Australian Government

Department of Health and Ageing

Biomedical component of the Australian Health Survey: Public health objectives

January 2011

Table of Contents

1. Introduction

The new Australian Health Survey, to be implemented by the Australian Bureau of Statistics (ABS) in 2011-13, builds on previous national health and nutrition surveys, such as the National Health Survey (NHS), National Aboriginal and Torres Strait Islander Health Survey (NATSIHS) and the 1995 National Nutrition Survey, and will include both a household survey component, conducted by professional interviewers, and a biomedical component.

The Australian Health Survey will be the first national health survey with a biomedical component conducted in Australia since the Risk Factor Prevalence Studies conducted by the Heart Foundation in the 1980's and the AusDiab cohort study conducted by the International Diabetes Institute (now Baker IDI) in 1999/2000 and 2004/05.

Participants in the Australian Health Survey will complete an initial household interview where they will be asked a set of core questions on topics such as demographics and health status, and have their blood pressure, height, weight and waist circumference measured. A sub-sampling approach will then be taken to collect a wide range of important information while not overburdening householders. Respondents will therefore subsequently be asked either questions relating to general health issues (e.g. diagnosed conditions, disability status and health service use) or detailed questions focussing on the topics of diet and physical activity.

After completion of the household interview, participants will be invited to take part in the biomedical component of the Australian Health Survey which will involve voluntarily attending a local pathology collection centre to provide samples of blood and urine, collected by accredited phlebotomists. Urine samples will be collected from participants aged 5 years and over, and blood and urine samples will be collected from participants aged 12 years and over who attend the collection centres. Samples collected in the Australian Health Survey will be sent to laboratories to be analysed for selected markers of chronic disease and nutrition status, using centralised processing where possible.

This paper provides the rationale behind the selection of markers of chronic disease and nutrition status to be included in the biomedical component of the Australian Health Survey. Sections 2 and 3, respectively, discuss the markers of chronic disease and nutrition status to be included in the biomedical component of the Australian Health Survey.

2. Markers of chronic disease

Major chronic diseases in Australia

The Australian Institute of Health and Welfare (AIHW) reports that cardiovascular disease, diabetes and chronic kidney disease together account for almost two thirds of all deaths and approximately one quarter of the burden of disease in Australia (AIHW 2009a). As such, measuring and monitoring the prevalence of these conditions and their determinants is essential for policy development, health service planning and policy and program evaluations.

Estimates of the prevalence of cardiovascular disease, diabetes and chronic kidney disease have previously been provided by the NHS and NATSIHS; however these surveys rely on self-reported information.   Self-reported prevalence estimates have been found to substantially underestimate the true prevalence of cardiovascular disease, diabetes and chronic

kidney disease as they do not include data on undiagnosed cases of disease. The Australian Health Survey aims to collect information on diagnosed and undiagnosed cases of disease to provide more accurate prevalence estimates, by collecting biomedical samples from survey participants and analysing these for chronic disease biomarkers.

The Australian Health Survey is a population survey that aims to capture a picture of the health of all Australians. The measures of chronic disease risk factors and nutritional status that it takes reflect this objective. Measures are not chosen for their ability to diagnose individuals, but rather to identify differences in population sub-groups and to monitor trends over time.

Chronic disease risk factors

Cardiovascular disease, Type 2 diabetes and chronic kidney disease share many common modifiable risk factors including smoking, poor diet, obesity, and physical inactivity (Table 1), and are therefore largely preventable.

Indicators for all of the risk factors identified in Table 1, with the exception of low birth weight, will be collected in the Australian Health Survey. Linking these data on risk factors to the data on the markers of chronic disease provided from analysis of blood and urine samples will provide a valuable opportunity to examine associations between risk factors and the presentation of disease.

Many of the risk factors identified in Table 1, including obesity, impaired glucose regulation, excessive alcohol, physical inactivity, poor diet and high cholesterol are also risk factors for fatty liver disease, a condition that is estimated to affect around 10% of Australians (Digestive Health Foundation 2005). As fatty liver disease is associated with many of these lifestyle related risk factors, selected markers of this condition will also be included in the biomedical component of the Australian Health Survey.

Table 1. Risk factors for cardiovascular disease, Type 2 diabetes and chronic kidney disease

Risk factor	Cardiovascular disease	Type 2 diabetes	Chronic kidney disease
Overweight and obesity	Yes	Yes	Yes
Physical inactivity	Yes	Yes	Yes
Poor diet	Yes	Yes	Yes
Tobacco smoking	Yes	Yes	Yes
Excessive alcohol	Yes		
High blood pressure	Yes		Yes
High blood cholesterol	Yes	Yes	
Impaired glucose regulation		Yes	
Depression	Yes		
Low birth weight	Yes	Yes	Yes

Source: AIWH 2009a, p11.

2.1 Cardiovascular Disease

Cardiovascular disease, diseases of the heart and vascular system, is recognised as a national health priority in Australia. Cardiovascular disease is the leading cause of death in Australia for both men and women. In 2007, cardiovascular disease accounted for over one third of all deaths (AIHW 2010). Between 2002 and 2005, death rates for cardiovascular disease were three times higher among Indigenous Australians compared to non-Indigenous Australians (AIWH 2008b).

In 2001 it was estimated that 16% of the population had four or more risk factors for cardiovascular disease (AIHW 2005 cited in AIHW 2009a). Australia's Aboriginal and Torres Strait Islander populations are particularly affected —the AIHW reports that nearly all cardiovascular disease risk factors are more common in the Indigenous population compared to non-Indigenous Australians, with Indigenous people more likely to have multiple risk factors, and a greater number of risk factors, compared to non-Indigenous Australians (AIWH 2008b).

Cardiovascular disease has the highest direct health care expenditure of all disease groups (AIHW 2010). The main indicators of cardiovascular disease to be measured in the Australian Health Survey are blood lipids: total cholesterol, triglycerides, high density lipoprotein and low density lipoprotein. In addition, blood pressure will be measured in the household interview component of the Australian Health Survey to determine the proportion of people who have hypertension (high blood pressure), which, as indicated in Table 1, is a risk factor for cardiovascular disease and chronic kidney disease.

2.1.1 Total cholesterol

High blood cholesterol can lead to atherosclerosis (clogged arteries) which increases the likelihood of heart attack, stroke or angina. The association between cholesterol and cardiovascular disease is such that as blood cholesterol increases, so too does cardiovascular disease risk and therefore there is no single cut point at which risk of cardiovascular disease begins. Total cholesterol can be measured in a fasting or non-fasting blood sample, high total cholesterol is considered to be ≥ 5.5 mmol/L (AIHW 2008c). The 1999/2000 AusDiab study estimated that 51.2% of the Australian population has high total cholesterol (Dunstan et al 2001).

2.1.2 Triglycerides

Triglycerides are a type of blood fat formed from the digestion of fat in foods and so can increase after eating. Consequently triglycerides need to be analysed in a fasting blood sample. High triglycerides can contribute to atherosclerosis and therefore an increased risk of cardiovascular disease. A high triglyceride level is considered to be ≥ 2.0 mmol/L (AIHW 2008c). High triglycerides can be caused by excess intake of energy, fats, alcohol and overweight/obesity. The 1999/2000 AusDiab study estimated that 20.5% of Australians have high triglyceride levels (Dunstan et al 2001).

2.1.3 High density lipoprotein (HDL)

HDL cholesterol makes up about 20-30 % of total serum cholesterol. It is often known as 'good cholesterol' as it acts to reduce the build up of cholesterol within the arteries so higher HDL levels are associated with reduced cardiovascular disease risk. Low HDL is defined as ≤1 mmol/L (AIHW 2008c). Using this definition, the 1999/2000 AusDiab study reported that 11.9% of Australian adults had HDL cholesterol that was ≤1 mmol/L (Dunstan et al 2001).

2.1.4 Low density lipoprotein (LDL)

LDL makes up between 60-70% of total serum cholesterol. LDL contributes to a build-up of plaque in the artery walls; elevated LDL levels increase the risk of heart attack or stroke and is often termed 'bad cholesterol'. Elevated LDL is considered to be ≥3.5 mmol/L (AIHW 2008c). The 1999/2000 AusDiab study reported that 45.8% of Australian adults have elevated LDL cholesterol, with males being more likely than females to have elevated LDL cholesterol (49.8% of males had elevated LDL compared to 42.1% of females) (Dunstan et al 2001).

LDL can be determined two ways: measured directly or using the Friedewald calculation (LDL cholesterol = total cholesterol – HDL cholesterol – triglyceride / 2.2). Each method has its advantages and disadvantages. While the calculation does not cost anything to perform given that the variables in the calculation will be measured in the Australian Health Survey, it can only be calculated using fasting samples since the equation includes triglyceride levels. In addition, the calculation is unreliable if triglycerides are ≥4.5 mmol (Royal College of Pathologists of Australasia 2010).

One alternative is to directly measure LDL which does not require a fasting sample but is more costly than calculating LDL values. Another alternative, which will be used in the Australian Health Survey, is to measure Apolipoprotein B-100 (Apo B) levels in blood taken from participants who have fasted (Benn et al 2006). Apo B is the major protein of LDL such that one LDL particle contains one Apo B molecule (Mahley et al 1984). Measurement of Apo B levels is especially useful when someone has elevated triglyceride levels thus preventing accurate LDL cholesterol calculations. A range of Apo B levels from 0.6-1.2 g/L is normal for females, from 0.7-1.3 g/L for males, elevated levels indicate hyperlipidemia. Ideally, for the most accurate interpretation of Apo B results, note should be made of heart attacks, surgery, infection, injury or pregnancy in the previous two months. A ratio of Apo B to LDL calculated can also be derived, which is considered a better measure of cardiovascular risk than LDL calculated alone as it estimates the proportion of LDL particles that contain cholesterol.

2.1.5 Blood pressure

Risk factors for high blood pressure include high salt and saturated fat intake, obesity, excessive alcohol consumption and physical inactivity (AIHW 2008c). As illustrated in Table 2.1, high blood pressure is also a risk factor itself for cardiovascular disease and chronic kidney disease. The risk associated with high blood pressure follows a continuum, that is, there is no definite point at which risk begins, but rather as blood pressure increases, so too does risk of cardiovascular disease (AIHW 2009). The AIHW defines high blood pressure as systolic blood pressure ≥140mmHg, or diastolic blood pressure ≥90mmHg, or receiving medication for high blood pressure (AIHW 2008c). The 1999/2000 AusDiab study reported that the prevalence of high blood pressure increased with age, and estimated that 78.2% of males and 74.5% of females aged over 75 years have high blood pressure (Dunstan et al 2001).

2.2 Type 2 diabetes

Diabetes is recognised as a national health priority in Australia. It was associated with 9.5% of all deaths in 2007 and is estimated to be the sixth leading cause of disease burden in 2010 (AIHW 2010).

Based on self-reported data from the 2007-08 NHS, the AIHW estimates that the prevalence of diabetes in Australia is increasing, with 4% of Australians reporting to have diabetes, up from 3.8% in 2004-05 (AIWH 2010). Diabetes disproportionately affects certain population groups, with those who are most socioeconomically disadvantaged and those who live in outer regional, remote or very remote locations having greater rates of diabetes compared to the general Australian population. In addition, the AIHW reports that age-standardised prevalence rates for diabetes among Indigenous Australians is almost 3-times higher than that of non-Indigenous Australians (11% in Indigenous Australians compared to 4% among non-Indigenous Australians (AIWH 2008 cited in AIHW 2010).

It is important to recognise that there are different types of diabetes. Type 1 diabetes is an autoimmune disease that manifests mainly in children and young adults. Currently there is no known way to prevent Type 1 diabetes; it is thought to be triggered by genetic and environmental factors. Type 2 diabetes is the most common form of diabetes, accounting for around 85-90% of cases of diabetes in Australia (AIHW 2010).

Type 2 diabetes mostly occurs in people aged over 50 years of age, but is also becoming increasingly common in younger age groups (AIHW 2010). As indicated in Table 2.1, the risk factors of Type 2 diabetes include physical inactivity, poor diet, obesity and tobacco smoking, and thus unlike Type 1 diabetes, Type 2 diabetes is largely preventable.

A third type of diabetes, gestational diabetes, can occur in pregnant women and usually disappears after the baby is born, but increases a woman's risk of developing Type 2 diabetes later in life (AIHW 2010).

Due to its association with lifestyle related risk factors, and preventable nature, Type 2 diabetes will be the focus of testing in the Australian Health Survey. The 2001 AusDiab study estimated the prevalence of Type 2 diabetes in Australians aged 25 and over to be 7.5% (Dunstan et al 2001). Only half of the AusDiab participants found to have diabetes were aware that they had the condition, indicating the vastly inaccurate nature of self-reported prevalence estimates.

The main indicators of diabetes that will be included in the biomedical component of the Australian Health Survey are fasting plasma glucose and glycosilated haemoglobin (HbA1c).

2.2.1 Fasting plasma glucose

The AIHW (2008) classifies diabetes as fasting plasma glucose ≥ 7.0 mmol/L (or 2-hour plasma glucose ≥ 11.1mmol/L but two hour measurements are not feasible for the Australian Health Survey). Normal plasma glucose is defined as < 6.1mmol/L.

A fasting plasma glucose reading that is < 7.0mmol/L but greater ≥ 6.1 mmol/L indicates either impaired fasting glucose or impaired glucose tolerance (a 2-hour glucose tolerance test would required to distinguish between these two states).

2.2.2 HbA1C

HbA1C represents the percentage of circulating haemoglobin to which glucose is bound. It provides an indication of the average blood glucose concentration over the last three months and is used as an indicator of diabetes management, with higher HbA1C values indicating poorer diabetes control. Poorly managed diabetes increases the risk of cardiovascular disease and other complications. The proportion of people with diabetes who have an HbA1c ≤ 7% is

an indicator identified in the Council of Australian Governments (COAG) National Healthcare Agreement.

2.3 Chronic kidney disease

Chronic kidney disease refers to kidney damage or reduced kidney function that lasts for a period of three months or longer (AIHW 2010). As indicated in Table 1, there are a number of lifestyle related risk factors for chronic kidney disease which include smoking, obesity, high blood pressure and physical inactivity. Cardiovascular disease and diabetes are also risk factors for chronic kidney disease (AIHW 2009b). The AIHW reports that chronic kidney disease contributed to nearly 10% of all deaths in 2007 and more than 12.5% of hospitalisations in 2007-08 (AIHW 2010).

Chronic kidney disease can be categorised into five stages based on the degree to which kidney function is reduced. The early stages of chronic kidney disease are often asymptomatic; symptoms may not present until up to 90% of kidney function is lost (AIHW 2009b). Thus the prevalence of stage 1 - 4 kidney disease may be underestimated if based on self-reported data. Using data from the 1999/2000 AusDiab study, the AIHW estimated that the prevalence of stage 1 and 2 kidney damage in Australia was 5.6% and the prevalence of stage 3 - 5 kidney damage was 7.8% (AIHW 2009b).

Prevalence is strongly associated with age—AIHW estimates that 30.6% of Australians aged over 65 years had stage 3 - 5 kidney damage in 1999/2000 (AIHW 2009b). Again, Aboriginal and Torres Strait Islanders are more at risk—the rate of hospitalisations for end-stage kidney disease is nearly seven times higher for Indigenous Australians compared to non-Indigenous Australians (AIHW 200b).

In order to measure the presence and stage of chronic kidney disease, two tests will be included in the Australian Health Survey: urinary albumin creatinine ratio (ACR) and estimated Glomerular Filtration Rate (eGFR). Levels of urinary albumin, serum and urinary creatinine will also be reported separately.

2.3.1 Urinary albumin creatinine ratio (ACR)

In early stages of kidney disease, the kidneys may leak protein into the urine without any other signs of kidney impairment. When albumin, a type of protein, is detected in the urine it is known as albuminuria. Albuminuria is considered to be present when the urinary ACR is ≥ 2.5 mg/mmol for males and ≥3.5 mg/mmol for females (Barr et al 2006). The 1999/2000 AusDiab study reported that 6.6% of participants had albuminuria (Atkins et al 2004; Chadban et al 2003, cited in AIHW 2009b).

2.3.2 Estimated glomerular filtration rate (eGFR)

Glomerular filtration rate (GFR) is the amount of blood the kidneys filter per minute. It is not possible to measure GFR directly, and as such, GFR is estimated using a formula that includes an individual's age, gender and serum creatinine. Serum creatinine is a waste product that is made by the muscles; it is usually removed by the kidneys to be excreted in urine, but when kidney function is impaired the amount of creatinine in the blood increases.

A number of different formulas have been developed for estimating glomerular filtration rate; the currently recommended formula is the MDRD175 formula below (Matthew et al 2007).

$$\text{eGFR (mL/min/1.73m}^2) = 175 \times (\text{serum creatinine (umol/L)} \times 0.0133)^{-1.154} \times (\text{age (years)})^{-0.203} \times (0.742 \text{ [if female]})$$

The five stages of chronic kidney disease are classified depending on eGFR values and the presence of other signs of kidney damage such as albuminuria (Table 2).

Table 2: Criteria to classify different stages of kidney damage

Stage	Criteria
Normal function	eGFR ≥90 mL/min/1.73m^2
Stage 1 kidney damage	eGFR ≥90 mL/min/1.73m^2 + albuminuria
Stage 2 kidney damage	eGFR 60-89 mL/min/1.73m^2 + albuminuria
Stage 3 kidney damage	eGFR 30-59 mL/min/1.73m^2
Stage 4 kidney damage	eGFR 15-29 mL/min/1.73m^2
Stage 5 kidney damage	eGFR ≥90 mL/min/1.73m^2

Source: AIHW 2009b

2.4 Liver damage

Fatty liver disease occurs when fat accumulates in the liver. It is often asymptomatic and consequently self-reported data is likely to considerably underestimate the prevalence of fatty liver disease. The Australian Health Survey will measure two blood enzymes related to liver function to provide an indication of the proportion of the population who have some form of liver damage. This information will not provide prevalence estimates for fatty liver disease, as diagnosis requires other considerations such as medical history, physical examination, in addition to blood tests.

There are a range of liver function tests that may be undertaken. The liver enzymes that will be measured in the Australian Health Survey are alanine aminotransferase (ALT) and gamma glutamyltransaminase (γ-GT). These measures were chosen following expert advice that they are the most sensitive of the liver function tests available and provide the best indication of liver damage. Reference ranges from the analytical laboratory will be used to determine whether results are abnormal or otherwise.

2.4.1 Gamma glutamyltransaminase (γ-GT)

γ-GT is currently the most sensitive enzymatic indicator of liver disease and is also increased in people with heavy alcohol intakes (Centers for Disease Control and Prevention 2008). In the 2004 NSW Schools Physical Activity and Nutrition Survey (SPANS), 3.5% and 2.4% of year 10 boys and girls respectively had elevated γ-GT, when elevated γ-GT was defined as > 32u/L for boys and > 20 u/L for girls (Booth et al 2006).

2.4.2 Alanine aminotransferase (ALT)

Elevated ALT indicates a degree of liver inflammation. In the 2004 NSW SPANS, 9.0% and 5.3% of year 10 boys and girls respectively had elevated ALT, which was defined as > 30u/L (Booth et al 2006).

2.5 Tobacco smoking

As indicated in Table 1, tobacco smoking is a risk factor for cardiovascular disease, diabetes and chronic kidney disease. It is also a major risk factor for cancer and many other diseases and conditions (AHIW 2010). The AIHW describes tobacco smoking as the "single most preventable cause of ill health and death in Australia" (AIHW 2010 p.84).

Using data from the National Drug Strategy Household Survey, the AIHW estimate that around 16.7% of Australians aged 14 years and over smoke on a daily basis, 55.4% of the population have never smoked, and around 25% are former smokers (AIWH 2010). The survey found there are considerable differences in smoking rates between different population groups; people who were unemployed, unable to work, living in rural or remote areas or living in areas with low socioeconomic resources were more likely to smoke. Indigenous people were also more likely to smoke than non-Indigenous people (34% of Indigenous people smoked compared to 19% of non-Indigenous).

While the National Drug Strategy Household Survey and NHS provide information on smoking habits in the population, including exposure to second-hand smoke, these estimates may be affected by reporting bias. To provide more objective data on population exposure to tobacco smoke, including passive exposure, the Australian Health Survey will measure serum cotinine, a metabolite of nicotine.

2.5.1 Serum cotinine

Cotinine can be measured in serum, urine and saliva samples, however, urinary cotinine measurements are less reliable than saliva and serum measures (Watts et al 1990). Initially it was intended that the Australian Health Survey would measure salivary cotinine, as this would enable measurement of exposure to tobacco smoke in children aged 5 years and over (blood samples will only be taken from children aged over 12 years). However, the Department has been advised that there are no laboratories in Australia able to measure salivary cotinine and thus serum cotinine will be analysed in blood samples collected in the Australian Health Survey.

Serum cotinine is able to distinguish between non-smokers, passive smokers and active smokers (Watts et al 1990). The serum cotinine levels with which to classify participants in these categories are dependent on the analytical method used.

Summary

The Australian Health Survey will make a series of biomedical tests on samples given by respondents to allow an assessment of the health of the nation.

Markers of chronic disease risk factors that will be measured are suitable population indicators of cardiovascular disease, Type 2 diabetes, chronic kidney disease, liver damage and smoking.

3. Markers of nutrition status

The Nutrition and Physical Activity component of the Australian Health Survey will provide valuable information on survey participants' intake of food and drink, including many vitamins and minerals. However, food consumption and food composition data can be unreliable for certain nutrients, and for others the actual amount of the nutrient absorbed may differ to the amount consumed. Therefore the Australian Health Survey will analyse participants' blood and urine samples for selected nutrients.

The following section discusses the nutrients that will be measured in the biomedical component of the Australian Health Survey and the reasons for their inclusion. It should be noted that there are limited comparative data for these markers as this will be the first biomedical survey conducted on a national scale.

3.1 Folate status

Folate is a B-group vitamin that is essential for growth and development. Folate plays an important role in foetal development—adequate maternal folate status is critical in the first few weeks of pregnancy. There is strong evidence that increasing maternal intake of folic acid (the synthetic form of folate) during the periconceptional period can reduce the incidence of neural tube defects such as spina bifida.

In September 2009, legislation was introduced in Australia requiring all bread making wheat flour (except organic flour) to contain added folic acid. This measure aims to assist women of childbearing age to achieve adequate folate status prior to falling pregnant and in the first trimester, and subsequently reduce the incidence of neural tube defects in Australia.

Folate status will be determined for all participants in the biomedical component of the Australian Health Survey This will provide an indication of folate intakes of women of childbearing age, while also providing the opportunity to assess the folate status of members of the population whom are not the target of the folic acid fortification policy and therefore determine whether folic acid fortification has resulted in any potential excessive folic acid intakes in the non-target population. To provide data for monitoring and evaluating the success of this measure, erythrocyte folate and serum folate will be analysed in Australian Health Survey participants' blood samples.

3.1.2 Erythrocyte folate

Erythrocyte folate concentrations reflect folate stores and are less sensitive than serum folate to fluctuations in dietary folate intakes (Gibson 2005). In 2008, a World Health Organization (WHO) technical consultation on folate and vitamin B12 deficiencies recommended that for population health monitoring, deficiency should be defined as erythrocyte folate < 340 nmol/L (WHO 2008). This figure was derived using data from the National Health Examination Survey III (NHANES) in the United States whereby the cut-off for folate deficiency was set at the point where homocysteine (a metabolite in the blood associated low folate intakes) becomes elevated.

3.1.3 Serum folate

Serum folate levels reflect recent dietary folate intake rather than folate tissue stores (Gibson 2005). The 2008 WHO technical consultation on folate and vitamin B12 deficiencies recommended that folate deficiency should be defined as serum folate < 10 nmol/L in population based studies (WHO 2008). This value was also based on the point at which homocysteine concentrations begin to increase.

3.2 Vitamin B12 status

Vitamin B12 is found naturally in foods of animal origin, such as meat and eggs, but may also be added to other foods such as soy-based beverages. Consequently, those who avoid animal products such as vegans and vegetarians may be at risk of B12 deficiency. Vitamin B12 deficiency may also occur due to vitamin B12 malabsorption which can be common in the elderly due to physiological changes associated with ageing that reduce B12 absorption (Gibson 2005).

Prior to the introduction of mandatory folate fortification, some groups raised concerns that folic acid intakes > 1,000 µg per day may mask B12 anaemia and delay the diagnosis and eventual treatment of severe vitamin B12 deficiency in older people (FSANZ 2006). This could occur by folic acid correcting the anaemia that can accompany vitamin B12 deficiency which is one of the clinical signs traditionally relied on for diagnosis. However, at the levels at which bread-making flour will be fortified with folic acid, Food Standards Australia New Zealand (FSANZ) estimates that the risk of folate delaying the diagnosis of vitamin B12 deficiency is limited, particularly as the diagnosis of vitamin B12 deficiency relies on a combination of clinical tests.

Nevertheless, data on the prevalence of vitamin B12 deficiency in Australia will assist with the monitoring and evaluation of the mandatory folate fortification program. Thus the NHMS will measure plasma B12 concentrations in survey participants' blood samples. The 2007 WHO technical consultation on folate and vitamin B12 deficiencies recommended that B12 deficiency be defined as plasma B12 < 150 pmol/L (WHO 2007). Similar to the folate deficiency cut-off, this value has been based on data from NHANES III.

3.3 Iodine status

Iodine is an essential part of the thyroid hormones that regulate metabolism. Iodine also plays a role in physical and mental development and thus adequate thyroid intakes are important for young children and women of childbearing age (Gibson 2005).

In 2009, a mandatory iodine fortification program was introduced in Australia and New Zealand requiring iodised salt to be used in all bread manufacture, with the exception of organic bread. This legislation was introduced in response to evidence of widespread mild iodine deficiency in Australia and New Zealand, particularly the south eastern Australian states (APHDPC 2007; Li et al 2006). It was estimated that a large proportion (43%) of the Australian population aged over 2 years were not achieving adequate iodine intakes, and that introducing mandatory iodine fortification would reduce this to less than 5% (FSANZ 2008).

To provide data for monitoring the effectiveness of the mandatory iodine fortification program, and assess the potential for excess iodine intakes, the AHS will measure the iodine concentration of spot urine samples collected from survey participants. While this is a suitable measure for assessing population iodine status, spot urine samples are **not** suitable for assessing individual iodine status because an individual's iodine intake and subsequent excretion, can be highly variable from day-to-day (Gibson 2005).

In order to determine the iodine status of a population, the WHO and International Council for Control of Iodine Deficiency Disorders have developed a set of cut off levels with which to compare population median iodine concentrations (Table 3.3).

Table 3: Criteria for assessing population iodine status

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

*Applies to adults and children, refer to WHO 2007 for cut offs for pregnant and lactating women.

Source: WHO 2007a (p. 33)

3.4 Sodium status

Sodium intake has been consistently associated with blood pressure (NHMRC 2005). Sodium occurs naturally in many foods, but is also part of dietary salt which is commonly added to foods during commercial food manufacture and also home food preparation. In the Nutrition and Physical Activity component of the Australian Health Survey respondents will be asked about discretionary use of salt, i.e. salt added in cooking or when eating, however this will not be quantified. FSANZ (2009) reports that 62% of Australians aged 2 years and over are discretionary salt users, and it is estimated that up to 18% of salt intake is due to discretionary use (Matts & Donnelly 1991 cited by FSANZ n.d). Therefore the sodium intake data derived from reported food consumption and food composition tables in the Australian Health Survey may not accurately describe the population's dietary sodium intake. To complement the sodium intake data collected in the Nutrition and Physical Activity component of the Australian Health Survey, the sodium concentration in urine samples will also be measured in the biomedical component.

In order to quantify the total amount of sodium consumed by individuals per day, collection of urine over a 24 hour period is required. However, asking participants to collect their urine over a 24 hour period would be significantly burdensome and is likely to deter participants from being involved in the biomedical component of the Australian Health Survey. Consequently, the Australian Health Survey will only collect spot urine samples to analyse for sodium content.

While measuring the sodium concentration of a spot urine sample does not provide information on an individual's sodium intake since an individual's urinary sodium excretion varies throughout the day, spot urine samples can be used to monitor trends in dietary sodium on a population scale, and compare different population sub-groups (National Centre for Social Research 2007).

The sodium concentration of spot urine samples will be expressed as a ratio of urinary sodium/urinary creatinine. This will correct for variability in urine dilution, as a relatively constant amount of creatinine is excreted in urine each day (National Centre for Social Research 2007). There are currently no reference values against which to compare sodium concentrations from spot urine samples. In the Australian Health Survey, mean urinary sodium/creatinine ratios will be determined to compare different subgroups in the population and used to monitor trends over time.

3.5 Potassium status

Potassium intake is also associated with blood pressure. Measuring potassium concentrations in spot urine samples raises similar problems to sodium in that spot urine samples do not accurately reflect the potassium intake for an individual. Like sodium, the data can be used to monitor trends in potassium intakes and compare different subgroups of interest and therefore mean urinary potassium/creatine ratios will be calculated.

Measuring urinary potassium concentration will also allow for calculation of the urinary sodium/ potassium ratio, which has been reported to be significantly associated with cardiovascular events, and to a greater extent than urinary sodium or potassium concentration alone (Cook et al 2009).

3.6 Vitamin D status

Inadequate vitamin D status is a risk factor for osteoporosis (AIHW 2008a), a condition that is estimated to affect approximately 3% of Australians (AIHW 2010). The condition is more common in females (82% of those reporting to have been diagnosed with osteoporosis are female) and the prevalence increases with age (AIHW 2010). Arthritis and other musculoskeletal conditions such as osteoporosis were declared a National Health Priority in 2002, and were estimated to account for 4% of the total burden of disease in Australia in 2010 (AIHW 2010).

A major contributor of vitamin D for healthy adults is that which has been synthesised in the skin due to exposure to sunlight, but dietary vitamin D intake also contributes towards vitamin D status (Lai et al 2010). Consequently, information on dietary vitamin D intake alone is not enough to determine whether an individual has adequate vitamin D status. Further, because analysis of vitamin D content of foods can be considerably difficult (Cunningham et al 2010), vitamin D will not be included in the food composition database supporting the Nutrition and Physical Activity component of the Australian Health Survey.

Serum 25-hydroxyvitamin D (25(OH)D) will be measured in the NHMS to provide information on participant's vitamin D status. Serum 25(OH)D reflects vitamin D from both dietary intake and skin synthesis (Gibson 2005) and provides a good indication of vitamin D stores (Lai et al 2010). There is considerable seasonal variation in serum 25(OH)D with the highest levels occurring in late summer and lowest occurring in late winter (Gibson 2005). This has implications for interpreting vitamin D results from the biomedical component of the Australian Health Survey given that enumeration will pause in August and September 2011 during the 2011 Census.

Table 4 presents recently recommended definitions of vitamin D status based on serum 25(OH)D levels, however there can be considerable inter-laboratory and inter-assay variation in measurements and some experts have recommended using assay-specific cut-offs instead (Lai et al 2010).

Table 4: Criteria for assessing vitamin D status

25(OH)D (nmol/L)	Vitamin D status
> 75	Sufficient
50-75	Insufficient
< 50	Deficient

Source: Carter et al 2004 cited by Lai et al 2010.

3.7 Iron status

Iron deficiency, especially iron deficiency anaemia, is one of the most serious nutritional concerns worldwide. It is highly prevalent in both industrialised and non-industrialised (WHO 2001). Iron deficiency, with or without anaemia, can delay or impair infant, child and adolescent mental and physical development, reduce immune status and increase morbidity relating to infections in all population groups and reduce the physical work capacity and productivity (WHO 2001). There are three stages in the development of iron deficiency anaemia:

- Iron depletion (low iron stores): involves a reduction in the amount of iron stored in the liver. Levels of transport iron and haemoglobin are normal, but serum ferritin concentrations are reduced.
- Iron deficiency: involves the depletion of iron stores and the iron supply to the red blood cells is reduced. Serum transferrin receptor is increased and haemoglobin levels may be low or within the normal range.
- Iron deficiency anaemia: the third and final stage of iron deficiency, involves exhaustion of iron stores, low circulating iron and the reduced haemoglobin concentration in circulating red blood cells (Gibson 2005).

In order to determine the prevalence of these three stages of iron deficiency anaemia, the Australian Health Survey will measure participants' serum feritin, serum transferrin receptor, haemoglobin and C-Reactive Protein.

3.7.1 Serum feritin

Serum ferritin is the only measure of iron status that provides an indication of deficient, excess or normal iron status (Gibson 2005). Serum ferritin $\geq$ 15 ug/L indicates the presence of sufficient iron stores, with higher values reflecting the size of the iron stores (WHO 2007b). If infection or inflammation are present, serum feritin may not provide an accurate indication of the size of individual's iron stores, as serum feritin may appear normal even when iron stores are low (WHO 2001). Thus the Australian Health Survey will include a marker of inflammation to assist with interpretation of the iron results.

Serum feritin levels > 150 ug/L for females and > 200ug/L for males indicates severe risk of developing iron overload, which can have adverse effects on health status (WHO 2001).

3.7.2 Serum transferrin receptor

Serum transferrin receptor reflects the body's demand for iron, levels are increased in iron deficiency anaemia, and when iron stores are depleted, serum transferin receptor can be used to assess the severity of iron insufficiency provided there are no other causes of abnormal erythropoiesis (such as thalassemia or haemolytic anaemia) (WHO 2007b). Serum transferrin receptor is less affected by inflammation or infection compared to serum ferritin and it does not vary with age, gender, or pregnancy (WHO 2001). As there are currently no internationally standard reference ranges for serum transferrin receptor, results will be compared to reference ranges generated by the assay manufacturer.

3.7.3 Haemoglobin

Haemoglobin is the oxygen-carrying component of red blood cells. Since iron is an essential part of the haemoglobin molecule, haemoglobin concentration of whole blood is often used to test for iron deficiency anemia (Gibson 2005), however iron deficiency is not the only cause of anemia which is why the additional iron tests are required. Table 5 provides the haemoglobin values used to determine whether anaemia is present in a population.

Table 5: Haemoglobin values for detecting anaemia in the population

Population	Haemoglobin value below which anaemia is present
12-14 yr. olds	120 g/L
Non-pregnant women aged 15+	120 g/L
Pregnant women	110 g/L
Men aged 15+	130 g/L

Source: WHO 2001.

Note: Reference ranges for children under 12 years not included in Table 3.7.3 as NHMS will only collect blood samples from children aged 12 years and above.

3.7.4 C-reactive protein (CRP)

CRP is an acute-phase protein that is increased during an inflammation or infection. It will be measured in the Australian Health Survey to assist with interpreting the serum feritin results that can be affected by inflammation. A CRP value of > 3-10 mg/L indicates inflammation (WHO 2007b).

Summary

The Australian Health Survey will conduct tests on biomedical samples to assess levels of certain nutrients in the population. The markers of nutrition status that will be measured are population level indicators for folate, Vitamin B12, iodine, sodium, potassium, Vitamin D and iron.

References

Australian Institute of Health and Welfare (AIHW) 2008a, *Arthritis and Osteoporosis in Australia 2008,* Arthritis series no. 8. Cat. no. PHE 106. Canberra: AIHW.

Australian Institute of Health and Welfare (AIHW) 2008b, *Cardiovascular disease and its associated risk factors in Aboriginal and Torres Strait Islander peoples 2004–05*, Cardiovascular disease series no. 29. Cat. no. CVD 41. Canberra: AIHW.

Australian Institute of Health and Welfare (AIHW) 2008c, *Indicators for chronic diseases and their determinants, 2008*. Cat. no. PHE 75. Canberra: AIHW.

Australian Institute of Health and Welfare (AIHW) 2009a, *Prevention of cardiovascular disease, diabetes and chronic kidney disease: targeting risk factors*, Cat. no. PHE 118. Canberra: AIHW.

Australian Institute of Health and Welfare (AIHW) 2009b, *An overview of chronic kidney disease in Australia, 2009.* Cat. no. PHE 111. Canberra: AIHW.

Australian Institute of Health and Welfare (AIHW) 2010, *Australia's Health 2010.* Australia's health series no. 12, Cat. no. AUS 122. Canberra: AIHW.

Australian Population Health Development Principle Committee (APHDPC) of the Australian Health Ministers Advisory Committee 2007, *The Prevalence and Severity of Iodine Deficiency in Australia,* accessed 30 September 2010.

Barr, ELM, Magliano, DJ, Zimmet, PZ, Polkinghorne KR, Atkins, RC, Dunstan, DW, Murrary, SG & Shaw, JE, *AusDiab 2005- The Australian Diabetes, Obesity and Lifestyle Study: Tracking the Accelerating Epidemic; Its Causes and Outcomes,* Melbourne: International Diabetes Institute.

Benn M, Nordestgaard BG, Jensen GB, Tybjærg-Hansen A 2006. Improving prediction of ischemic cardiovascular disease in the general population using Apolipoprotein B: The Copenhagen Heart Study, *Arterioscler Thromb Vasc Biol* vol 27, pp 661-670.

Booth, M, Okely, AD, Denney-Wilson, E, Hardy L, Yang, B & Dobbins, T, 2006. *NSW Schools Physical Activity and Nutrition Survey (SPANS) 2004: Full Report.* Sydney: NSW Department of Health.

Centers for Disease Control and Prevention (CDC). National Center for Health Statistics (NCHS). National Health and Nutrition Examination Survey Laboratory Protocol. Hyattsville, MD: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2008.

Cook, NR, Obarzanek, E, Cutler, JA, Buring, JE, Rexrode, KM, Kumanyika, SK, Appel, LJ & Whelton, PK for the Trials of Hypertension Prevention Collaborative Research Group 2009, 'Joint effects of sodium and potassium intake on subsequent cardiovascular disease. The trials of hypertension prevention follow-up study', *Archives of Internal Medicine,* Vol. 169, no. 1, pp. 32-40.

Cunningham J, Tompsett S, Abbey J, Sobolewski R & Mackerras D 2010, Food composition–essential data in epidemiological studies of food and health, *Australasian Epidemiologist,* vol.17, pp. 32 –34.

Digestive Health Foundation, *Facts about Fatty Liver Disease,* accessed 15 September 2010.

Dunstan, D, Zimmet, P, Welborn, T, Sicree, R, Armstrong, T, Atkins, R, Cameron, A, Shaw, J & Chadban, S 2001, *Diabesity & Associated Disorders in Australia – 2000: The Accelerating Epidemic. The Australian Diabetes, Obesity and Lifestyle Study (AusDiab).* Melbourne: International Diabetes Institute.

Food Standards Australia New Zealand (FSANZ), 2006, *Final Assessment Report: Proposal P295: Consideration of Mandatory Fortification with Folic Acid,* accessed 23 September 2010.

Food Standards Australia New Zealand (FSANZ) 2008*, Proposal P1003: Mandatory Iodine Fortification for Australia: Approval Report*, accessed 23 September 2010.

Food Standards Australia New Zealand (FSANZ) 2009, *Salt intake from processed food and discretionary use in Australia,* accessed 6 October 2010.

Gibson, RS, 2005, *Principles of Nutritional Assessment, 2nd ed,* New York: Oxford University Press.

Lai, JKC, Lucas, RM, Clements, MS, Harrison, SL & Banks E 2010 'Assessing vitamin D status: Pitfalls for the unwary', *Molecular Nutrition and Food Research,* vol. 51, pp. 1-10.

Li, M, Eastman, CJ, Waite, KV, Ma, G, Zacharin, MR, Topliss, DL, Hardin PE, Walsh, JP, Ward, LC, Mortimer, RH, Mackenzie, EJ, Byth, K & Doyle, Z 2006, 'Are Australian children iodine deficient? Results of the Australian National Iodine Nutrition Study', *Medical Journal of Australia,* vol. 184, pp. 165-169.

Mahley RW, Innerarity TL, Rall SC, Weisgraber KH 1984. Plasma lipoproteins: apolipoprotein structure and function, *J Lipid Research*, vol 25, pp 1277-1294.

Matthew, TH, Johnson, DW & Jones, GRD on behalf of the Australasian Creatinine Consensus Working Group 2007, Chronic kidney disease and automatic reporting of estimated glomerular filtration rate: revised recommendations*, Medical Journal of Australia,* vol. 197, no. 8, pp.459-463.

National Centre for Social Research 2007, *A survey of 24 hour and spot urinary sodium and potassium excretion in a representative sample of the Scottish population,* accessed 29 September 2010.

National Health and Medical Research Council (NHMRC) 2005, *Nutrient Reference Values for Australia and New Zealand,* Canberra: NHMRC

Royal College of Pathologists of Australasia 2010, *Cholesterol (HDL and LDL) - plasma or serum,* accessed 13 September 2010.

Watts, RR, Langone, JL, Knight, GJ & Lewtas, J 1990, Cotinine analytical workshop report: Consideration of analytical methods for determining cotinine in human body fluids as a measure of passive exposure to tobacco smoke, *Environmental Health Perspectives,* vol. 84, pp. 173-182.

World Health Organization (WHO) 2001, *Iron Deficiency Anaemia - Assessment, Prevention, and Control: A Guide for Programme Managers,* accessed 1 September 2010.

World Health Organization (WHO) 2008, Conclusions of a WHO technical consultation on folate and vitamin B12 deficiencies, *Food and Nutrition Bulletin*, vol. 29, no. 2 (supplement).

World Health Organization (WHO) 2007a, *Assessment of Iodine Deficiency Disorders and Monitoring their Elimination: A Guide for Programme Managers, 3rd ed*, accessed 1 October 2010.

World Health Organization (WHO) 2007b, *Assessing the Iron Status of Populations, 2nd ed*, accessed 1 September 2010.