	350
		Expected Count	115.0	88.3	146.7	350.0
		% within Health problem Goitre	37.4%	26.6%	36.0%	100.0%
		% within Education categorical	94.9%	87.7%	71.6%	83.3%
		% of Total	31.2%	22.1%	30.0%	83.3%
	Yes	Count	7	13	50	70
		Expected Count	23.0	17.7	29.3	70.0
		% within Health problem Goitre	10.0%	18.6%	71.4%	100.0%
		% within Education categorical	5.1%	12.3%	28.4%	16.7%
		% of Total	1.7%	3.1%	11.9%	16.7%
Total		Count	138	106	176	420
		Expected Count	138.0	106.0	176.0	420.0
		% within Health prblem Goitre	32.9%	25.2%	41.9%	100.0%
		% within Education categorical	100.0%	100.0%	100.0%	100.0%
		% of Total	32.9%	25.2%	41.9%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	32.308[a]	2	.000
Likelihood Ratio	34.132	2	.000
Linear-by-Linear Association	31.095	1	.000
N of Valid Cases	420		

[a] 0 cells (.0%) have expected count less than 5. The minimum expected count is 17.67.

F.21 Health problem Mental retardation * Education categorical

Cross Tabulation

			Education categorical			Total
			Secondary school	Diploma, trade or technical certificate	Tertiary or professional qualification	
Health problem Mental retardation	No	Count	132	98	153	383
		Expected Count	125.8	96.7	160.5	383.0
		% within Health problem Mental retardation	34.5%	25.6%	39.9%	100.0%
		% within Education categorical	95.7%	92.5%	86.9%	91.2%
		% of Total	31.4%	23.3%	36.4%	91.2%
	Yes	Count	6	8	23	37
		Expected Count	12.2	9.3	15.5	37.0
		% within Health problem Mental retardation	16.2%	21.6%	62.2%	100.0%
		% within Education categorical	4.3%	7.5%	13.1%	8.8%
		% of Total	1.4%	1.9%	5.5%	8.8%
Total		Count	138	106	176	420
		Expected Count	138.0	106.0	176.0	420.0
		% within Health problem Mental retardation	32.9%	25.2%	41.9%	100.0%
		% within Education categorical	100.0%	100.0%	100.0%	100.0%
		% of Total	32.9%	25.2%	41.9%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	**7.603[a]**	**2**	**.022**
Likelihood Ratio	**7.862**	**2**	**.020**
Linear-by-Linear Association	**7.453**	**1**	**.006**
N of Valid Cases	**420**		

[a] 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.34.

F.22 Health problem I do not know
* NEW Ethnicity 3 cat

Cross Tabulation

I			NEW Ethnicity 3 cat			Total
			Aust/Aust Aboriginal/TSI	New Zealand/Polynesian	Asian/African/Other	
Health problem I do not know	No	Count	89	12	92	193
		Expected Count	101.5	15.0	76.5	193.0
		% within Health problem I do not know	46.1%	6.2%	47.7%	100.0%
		% within NEW Ethnicity 3 cat	39.9%	36.4%	54.8%	45.5%
		% of Total	21.0%	2.8%	21.7%	45.5%
	Yes	Count	134	21	76	231
		Expected Count	121.5	18.0	91.5	231.0
		% within Health problem I do not know	58.0%	9.1%	32.9%	100.0%
		% within NEW Ethnicity 3 cat	60.1%	63.6%	45.2%	54.5%
		% of Total	31.6%	5.0%	17.9%	54.5%
Total		Count	223	33	168	424
		Expected Count	223.0	33.0	168.0	424.0
		% within Health problem I do not know	52.6%	7.8%	39.6%	100.0%
		% within NEW Ethnicity 3 cat	100.0%	100.0%	100.0%	100.0%
		% of Total	52.6%	7.8%	39.6%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	9.732[a]	2	.008
Likelihood Ratio	9.745	2	.008
Linear-by-Linear Association	8.237	1	.004
N of Valid Cases	424		

[a] 0 cells (.0%) have expected count less than 5. The minimum expected count is 15.02.

F.23 Health problem Goitre
* NEW Ethnicity 3 cat

Cross Tabulation

			NEW Ethnicity 3 cat			Total
			Aust/Aust Aboriginal/TSI	New Zealand/Polynesian	Asian/African/Other	
Health problem Goitre	No	Count	204	30	119	353
		Expected Count	185.7	27.5	139.9	353.0
		% within Health problem Goitre	57.8%	8.5%	33.7%	100.0%
		% within NEW Ethnicity 3 cat	91.5%	90.9%	70.8%	83.3%
		% of Total	48.1%	7.1%	28.1%	83.3%
	Yes	Count	19	3	49	71
		Expected Count	37.3	5.5	28.1	71.0
		% within Health problem Goitre	26.8%	4.2%	69.0%	100.0%
		% within NEW Ethnicity 3 cat	8.5%	9.1%	29.2%	16.7%
		% of Total	4.5%	0.7%	11.6%	16.7%
Total		Count	223	33	168	424
		Expected Count	223.0	33.0	168.0	424.0
		% within Health problem Goitre	52.6%	7.8%	39.6%	100.0%
		% within NEW Ethnicity 3 cat	100.0%	100.0%	100.0%	100.0%
		% of Total	52.6%	7.8%	39.6%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	30.801[a]	2	.000
Likelihood Ratio	30.302	2	.000
Linear-by-Linear Association	28.661	1	.000
N of Valid Cases	424		

[a] 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.53.

F.24 Health problem Mental retardation * NEW Ethnicity 3 cat

Cross Tabulation

			NEW Ethnicity 3 cat			Total
			Aust/Aust Aboriginal/TSI	New Zealand/Polynesian	Asian/African/Other	
Health problem Mental retardation	No	Count	209	32	146	387
		Expected Count	203.5	30.1	153.3	387.0
		% within Health problem Mental retardation	54.0%	8.3%	37.7%	100.0%
		% within NEW Ethnicity 3 cat	93.7%	97.0%	86.9%	91.3%
		% of Total	49.3%	7.5%	34.4%	91.3%
	Yes	Count	14	1	22	37
		Expected Count	19.5	2.9	14.7	37.0
		% within Health problem Mental retardation	37.8%	2.7%	59.5%	100.0%
		% within NEW Ethnicity 3 cat	6.3%	3.0%	13.1%	8.7%
		% of Total	3.3%	0.2%	5.2%	8.7%
Total		Count	223	33	168	424
		Expected Count	223.0	33.0	168.0	424.0
		% within Health problem Mental retardation	52.6%	7.8%	39.6%	100.0%
		% within NEW Ethnicity 3 cat	100.0%	100.0%	100.0%	100.0%
		% of Total	52.6%	7.8%	39.6%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.048[a]	2	.029
Likelihood Ratio	7.141	2	.028
Linear-by-Linear Association	5.346	1	.021
N of Valid Cases	424		

[a] 1 cells (16.7%) have expected count less than 5. The minimum expected count is 2.88.

F.25 Health problem Goitre

* Weeks pregnant recoded into BINARY

Cross Tabulation

			Weeks pregnant recoded into BINARY		Total
			Up to (including) 28 weeks	29 weeks or more	
Health problem Goitre	No	Count	140	214	354
		Expected Count	149.9	204.1	354.0
		% within Health problem Goitre	39.5%	60.5%	100.0%
		% within Weeks pregnant recoded into BINARY	77.8%	87.3%	83.3%
		% of Total	32.9%	50.4%	83.3%
	Yes	Count	40	31	71
		Expected Count	30.1	40.9	71.0
		% within Health problem Goitre	56.3%	43.7%	100.0%
		% within Weeks pregnant recoded into BINARY	22.2%	12.7%	16.7%
		% of Total	9.4%	7.3%	16.7%
Total		Count	180	245	425
		Expected Count	180.0	245.0	425.0
		% within Health problem Goitre	42.4%	57.6%	100.0%
		% within Weeks pregnant recoded into BINARY	100.0%	100.0%	100.0%
		% of Total	42.4%	57.6%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.828[a]	1	.009		
Continuity Correction[b]	6.158	1	.013		
Likelihood Ratio	6.747	1	.009		
Fisher's Exact Test				.012	.007
Linear-by-Linear Association	6.812	1	.009		
N of Valid Cases	425				

[a] 0 cells (.0%) have expected count less than 5. The minimum expected count is 30.07.

[b] Computed only for a 2x2 table

F.26 Iodine in supplement taken since becoming pregnant

* Do you feel that your diet provides enough iodine when you are pregnant?

Cross Tabulation

			Do you feel that your diet provides enough iodine when you are pregnant?				Total
			No, I do not think my diet provides enough iodine	Yes, I am confident that my diet provides enough iodine	I do not know if my diet provides enough iodine	I do not know what iodine is	
Iodine in supplement taken since becoming pregnant	No iodine	Count	8	36	69	27	140
		Expected Count	9.9	33.8	80.9	15.4	140.0
		% within Iodine in supplement taken since becoming pregnant	5.7%	25.7%	49.3%	19.3%	100.0%
		% within Do you feel that your diet provides enough iodine when you are pregnant?	27.6%	36.4%	29.1%	60.0%	34.1%
		% of Total	2.0%	8.8%	16.8%	6.6%	34.1%
	Contains iodine	Count	21	63	168	18	270
		Expected Count	19.1	65.2	156.1	29.6	270.0
		% within Iodine in supplement taken since becoming pregnant	7.8%	23.3%	62.2%	6.7%	100.0%
		% within Do you feel that your diet provides enough iodine when you are pregnant?	72.4%	63.6%	70.9%	40.0%	65.9%
		% of Total	5.1%	15.4%	41.0%	4.4%	65.9%
Total		Count	29	99	237	45	410
		Expected Count	29.0	99.0	237.0	45.0	410.0
		% within Iodine in supplement taken since becoming pregnant	7.1%	24.1%	57.8%	11.0%	100.0%
		% within Do you feel that your diet provides enough iodine when you are pregnant?	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	7.1%	24.1%	57.8%	11.0%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	16.817[a]	3	.001
Likelihood Ratio	16.021	3	.001
Linear-by-Linear Association	3.392	1	.066
N of Valid Cases	410		

[a] 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.90.

F.27 Iodised salt use BINARY minus I do not know

* Do you feel that your diet provides enough iodine when you are pregnant?

Cross Tabulation

			Do you feel that your diet provides enough iodine when you are pregnant?				
			No, I do not think my diet provides enough iodine	Yes, I am confident that my diet provides enough iodine	I do not know if my diet provides enough iodine	I do not know what iodine is	Total
Iodised salt use BINARY minus I do not know	No	Count	16	40	111	25	192
		Expected Count	15.9	48.1	109.4	18.6	192.0
		% within Iodised salt use BINARY minus I do not know	8.3%	20.8%	57.8%	13.0%	100.0%
		% within Do you feel that your diet provides enough iodine when you are pregnant?	55.2%	45.5%	55.5%	73.5%	54.7%
		% of Total	4.6%	11.4%	31.6%	7.1%	54.7%
	Yes	Count	13	48	89	9	159
		Expected Count	13.1	39.9	90.6	15.4	159.0
		% within Iodised salt use BINARY minus I do not know	8.2%	30.2%	56.0%	5.7%	100.0%
		% within Do you feel that your diet provides enough iodine when you are pregnant?	44.8%	54.5%	44.5%	26.5%	45.3%
		% of Total	3.7%	13.7%	25.4%	2.6%	45.3%
Total		Count	29	88	200	34	351
		Expected Count	29.0	88.0	200.0	34.0	351.0
		% within Iodised salt use BINARY minus I do not know	8.3%	25.1%	57.0%	9.7%	100.0%
		% within Do you feel that your diet provides enough iodine when you are pregnant?	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	8.3%	25.1%	57.0%	9.7%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.955[a]	3	.047
Likelihood Ratio	8.192	3	.042
Linear-by-Linear Association	4.049	1	.044
N of Valid Cases	351		

[a] 0 cells (.0%) have expected count less than 5. The minimum expected count is 13.14.