

Optimising dietary intake and nutrition related health outcomes in Aboriginal women and their children

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Statement of originality

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Thesis by publication

I hereby certify that this thesis is in the form of a series of published papers of which I am joint author. I have included as part of the thesis a written statement from each co-author, endorsed by the Faculty Assistant Dean (Research Training), attesting to my contribution to the joint publications.

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Conflict of interest

Amy Ashman reports no conflict of interest.

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Author note

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Throughout this document, the terms Indigenous and Aboriginal are both used. Indigenous Australians refer to both Aboriginal and Torres Strait Islander peoples, and the term Indigenous is used in this document to refer to Indigenous people throughout Australia, or Indigenous people internationally. In NSW, where the research described in this thesis takes place, the traditional custodians of the land self-identify as Aboriginal, rather than Indigenous. Therefore in this thesis 'Aboriginal' is used to describe research study participants in the Gomeroi gaaynggal and Diet Bytes and Baby Bumps studies. For publications in international journals, the term Indigenous has been used.

The PhD candidate is an Accredited Practising Dietitian (APD), and therefore the research described in this thesis is from a dietitian's perspective, with reference to how members of the dietetic profession can assist with optimising the dietary intakes and nutrition-related health outcomes of Aboriginal mothers and their infants.

Glossary of common abbreviations

ACAES: Australian Child and Adolescent Eating Survey

AES: Australian Eating Survey

AGTHE: Australian Guide to Healthy Eating

APD: Accredited Practising Dietitian

BMI: Body Mass Index

CI: Confidence Interval

DAA: Dietitians Association of Australia

DBBB: Diet Bytes and Baby Bumps study

EAR: Estimated Average Requirement

FFQ: Food Frequency Questionnaire

IQR: Interquartile Range

kg: Kilograms

mg: Milligrams

n: Numbers (sample)

NHMRC: National Health and Medical Research Council

NRV's: Nutrient Reference Values

NSW: New South Wales

PBF: Percentage Body Fat

RDI: Recommended Dietary Intake

SD: Standard Deviation

VFA: Visceral Fat Area

WHO: World Health Organization

µg: Micrograms

24-R: 24-Hour Food Recall

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Abstract

Aboriginal Australians have high rates of many chronic diseases, the causes of which are multi-factorial. Optimal nutrition throughout life is protective against a number of adverse health outcomes, and can begin with setting the scene for lifelong health *in utero* and in the first years of life. However, little is currently known about the dietary intakes of Aboriginal Australian women in pregnancy and in the postpartum period, and their children, particularly in early infancy. This thesis by publication is presented as a series of published research articles. Specific research aims and the results of studies arising from this thesis are summarised below.

Dietitians are well-placed to support and work alongside Aboriginal communities in developing and supporting strategies to optimise nutrition for Aboriginal woman and children. Dietitians must demonstrate cultural competency, however opportunities for practical experiences working with Aboriginal communities are limited during undergraduate nutrition degree programs. The aim of the first study was to evaluate the cultural awareness experiences of student and new-graduate dietitians working in an Aboriginal ArtsHealth setting. Six participants reported on their experiences through either written feedback (via email) or oral feedback (via semi-structured interview). A generic inductive approach was used for qualitative data analysis. Key themes emerged around ‘building rapport’ and ‘developing cultural understanding’. Some participants reported an increased understanding of the context around health disparity for Aboriginal Australians, and the experiences of the student and new-graduate dietitians were overwhelmingly positive.

To optimise nutrition, current nutrition practices and dietary intakes need to be quantified. The second study of this thesis reports on the dietary intakes and anthropometric and body composition measures of a sample of women and their infants from the Gomeroi gaaynggal study, a prospective longitudinal cohort of Aboriginal women and their children in regional NSW from pregnancy to five years postpartum. A cross-sectional analysis of n=73 mother-child dyads from three months to five years postpartum found a breastfeeding initiation rate of 85.9%, with

a median (interquartile range [IQR]) duration of 1.4 months (0.5 – 4.0). Introduction of infants to solid foods and cow's milk were at 5.0 months (4.0–6.0) and 12.0 months (10.0–13.0) respectively. At one year postpartum 66.7% of women were overweight or obese, and 63.7% were overweight or obese at 2 years postpartum. Results from the Gomeroi gaaynggal cohort were preliminary, but suggest that women in this cohort may benefit from further support to optimise nutrition for themselves and their children.

Providing women with tailored nutrition advice requires appropriate tools for dietary assessment. Image-based dietary records are emerging as a novel method for dietary assessment that limits some of the participant burden associated with traditional methods of dietary assessment. The Diet Bytes and Baby Bumps study used image-based dietary records captured via smartphones and a purpose-built brief tool (the Selected Nutrient and Diet Quality [SNaQ] tool) to assess nutrient and food group intakes of pregnant women and to inform the delivery of tailored nutrition advice to participants during their pregnancy. Twenty-five women (27 recruited, including 8 Aboriginal Australians, one withdrawn, one incomplete), had image-based records appropriate for analysis. Median intakes of core food groups of grains and cereals, vegetables, fruit, meat and dairy were reported as being below recommendations, but intakes of energy-dense, nutrient-poor foods exceeded recommendations. Cohen kappa showed moderate to substantial agreement between the SNaQ tool and the nutrient analysis software when assessing adequacy of micronutrient intakes. Relative validity was established by comparison of the image-based dietary records and 24-hour food recalls. There were significant correlations between the two methods of dietary assessment for energy, macronutrients and micronutrient intakes ($r=.40-.94$, all $P<.05$), with acceptable agreement between methods. Seventeen women reported changing their diets as a result of receiving personalised nutrition advice. The DietBytes method of image-based dietary assessment was well-received, with 88% of participants stating they would use the method again, including all Aboriginal participants.

A systematic review was conducted to identify existing programs that have aimed to improve nutrition-related outcomes in Indigenous pregnant women worldwide, and to identify positive factors contributing to successful programs. This review consisted of 27 studies (20 programs) from Australia, Canada, and the United States of America; the most prevalent outcome measures were breastfeeding initiation/duration (n=11 programs) and birth weight (n=9 programs). Activities employed within programs that resulted in statistically significant improvements in health and/or nutrition outcomes included individual counselling and education, and involvement of peer counsellors or other Indigenous program staff. In successful programs, emphasis was placed on designing nutrition interventions in collaboration with Indigenous communities.

This research thesis has highlighted key areas for improving dietary intake and nutrition-related health of Aboriginal Australian women and their children, including breastfeeding duration, appropriate timing of introduction to solid food and cow's milk, nutrient and food group intake of pregnant and postpartum women, and improving rates of overweight and obesity in women postpartum. An image-based dietary record method of dietary assessment has demonstrated relative validity and acceptability for dietary assessment of Aboriginal pregnant women and acceptability to guide nutrition counselling. Dietitians can best support Aboriginal women and children by working in collaboration with communities to optimise nutrition, and support practice-based student experiences during university training where possible to assist in development of cultural competency skills.

Chapter 1 Background and overview to the thesis

1.1 Overview

This introductory chapter provides an overview of the importance of optimal nutrition during the perinatal period for women and their infants (section 1.2). The health and nutrition of Australia's Indigenous people is discussed in section 1.3. Section 1.4 provides a summary of dietary assessment methods and includes the contribution that Accredited Practising Dietitians (APD) can make in supporting optimum dietary intakes and nutrition-related outcomes. This chapter concludes with section 1.5 which outlines the research aims of this thesis, and section 1.6, which summarises the thesis structure.

1.2 Maternal and infant nutrition

1.2.1 Developmental origins of health and disease

Many chronic diseases have their origins *in utero*. Barker's developmental origins hypothesis proposes that exposure to under-nutrition in foetal life and infancy predisposes a child to the later life development of chronic disease, through permanent changes to body somatotype, physiology and metabolism [1]. Low birth weight (LBW) predisposes individuals to an increased risk of chronic disease, including coronary heart disease, hypertension, stroke and Type 2 diabetes mellitus (T2DM), particularly when followed by rapid 'catch up' growth in early childhood [1, 2]. The Barker hypothesis has particular relevance to Indigenous (Aboriginal and Torres Strait Islander) Australian women, who have higher rates of LBW (weighing less than 2500g at birth) babies than non-Indigenous women. In Australia in 2014 the proportion of LBW in live born babies of Indigenous mothers was 11.8%, nearly twice the rate compared to babies born from non-Indigenous mothers (6.2%) [3].

1.2.2 Nutrition during pregnancy

The experiences of a foetus *in utero* and in his or her early years have profound implications for their future development, wellbeing and health [4, 5]. A growing

field of science, the developmental origins of health and disease (DOHaD), is showing that the intrauterine environment and exposures can significantly affect the way a human develops and the health and disease experienced later in life. In particular, studies have shown that the embryo and foetus adjust their patterns of growth after birth in response to the nutrients available in the environment *in utero*, as well as exposure to the presence of stressors [6]. Even food preferences may be shaped by these early exposures, as some studies have shown that babies can develop taste preferences *in utero* [7].

Appropriate weight gain during pregnancy is important for both the health of mother and infant, and guidelines for gestational weight gain have been developed by the Institute of Medicine [8]. These guidelines are for total weight gain and rate of weight gain during pregnancy, and recommendations are based on pre-pregnancy body mass index (BMI). Excessive gestational weight gain increases the risk of long-term overweight or obesity for women, pregnancy-associated hypertension and complications during labour and delivery; and is associated with infant birth weight [9].

1.2.3 Breastfeeding

In the postnatal period, nutrition continues to play an essential role in the growth and development of the infant. Sub-optimal infant feeding is responsible for 45% of neonatal infectious deaths, 30% of deaths from diarrhoea and 18% of deaths from acute respiratory infection in children under five years globally [10]. Breast milk is the optimal food for infants, and has health advantages for infants and mothers as well as economic benefits for the family and society [11]. Exclusive breastfeeding to around six months is recommended, and can be continued to 12 months and beyond with the introduction of complementary foods at around six months [11]. Breast milk contains a range of nutrients essential for early development, with many nutrients in forms that are readily absorbed and bioavailable: iron, for instance, is highly bioavailable in breastmilk, with absorption of 50–70% [11]. Breastfeeding is associated with the lowest risk of morbidity and mortality among infants, including reduced risks of gastrointestinal infections, otitis media, reflux

and asthma [11], and may provide some protection against later-life obesity [12, 13]. The benefits of breastfeeding appear to be stronger for children, with the evidence for long-term protection against diabetes, blood pressure and cholesterol levels less clear [13]. There is an association between breastfeeding and intelligence, though the magnitude of this effect is small [13]. For mothers, breastfeeding reduces the risk of haemorrhage after birth, and may reduce the risk of T2DM, breast cancer and ovarian cancer in later life [11].

1.2.4 Infant nutrition

By six months of age infants need an increased amount and/or range of nutrients (including iron and zinc) and energy for sufficient growth than can be provided solely by breast milk or infant formula [11]. From around six months, infants should be offered a range of foods of appropriate textures and consistencies to meet their developmental needs, with a particular focus on iron-rich foods. By 12 months infants should be able to consume a wide variety of nutritious foods [11]. Breast milk continues to be a valuable source of bioavailable nutrients between six to 12 months. Introducing foods too early may result in a decline in maternal breast milk production and increased risk of diarrhoeal diseases due to exposure of pathogens in food, while late introduction may cause growth faltering, compromise development of the immune system and lead to deficiencies of key micronutrients of iron and zinc [11].

1.2.5 Postpartum nutrition and body composition

Maternal postnatal diet influences a child's dietary intake, child growth and consequently, future health trajectory. The literature suggests that parents, particularly mothers, are key role models for eating habits of their children; and mothers consuming a wide variety of nutritious foods increases the likelihood that their children will do the same [14, 15]. Unhealthy food habits in childhood have been shown to track into adulthood, contributing to the development of future chronic diseases [16, 17]. It is therefore imperative that the stage is set in childhood for healthy eating habits that will last a lifetime.

Retention of gestational weight gain in the postpartum period increases a woman's risk of long-term overweight and obesity, and weight gain before a subsequent pregnancy is associated with an increased risk of gestational diabetes, macrosomia in the infant, pre-eclampsia and still birth [18]. There is an increased risk for the development of chronic disease in women of childbearing age, when there is not a return to a healthy weight postpartum after pregnancy weight gain [19, 20].

1.3 Health and nutrition of Indigenous Australians

1.3.1 Overview

Poor nutrition is a major and modifiable contributing factor in the development of ill-health and chronic disease [21]. Many health conditions that have nutrition-related trajectories are over-represented in Indigenous Australians. The largest mortality gap occurs for circulatory disease; endocrine, metabolic and nutritional diseases (including diabetes), neoplasms and respiratory disease [22]. For women in particular, diabetes is the leading cause of the gap in mortality [22].

Historically, Indigenous Australians led a hunter-gatherer lifestyle, with diets that were nutrient-dense; high in protein and micronutrients [23]. Foreign settlers in the 1700's introduced new foods from their homeland; combined with policies that discriminated against Indigenous Australians, this resulted in a transition to more Western dietary practices. Contemporary Indigenous Australians are faced with the legacy of this colonisation, which has had a lasting impact on socio-economic determinants of health [23]. Environmental disadvantages and geographical factors influence food availability and affordability, and issues of food security are exacerbated by poverty and contribute to the lasting discrepancies in nutrition-related health outcomes between Indigenous and non-Indigenous Australian [23].

There has been much progress in reducing disparities in health, education, and employment outcomes for Indigenous Australians [24]. However, more needs to be done to address the discrepancies in nutrition-related health outcomes and contribute to improvements in dietary intakes and overall nutritional health.

1.3.2 Historical context of the health and nutrition of Indigenous Australians

Internationally there are many populations who self-identify as Indigenous, including Aboriginal and Torres Strait Islander people of Australia, Maori people of New Zealand, Indigenous people of the Americas (e.g. Lakota people of the USA, the Inuit people of Canada and the USA, the Mayas of Guatemala), and the Sami or Laplander people of northern Scandinavia. Indigenous people are the original inhabitants of a land at the time when people of different cultures or ethnicities arrived and settled; the new arrivals eventually became the population majority [25]. While no official definition exists, the term Indigenous encompasses the following aspects: a historical context of pre-colonisation; a strong link to land and natural resources; distinct social, cultural and political systems and language, culture and beliefs from the dominant culture; and a determination to maintain and/or reproduce ancestral environments and systems as a distinct people and community [25]. It is considered more appropriate to identify, rather than define, Indigenous people, however an understanding of the term is based around self-identification as an Indigenous person, and acceptance by an Indigenous community as a member [25].

Indigenous Australians have diverse cultural practices and speak a multitude of languages, with approximately 120 languages still spoken today [26]. Traditionally, Indigenous Australians hunted and gathered food sustainably, and ate the varied animals, fish and plants that were available in the diverse Australian landscapes in which they resided [23]. Particularly in inland areas, people were semi-nomadic; moving on to new areas in search of food and water as needed [23]. Hunter-gatherer methods of obtaining food procured a diet that was high in protein, complex carbohydrates, and micro-nutrients, and low in sugars, and the act of sourcing food involved a high degree of physical activity and social interaction [23].

After the arrival of Europeans in the late 1700s, many Indigenous Australians were forcibly removed from their land and moved on to missions, cattle stations and government settlements. They became dependant on European settlers for staple

foods, supplemented with bush foods. Available foods had often travelled long distances and were therefore often highly processed, nutrient-poor, and high in added sugar, fat and salt. The transition from a nutrient-rich, high-fibre, high-protein, low-saturated fat diet to a nutrient-poor diet high in refined carbohydrate and saturated fat, combined with a decrease in levels of physical activity (previously required to obtain sustenance), were significant risk factors for development of diet-related diseases [23].

This period of Australia's history has had widespread repercussions far beyond nutritional consequences. Risk factors for poor health outcomes encompass not only biomedical and behavioural risk factors, but include the emotional, social, political and economic disadvantage faced by many Indigenous Australians today, another legacy of the oppression and injustices committed by early European settlers. The repercussions of such atrocities as the Stolen Generation can be felt today in Australia, and the intergenerational trauma caused by this separation from family and culture has had a major impact on the Indigenous Australian society [27]. Indigenous people experience substantial disadvantage in education, socioeconomic status and disproportionate rates of poverty and unemployment than non-Indigenous Australian; these disadvantages, as well as historical legacies and lifestyle factors (including poor nutrition) contribute to the gap in morbidity and mortality experienced by Indigenous Australians today [28, 29].

1.3.3 Current health status of Indigenous Australians

The health of Australia's Indigenous people has been improving in recent years, including decreases in mortality from chronic disease. The rate of death from circulatory disease fell by 40% between 1998 and 2012, causing a narrowing in the gap between Indigenous and non-Indigenous Australians; deaths from kidney disease and respiratory disease also declined during this period [22]. There were also improvements in child mortality, with rates declining by 33% between 1998 and 2013 [30]. However, Indigenous Australians still experience poorer health outcomes for many health conditions, including both chronic, non-communicable diseases and acute infectious diseases. Currently, there is approximately a 10-year

difference in life expectancy between Indigenous and non-Indigenous Australians. Between 2010–12, life expectancy at birth was 69.1 years for Indigenous men (79.7 years for non-Indigenous men) and 73.7 years for Indigenous women (83.1 years for non-Indigenous women). The life expectancy gap has decreased by 0.8 years for men and by 0.1 years for women since 2005–07 [30]. The main causes of death of Indigenous Australians in 2009–13 were circulatory diseases (26% versus 32% for non-Indigenous Australians), cancer (20% versus 30%), external causes (15% versus 6%), endocrine diseases, including diabetes (9% versus 4%) and respiratory diseases (8% for both Indigenous and non-Indigenous Australians) [30]. The Council of Australian Governments (COAG) Closing the Gap targets aim to close the gap between Indigenous and non-Indigenous Australians in terms of life expectancy by 2031, and to halve the gap in child mortality by 2018. Between 1998 and 2015, the child mortality gap narrowed by 31% [24].

Sub-optimal nutrition is a significant risk factor in the development of a number of chronic health conditions, including cardiovascular disease, T2DM, overweight and obesity, renal disease, poor oral health and some cancers. In 2012–13, self-reported data showed that 67% of Indigenous Australians reported having at least one chronic health condition (a similar rate as for non-Indigenous Australians) with one third (33%) reporting three or more conditions [30]. One fifth (20%) of Indigenous Australian adults had high blood pressure, and one quarter (25%) had abnormal or elevated total cholesterol levels [30]. Adjusting for age, Indigenous adults are more likely to have high triglyceride levels (27%) than non-Indigenous Australians (14%, rate ratio of 1.9), but less likely to have elevated total cholesterol (26% for Indigenous adults, 33% for non-Indigenous adults, rate ratio of 0.8) [30].

T2DM is a significant health problem Australia-wide. Around 4.4% of all Australians (one million people) had T2DM in 2014–15, an increase from 3.8% (840,000 people) in 2011–12 [31]. The latest results from the National Aboriginal and Torres Strait Islander Health Measures Survey of 3,300 Indigenous Australians showed greater than one tenth (11.1%) of adults had diabetes in 2012–13, and a further 4.7% were at high risk of developing diabetes [32]. Increasingly, T2DM is

being found in children, with one recent account of a five year old Aboriginal child being diagnosed with the condition [33].

Two thirds (65.3%) of Indigenous adults had at least one risk factor for cardiovascular disease, and one fifth (17.9%) showed signs of chronic kidney disease (CKD) with over half of adults with diabetes having indicators for CKD [32]. Compared with non-Indigenous Australians, Indigenous Australians are twice as likely to have indicators of CKD (rate ratio 2.1) and more likely to have dyslipidaemia (rate ratio 1.1) [32].

Excess body weight is a major risk factor in the development of many chronic diseases [34]. Obesity is more prevalent in Indigenous Australians at every age. In 2004–5, 60% of Indigenous adults were overweight or obese [35]. By 2012–13, this figure rose to 69%, with 29% overweight (BMI 25.0–29.9 kg/m²) and 20% obese (BMI >30.0 kg/m²). Adjusting for age, Indigenous adults were 1.2 times as likely as non-Indigenous adults to be overweight or obese [30]. In a study of a large number of remote Indigenous communities, Wang *et al.* (2000) showed a large proportion of ‘extreme’ BMI (both under- and over-weight) with high levels of chronic energy deficiency as well as energy excess as evidenced by high rates of obesity (particularly in women) [36]. High waist circumference (above 94cm for men and 80cm for women) is another risk factor for chronic disease development and a good indicator of abdominal obesity. In 2012–13, 60% of Indigenous men and 81% of women (aged >18 years old) had a high waist circumference (the average waist circumference for men was 99.7cm; 97.4cm for women) [37].

1.3.4 Current nutritional health status of Indigenous Australian women and infants

As discussed in section 1.2, the perinatal period plays an important role in long-term nutritional health for both mother and child. Maternal under-nutrition is associated with greater risk of preterm birth and foetal growth restriction [38]. A study of 503 Aboriginal infants born in Darwin found that mothers with a BMI less than 18.5kg/m² had a five-fold risk of giving birth to a LBW baby and a greater risk of intrauterine growth retardation [39]. The study found maternal malnutrition to

be the cause of 28% of cases of LBW and 15% of cases of growth retardation [39]. Overweight in mothers is also a health concern. A cross-sectional survey of Indigenous women of childbearing age in rural Queensland found poor nutrition-related health amongst this cohort (n=424 Aboriginal, n=232 Torres Strait Islander) [40]. Forty-one percent of Aboriginal women (n=172) had central obesity, and incidence of new T2DM diagnosis was 29.1 per 1000 person-years in Aboriginal women [40]. One third of the Aboriginal women (n=134) in this cohort had very low red cell folate levels (31.6% were below reference range). Folate in the peri-conception period significantly reduces the risk of neural tube defects [40]. Self-reported fruit and vegetable intake was low, with only 12 (<2%) of the 656 Aboriginal and Torres Strait Islander women reporting intake that met recommendations [40]. Much of the existing literature does not report on maternal dietary intake during pregnancy. There is a need for up-to-date, well-performed research into the dietary intakes of Indigenous Australian women during pregnancy and postpartum, and what they are feeding their infants, particularly in a variety of geographical localities.

The majority of Australian women initiate breastfeeding, although rates decline to 50–60% by six months and down to around 25% by 12 months. Only a small proportion exclusively breastfeed in this period [11]. In 2012–13, 83% of Indigenous infants aged 0–3 years old and 93% of non-Indigenous infants had been breastfed [22]. Indigenous infants were more likely to have been breastfed for less than one month (16%) compared with non-Indigenous infants (10%) and less likely to have been breastfed for 12 months or more (12% and 21% respectively) [22]. Rates of breastfeeding vary across states and localities. Breastfeeding rates amongst Indigenous mothers may be lower in urban communities than in remote areas, where traditional lifestyles are more likely to be maintained [41]. A study of breastfeeding rates amongst Aboriginal women in Western Australia found that 71% of infants were breastfed for three months or more [42]. This study concurred with a review that found that in urban communities, rates of breastfeeding are similar to those of non-Indigenous mothers of low-socioeconomic status, and that greater residential isolation was associated with longer breastfeeding duration for

Aboriginal and Torres Strait Islander infants [41]. Breastfeeding declined in the first few months postpartum and was accompanied by early introduction of solid foods and fluids that are not recommended until children are significantly older [41]. By contrast, infants residing in areas of moderate isolation were 3.2 times more likely to be breastfed for ≥ 3 months than those in a metropolitan area (Perth), and this increased to 8.6 times in areas of extreme isolation ($P<.01$) [42]. The 2012–13 health survey did not find significant variation in breastfeeding rates by remoteness; however it did find significant variation between states: the disparity in the proportion of breastfed infants in Indigenous and non-Indigenous infants was smallest for the Australian Capital Territory (ACT) (with a respective 95% and 97% of infants breastfed) and greatest for South Australia (76% and 93%) [22]. A study of Indigenous infants in Perth in the mid-1990s found high rates of introduction of sweetened drinks and fast foods in infants 12 months and younger [43]. In Brisbane, a questionnaire administered to 61 Indigenous mothers revealed that 59% had initiated breastfeeding, however only 24.6% were breastfeeding at four months (with only 19.7% exclusively breastfeeding) [44]. Eighty percent of 4–6 month olds and 37.5% of 0–3 month olds had been introduced to solid foods in the same metropolitan area [44]. These results have implications for infant and maternal health as well as for researchers, clinicians, health promotion workers, and anyone who provides health care for Indigenous Australians. No two communities are the same, and this highlights that tailored approaches to support and promote breastfeeding may be needed.

Childhood overweight and obesity is a significant concern world-wide, as rates are increasing in economically developing countries and amongst disadvantaged children in economically developed countries. A study of urban Indigenous preschool children in the ACT revealed that the prevalence of overweight and obesity was significantly higher for Indigenous (18%) than non-Indigenous (14%) children ($P=.02$) [45]. Across Australia, an estimated 30% of Indigenous children are overweight (20%) or obese (10%), and 8% are underweight [46]. Poor diet, low levels of physical activity and increasing amounts of ‘screen time’ all contribute to endemic childhood obesity across the Australian population. Excess body weight in

childhood is associated with later-life overweight and obesity, and it is therefore imperative to curb rates in childhood at the earliest opportunity.

1.3.5 Determinants of health for Indigenous Australians

1.3.5.1 Behavioural determinants of health

Adverse health behaviours, including sub-optimal dietary intake, alcohol consumption, smoking and physical inactivity, are risk factors for poor health outcomes. Indigenous Australians are 2.6 times as likely as non-Indigenous Australians to smoke daily (42%), however the rate of smoking decreased by 7% (51% to 44%) between 2002 and 2012–13 [30]. Binge drinking is a concern for Indigenous and non-Indigenous Australians alike, with 54% of Indigenous Australians who drank reporting drinking more than four drinks on a single occasion. However, 26% of Indigenous Australians aged 15 years and older report not having had any alcohol in the previous 12 months, an abstention rate 1.6 times higher than for non-Indigenous Australians [30].

Poor dietary intake and nutritional status is detrimental to health. In Australia, recommendations on the types and quantities of food recommended for optimal nutrition and health are specified in the evidence-based Australian Dietary Guidelines (ADG) [47]. Guideline 2 encourages all Australians to partake of a variety of foods from five ‘core’ nutritious food groups each day: 1) vegetables and legumes; 2) fruit; 3) grain (cereal) foods; 4) lean meat, poultry, fish and vegetarian alternatives; and 5) dairy foods [47]. Guideline 3 recommends limiting the intake of energy-dense, nutrient-poor, ‘discretionary’ foods (foods high in saturated fat, sugar, salt and/or alcohol) [47].

Results of the National Aboriginal and Torres Strait Islander Nutrition and Physical Activity Survey (NATSINPAS) 2012–13 revealed that on average 41% of total daily energy intake for Indigenous Australians was from discretionary foods (established by 24-hour food recall [24-R]) [48]. This is the equivalent to over six serves of discretionary foods per day [49]. Around 14% of total energy intake [50] was from what the World Health Organization (WHO) defines as “free sugars”:

monosaccharides or disaccharides added to food and drinks by an individual or manufacturer, and sugars naturally present in honey and fruit juice [51]. Although intake of free sugars was high for all Australians, with non-Indigenous people consuming 14 teaspoons (60g) per day on average, in 2012–13, Indigenous Australians were estimated to have consumed an average of 18 teaspoons (75g) of sugar per day [50]. Young Indigenous women (aged 19–30 years) were particularly high consumers; consuming on average 21 teaspoons (87g) of free sugar per day: 17% of their total energy intake [50]. This is the equivalent of over two cans of soft drink; indeed soft, sport and energy drinks accounted for 28% of the intake of free sugars for Indigenous Australians [50].

Consumption of fruit and vegetables is key to a healthy diet. Fruit and vegetables are rich in micronutrients and fibre and their intake is protective against numerous health conditions [47]. The 2004–5 National Aboriginal and Torres Strait Islander Health Survey found that in non-remote areas, only 42% of Indigenous Australians were eating the recommended daily intake of fruit and 10% met the recommended daily intake of vegetables [35]. This was unchanged in 2012-13, when 43% of Indigenous people over 15 years of age reported meeting recommendations for fruit intake (at two or more serves per day) and only 5% reported adequate serves of vegetables per day (recommendations are for 5 serves per day). Women had higher intakes than men, with 7% reporting meeting recommendations for vegetable intake (compared to 3% of men) [52]. On average Indigenous Australian adults consumed 2.1 serves of vegetables and 1 serve of fruit per day in 2012-13 [49]. Children (aged 2-18 years) consumed fewer serves of vegetables than adults (1.4 serves per day on average); however they consumed more fruit (1.6 serves per day) [49]. Low fruit and vegetable intake alone has been estimated to account for 4% of the total burden of disease and injury for Australia's Indigenous people [53].

Dairy foods (milk, cheese, yoghurt) and their alternatives (e.g. non-dairy enriched or fortified milk) are rich sources of calcium and protein in the Australian food supply. Indigenous Australians consumed fewer than the recommended number of serves of these foods in each age group, except for children aged 2–3 years and girls

aged 4–8 years [49]. Children aged 2-18 consumed a greater number of serves per day (1.4 serves) than adults over 19 years (1.1 serves). Around a third (31%) of these serves was from higher fat options (fat content greater than 10g per 100g, e.g. higher fat cheese and yoghurt), and 54% was from medium fat foods (4–10g per 100g, e.g. regular milk); the remaining 15% was from reduced and lower-fat foods (<4g per 100g, e.g. reduced-fat milk) [49]. The ADG recommends choosing reduced and lower-fat choices from this food group most of the time (in order to meet nutrient recommendations without consuming excess dietary energy) [47]. Indigenous Australians consumed fewer serves, and a smaller proportion from lower-fat foods than non-Indigenous Australians for this food group [49].

Lean meats and their alternatives (red meat, chicken, poultry, fish, and eggs, tofu, legumes, nuts and seeds) are key sources of protein and micronutrients (including iron, zinc, iodine, vitamin B12 and omega-3 fatty acids) [47]. On average, Indigenous Australians consumed 1.6 serves from this food group per day (similar to the 1.7 serves consumed by non-Indigenous people); Indigenous people in remote areas consumed 0.6 serves less than their counterparts residing in non-remote locations [49]. Red meat and poultry made up 79% of the serves consumed from this food group [49]. It should be noted that non-lean, processed and luncheon meats (e.g. higher-fat sausages, salami, battered fish, and bacon) were not included as serves from this food group, and are considered discretionary foods. Overall, Indigenous Australians consumed on average 0.5 serves of processed meats and 0.4 serves of non-lean meats per day, most commonly sausages, which accounted for 15% of discretionary meat intake [49].

Wholegrain foods (including bread, breakfast cereals, rice and pasta) are major sources of fibre in the Australian diet. Sufficient intakes of fibre are protective against weight gain and development of chronic diseases such as T2DM and cardiovascular disease [47]. On average, Australia's Indigenous people consumed 4.1 serves of these foods per day (4.6 serves in remote areas, 4.0 serves in non-remote areas, average 4.5 serves among non-Indigenous Australians). Only one

quarter of serves were from wholegrain and/or high fibre food choices, which are recommended in the ADG [49].

Insufficient intake of 'core' food groups is reflected in sub-optimal micronutrient intakes. In 2012–13, 7.6% of Indigenous Australian adults were at risk of anaemia, almost twice as many as the non-Indigenous population (rate ratio 1.9) [32]. This risk was higher for Indigenous people living in remote areas (10.1%) compared with non-remote areas (6.9%), and higher for women (10.3%) than men (4.8%) [32]. Iodine is an essential nutrient for normal growth and development (including brain development) that is particularly important during pregnancy. In 2012–13 Australia's Indigenous population were iodine sufficient and were less likely than non-Indigenous people to have iodine levels below acceptable levels (rate ratio 0.8) [32].

1.3.5.2 Socio-economic determinants of health

The social and economic circumstances in which we conduct our lives have an impact on our health status. Education, employment and living conditions are all social determinants of health, and a high socioeconomic status is associated with better health outcomes [30]. Indigenous Australians face disadvantage in nearly all walks of life, including social, environmental, economic, political and educational disadvantage, that contribute to health disparities for Indigenous Australians [29]. It is estimated that the disadvantages in socioeconomic indicators are associated with between one third and one half of the disparity in health for Indigenous Australians [22]. Indigenous Australians with the lowest income and educational attainment, or those who are unemployed, are less likely to self-report their health as 'very good' or 'excellent' than those with higher socioeconomic positions [30]. Unemployment is a significant risk factor for poor health for Indigenous Australians. Unemployed Indigenous Australians have lower intakes of fruit and higher rates of smoking and substance use than employed Indigenous Australians [30].

1.3.5.3 Geography and food security

Nearly two thirds (65.2%) of Australia's Indigenous people live in regional (43.8%) or remote (21.4%) areas [54], where there are challenges with accessing adequate and affordable food [23]. Fresh foods, including fruit and vegetables, may need to be transported from long distances; increasing their cost and decreasing quality and nutritional value. Fresh fruit and vegetables are more expensive in remote areas, and the variety of fruit and vegetables is lower in remote and low socioeconomic areas [55]; geographic isolation exacerbates the financial constraints to accessing food [56]. The health consequences of poor nutrition are amplified by poorer access to medical attention and facilities in regional and remote areas [57].

1.3.6 Programs to support optimal nutrition for Indigenous Australians

As illustrated in the above sections (sections 1.3.2-1.3.5), the dietary intakes of Australia's Indigenous people are on average sub-optimal, and nutrition-related conditions and diseases are over-represented in Aboriginal Australians. However there is an evidence gap for dietary intakes of Aboriginal women during pregnancy and the postpartum period. As a significant determinant of health, it is imperative that optimising nutrition is at the forefront of programs and policies devised to improve health outcomes for Australia's Indigenous people; however this is not always the case. The recently released 2016 Close the Gap progress and priorities report caused controversy when it failed to acknowledge the essential role of food and nutrition in closing the gap in health outcomes [58]. The report acknowledged that nutritional disorders contribute towards mortality for Indigenous Australians [59], however it failed to discuss the impact of nutrition programs on limiting the burden of disease, despite overwhelming evidence of the protective role of nutrition against ill-health. Meanwhile the 2016 Global Nutrition Report places a high emphasis on the preventative role of nutrition as central to sustainable development goals. The report calls for significant improvements in child stunting, wasting, and overweight; anaemia; exclusive breastfeeding; and low birthweight; and to halve the prevalence of adult overweight, diabetes, and obesity by 2025 [60].

Programs to improve nutrition for Australia's Indigenous people may be underfunded, understaffed, or remain un-evaluated. A study examining the inclusion of nutrition components in Australian government health policy from 2000-2012 revealed that in the first half of this period, there was comprehensive inclusion of nutrition in health policies related to Indigenous Australians [61]. However, more recent policy reports suggest that nutrition is no longer a priority, with a greater emphasis placed on reduction of tobacco smoking [61].

A 2010 review by Clifford *et al.* described and evaluated the methodologies of interventions to reduce smoking, poor nutrition, alcohol misuse and physical inactivity (SNAP) risk factors in all Indigenous Australians populations. The authors found a shortage of studies that focussed on implementing change in Indigenous health and evaluating these outcomes. A search of peer-reviewed journals identified twelve separate studies with a nutrition or physical activity-targeted intervention, either alone or in combination [62]. Eleven of these included a nutrition component and no systematic reviews on nutrition or physical activity interventions in Indigenous Australians were identified [62].

Overall, a weak intervention effect was found for previous intervention studies focussing on SNAP risk factors in Indigenous Australians, with few randomised or comparison group study designs [62]. Clifford *et al.* (2011) had several important findings and recommendations for future research directions. The authors identified a need for more rigorous evaluation of interventions that target SNAP risk factors for Indigenous Australians, including nutrition interventions, and a need for the reliability and validity of evaluation methods to be established. The authors suggest that a promising direction for future research appears to be a two-pronged approach through community-wide interventions combined with intervention of greater intensity for high-risk individuals [62].

The 'Approaches to Failure to Thrive' nutrition awareness project in the Ngaanyatjarra Pitjantjatjara Yankunytjatjara region of Central Australia aimed to reduce the prevalence of failure to thrive in infants. Intervention focussed on developing awareness and knowledge of young mothers about the problems of

failure to thrive and promoting health practices and strategies, promoting traditional food, and improving quality, variety and availability of food in community stores [63]. Methodology involved outreach and education programs, crises intervention, community food store education and recommendations and producing a culturally-appropriate nutrition resource manual for mothers [63]. Preliminary evaluations on 212 mothers and children in eight communities showed 26% attendance at workshops. Issues identified by the authors included; late intervention, family denial or lack of awareness of a problem, misconceptions of 'what is healthy' and repeated presentations of disease and illness. There were no changes to hospital admissions of children to hospitals in the local district [63] .

A 1997 review of interventions to promote and support breastfeeding and appropriate infant nutrition found 46 programs across Australia, of which 22 were specifically targeted at Indigenous women. Only 13 of the 46 programs reported undergoing formal evaluation [41]. The majority (n=28) of programs had breastfeeding and infant nutrition support services integrated into routine health care provision. While most of the programs included in this review had not been evaluated, many of the Indigenous services had insight into what worked well. In particular, community ownership, empowerment and participation were key elements in all programs, as well as the need to work across cultural boundaries, with many programs having Indigenous and non-Indigenous staff working side by side. Building trust with the community was highlighted, built through long-term contacts. Program workers were advised to start small and progress in response to the community, include individual counselling and support alongside general health promotion activities, involve the wider family group, train community based workers, ensure resources are culturally-specific (and these can be produced locally with the community), offer home visits and transportation, build group support networks (e.g. playgroups), and coordinate care plans for individuals to ensure they receive appropriate and targeted advice and support. The author found that breastfeeding and infant nutrition were not seen as priority issues by all health service providers surveyed [41].

There is limited literature on nutrition interventions in Australian Indigenous populations. Clifford et al. (2001) found that only 10% of original research publications between 1987 and 2003 were intervention studies [62]. Publications reporting on nutrition intervention during pregnancy and postpartum for Indigenous women are especially scarce.

Of the few peer-reviewed studies assessing the effects of nutrition intervention in Australian Indigenous populations, the overall methodological quality is sub-optimal. Initiatives exist at the community level, but often go un-evaluated and un-reported, particularly in peer-review, so their efficacy can be difficult to assess. Several studies highlighted the need for more rigorous evaluation, while recognising that funding and small sample sizes can be barriers to achieving this [63]. Evaluation procedures should be of a higher methodological value and use validated and reliable evaluation tools [62]. There is therefore a clear need for well-performed, rigorously evaluated studies in the area of Indigenous nutrition, particularly in the area of pregnancy and infant nutrition.

1.4 Nutrition assessment

1.4.1 The role of the nutrition health professional

With a high prevalence of nutrition-related health conditions, and national rates demonstrating sub-optimal dietary intakes for Indigenous Australians, there are clear roles for dietitians working in Indigenous health. Dietitians may work in a number of practice settings towards improving nutrition, including the provision of personalised medical nutrition therapy and dietary counselling in clinical settings, through health promotion and public health interventions, and through the development of policy and recommendations for best practice [64]. Dietitians must have a clear understanding of the determinants of health for Aboriginal people and the challenges in addressing these. Cultural competency is required for sensitive and effective best practice for health professionals working with Aboriginal and Torres Strait Islander people and communities [65].

1.4.2 Dietetic cultural competencies

The disparities in health for Indigenous Australians are due in part to poor cross-cultural interactions between health professionals and Indigenous people [66]. Additionally, Indigenous Australians may experience difficulties with accessing primary health care and medical services. Access to health care is not only defined as the geographical distance to services (availability), but also the affordability of services, and their cultural acceptability [30]. Aboriginal and Torres Strait Islander community controlled services provide clients with culturally safe health providers, although mainstream health providers still have a way to go to meet the cultural needs of Indigenous clients.

In Australia, Accredited Practising Dietitians (APD) must meet National Competency Standards developed and endorsed by the Dietitians Association of Australia (DAA) [67]. The National Competency Standards may be used for the following purposes, amongst others: for students to determine what is expected of them on entry to the dietetic workforce; for practitioners to assess students and decide on expected performance in the workplace; and to assist universities in designing curricula and graduating competent students [67]. In 2011, less than 1% of employed dietitians in Australia identified as Aboriginal or Torres Strait Islander (8/2831, 0.3%) [68].

The competency standards for dietitians include elements of cultural competency that must be demonstrated by student dietitians via the following observable or measurable actions: “reflects on own culture, values and beliefs and their influence on practice”; “seeks out culturally specific information to inform practice”; and “works respectfully with individuals, groups and/or populations from different cultures”[67]. Cultural competency in health care refers to “interventions that aim to improve the accessibility and effectiveness of health care services for people from racial/ethnic minorities” [69]. Students enrolled in DAA accredited dietetics programs typically complete 20 weeks of practical placement experience as part of their degree programs, during which they are required to demonstrate these competencies and prove their ability to practice safely as nutrition health

professionals. This limited amount of time means that not all students will have the opportunity to work directly with Indigenous Australian clients or communities.

1.4.3 Traditional methods of nutrition assessment

Dietitians can provide expert advice to optimise maternal and child nutrition for Indigenous Australians, but to do so they must first establish what people are already eating. Diet is multifaceted, affected by factors such as food availability, seasonality, affordability, personal preferences, and day-to-day variations in dietary intake. Obtaining accurate measures of dietary intake therefore remains a challenge in nutrition research. Biomarkers of dietary intake include: the doubly-labelled water method for assessment of energy intake; urinary nitrogen extraction for assessment of protein intake; and plasma carotenoids and skin colour measured by reflectance spectroscopy for assessment of fruit and vegetable intake. Dietary biomarkers can provide objective estimations of dietary intake; however their use is costly and may not be feasible for use in all settings.

Self-reported dietary intake is an acceptable and practical method to assess dietary intake, and can be used in a variety of settings. Retrospective methods of dietary intake (e.g. 24-R), food frequency questionnaires (FFQ), diet history interview) do not place a burden on individuals. However they are reliant on the individuals' ability to accurately recall everything they ate, to know the contents of consumed foods, and to estimate the quantity of foods and drinks consumed [70]. FFQ are self-administered surveys that ask the user about the frequency of foods consumed over a period of time; unlike other methods of dietary assessment, they use a closed list of foods (which may be a short or extensive list) [71]. FFQs include foods most commonly consumed in a study population; however they may miss some culturally-specific foods not commonly eaten within the general Australian population (e.g. regional bush foods).

Prospective dietary assessment methods include weighed and estimated food records, where individuals record details of food and drinks consumed at the time of consumption. Estimated food records require estimation of portion sizes of food and beverages, using photographs, household measuring vessels or natural food

units as aids to assist with estimation [72]. Weighed food records require weighing of food and drinks items to determine portion size [73]. Keeping food records requires individuals to record types and amounts of food and drinks consumed, preferably at the time of consumption in order to limit dependence on memory [74]. Records may be kept for one or more days, either on paper or electronically. Use of food records is often considered time-consuming and requires literacy and/or numeracy skills involved with recording and weighing all foods (including ingredients), therefore requiring a high level of motivation and adherence from participants in order to be useful and accurate [70]. Paper-based dietary records may become lost or forgotten. In all dietary assessment methods, errors in reporting may occur even in highly-motivated respondents, including misreporting of types of foods and failure to report all foods [75]. In retrospective methods of assessment, the individual must be able to conceptualise the portion size consumed, which is an additional burden on the respondent and may be a source of estimation bias [76]. Accuracy of records begins to decrease after four consecutive reporting days, due to respondent fatigue [77]. Intake captured on non-consecutive recording days may therefore be more representative of variety in an individual's diet, as items consumed on consecutive days may be the same (e.g. eating leftovers from the day before) or related (e.g. eating less one day due to eating more the day before) [74]. Three days of recording intake has been shown to be sufficient for establishing mean energy intakes for groups of individuals, however more days may be required to properly establish macro- and micronutrient intakes [78]. A limitation of prospective methods of dietary assessment is that the act of keeping records may result in individuals changing their usual eating and drinking behaviours (reactivity) [70, 79, 80]. For example, participants may eat different kinds of foods than usual (e.g. simpler dishes that are easier to record) or eat less than usual (to limit the burden of recording or due to social desirability bias) [70].

Dietary records may contain inherent biases in sample selection (e.g. they may not be appropriate for non-literate people) and in record completion (e.g. will only be accurately completed by those who are motivated to do so) [74]. Under-reporting of energy intake is a limitation of both prospective and retrospective methods of

dietary assessment [81, 82]. Misreporting of dietary intake is common, including reporting of implausibly low energy intakes [79]. Food records may be vulnerable to under-reporting due to the challenges that recording itself presents [83], or through atypical intake, incomplete recording, or deliberate inaccurate reporting of intake [79]. In addition, for food records to be useful and meaningful, they require coding by researchers, dietitians or other trained individual.

While food records have their limitations, they remain practical and appropriate methods of dietary assessment that are commonly used in both research and practice settings. Food records have a number of benefits: they are prospective and hence not reliant on memory; and measuring or estimating amounts consumed at the actual time of consumption minimises the bias associated with individuals recalling portion sizes of previously eaten items [70]; they are based on actual, not relative, intake; can allow for open-ended information and high specificity [75], and can capture day-to-day variation in dietary intake.

The limitations of current methods of dietary assessment have prompted the Institute of Medicine in the United States of America to include the need to improve dietary assessment and planning methods as a continuing knowledge gap [84]. Any new methods must be validated against recognised standard methods before they can be useful in clinical or research settings. Thompson (2013) *et al.* further recommend that any use of a novel method in a new population requires additional evaluation on the validity of using the method in the new population [74].

1.4.4 Use of image-based records for nutrition assessment and intervention

Using images to capture dietary intake shows promise as a novel method of dietary assessment, which may limit some of the participant burden associated with traditional food records. Food and drinks are photographed before and after consumption. Image analysis to quantify dietary intake may be automated, semi-automated or manual. A dietitian or other trained person may then interpret this analysis (i.e. compare intake to practice guidelines) and feedback on dietary intake may be provided to the individual [85, 86]. Images consist of the food or drink

consumed next to a fiducial marker, an object (e.g. card) of known dimensions which acts as a reference object to assist in assessment of portion size [87]. Additional information provided (e.g. via text or voice description) can provide richer details on food/drinks consumed. Image dietary records may be used as standalone methods to report diet (image-based dietary records) or to support and enhance other methods of dietary assessment (image-assisted dietary records) [85]. Images can be captured actively by the individual (e.g. via camera or built-in camera on an electronic device), or passively (e.g. through a wearable device which automatically captures images without the individual needing to interact with the device). In image records, the onus of estimating portion size is shifted from the person reporting their intake (as in weighed or estimated food records), to the dietitian performing the analysis of the images; the method is not reliant on participants' memory or proxy reports; and their use is not dependent on literacy or numeracy skills. Image records may be considered less burdensome by participants than more traditional methods, which is desirable as less burdensome methods may result in improved compliance [83]. Estimates of portion sizes from images can be linked to nutrient databases for practical analysis of nutrient intakes [76]. Image-based or image-assisted dietary records have previously been described or evaluated in cohorts of children [88], Aboriginal infants and children [89], adolescents [87, 90], healthy adults [91-94], overweight adults [94], and adults with T2DM [86, 95]. However, to date no studies have reported on using images to capture dietary records of pregnant women or Indigenous Australian adults.

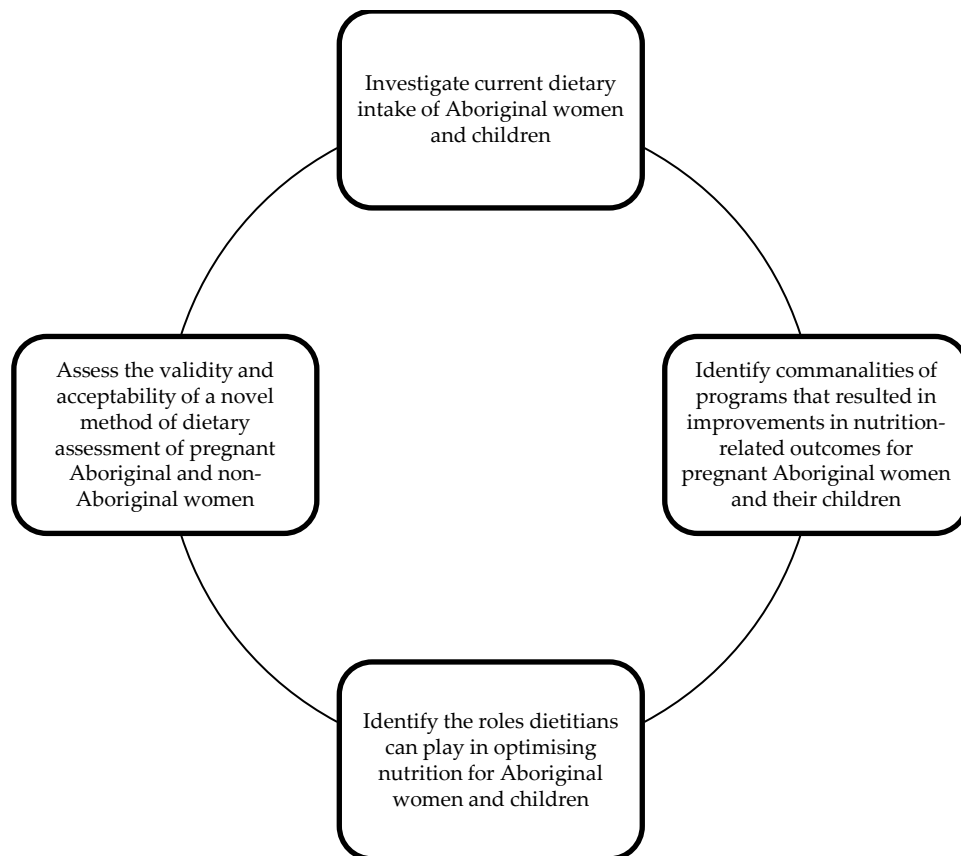
eHealth is a relatively new field in health and medical research, and refers to the delivery or enhancement of health services and information through the internet and related technologies [96]. eHealth technologies such as computers and smartphones offer a unique platform for the capture and transfer of image-based dietary records. Images can be relayed over the internet and analysed in real time, which allows for rapid feedback on dietary intake which can be personalised for the individual.

Smartphone ownership is prevalent and on the rise in Australia, with 77% of Australian adults owning a smartphone [97]. Smartphones contain features that make them ideal for the capture of image records, including internet connectivity, built-in cameras and microphones, capacity to store many images, and the ability to download software that enables recording (i.e. smartphone applications [apps]). Using smartphones in health and in research allow for geographical distance between clients/participants and health professionals/researchers, as data can be easily transmitted via the internet [98]. For many, smartphones are easy to use (with some initial training as required), and offer a more novel alternative to traditional methods [96]. Use of smartphones to collect photographic dietary records which can be shared via the internet may reduce the burden of time on participants associated with collecting detailed dietary records, and they offer a platform for the provision of tailored feedback through the same medium with which dietary intake data was collected.

1.5 Research aims

The observations made in the review of the literature have highlighted the need to focus on strategies to optimise nutrition for Aboriginal women and their infants. The overall aims of thesis are therefore outlined in Figure 1.1 and in the following text.

Figure 1.1 Overall aims of the research thesis



The specific research questions and aims of the research reported in this thesis are as follows:

Overarching research question: As healthcare practitioners, how can dietitians help to optimise nutrition for Aboriginal women and their children?

Research aims:

1. To explore the cultural awareness experiences of dietitians and student dietitians working with Aboriginal women and their infants.

Research question: What are the current dietary practices and nutrition-related health outcomes of Aboriginal women and their children?

Research aims:

2. To investigate nutrient intake and food group adequacy of pregnant Aboriginal and non-Aboriginal women.

3. To investigate nutrient intake adequacy of Aboriginal women postpartum.
4. To investigate anthropometric measures of women and their infants from a longitudinal cohort of Aboriginal Australians.
5. To investigate the infant feeding habits of children in a longitudinal cohort of Aboriginal Australians.

Research question: Are image-based dietary records acceptable and valid tools for dietary assessment and nutrition counselling of pregnant women?

Research aims:

6. To assess the relative validity of image-based dietary records for the assessment of nutrient intakes of pregnant Aboriginal and non-Aboriginal women.
7. To assess the relative validity of a purpose-built brief tool for the manual analysis of nutrient intakes from image-based dietary records.
8. To assess the acceptability of a smartphone method combined with telephone counselling from a dietitian, for provision of nutrition counselling during pregnancy.
9. To assess the perceived usability and acceptability of an image-based dietary assessment method by pregnant Aboriginal and non-Aboriginal women.

Research question: What strategies have resulted in improvements in nutrition-related outcomes for Aboriginal women and their children?

Research aims:

10. To systematically review pre-existing programs which aim to improve nutrition-related outcomes for pregnant Indigenous women and/or their infants; and to identify the factors associated with programs that resulted in positive outcomes.

1.6 Overview of thesis structure and studies

The thesis is comprised of a series of six research papers (presented as Chapters 2 – 7) which are currently published in peer-reviewed journals. These research papers have been included into the thesis as they have been published, in line with the University of Newcastle thesis by publication recommendations. Attempts have been made to keep the formatting of the thesis consistent, therefore spellings are in Australian English. An overall discussion of findings from the thesis and implications for future research and practice is presented as Chapter 8. References and Appendices can be found in Chapter 9 and Chapter 10, respectively.

Chapter 2 Cultural experiences of student and new graduate dietitians in the Gomeroi gaaynggal ArtsHealth program: a quality assurance project

This chapter was published in the Health Promotion Journal of Australia. It was received on the 29th April 2015, accepted on the 16th December 2015, and published online on the 20th April 2016. The reference for this publication is as follows:

Rae K., Bohringer E., **Ashman A.**, Brown L., Collins C. Cultural experiences of student and new-graduate dietitians in the Gomeroi gaaynggal ArtsHealth program: a quality assurance project. *Health Promotion Journal of Australia*. 2016;27(2):162-166. DOI: <http://dx.doi.org/10.1071/HE15028>

A brief description of the general inductive approach described in this chapter is provided in Appendix 10.1.

The work presented in this manuscript was completed in collaboration with the co-authors (Appendix 10.2) and permission to reproduce the published manuscript has been granted by the publishers (Appendix 10.3). ©Australian Health Promotion Association 2016 - reproduced with permission. Copyright approval has been granted to replicate the article in this thesis from Health Promotion Journal of Australia and all copyright and licensing requirements of the journal have been followed.

2.1 Overview

Dietitians are well-placed to work together with Aboriginal communities towards optimising nutrition for Aboriginal women and children. As undergraduate students, dietitians must demonstrate cultural awareness and culturally respectful communication in order to meet the competency standards required of new-graduates in the profession. However, opportunities for practical experiences of working with people from different cultures are limited.

The aim of this chapter, which reports on a quality assurance project, was to evaluate the cultural awareness experiences of dietitians and student dietitians working with Aboriginal women and their children in an ArtsHealth setting in Tamworth, NSW. This manuscript commences from section 2.2.

2.2 Abstract

Issue addressed: Undergraduate dietetic students must complete the requirements of cultural awareness and culturally respectful communication as elements of competency, but exposure to practical experiences may be limited. The Gomeroi gaaynggal ArtsHealth Centre was established in 2009 after community consultation with the Indigenous community in Tamworth, New South Wales. The Centre provides a safe and welcoming space where women can create art while discussing health issues with visiting health professionals and students. The quality assurance project aimed to evaluate the cultural experiences of student and new-graduate dietitians visiting an Aboriginal ArtsHealth centre.

Methods: Six student and new-graduate dietitians were invited to provide feedback on their experiences for this report. A generic inductive approach was used for qualitative data analysis.

Results: Key qualitative themes of 'building rapport' and 'developing cultural understanding' were identified. Four of the participants interviewed felt they gained a deeper understanding of the context around health disparity for Indigenous Australians through their experiences. Key ways to build rapport with community members were identified.

Conclusions: Results suggest that first-hand experiences working in an Aboriginal ArtsHealth centre are effective in building cultural competency skills for student and new-graduate dietitians. These experiences could be better supported through improved preparation for the cultural setting, and ongoing monitoring of participant experiences is recommended.

So what? The authors encourage undergraduate dietetic programs and students seek out opportunities for further development of cultural awareness through increased practical experiences working with Indigenous communities.

2.3 Introduction

It has been suggested that poorly handled cross-cultural interactions between health professionals and Indigenous Australians has contributed to the disparity in health between Indigenous and non-Indigenous Australians [66]. As food and nutrition experts, dietitians working alongside Indigenous communities have important roles to play in health promotion and the prevention and treatment of nutrition-related illness [99]. It is imperative that dietitians have a good understanding of the nutritional health issues faced by Indigenous people, the reasons contributing to these issues and the challenges in addressing them, and the meaning of health for Indigenous Australians. In addition they must learn to practice in a culturally competent manner [99, 100].

Education of dietitians occurs largely through theoretical university based curriculum and professional practice placements. The National Competency Standards for Entry Level Dietitians requires new graduates to demonstrate competency with cultural awareness with respect to Aboriginal and Torres Strait Islander peoples and communicate in culturally respectful ways (Table 2.1) and additional training is encouraged in order to gain a sound understanding of the nutrition issues for this population [67, 99]. Typically, tertiary education relating to cultural awareness aims to improve student knowledge of a variety of cultures. In addition, undergraduate students enrolled in university degree programs accredited by the Dietitians Association of Australia are required to complete a minimum of 20 weeks of professional practice placement throughout their degree program [101]. In this short and busy time period, it is not guaranteed that all students will have the opportunity to work with Indigenous communities, resulting in many new graduates completing their degree with little or no experience working with Indigenous Australians. Cultural competency of student and new-graduate dietitians remains a little-explored area in the literature. The aim of this

quality assurance (QA) activity was to evaluate the cultural experiences of student and new-graduate dietitians visiting an Aboriginal ArtsHealth centre.

Table 2.1 Student and new-graduate dietitian activities and projects at the Gomeroi gaaynggal Centre and examples of professional competencies demonstrated

Participant status (<i>n</i> ; year)	Activities	Project/role	Example of DAA competencies ^A demonstrated ^B
Second-year dietetic students (3; 2013)	Participation in ArtsHealth activities (e.g. cooking with women attending ArtsHealth, creating art, holding casual conversations about nutrition); conducting background literature review of nutrition issues for Indigenous Australians; conducting focus group of felt nutrition needs of ArtsHealth participants	Needs assessment as part of community nutrition professional placement: 'Assessing the need for dietetic support for Gomeroi mothers attending an ArtsHealth program'	2.3.3: Communicates in a way which respects other cultures, using socially and culturally appropriate strategies; 5.1.2: Identifies individual, socioeconomic, cultural and environmental determinants, including equity and social justice issues; 5.2.4: Identifies sociocultural and environmental determinants of the food supply, relevant to the nutrition issue; 9.6.1: Understands what is meant by cultural awareness with respect to Aboriginal and Torres Strait Islander and CALD communities and is aware of the skills required for communicating in a culturally respectful way; 9.6.2: Has a working knowledge of the nutrition issues and diet related diseases impacting on the health of Aboriginal and Torres Strait Islander and CALD communities
Fourth-year dietetic students (3; 2014)	Developing nutritious recipes alongside Aboriginal women; creating cookbook illustrated by ArtsHealth	Developed cookbook as part of community nutrition professional placement:	2.1.3: Interprets nutritional information and communicates it using socially and culturally appropriate language; 2.3.3, 5.2.4, 9.6.1, 9.6.2 as above

Participant status (<i>n</i> ; year)	Activities	Project/role	Example of DAA competencies ^A demonstrated ^B
	participants; presentation of cookbook to the community; participation in ArtsHealth activities	‘Coming together: mums and bubs’	
Fourth-year dietetic student (1; 2011)	Participation in ArtsHealth activities	ArtsHealth year- long volunteer	2.3.3, 9.6.1, 9.6.2. as above
New-graduate dietitian (1; 2013)	Collecting nutrition, health, and anthropometric data from participants in the Gomeroi gaaynggal study; participation in ArtsHealth activities	Research assistant on the Gomeroi gaaynggal study	2.1.3, 2.3.3, 9.6.1, 9.6.2 as above

^A[100]; ^BNote that these competencies demonstrated do not relate to the revised National Competency Standards 2015 [67] as these were not in effect during the time of student placements; DAA Dietitians Association of Australia; CALD culturally and linguistically diverse

2.4 Methods

2.4.1 Setting

In 2009 in Tamworth, a regional city in New South Wales (NSW), the Gomeroi gaaynggal ArtsHealth program was established with the broad aim of improving health knowledge and accessibility to appropriate healthcare for Indigenous women and their children. The ArtsHealth program is conducted through the University of Newcastle and supports research into kidney health of Indigenous Australians (the Gomeroi gaaynggal Study). This program has been developed in consultation with local Elders, Indigenous artists, health services, antenatal care providers, and university health educators [102, 103].

ArtsHealth has been formally defined as ‘creative activities that aim to improve individual and community health and healthcare delivery using arts-based

approaches, and that seek to enhance the healthcare environment through provision of artworks or performances' [104]. It has been well established that Aboriginal people envisage health and healthcare within a more holistic 'whole of life' framework compared to Westernised medical practices, by incorporating spiritual, mental, physical and social factors [105, 106]. Including spiritual expression (e.g. painting) in health promotion and prevention activities has potential to be a valuable tool for improving health and well-being [105].

The University of Newcastle Department of Rural Health (UONDRH) supports student placements, supervision and assessment within the north-west area of NSW for undergraduate medical and allied health students from the University of Newcastle and other universities [107]. Through a collaboration between Gomeroi gaaynggal and the academic staff at the UONDRH, students from a range of disciplines (including dietetics, physiotherapy, speech pathology, medicine and midwifery) have the opportunity to engage with the Indigenous women attending ArtsHealth, including discussing their health care roles and delivering health promotion activities.

Five dietetics students and a new-graduate dietitian who had worked at the centre were approached by authors KR or AA and asked if they would be willing to discuss the quality of their placement experiences for a QA activity and brief report. Participation by providing written feedback (via email) or oral feedback (via semi-structured interview) about their experiences implied consent. Participation was voluntary and those who provided feedback have reviewed this report and provided written consent to include their quotations. They were informed that they could opt to have their quotations removed and that they could withdraw without penalty. De-identified quotations are kept in a password-protected computer file and no names are used in this manuscript. The QA activity was carried out to evaluate the quality of the student and health professional placements at the ArtsHealth program in order to inform improvements for future students through ongoing monitoring of student experiences [108]. The authors sought advice from the Hunter New England Human Research Ethics Committee who advised that

ethical approval was not required by this Committee as this was deemed a quality improvement activity (personal communication, Nicole Gerrand, dated 6th March 2015).

A generic inductive approach [109] was used to summarise the data and identify key themes relating to the outcome of interest, the cultural awareness experiences of the participants.

2.5 Results and discussion

Describing their cultural experiences of visiting the Gomeroi gaaynggal ArtsHealth program, the two key themes that emerged from participant's reports were 'building rapport' and 'developing cultural understanding'. These are discussed below.

2.5.1 Building rapport

Building trust and rapport between health professionals and Indigenous communities can take time and patience [66, 102, 103]. Some of the new-graduate and student dietitians interviewed for this QA project commented that rapport was not immediate, but rather required repeated visits to the centre (see Table 2.2). Art was found to be the common ground from which conversation could flourish, and a useful medium through which to overcome any initial apprehension. Some students also reported that cooking lunch with the women served as an icebreaker activity, and that Gomeroi gaaynggal staff also helped to facilitate discussions.

The formal health professional/client relationship was not appropriate in this setting, and so the students and new-graduate dietitians had to first form connections with participating mothers:

"Once initial connections are established you can bring up the topics of nutrition and health." [New-graduate dietitian]

2.5.2 Developing cultural understanding

The dietitians felt that a deeper understanding of the context surrounding Indigenous health disparities needed to be embedded in the undergraduate curriculum, as highlighted in Table 2.2. From discussion with Elders, the new-graduate dietitian realised the importance of considering historical events when understanding why health disparities exist.

"That wasn't something I'd thoroughly considered before. I think at uni we are taught that these are the facts, these are the differences. To delve into 'why' would have helped increase my understanding." [New-graduate dietitian]

This is particularly pertinent given that this dietitian had been an international student and therefore did not have background knowledge of Australian history. Others concurred that there was a limited understanding of cultural issues at an undergraduate level:

"Yes we've been told about the disparities but there's no explaining why there's this difference... it's almost accepted." [Second-year student]

Some students felt that getting to know people from a different culture to one's own helps to dispose of pre-conceived ideas. Placement experiences with Indigenous people and communities allowed for students to further develop their cultural understanding and to understand how to work in a culturally appropriate way.

The experiences of the dietitians who have worked at the Gomeroi gaaynggal centre have been overwhelmingly positive. Says one student:

"I have no more fear of going into a new community. I definitely want to work in an Aboriginal community in the future." [Second-year student]

It is not feasible for every student to be involved in a project like Gomeroi gaaynggal. Many students may, however, have the opportunity to participate in health promotion activities with Indigenous communities as part of their student placements. Developing cultural competency is important for health professionals to work appropriately with Indigenous communities, including in the development

and implementation of health promotion projects [105]. The experiences reported here illustrate the value of student and new-graduate health professional participation in endeavours such as the Gomeroi gaaynggal ArtsHealth program. Encouraging dietitians to engage in these real-world experiences as early and regularly in their studies as possible is recommended. It must be acknowledged that a limitation of this report is the small sample size and future investigations could be strengthened by increasing the number of students interviewed.

Table 2.2 Summary of themes and quotations from student and new-graduate dietitians regarding their experiences working at Gomeroi gaaynggal ArtsHealth

Theme 1: Building rapport

‘I was a bit surprised when one of the mums asked me if there were many ‘blackfellas’ where I’m from. Can you say that word? How do I answer that?’ (Fourth-year student)

‘I thought it would take more time to break the barrier down but they accepted us immediately.’ (Second-year student)

‘It doesn’t really matter where you come from. Once you get to know people you see we are all the same.’ (Second-year student)

‘You could start a conversation about art as a way to develop rapport.’ (Fourth-year student)

‘As simple as it [painting] is, it was effective in breaking down the cultural barriers I felt existed when I had first arrived.’ (Fourth-year student)

‘Painting with the women made me feel more at ease and it’s no surprise that my interaction made them feel more comfortable with me too.’ (Fourth-year student)

‘Talking to them, cooking for them and producing the cookbook which incorporated their own artworks helped not only improve my knowledge of Indigenous women and of how to go about working with them but also helped form friendships with them which is a highlight of my experience working at the ArtsHealth program.’ (Fourth-year student)

‘In reality, in this community rapport takes a long time to build up. The biggest problem I’ve had is struggling with ways to bring up the topic of nutrition in an informal setting, or

knowing how and when to address nutritional issues.’ (New graduate)

‘I wasn’t prepared for how long it would take until I started to feel comfortable talking about food and nutrition or anything other than art.’ (New graduate)

Theme 2: Developing cultural understanding

‘At uni we would often have lectures, or parts of lectures, on nutritional and broader health issues among Aboriginal Australians. Advice about working with Aboriginal people was delivered as part of a larger lecture on cultural competence. On my community placements I had about two half-days of working with Aboriginal Australians on different nutrition projects. As I’m not Australian and only came here as an adult, I didn’t grow up knowing Aboriginal people or being that aware of the culture. I can definitely say my ‘real world’ experience before working here was limited.’ (New graduate)

‘We are given advice at uni, by non-Indigenous lecturers, on how to communicate with Aboriginal Australians. While this provided a general introduction to some of the ways to show cultural respect, nothing beats first-hand experience.’ (Fourth-year student)

2.6 Conclusion

This report was the first stage of a QA project. The results indicate a high quality of placement experiences, and suggest that first-hand experience working with Aboriginal people within their own environment is effective in building the skills needed to meet cultural competencies. It is recommended that students complete in-depth cultural training before commencement of a placement of this type. We suggest making the content of cultural awareness lectures as interactive as possible, incorporating practical advice for building rapport and addressing nutrition issues. Where possible, representatives from Indigenous communities could be involved in these activities. Educating students on the causes of health disparities for Indigenous people is essential to build a deeper understanding of why these disparities exist. The authors recommend implementation of these methods to ease the transition for student and new-graduate dietitians from classroom-based learning to the community. As part of the ongoing QA process, the UONDRH is

developing a more comprehensive education package for the delivery of cultural training. Continual monitoring of placement experiences at the Gomeroi gaaynggal ArtsHealth program is essential for provision of the best quality nutrition education service possible.

Chapter 3 A cohort of Indigenous Australian women and their children through pregnancy and beyond: The Gomeroi gaaynggal study

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The work presented in this manuscript was completed in collaboration with the co-authors (Appendix 10.4), and permission to reproduce the published manuscript has been granted by the publishers (Appendix 10.5).

3.1 Overview

As discussed in section 1.3, Aboriginal Australians continue to experience disparities in health outcomes compared with non-Aboriginal Australians, with many chronic diseases of high prevalence having nutrition-related trajectories. The experiences of the child *in utero* and in the early postpartum period ‘set the scene’ for an individual’s future health. In order to develop policies and procedures for the prevention of chronic disease and ill-health, the early origins of these diseases must be examined. This chapter reports on the methods of the Gomeroi gaaynggal

study, a longitudinal birth through postpartum cohort study of Aboriginal women and their children. The manuscript commences from section 3.2.

3.2 Abstract

Indigenous Australians have high rates of chronic diseases, the causes of which are complex and include social and environmental determinants. Early experiences *in utero* may also predispose to later-life disease development. The Gomeroi gaaynggal study was established to explore intrauterine origins of renal disease, diabetes, and growth in order to inform the development of health programs for Indigenous Australian women and children. Pregnant women are recruited from antenatal clinics in Tamworth, Newcastle, and Walgett, New South Wales, Australia, by Indigenous research assistants. Measures are collected at three time points in pregnancy and from women and their children at up to eight time points in the child's first 5 years. Measures of fetal renal development and function include ultrasound and biochemical biomarkers. Dietary intake, infant feeding and anthropometric measurements are collected. Standardised procedures and validated tools are used where available. Since 2010 the study has recruited over 230 women, and retained 66 postpartum. Recruitment is ongoing, and Gomeroi gaaynggal is currently the largest Indigenous pregnancy-through-early-childhood cohort internationally. Baseline median gestational age was 39.1 weeks (31.5–43.2, n=110), median birth weight was 3180g (910–5430g, n=110). Over one third (39.3%) of infants were admitted to special care or neonatal nursery. Nearly half of mothers (47.5%) reported tobacco smoking during pregnancy. Results of the study will contribute to knowledge about origins of chronic disease in Indigenous Australians and nutrition and growth of women and their offspring during pregnancy and postpartum. Study strengths include employment and capacity-building of Indigenous staff and the complementary ArtsHealth program.

3.3 Introduction

Internationally there are an estimated 370 million people across 70 countries who self-identify as Indigenous, including Aboriginal and Torres Strait Islander people of Australia, Maori people of New Zealand, Indigenous people of the Americas, and the Sami or Laplander people of northern Scandinavia [25, 110]. Disparities in Indigenous and non-Indigenous health continue worldwide. In both economically developed and developing nations where Indigenous people reside, Indigenous people experience poorer health status than the overall population [111]. There are significant disparities in birth outcomes for Indigenous people in Australia, New Zealand, the United States and Canada, including higher rates of still birth, infant mortality and preterm birth for Indigenous infants compared with non-Indigenous [112]. Indigenous infants in Australia and the United States are more likely to be of low birth weight [112]. Prospective pregnancy cohort studies of Indigenous peoples are unfortunately scarce, as they may be of great value in determining the causes and trajectories of poor health in these populations.

Indigenous Australians have a life expectancy ten years lower than non-Indigenous Australians [113]. Renal disease, diabetes, overweight and cardiovascular diseases are particularly prevalent in Indigenous Australians [52, 114], and are significant risk factors for development of hypertension and stroke. In 2012–13, heart disease affected around 12% of Indigenous Australians [52]. Overweight and obesity are significant public health concerns in Australia, with Indigenous Australians 1.6 times as likely to be obese as non-Indigenous Australians [115]. In 2012–13, 66% of Indigenous Australians over 15 years of age were overweight or obese [115].

The prevalence of preterm and low birth weight babies is higher for Indigenous Australians than for non-Indigenous women [116]. In 2012, 14.3% of babies of Indigenous mothers were born preterm, a greater proportion than the 8.3% of babies born preterm to non-Indigenous mothers [116]. The proportion of babies born of low birth weight (<2500g) to Indigenous mothers (11.8%) was nearly twice that as low birth weight babies born to non-Indigenous mothers (6.0%) [116].

There are many contributing factors to the continuing inequalities in health experiences and life expectancy, including a long history of colonisation and oppression in many of these countries resulting in a legacy of political, economic and social disadvantage for Indigenous peoples. Social and environmental determinants of health include education, employment and income, nutrition, breastfeeding, tobacco use and chronic infections. Optimal nutrition is a crucial factor influencing growth and development and is protective against ill-health. Healthy growth in the early years of life can be a good indicator of a child's health and nutritional status. The National Aboriginal and Torres Strait Islander Nutrition and Physical Activity Survey (NATSINPAS) identified areas for improvement in terms of dietary intake for Indigenous Australians, including increasing vegetable and fruit consumption and decreasing foods that are nutrient-poor and energy-dense [48]. Food insecurity can contribute to poor nutrient intake, and the NATSINPAS found that over one fifth of Indigenous Australians were living in a household where someone went without food when food ran out [48]. Breastfeeding provides both short and long-term health benefits for mother and child. In 2012–13, the rate of any breastfeeding was 83% for Indigenous children and 93% for non-Indigenous children [115]. Nearly half (44%) of Indigenous Australians aged 15 and over reported being tobacco smokers in 2012–13 [115].

There is evidence that many chronic diseases have their origins in the intrauterine environment. David Barker proposed and provided epidemiological evidence that under-nutrition during intrauterine life predisposed to earlier onset of chronic disease; poor supply of nutrients programmes structural and functional changes in the metabolism of the developing foetus to anticipate an extrauterine environment with low nutrient availability [1, 2, 117]. Barker *et al.* showed that low birth weight was associated with an increased risk of coronary heart disease, hypertension, stroke and type 2 diabetes mellitus later in life [1, 2]. This risk is heightened in children with low weight gain in the first 2 years of life, especially if followed by rapid increases in body fat mass when a high energy diet is consumed that conflicts with that anticipated from the intrauterine experience [1].

The functional units of the human kidney (nephrons) are formed by 34 weeks of gestation. Once formed, the number of nephrons in each kidney at birth will not change throughout life. A low nephron number predisposes an individual to chronic renal disease later in life [118]. Babies born early, particularly those born before 34 weeks, and those born small for gestational age are more likely to have low nephron numbers. A low nephron number will result in compensatory hyperfiltration by existing nephrons, making these nephrons prone to failure and leading to impaired renal function. Indigenous people are more likely to have a reduction in nephron number [118]. In 2012–13 Indigenous Australians were twice as likely as non-Indigenous Australians (rate ratio 2:1) to have signs of chronic kidney disease (CKD) (after adjusting for age), with almost one fifth of Aboriginal and Torres Strait Islander people aged ≥ 18 years having indicators of CKD in 2012–13 [32]. The rate of CKD for Indigenous women was 16.9% in 2012–13, and Indigenous women are more likely to have kidney disease than non-Indigenous women (rate ratio 3.6) [32, 52]. Rates of CKD are particularly high in remote areas of Australia where 33.6% of people were identified as having indicators of CKD in 2012–13, compared with 13.1% of people living in non-remote areas [32]. Diabetes, which poses a high risk for development of early onset renal disease, is also more prevalent in Indigenous Australians [32]. Aboriginal and Torres Strait Islander people are more than three times as likely to have diabetes than non-Indigenous Australians with 11% of the Indigenous population identified as having diabetes, diagnosed by fasting plasma glucose test (≥ 7.0 mmol/L indicative of diabetes) and glycated haemoglobin test (HbA1c $\geq 6.5\%$) in the Australian Aboriginal and Torres Strait Islander Health Survey 2012–13 [32].

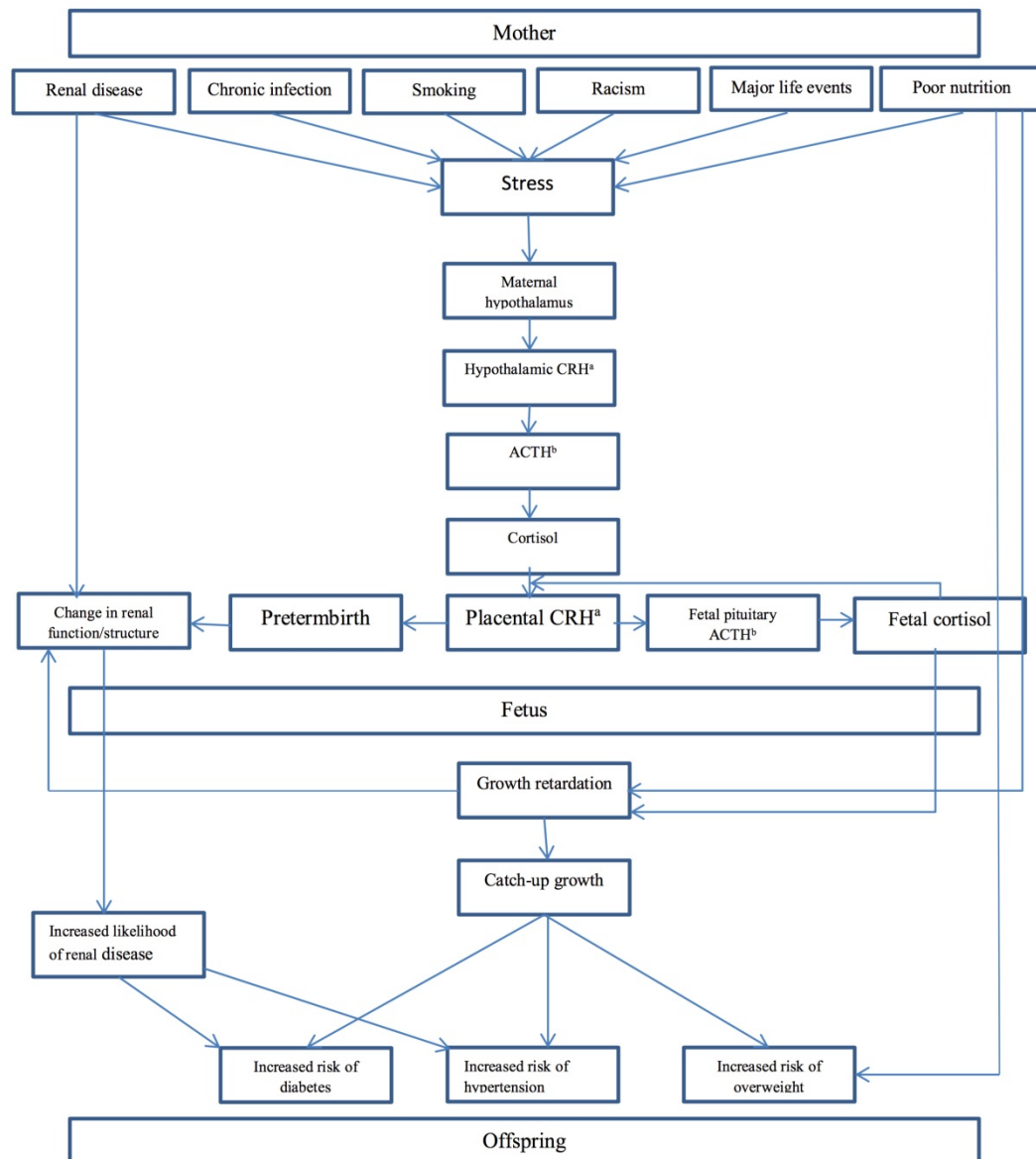
Preterm birth contributes to the prevalence of low birth weight in babies and to the subsequent predisposition to chronic disease development. There is evidence of a relationship between stress during pregnancy and preterm birth [119]. Stressors for Indigenous women include; chronic pre-existing renal disease, chronic infections, cigarette smoking and passive exposure to smoke, and poor nutrition. Social stressors include exposure to major life events (e.g. death of a loved one) and racism. In 2012–13, Indigenous Australians were 2.7 times as likely as non-

Indigenous Australians to experience high levels of psychological distress (major stressors included death of a family member or close friend, serious illness, unemployment, mental illness or problems with drugs or alcohol) [115]. Racism is a significant problem. In 2012–13, 16% of Indigenous Australians felt they had been treated badly because they were Indigenous [115].

Smith *et al.* have previously reported on the ‘placental clock’: a determinant of the length of human pregnancy gestation [120]. Placental secretion of corticotropin-releasing hormone (CRH) and maternal plasma concentrations of CRH rise exponentially during pregnancy, coinciding with a fall in concentration of CRH binding protein late in pregnancy. The subsequent surge in CRH bioavailability coincides with the onset of parturition, implying that high CRH acts as a prompt for the birth of offspring [120]. In women who deliver preterm babies, the hormone rises more rapidly than normal. The release of CRH is triggered by activation of the hypothalamic pituitary axis and its stimulation of the stress-hormone cortisol, causing a positive feed-forward system (see Figure 3.1). Therefore any stress in the pregnant woman’s life may result in preterm birth, and low birth weight infants. Exploring the reasons for stress-related hypercortisolaemia and methods for its prevention will potentially reduce the incidence of preterm birth of small babies.

The Gomeroi gaaynggal (Gomeroi babies) study aims to explore the relationship between exposure to stressors in the intrauterine environment and offspring health and growth outcomes (Figure 3.1). A specific aim is to investigate the developmental origins of renal disease and diabetes in Indigenous people, and in doing so to develop methods for the early detection and prevention of these chronic diseases.

Figure 3.1 Pathways to poor health outcomes in young Indigenous Australian People



^aCRH corticotrophin-releasing hormone; ^bACTH adrenocorticotrophic hormone

3.4 Method

3.4.1 Study design and setting

The Gomeroi gaaynggal study is a prospective longitudinal cohort of Indigenous mother-child dyads during pregnancy and up until the children are aged five years.

The study is primarily conducted at the Gomeroi gaaynggal centre, a facility of the University of Newcastle in Tamworth, New South Wales (NSW), Australia. NSW has the largest population of Indigenous Australians of any Australian state, with

one third of the country's Indigenous peoples residing here [54]. The 2011 census estimated 208,476 Indigenous people resided in NSW out of 669,881 Indigenous Australians in the country [54]. There are three recruitment sites in NSW for the study: Tamworth, (rural town), Newcastle (regional city) and Walgett (remote town).

The Gomeroi gaaynggal centre was established within walking distance of the Tamworth Aboriginal community to facilitate access and reduce socioeconomic barriers to recruitment and retention. Tamworth is in the Hunter New England region of NSW. As of 2012, the population of the Tamworth region was 58,922 persons [121]. In the 2011 census, 8.4% of the Tamworth regional population identified as Aboriginal and/or Torres Strait Islander [121].

Newcastle is a coastal city in Hunter New England. The population of the Newcastle local government area in 2012 was 157,273 persons, of whom a small percentage (2.6%) identified as Aboriginal or Torres Strait Islander in the 2011 census [122].

Walgett is a small remote town in northwest NSW. In the 2011 census, 823 of the 1626 counted residents in Walgett identified as Aboriginal or Torres Strait Islander (99% of whom identified as Aboriginal) [123]. This figure may be a modest estimation, as the Australian Bureau of Statistics estimated that nationally the Aboriginal 'undercount' was 17% [123].

3.4.2 Community consultation

Before commencing the study, researchers engaged in a two year process of community consultation with Indigenous stakeholders, including Elders, mothers' groups, schools, employment agencies and local Indigenous health organizations [124]. Through this consultation it was determined that the research would occur concurrently with a program that would provide immediate benefits to the community. An ArtsHealth program for women in pregnancy and post-delivery was established. As part of the program, a local Indigenous Elder and artist offers art mentorship and visiting health professionals and health students come to

discuss a range of health topics. The program offers a safe space, informal health information, contacts in the health services and resources to empower Indigenous women to make active changes to improve their health and that of their children. Further details of this community consultation and its outcomes have been published elsewhere [124].

3.4.3 Ethics approval

The Gomeroi gaaynggal study received ethics approval from the following committees: the Hunter New England Human Research Ethics Committee (reference number 08/05/21/4.01); the New South Wales Human Research Ethics Committee (reference number HREC/08/HNE/129); and the Aboriginal Health and Medical Research Council (reference number 654/08) (Appendix 10.6). Protocols are in place to ensure participants are referred to the appropriate health services if adverse results are found. Participants receive no reimbursements or financial incentives to participate.

3.4.4 Recruitment

Recruitment began in 2010 and is continuing at the time of publication. In Tamworth, participants are recruited by Indigenous research assistants at one of two antenatal clinic locations, including an Indigenous antenatal birth service. In Walgett, recruitment is conducted by an Indigenous research assistant at the Walgett Aboriginal Medical Service. In Newcastle, recruitment was through *Birra-li*, the Indigenous antenatal birth services. Engaging with and retaining the Newcastle cohort however proved difficult, and recruitment no longer occurs at this site. Pregnant women who identify as Indigenous Australians, or pregnant non-Indigenous women with Indigenous partners are eligible to participate and can enrol at any stage in their pregnancy. From three months postpartum, mother and infant dyads are eligible for the follow up study. Participants give written, informed consent to participate in the pregnancy study and provide renewed consent to continue into the postpartum follow up study (Appendix 10.7).

Data are collected once per trimester during pregnancy, four times during the infant's first year of life, (three, six, nine and twelve months) and when the child is aged two years. Where there are indicators of potential renal impairment in either mother or child, participant dyads are followed up until the child is aged five years. While attempts are made to see participants as close to these ages as possible, data collection is undertaken at times to suit participants.

Data collected at each time point for women participating in the Gomeroi gaaynggal study are shown in Table 3.1. Table 3.2 outlines the data collected at each time point for their children. Details of these variables are described below.

3.4.5 Biochemical data

Biological samples (maternal blood, urine and saliva, foetal cord blood, and child urine) are collected at various time points throughout the study (Table 3.1 and Table 3.2).

Biochemical measures assessed include: (i) plasma and urinary protein, electrolytes, urea, creatinine; (ii) serum cystatin C; (iii) urinary and plasma glucose; (iv) full blood cell count (including white cell count); (v) immunoglobulins; (vi) total immunoglobulin classes (IgA, IgG and IgM) and IgG specific for *Helicobacter pylori*; (vii) red cell folate; (viii) Vitamin B12; (ix) cortisol; (x) cotinine. The efficacy of novel renal biomarkers in this population which is at risk of CKD is being investigated.

In addition, we use the samples to examine markers of cardiovascular and kidney function in this cohort of Indigenous women in pregnancy.

Samples in the form of whole blood, serum, plasma, urine and saliva have been stored at -80°C in aliquots of 1ml to reduce the impact of freeze-thaw on samples for future use.

3.4.6 Blood pressure and ultrasound

Maternal blood pressure is taken using a Riester re-champion® blood pressure machine and cuff. Infants' blood pressure is taken at each study visit from 3 months

of age. A GE CRITIKON™ DURA-CUF™ blood pressure cuff for infants (8-13cm circumference) is used.

Ultrasound scans are conducted using a Phillips Cx50 Portable Diagnostic Ultrasound with a 5MHz convex transducer. Gestational age, single or multiple pregnancy, foetal anomalies and viability, and estimated date of delivery are determined at the first trimester scan. In the second trimester, foetal morphology and signs of abnormality are checked. In the final trimester renal arteries, umbilical arterial Dopplers, and liquor volume are assessed. Foetal measurements of head circumference, abdominal circumference and femur length are calculated to estimate foetal weight at each scan; foetal growth is monitored throughout pregnancy. Foetal kidney measures are anterior-posterior, transverse and length. These are taken as soon as the kidneys can be visualized and kidney volume is calculated from these measures [125].

3.4.7 Questionnaires

3.4.7.1 Nutritional assessment

Measures of dietary intake of women and infants are collected via:

- i) Food Frequency Questionnaires: the Australian Eating Survey for mothers [126] and the Australian Child and Adolescent Eating Survey for children [127];
- ii) Infant Feeding Recall (IFR) collects information on initiation and duration of breastfeeding and if infants have regularly consumed the following (and age of initiation): infant formula; cow's milk (as a drink); milk substitutes; solid foods. Questions for the IFR were selected from the NSW Child Health Survey 2001 and the 1995 National Nutrition Survey [128] [129];
- iii) Current Feeding Practices (CFP) questionnaire asks mothers about their child's sources of nutritional intake in the 24 hours preceding the interview, including intake of: vitamin or mineral supplements; medicine; plain water; sweetened or flavoured water (e.g. soft drinks or

cordial); fruit juice; tea or infusion; oral rehydration salts; any other food or fluids. The CFP is based on the recommendations of Webb *et al.* [130]. Both the IFR and CFP have been used in other cohort studies of women and their children in pregnancy and beyond [131];

- iv) Twenty-four hour food recalls of mothers and infants (via mothers) are conducted to report all food and fluid intake in the 24 hours preceding the interview day.

3.4.7.2 Psychosocial assessment

Validated psychosocial tests are all self-administered to determine aspects of psychosocial health for the women participating in the study:

- i) Stressful Life Events (an excerpt from the National Aboriginal and Torres Strait Islander Health Survey [NATSIHS]). The Stressful Life Events survey has been validated in Indigenous populations [132];
- ii) Impact of Event Scale (revised). The Impact of Event scale has not been validated in Indigenous people, however it has been used in a variety of population groups by Wadhwa *et al.* [133];
- iii) Kessler 10+. The Kessler 10+ has been found to be a useful tool for measuring psychological distress in middle-aged and older Indigenous Australians [134];
- iv) Discrimination survey (excerpt from the NATSIHS). The Discrimination survey has been validated in Indigenous populations [132].

Additional questionnaires elicit information for:

- i) medical history;
- ii) self-reported tobacco use;
- iii) self-reported alcohol consumption
- iv) maternal age, employment status, and educational attainment.

Details of previous pregnancy history, family medical history and gynaecological history, and offspring's gender, birth weight and Activity, Pulse, Grimace,

Appearance, and Respiration (APGAR) score, are obtained through the Obstetrics database set, antenatal records and the midwives birth register.

3.4.8 Anthropometry

Anthropometric measures are performed by an Accredited Practising Dietitian (APD) with Level One Anthropometrist certification from the International Society for the Advancement of Kinanthropometry (ISAK). All circumferences, girths, skinfold thicknesses, and lengths are measured in accordance with the ISAK protocol [135]. Measurements include:

- i) maternal pre-pregnancy weight (self-reported);
- ii) maternal height;
- iii) maternal body composition obtained using InBody 720™ bioelectrical impedance scales (Biospace Co., Ltd., Seoul, South Korea) including body mass index (BMI), visceral fat area, body fat mass, skeletal muscle mass, total body water and body fat percentage;
- iv) at each postpartum study visit maternal girths and circumferences are obtained including: mid-upper arm, waist, gluteal, upper thigh and calf;
- v) infant weight is obtained at each postpartum visit using infant scales;
- vi) infant length is measured crown-to-heel at each postpartum visit;
- vii) infant girths and circumferences: head, mid-upper arm, abdomen (at level of umbilicus), mid-thigh and calf;
- viii) skinfold thicknesses of infants are obtained using Harpenden skinfold calipers at the following sites: subscapular, biceps, iliac crest, front thigh and medial calf [135].

3.4.9 Data management

Participants are given unique study identification numbers in order to avoid labelling documentation with identifying details. Data is collected either electronically or on paper, and is transferred to electronic storage. Data is stored electronically in excel spreadsheets only available to members of the research team.

Paper data is coded and stored in locked filing cabinets accessible by the research team only.

Table 3.1 Data collected of mothers at each study visit for the Gomeroi gaaynggal cohort

Data collected	Pregnancy			Postnatal							
	1T	2T	3T	3m	6m	9m	12m	2yr	3yr	4yr	5yr
Anthropometry											
Maternal anthropometry: InBody weight and body composition	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Maternal anthropometry: height	✓										
Maternal anthropometry: girths				✓	✓	✓	✓	✓	✓	✓	✓
Maternal pre-pregnancy weight (self-reported)	✓										
Samples collected											
Maternal blood sample	✓	✓	✓	✓	✓		✓	✓			
Maternal urine sample		✓	✓		✓		✓	✓			
Maternal saliva collection	✓	✓	✓								
Blood Pressure											
Maternal blood pressure	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dietary Intake											
Maternal nutrient supplementation history				✓							
Maternal 24 h recall	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Australian eating survey			✓		✓		✓	✓	✓	✓	✓
Other											
Maternal and child health questionnaire: full				✓							
Maternal and child health questionnaire: review					✓	✓	✓	✓	✓	✓	✓
Maternal psychosocial survey	✓	✓	✓								

T trimester; m months; y years.

Table 3.2 Data collected of offspring at each study visit for the Gomeroi gaaynggal cohort

Data Collected	Pregnancy		Postnatal	

	1T	2T	3T	3m	6m	9m	12m	2yr	3yr	4yr	5yr
Foetal Ultrasound Scan	✓	✓	✓								
Anthropometry											
Child anthropometry: length or height, weight, skinfold thicknesses and girths				✓	✓	✓	✓	✓	✓	✓	✓
Samples collected											
Cord blood: <i>taken immediately post-delivery</i>											
Child blood sample							✓	✓			
Infant urine ^a				✓	✓	✓	✓	✓	✓	✓	✓
Blood Pressure											
Child blood pressure				✓	✓	✓	✓	✓	✓	✓	✓
Dietary Intake											
Infant feeding questionnaire				✓	✓	✓	✓				
Current feeding practices Questionnaire				✓	✓	✓	✓				
Child 24 h recall						✓	✓	✓	✓	✓	✓
Australian child and adolescent eating survey								✓	✓	✓	✓
Other											
Maternal and child health questionnaire: full				✓							
Maternal and child health questionnaire: review					✓	✓	✓	✓	✓	✓	✓

T trimester; m months; y years

^aUrine sample either from nappy or collection from child, as appropriate.

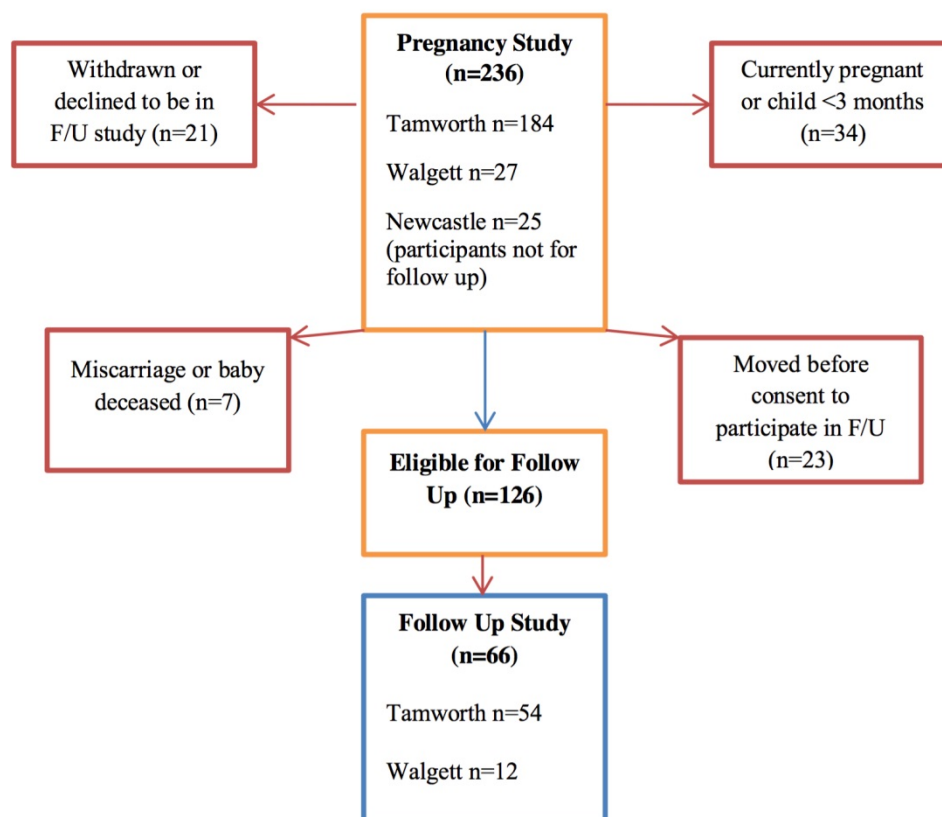
3.5 Results

Recruitment for the Gomeri gaaynggal study is ongoing. At the time of manuscript preparation, 236 mother-child dyads have been recruited into the study in their pregnancy. There has been a loss to this cohort of 76 women, including 21 women who have either withdrawn or declined to participate in follow up; 23 women who have moved from the study sites before consenting to participate; and a further seven women who have either miscarried or withdrawn due to infant death. The Newcastle cohort of 25 women is not eligible for follow up given the difficulties with accessing this population. In addition 34 women are at the time of

writing either currently pregnant or have infants <3 months of age. Of the 126 women currently eligible for participation in the postpartum follow up study, over half (52% n=66) have been retained and are attending study visits to date (see Figure 3.2).

Preliminary results from a baseline sample of $n=110$ participant dyads are presented below. The data generally reflected a higher prevalence of values outside normal ranges.

Figure 3.2 Gomeri gaaynggal study numbers



3.5.1 Pregnancy outcomes

Baseline characteristics of mothers are displayed in Table 3.3. Just over 6% of participants were recorded as having gestational diabetes (diagnosed by a fasting glucose of ≥ 5.5 mmol/l) in their current pregnancy, and 2.6% had type 2 diabetes mellitus. In the general population, 3–8% of pregnant women will develop gestational diabetes [136]. Median gestational age for this cohort was 39.1 weeks

(range: 31.5–43.2, $n=110$), and median birth weight of infants was 3180g (910–5430g, $n=110$). Median birth weight was 3093g for females (range: 1620–5430g, $n=46$) and 3078g for males (910–5170g, $n=54$). The majority of infants born in this cohort had APGAR scores >7 (82.2%), and 4.4% had scores 0–3. Over a third of infants (39.3%) had admission to special care or neonatal care nursery. The twinning rate for this cohort was 4.8%. Further pregnancy outcomes are displayed in Table 3.4.

3.5.2 Risk factors for chronic disease

Median plasma total cholesterol for women in the cohort was 5.9 mmol/L (range: 2–8.6, $n=195$), averaged over all study visits in pregnancy. Levels above 4 mmol/L indicate increased risk of coronary heart disease, though hypercholesterolaemia naturally occurs in pregnancy. Median plasma triglycerides were 2.4 mmol/L (0.3 – 7.3, $n=192$, reference range <2 mmol/L). Cholesterol and triglyceride levels of participants will continue to be monitored postpartum. Median plasma glucose was 4.4 mmol/L (2.4–12.8, $n=208$, reference range 3.5– 7.8 mmol/L random plasma glucose for adults). Nearly half of the cohort to date reported being a tobacco smoker during their pregnancy (47.5%). Eleven women who reported being non-smokers had detectable levels of cotinine but in only two of these women were plasma cotinine levels >1.0 ng/ml. This corresponds with national data where smoking during pregnancy was reported by 48% of Indigenous mothers in 2012 [116]. Further results are displayed in Table 3.4 and Table 3.5.

3.5.3 Renal function of mothers

Measures of renal function are presented in Table 3.5. The mean urinary albumin to creatinine and also protein to creatinine ratios showed 16% of samples had evidence of clinical proteinuria. Eighteen women (10% of cohort) had urinary protein to creatinine ratios ≥ 30 mg/mmol, and six had more than one sample with proteinuria. Three women with proteinuria had type 1 diabetes, and one woman had gestational diabetes mellitus, therefore proteinuria is unexplained in most samples. These four women were either normotensive or did not have a recorded blood pressure. Only five women ever recorded a systolic blood pressure ≥ 140 mmHg, and six women a diastolic pressure ≥ 90 mmHg. Both diastolic pressure and

plasma Cystatin C (a measure of glomerular filtration rate) showed gestation dependent increases (all $P<.001$). In this population of Indigenous Australian women, the incidence of high blood pressure is low, but there is an increased prevalence of proteinuria.

Table 3.3 Baseline characteristics of participants in the Gomeroi gaaynggal study

		Mean (SD)	Range	Median
Age (years)		26 (5.9)	13.8 – 40.9	25
Current Diabetes Status		%		
Diabetes Type I		1.03		
Diabetes Type II		2.56		
Gestational diabetes		6.15		
Past Pregnancy history		%	Range	
Total number past pregnancies	≤1	17.07	0–23	
	2–4	50.00		
	5–9	28.06		
	≥10	4.88		
Total number live children	≤1	29.27	0–9	
	2–4	51.22		
	5–9	19.52		
	≥10	0.00		
Miscarriages	≤1	82.28	0–16	
	2–4	12.66		
	5–9	2.53		
	≥10	15.2		
Termination	0	75.95	0–3	
	1	17.72		
	2	5.06		
	3	1.27		
SUDI	0	97.47		
	1	2.53		
Stillbirths	0	97.47		
	1	2.53		

SUDI sudden unexpected deaths in infants.

Table 3.4 Pregnancy outcomes of participants in the Gomeroi gaaynggal study

	Total (n=110)			
	Mean (n)	Median	SD	Range
Gestational age at delivery (weeks)	38.63 (110)	39.10	1.947	31.5–43.2
Birth weight at delivery (g)	3179.3 (110)	3180.00	689.79	910–5430
GROW BW centile ^[137]	34.1(109)	25.4	29.59	0–100

Baby length at birth (cm)	49.2 (79)	49.00	2.29	45–55
Baby head circumference at birth (cm)	34.37 (83)	34.50	1.98	26–38
First APGAR measure	8.09 (90)	9.00	1.65	1–9
Second APGAR	8.84 (90)	9.00	0.997	2–10

GROW BW gestation related optimal weight birth weight; APGAR appearance, pulse, grimace, activity, respiration.

Table 3.5 Anthropometric, biochemical and haematological measures of participants in the Gomeri gaaynggal study (combined for all visits during pregnancy)

	Mean (n)	Median	SD	Range	Normal range ^{a[138]}
Body composition					
Weight (kg)	85.3 (78)	84	23.5	45–148	
Height (cm)	164.5(109)	164.00	6.6	152–185	
Body mass index (kg/m ²)	30.7 (107)	30	8.6	15–52	
% Body fat (%)	41.7 (54)	43.6	11.2	17–63	
Visceral fat area (cm ²)	202 (53)	158	158	38–870	
Body fat mass (kg)	38.8 (54)	36.9	18.9	12–84	
Skeletal muscle mass (kg)	26.8 (54)	26.8	3.9	18–36	
Total water (L)	36 (53)	34.7	4.7	25–48	
Intracellular water (L)	22.2 (53)	21.4	2.9	15–29	
Extracellular water (L)	13.8 (53)	13.3	1.8	10–19	
Blood pressure					
Systolic (mmHg)	113(167)	110	13	80–150	
Diastolic (mmHg)	68 (167)	65	11	45–104	
Renal function					
Plasma cystatin C (mg/L)	0.85 (206)	0.80	0.28	0.38–2.1	0.40–0.99
Plasma sodium (mmol/L)	136 (209)	135	2.2	128–145	134–145
Plasma potassium (mmol/L)	4.1 (207)	4.0	0.5	3–6	3.5–5.0
Plasma creatinine (μmol/L)	49 (208)	48	8.9	20–83	49–90 ^b
Urinary creatinine (mmol/L)	10.4 (168)	8.7	8.2	0.1–41.7	^c
Urinary protein (g/L)	0.14 (170)	0.07	0.2	0.01–1.9	<0.15
Urinary protein/creatinine (mg/mmol)	25.7 (168)	11.8	63	0–700	<30
Urinary albumin (mg/L)	22 (171)	8.00	53	2–473	<30
Urinary albumin/creatinine (mg/mmol)	2.8 (170)	1.4	5.461	0.2–50	<3.5 ^d
Nutritional biomarkers					

Plasma glucose (random) (mmol/L)	4.6 (208)	4.4	1.2	2.4–12.8	3.5–7.8
Plasma total cholesterol (mmol/L)	6.4 (195)	5.9	5.9	2–8.6	<4
Plasma triglycerides (mmol/L)	2.5 (192)	2.4	1.1	0.3–7.3	<2
Plasma vitamin B12 (pmol/L)	169 (154)	150	74	59–403	138–652
Red cell folate (nmol/L)	1505 (168)	1358	750	280–4381	285–1475
Immune/inflammatory markers					
C-reactive protein (mg/L)	8.9 (180)	5.8	13	0.2–109	<5.0
IgA (g/L)	7. (162)	1.7	68	0.5–862	0.69–3.37
IgM (g/L)	1.2 (161)	1.1	0.6	0.3–3.4	0.48–2.38
IgG (g/L)	10.4 (162)	8.7	18.3	3.4–240	6.72–14.40
IgG <i>Helicobacter pylori</i> (U/ml)	16.2 (101)	8.9	17.3	2–82	^c
Full blood count					
White blood cells (x10 ⁹ /L)	10.3 (177)	10.30	2.7	3–18	4–11 ^e
Red blood cells (x10 ¹² /L)	4 (176)	4.0	0.4	2.6–5.1	3.8–5.2 ^f
Haemoglobin (g/L)	116 (179)	117	13.3	11–138	115–160 ^d
Haematocrit	0.35 (179)	0.35	0.03	0.25–0.43	0.34–0.47 ^d
Other measures					
Plasma cortisol (random) (nmol/L)	418 (154)	423	133	13–878	80–535
Cotinine (ng/ml)	67 (148)	0.8	99	0–580	^c

^aReference ranges are non-pregnant male/female ranges unless otherwise stated.

^bReference range for females ≥19 years old.

^cReference range not defined by laboratory.

^dReference range for adult female.

^eReference range for >21 years male and female.

^fReference range for pregnancy 1–42 weeks gestation.

3.6 Discussion

Current participant numbers are modest and initial difficulties with participant recruitment and retention were overcome through the employment of Indigenous staff, development of community trust, provision of transport and improved access to local health services. In the remote community, the involvement of the Walgett Aboriginal Medical Service has greatly assisted with recruitment [124]. Recruitment is ongoing and is steadily increasing each year, and the Gomeroi gaaynggal study is currently the largest Indigenous pregnancy-through-early-childhood cohort of its kind.

Irregularity of attendance at antenatal visits has been a limitation and resulted in an irregular sampling schedule. Additionally, funding was not received to start data collection for the follow-up study for a period of time, and therefore there is a potential loss of follow-up data from the women and children who were early study recruits. The time commitments are particularly burdensome for women with very young children who are in the ongoing follow up study. In addition, the study design could have been enhanced by collecting psychosocial data in the postnatal period, and collecting pregnancy dietary intake data from the start of the study.

The strengths of this study are many and include the large number of variables measured (see Figure 3.3), and the use of validated tools for collection of nearly all variables. The use of cotinine as a biomarker of tobacco use/exposure will be validated in Indigenous Australian pregnant women as one of the unique methodologies of this study. Other unique measurements collected include the body composition measures acquired through the InBody 720™ body composition scales. To the authors' knowledge, little work has been done on body composition of Indigenous women during their pregnancy using bioelectrical impedance scales. The regular and systematic measuring of body composition and growth of mothers and their children, and enquiry into their dietary intake, will contribute to what we know about Indigenous nutrition and growth during pregnancy and the postpartum period. Biological samples collected will be revealing as to cardiovascular and kidney function in this cohort of Indigenous women in pregnancy. To our knowledge, these parameters have not been analysed in a similar population of Indigenous pregnant women, and hence the implications for chronic disease are poorly understood.

The study's three locations reflect the diversity of NSW's Indigenous population in regional, rural and remote areas [54]. Ongoing extensive community engagement involved in the design and founding of the Gomeroi gaaynggal study resulted in the ArtsHealth program, which has become a popular initiative with women in the local community and an excellent complement to the research components. One of the greatest assets to the study has been the employment of Indigenous staff, who

contribute their expertise and community connections and knowledge. Through their work they are given opportunities to increase their research skills and gain professional qualifications that will see research capacity developed by Indigenous communities.

Community consultation is not only essential before conducting research in Indigenous communities [139], it is a crucial process for the success of the research study and has valuable benefits for both the researchers and the community [124].

It is anticipated that earlier recognition of those who are at risk of developing chronic disease (including renal disease and diabetes) and appropriate referrals to health services will lead to better health for participating women and their children. On a larger-scale, the contributions to the literature on early origins of chronic disease amongst Indigenous Australians will greatly assist in the formation of policy, intervention, and health promotion activities aimed at improving health outcomes for this vulnerable population.

Figure 3.3 Measures in the Gomeroi gaaynggal study

The Gomeroi gaaynggal Study			
Biochemical Data	Ultrasound and Blood Pressure	Ultrasound and Blood Pressure	Anthropometrics
-Renal Measures <i>Prorenin</i> <i>Albumin</i> <i>Glucose</i> <i>Uric acid</i> <i>Renin</i> <i>Electrolytes</i> <i>Creatinine</i> <i>Protein</i> <i>Angiotensin-converting enzyme</i> <i>Angiotensin</i> <i>Cystatin C</i> -Immunological Measures <i>Total Ig</i> <i>IgG for Staph, Bacterial and Viral PCR</i> <i>Cytomegalovirus-10</i> <i>Helicobacter pylori</i> -Metabolic and Cardiovascular Measures <i>Homocysteine</i> <i>B12</i> <i>Folate</i> <i>Transferrin</i> <i>Liver function tests</i> <i>Triglycerides</i> <i>Cholesterol</i> -Tobacco-by-products <i>Cotinine</i> -Stress Hormones <i>Cortisol</i> <i>Corticosteroid-binding globulin</i> <i>Corticotrophin-releasing hormone</i> -Haematology <i>Full Blood Count</i> <i>ABO blood</i> <i>Lewis blood groups</i> <i>Haematocrit</i> <i>Haemoglobin</i> -Reproductive Health <i>Estriol</i> <i>Estradiol</i> <i>Progesterone</i>	-Blood Pressure -Ultrasound <i>Foetal renal volume</i> <i>Gestational age</i> <i>Foetal anomaly and viability</i> <i>Date of delivery</i> <i>Renal and umbilical arteries</i> <i>Liquor volume</i> <i>Estimates of foetal weight</i>	-Nutritional Assessment <i>Australian Eating Survey</i> <i>Australian Child and Adolescent Eating Survey</i> <i>Infant Feeding Recall</i> <i>Current Feeding Practices</i> <i>Maternal 24 hour recall</i> <i>Child 24 hour recall</i> -Psychosocial Assessment <i>Stressful Life Events</i> <i>Kessler 10+</i> <i>Discrimination survey</i> -General Health -Self-reported Tobacco Use -Self-reported Alcohol Consumption -Demographic and Socioeconomic information	-Maternal and Child Weight -Maternal Height -Child Length -Maternal Circumferences <i>Waist</i> <i>Gluteal</i> <i>Mid-upper arm</i> <i>Thigh</i> <i>Maximum calf</i> -Child Circumferences <i>Head</i> <i>Abdomen</i> <i>Mid-upper arm</i> <i>Mid-thigh</i> <i>Maximum calf</i> -Child Skinfolds <i>Subscapular</i> <i>Bicep</i> <i>Front thigh</i> <i>Iliac crest</i> <i>Medial calf</i> -Maternal Body Composition <i>InBody 720</i>

Chapter 4 Dietary intakes and anthropometric measures of Indigenous Australian women and their infants in the Gomeroi gaaynggal cohort

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The work presented in this manuscript was completed in collaboration with the co-authors (Appendix 10.8), and permission to reproduce the published manuscript has been granted by the publishers (Appendix 10.9).

4.1 Overview

In order for dietitians and policy makers to be able to optimise nutritional status and nutrition-related health for Aboriginal Australians, evidence is required regarding current dietary intakes and their subsequent impact on body composition. This chapter reports on a cross-sectional analysis from a longitudinal cohort of Aboriginal women and children, which aimed to report on the nutritional intakes and anthropometric measures of Aboriginal mothers and their children. The manuscript commences from section 4.2.

4.2 Abstract

Indigenous Australians continue to experience disparities in chronic diseases, many of which have nutrition-related trajectories. Optimal nutrition throughout the lifespan is protective for a number of adverse health outcomes, however little is known about current dietary intakes and related anthropometric outcomes of Indigenous women and their infants. Research is required to identify nutrition issues to target for health promotion activities. The Gomeroi gaaynggal program is an ongoing, prospective cohort of pregnant Indigenous Australian women and their children. A cross-sectional examination of postnatal dietary intakes and anthropometric outcomes of mothers and children are reported. To date, 73 mother-child dyads have participated postpartum. Breastfeeding initiation was 85.9% and median (interquartile range) duration of any breastfeeding was 1.4 months (0.5–4.0). Infants were introduced to solid foods at 5.0 months (4.0–6.0) and cow's milk at 12.0 months (10.0–13.0). At 12 months postpartum, 66.7% of women were overweight or obese, 63.7% at 2 years. Compared to recommendations, reported median maternal nutrient intakes from 24 hour recall were low in fibre, folate, iodine, calcium, potassium and vitamin D and high in proportions of energy from total and saturated fat. Limitations of this study include a small sample size and incomplete data for the cohort at each time point. Preliminary data from this ongoing cohort of Indigenous Australian women and children suggest that women may need support to optimise nutrient intakes and to attain a healthy body weight for themselves and their children.

4.3 Introduction

Optimal nutrition throughout the lifespan is critical for growth and development of infants and optimal weight trajectories through to adulthood, and is protective against a variety of infections and chronic diseases. Sub-optimal nutrition in both pregnancy and infancy has been linked with the development of chronic diseases later in life, including diabetes and cardiovascular diseases [2, 140, 141]. The environmental influences and subsequent epigenetic adaptations occurring during the formative stages of foetal and infant growth and development are now

recognised as significant contributing factors to future health and disease risk [142]. Emerging evidence suggests that *in utero* and postnatal nutritional influences may confer epigenetic changes in infants [142-144]. Healthy food habits have been shown to track from infancy throughout childhood and into adulthood, and therefore optimal nutrition should begin early [16, 17]. Growth is rapid during infancy and inadequate nutrition during this time can have a detrimental impact on growth, with the potential for stunting [11]. Impaired growth can lead to poor neurological outcomes, and rapid catch-up growth may be a risk factor for obesity and later development of chronic disease [145-148]. Growth in the early years of life can be a good indicator of a child's health and nutritional status, and is an indicator of the health of a population. Little is known about the dietary intakes and related anthropometric outcomes of Australian Indigenous women and their children.

Within Australia Indigenous people continue to experience poorer health than non-Indigenous people; the result of a legacy of social and economic disadvantage [149]. Indigenous Australians have a ten year reduction in life expectancy compared with non-Indigenous Australians [113] and there is a high prevalence of renal disease, diabetes and cardiovascular diseases [150, 151]. In 2012–13, around one in eight Indigenous Australians had heart disease (12%), and one in 12 (8.2%) had diabetes mellitus and/or elevated blood or urinary glucose levels, a rate 3–5 times as high as comparable rates for non-Indigenous Australians [151]. Issues of food insecurity, which prevail in many Indigenous communities, may contribute to a greater prevalence of nutrition-related chronic diseases. In the National Aboriginal and Torres Strait Islander Nutrition and Physical Activity Survey (NATSINPAS) 2012–13, more than one in five Indigenous Australians were living in a household where someone went without food when the household ran out [48]. The NATSINPAS results highlight areas of concern for the dietary intakes of Indigenous Australians, including a smaller proportion consuming vegetables and fruit and a higher proportion of daily energy from discretionary foods (foods that are low in nutrient density but high in energy density) than non-Indigenous Australians [48].

Existing and emerging research is beginning to inform our knowledge of current dietary practices and infant feeding behaviours of Indigenous infants and children [42, 43, 152]. However, there is still a fundamental gap in what is known about the diets and eating habits of Indigenous Australian families, including women and their children. There is little in the current literature on how dietary intake changes over the lifespan in Indigenous Australians, and how this can influence body composition in terms of both optimal infant growth and maternal postpartum weight. There is a need for further research into early infant diets around introduction to solid foods, weaning diets and types of first food, not just breast and formula feeding [153], and the macro- and micronutrient intakes of Indigenous women in the critically important child-bearing years. Given that a high proportion of Indigenous Australians reside in rural and remote locations, research should reflect the diversity of Indigenous people living in non-urban communities. Research into current infant feeding practices and maternal dietary intake in the postpartum period will help identify areas to target future nutrition promotion strategies.

To understand the diets of Indigenous women and their young children and the impact on maternal and infant health and body composition, this study reports on the cross-sectional dietary intakes and anthropometric measures from a longitudinal cohort of Indigenous Australian women and their children. Maternal postpartum diet including intake of energy, macronutrients and selected micronutrients, and anthropometrics, in addition to infant feeding practices and anthropometrics are presented.

4.4 Methods

4.4.1 Study design and setting

The Gomeroi gaaynggal study is a prospective longitudinal cohort of Indigenous Australian mother-child dyads followed from pregnancy through the postnatal period until children are aged five years. We present here a cross-sectional description of postpartum data on maternal dietary intakes, infant feeding patterns and anthropometry of maternal-child dyads.

The study is set in two locations of New South Wales (NSW), Australia approximately 350km apart. The first is a large rural town of approximately 60,000 residents, 8.4% of which identified as being of Indigenous heritage in the recent census. The second is a remote town with a population of <2000 residents, approximately half of which identify as being Indigenous. National estimates indicate there is an 'undercount' of approximately 17% for Indigenous people [54]. The two towns are within the same Aboriginal cultural nation; however, they differ in terms of access to medical and daily household services, including a broad range of grocery options. The remote town scored 856 on the SEIFA Index of Relative Socio-Economic Disadvantage, and the rural location scored 960. A lower score indicates relatively greater disadvantage (e.g. many households with low income, many people in low-skilled occupations or with no qualifications) [154].

The Gomeroi gaaynggal study was established after a period of community consultation with Aboriginal community members [102]. All members of the research team involved in recruitment of participants are Aboriginal, and Aboriginal researchers are involved in all stages of the research project. The Gomeroi gaaynggal Steering Committee consists of community representatives and was established in order to ensure continued community partnership in the study.

The research study runs alongside the Gomeroi gaaynggal ArtsHealth program, which is an important initiative. Further details of this program have been published elsewhere [102, 103]. ArtsHealth provides an opportunity for health professionals and student health professionals, including dietitians, to engage with mothers about their health issues and those of their children. Incorporating creative expression (e.g. through art) in health promotion activities has potential to improve health and well-being using culturally relevant practices [105]. All participants attending the research study are invited to attend ArtsHealth activities. This helps build a relationship between these participants and members of the research team, which contributes towards improving participant retention.

4.4.2 Recruitment and retention

Participants are recruited by Aboriginal research staff during pregnancy and provide written consent to continue to participate in the study cohort following delivery. Those mother-child dyads who identify as Indigenous Australians or who deliver an Indigenous infant are eligible. Recruitment commenced in 2010 and is ongoing at time of publication.

Participants are informed about the postpartum data collection, and are booked in to attend their first postpartum visit during their last pregnancy study visit. Women attend up to eight postnatal visits. Data collection occurs four times during the infant's first year of life (at three, six, nine, and twelve months) and annually thereafter until children are five years of age. Attempts are made to obtain all measures from participants at each study visit. Given the time burden on participants this is not always possible. Results are reported on all available data. Postpartum anthropometric measures were not included in this analysis for women who had given birth to a subsequent child at any postpartum study visit. Anthropometric and dietary intake data of women who were pregnant at the time of study visit is also not reported here as this is not comparable with postpartum data.

Attempts are made to retain participants through a number of methods, including 'Study Days' where all participants are invited to attend the centre and door prizes are offered as incentives, offering home visits and transportation to the centre, and offering the option to collect some survey data over the telephone. The study also partners with a literacy programme that provides free children's books for participants.

4.4.3 Outcome measures

4.4.3.1 Dietary intake

Twenty-four hour food recall (24R)

Twenty-four hour food recalls of mothers are conducted by an Accredited Practising Dietitian (APD) at every visit. Women are asked to report all food and

fluid intake over the 24 hours of the day preceding interview, regardless of day of the week. Women provide a recall of one day (day preceding study session) at each visit. The multiple pass method is used for the Gomeroi gaaynggal study and involves retrieving a quick list of foods/drinks and probing for forgotten foods, collecting detailed information of recalled food and drink items, and a final review to gather any information not already collected. The recall protocol used in the current study is based on standardised protocols used in other projects [155, 156]. Recalls were entered into FoodWorks 7 Professional food and nutrient analysis software (FoodWorks version 7.0.3016, ©2012 Xyris Software [Australia] Pty Ltd) using the nutrient database AusNut 2007 [157].

Infant feeding recall (IFR)

Information on infant feeding practices is collected using the IFR and administered by interview with an APD. Questions for the IFR were devised from the NSW Child Health Survey 2001 and the 1995 National Nutrition Survey [128, 129] as suggested by Hector *et al.* [158]. The IFR is used at every visit up until 12 months and asks about breastfeeding initiation and duration and timing of introduction of formula, solid foods, cow's milk and milk substitutes. The IFR is used after 12 months when participants have continued breastfeeding or introduced formula, cow's milk, milk substitutes or solid foods beyond the 12-month visit.

Current feeding practices (CFP)

The CFP questionnaire is administered via interview with an APD at every postpartum study visit. The CFP asks mothers about their child's current diet and primary sources of nutrition in the preceding 24 hours. The CFP is based on the recommendations of Webb *et al.* [130]. Both the IFR and CFP have been used in other cohort studies of women and their children in the postpartum period [131].

Anthropometry

Maternal and child anthropometric measures are obtained by an APD and Level One Anthropometrist certified by the International Society for the Advancement of Kinanthropometry (ISAK). Maternal anthropometric measures obtained include weight, body mass index (BMI), percentage body fat (PBF), body fat mass (BFM),

skeletal muscle mass (SMM) and visceral fat area (VFA) and are obtained during pregnancy and at each postpartum visit through the use of InBody 720™ body composition bio-impedance scales (Biospace Co., Ltd., Seoul, Korea). These scales are available in the rural study location, but not the remote study location; therefore only weight data are collected for women at the latter location. Weight is collected in the remote location with an electronic scale (WeightWatchers® Body Weight Precision Electronic Scale model WW39A). Scales are maintained as per manufacturers' instructions.

Maternal pre-pregnancy weight is obtained through participant's medical records or self-reported via interview during the postpartum data collection. Infant birth weight, length, head circumference and Gestation Related Optimal Weight (GROW) centile is collected from participant's medical records. GROW centiles are individualised standards adjusted for physiological pregnancy factors that affect foetal growth (e.g. maternal weight, height, parity and ethnicity) [137]. Infant weight is obtained at each postpartum visit using infant scales (model BD-590; Tanita Corporation, Tokyo, Japan). Infant length is measured crown-to-heel at each postpartum visit. Infant head circumference, mid-upper arm circumference and subscapular skinfold are measured in accordance with the ISAK protocol [135].

4.4.4 Statistical analysis

Analyses were performed to ascertain normality of data distribution, and appropriate descriptive statistics. Data on duration and timings of infant feeding are reported in months. All analyses were programmed using Stata® (version 12.1; StataCorp LP, Texas, USA).

4.5 Results

A total of 241 participants have been recruited in the Gomeroi gaaynggal study as of October 2015 (78.4% rural, 11.2% remote). Of the 135 currently eligible to continue participation postpartum, just over half (54.1%) have been retained (n=73 mothers, 74 infants, including one set of twins), of which 83.6% reside rurally and 16.4% remotely (Figure 4.1). Five women had more than one child in the cohort.

Demographic data are summarised in Table 4.1. Self-reported data indicate that 10.8% of postpartum participants have or have ever had hypertension (n=7/65), and 3.1% have ever been diagnosed with diabetes (Type 1 or Type 2) (n=2/65). There were high rates of self-reported overweight or obesity (26.2%, n=17/65), asthma (36.9%, n=24/65), depression (38.1%, n=16/42) and other mental illness (12.8%, n=5/39). Thirty-nine percent of mothers (39.1%) reported smoking postpartum, similar to that observed during pregnancy.

Figure 4.1 Flow chart to show retention of the Gomeri gaaynggal pregnancy cohort into the Gomeri gaaynggal postpartum study (as of October 2015)

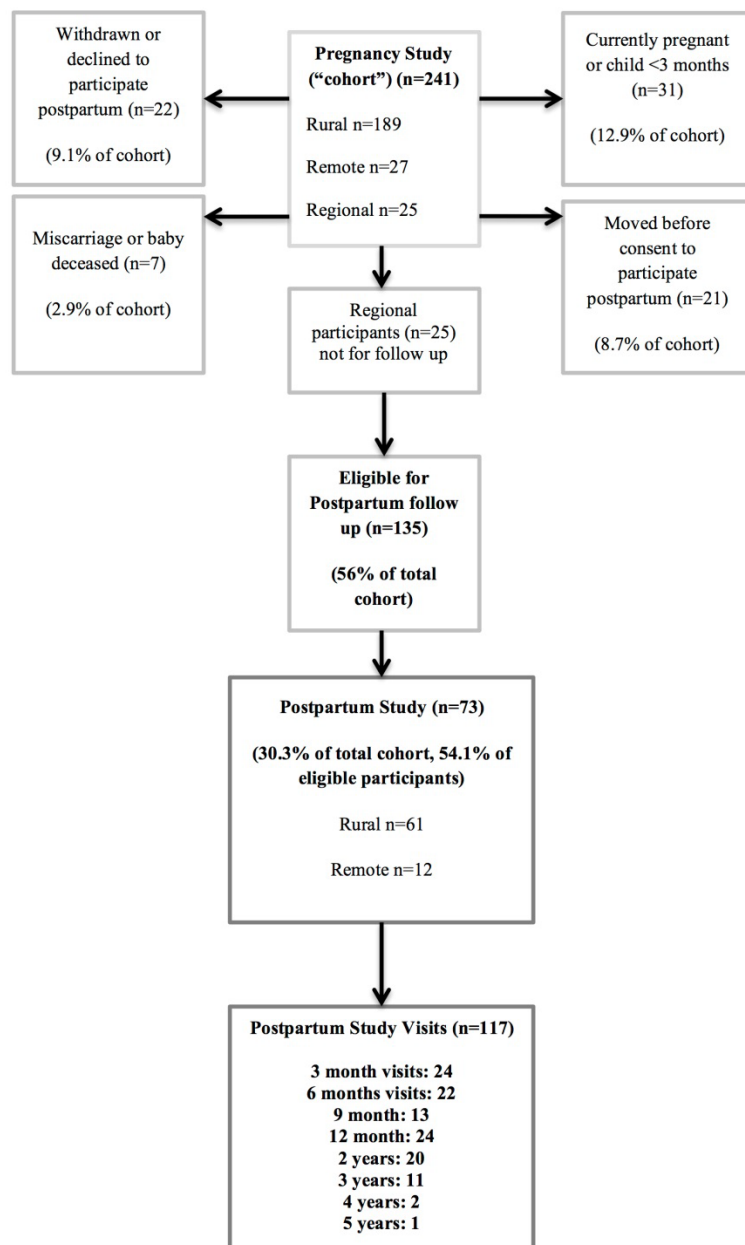


Table 4.1 Demographic characteristics of mothers and infants attending at least one postpartum study visit

Characteristics	n	Median (interquartile range)	Minimum- maximum values
Length of gestation (days)	67	273 (266–281)	203–294
Length of gestation (weeks)	67	39 (38–40.1)	29–41
	n/total n	Proportion %	
Infants			
Female	30/74		40.5
Preterm	6/74		8.1
Maternal Education^{a,b}			
<Year 10	11/66		16.7
School certificate (year 10 or equivalent)	21/66		31.8
High school certificate (year 12 or equivalent)	9/66		13.6
Trade/apprenticeship/TAFE certificate/diploma	17/66		25.8
Undergraduate university degree	2/66		3.0
Postgraduate university degree	2/66		3.0
Currently studying	4/66		6.1
Maternal Health^{c,d} (had/have any of the following conditions)			
Hypertension	7/65		10.8
Diabetes (type 1 or 2)	2/65		3.1
Kidney disease	1/65		1.5
Asthma	24/65		36.9
Valvular heart disease	4/65		6.2
Ischaemic heart disease	0/65		0
Overweight/obesity	17/65		26.2
Thyroid disease	0/65		0
Chronic pain	5/65		7.7
Depression ^e	16/42		38.1
Other mental illness ^e	5/39		12.8
Maternal smoking postpartum^c	25/64		39.1
Infant Health^f (had/have^d any of the following conditions)			
Reflux	7/70		10.0
Asthma	4/70		5.7
Middle ear infection	10/70		14.3
Kidney disease	0/70		0

Heart disease/murmur	0/70	0
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TAFE technical and further education.

^aHighest level of education attained. In Australia, year 10 is typically completed at 16 years of age, year 12 is typically the last year of high school and completed at 18 years of age.

^bIf participant has attended >1 visit, this is reported from most recent visit.

^cSelf-reported medical history.

^dReported at any study visit.

^eQuestions on self-reported mental health were not asked about in earlier study visits.

^fReported by mother.

Median (interquartile range) maternal age at first pregnancy visit was 24.9 years (21.3– 29.4) for the whole cohort and 24.0 (21.1–31.3) for participants retained postpartum. The median gestational age at delivery for the whole cohort was 39.1 weeks (37.6–40.1) and 39.0 weeks (38.0–40.1) for those retained postpartum. Female children make up 42% of the Gomeri gaaynggal cohort and 41% of the postpartum study. Twenty-two babies were born preterm, of which six preterm babies continued to participate postpartum.

Table 4.2 and Table 4.3 summarise the infant feeding practices from this group. The rate of breastfeeding initiation (any breastfeeding, even if only once) was 85.9%, with duration of breastfeeding ranging from 1 day to 24 months. Anthropometric measures of participating infants are summarised by study visit in Table 4.4. Birth GROW centiles were (mean \pm SD) 51.2 \pm 30.3 (n=59) for all infants; 50.9 \pm 27.3 for male infants (n=28); 48.8 \pm 31.0 for female infants (n=27); and 69.3 \pm 46.9 for preterm infants (n=4).

Table 4.2 Summary of infant feeding practices of infants in the Gomeri gaaynggal study (n=71)

Infant feeding practices	n/total n	Percentage
Initiated breastfeeding	61/71	85.9%
	n	Median (interquartile range)
Duration of breastfeeding (months)	50	1.4 (0.5–4.0)
Age of introduction to solid foods (months)	56	5.0 (4.0–6.0)
Age of introduction to cow's milk (months)	37	12.0 (10.0–13.0)

Table 4.3 Infant feeding practices at each study visit in the Gomeri gaaynggal study (n=109 visits)

Infant feeding practices	3 months [% (n)] (n=25)	6 months [% (n)] (n=17)	9 months [% (n)] (n=14)	12 months [% (n)] (n=23)	>12 months–5 years [% (n)]
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(n=30)					
Ever given regularly					
Cow's milk	4.0 (1)	5.9 (1)	21.4 (3)	73.9 (17)	93.3 (28)
Solid foods	28.0 (7)	88.2 (15)	100.0 (14)	100.0 (23)	100.0(30)
Current feeding practices: infant intake in past 24 h					
Breastfed	24.0 (6)	29.4 (5)	35.7 (5)	8.7 (2)	6.7 (2)
Infant formula	88.0 (22)	70.6 (12)	71.4 (10)	47.8 (11)	6.7 (2)
Solid or semi-solid food	20.0 (5)	82.4 (14)	92.9 (13)	100.0 (23)	100.0 (30)
Cow's milk	4.0 (1)	5.9 (1)	14.3 (2)	47.8 (11)	56.7 (17)
Sweetened/flavoured water	0 (0)	5.9 (1)	7.1 (1)	26.1 (6)	50.0 (15)
Fruit juice	8.0 (2)	17.7 (3)	21.4 (3)	47.8 (11)	63.3 (19)
Plain water	16.0 (4)	58.8 (10)	78.6(11)	82.6 (19)	96.7 (29)
Vitamin/Mineral supplement	4.0 (1)	0 (0)	0 (0)	4.4 (1)	6.7 (2)
Medicine	32.0 (8)	52.9 (9)	21.4 (3)	21.7 (5)	23.3 (7)

Infant age reported as visit at corrected age rather than chronological age if infant was preterm.

Table 4.4 Anthropometric measures of infants in the Gomeroi gaaynggal study at each study visit

Anthropometric measures	Birth [mean± SD (n)] (n=58)	3 months [mean± SD (n)] (n=24)	6 months [mean± SD (n)] (n=19)	9 months [mean± SD (n)] (n=12)	12 months [mean± SD (n)] (n=22)	2 years [mean± SD (n)] (n=17)
Birth weight (g) and infant weight (kg)						
All infants	3356.7 ± 596.3 (58)	6.3 ± 1.1 (24)	7.9 ± 1.1 (19)	8.6 ± 1.3 (12)	10.6 ± 1.8 (21)	12.4 ± 1.9 (17)
Male	3434.8 ± 487.5 (28)	6.5 ± 0.9 (11)	8.0 ± 1.0 (9)	8.9 ± .8 (6)	10.3 ± 1.0 (11)	12.4 ± 1.8 (8)
Female	3362.5 ± 544.0 (26)	6.2 ± 1.4 (10)	7.7 ± 1.3 (8)	8.5 ± 1.7 (5)	10.7 ± 2.7 (8)	11.8 ± 1.2 (8)
Preterm	2772.5 ± 1279.9 (4)	6.1 ± 1.0 (3)	8.3 ± .1 (2)	6.8 (1)	11.7 ± 1.5 (2)	16.9 (1)
Infant length (cm)						
All infants	49.7 ± 1.9 (54)	61.7 ± 3.0 (24)	67.8 ± 3.5 (19)	71.2 ± 4.2 (12)	78.1 ± 3.3 (21)	87.1 ± 4.4 (17)
Male	50.1 ± 2.17 (28)	61.9 ± 3.1 (11)	69.4 ± 3.3 (9)	73.0 ± 4.2 (6)	78.1 ± 3.1 (11)	87.3 ± 4.1 (8)
Female	49.4 ± 1.4 (23)	61.4 ± 3.3 (10)	66.3 ± 3.5 (8)	69.8 ± 4.0 (5)	77.5 ± 3.8 (8)	86.0 ± 4.1 (8)
Preterm	49.2 ± 1.6 (3)	61.9 ± 2.7 (3)	66.4 ± 1.2 (2)	67.5 (1)	80.1 ± 2.7 (2)	95.0 (1)

Infant head circumference (cm)						
All infants	34.5 ± 1.8 (56)	40.9 ± 1.2 (24)	43.5 ± 2.0 (19)	44.5 ± 1.8 (11)	47.2 ± 1.3 (20)	48.3 ± 1.9 (17)
Male	34.9 ± 1.6 (28)	41.3 ± 1.2 (11)	44.0 ± 2.3 (9)	45.8 ± .6 (5)	47.4 ± 1.3 (11)	48.3 ± 2.3 (8)
Female	34.3 ± 1.1 (24)	40.4 ± 1.3 (10)	42.5 ± 1.5 (8)	43.3 ± 1.9 (5)	46.7 ± 1.1 (7)	47.9 ± 0.9 (8)
Preterm	32.3 ± 4.2 (4)	41.0 ± .5 (3)	44.8 ± 1.1 (2)	43.5 (1)	47.9 ± 1.2 (2)	52.0 (1)
Infant mid-upper arm circumference						
All infants	nd	14.2 ± 1.5 (22)	15.6 ± 1.3 (16)	15.4 ± 1.4 (11)	16.6 ± 1.4 (19)	16.5 ± 1.2 (13)
Male	nd	14.2 ± 1.2 (10)	15.7 ± .9 (9)	16.2 ± .7 (5)	16.2 ± 1.3 (10)	16.6 ± 1.4 (5)
Female	nd	14.2 ± 1.9 (9)	15.5 ± 1.9 (6)	15.0 ± 1.6 (5)	17.0 ± 1.6 (7)	16.1 ± 0.6 (7)
Preterm	nd	14.1 ± 1.5 (3)	16.0 (1)	13.5 (1)	17.2 ± 1.0 (2)	18.6 (1)
Infant subscapular skinfold						
All infants	nd	7.4 ± 1.2 (18)	7.9 ± 1.5 (19)	6.6 ± 1.2 (9)	7.4 ± 1.7 (17)	6.7 ± 1.2 (10)
Male	nd	7.7 ± .9 (8)	7.6 ± 1.1 (9)	6.8 ± .7 (5)	6.8 ± 1.2 (10)	6.6 ± 1.4 (5)
Female	nd	7.2 ± 1.4 (7)	8.1 ± 2.1 (7)	6.9 ± 1.4 (3)	8.2 ± 2.2 (5)	7.0 ± 1.1 (4)
Preterm	nd	7.1 ± 1.8 (3)	8.6 ± 0.4 (2)	4.2 (1)	8.4 ± 2.1 (2)	6.2 (1)

nd

no data available

Infant age reported as corrected age rather than chronological age if infant was preterm up until but not including 2 years.

Table 4.5 presents selected nutrient intakes of postpartum women. None of the breastfeeding women reported taking a vitamin or mineral supplement on the recall day. Less than 50% of breastfeeding women were meeting the Estimated Average Requirement (EAR) for nutrients including folate, iodine, calcium, potassium and vitamin D intake or the Adequate Intake (AI) for fibre. Inadequate intakes of these same nutrients were found in non-breastfeeding women when nutrient supplement use was not included. Higher median intakes of folate, iodine, calcium, vitamin C, iron, zinc and vitamin D were reported amongst non-breastfeeding participants who were also taking supplements (n=8 over a total of 10 study visits), but the proportion meeting EAR or AI remained low for all, except for iron (51.7% had intake ≥8mg/day). None of the breastfeeding women, and only five

non-breastfeeding women, reported drinking alcohol in the 24-hour recall (range 1.0%–26.5% of total energy from alcohol).

Table 4.5 Intake of selected nutrients compared with Nutrient Reference Values for women aged 19-50 years (participants n=53, over n=75 study visits^a)

Nutrients	Breastfeeding ^b (n= 17)			Not breastfeeding (n= 58)					
				With vitamin/mineral supplement use (all)			Without vitamin/mineral supplement use (all)		
	Median (IQR)	NRV	% meeting NRV (n)	Median (IQR)	NRV	% meeting NRV (n)	Median (IQR)	NRV	% meeting NRV (n)
Energy (kJ)	8588 (5930-9950)	Additional 2.0-2.1 MJ/day	na	6246 (4580-8243)	na	na	6246 (4580-8243)	na	na
Carbohydrate (g)	206.0 (191.7-260.4)	na	na	142.8 (116.0-219.7)	na	na	142.8 (116.0-219.7)	na	na
Energy from carbohydrate (%)	44.1 (38.1-50.8)	45-65% (AMDR)	47.1 (8)	41.5 (33.8-48.2)	45-65% (AMDR)	43.1 (25)	41.5 (33.8-48.2)	45-65% (AMDR)	43.1 (25)
Total Sugars (g)	95.7 (90.1-106.4)	na	na	69.8 (47.5-122.8)	na	na	69.8 (47.5-122.8)	na	na
Energy from total sugars (%)	18.1 (14.9-22.0)	na	na	19.3 (14.9-26.2)	na	na	19.3 (14.9-26.2)	na	na
Protein (g)	84.9 (54.7-104.8)	na	na	73.0 (51.8-92.3)	na	na	73.0 (51.8-92.3)	na	na
Energy from protein (%)	16.9 (15.5-18.4)	15-25% (AMDR)	76.5 (13)	19.4 (14.1-23.3)	15-25% (AMDR)	43.1 (25)	19.4 (14.1-23.3)	15-25% (AMDR)	43.1 (25)
Fat, total (g)	71.1 (55.1-111.9)	na	na	62.3 (41.9-77.3)	na	na	62.3 (41.9-77.3)	na	na
Energy from total fat (%)	35.3 (30.9-42.8)	20-35% (AMDR)	41.2 (7)	34.9 (28.1-42.1)	20-35% (AMDR)	48.3 (28)	34.9 (28.1-42.1)	20-35% (AMDR)	48.3 (28)

Nutrients	Breastfeeding ^b (n= 17)			Not breastfeeding (n= 58)					
				With vitamin/mineral supplement use (all)			Without vitamin/mineral supplement use (all)		
	Median (IQR)	NRV	% meeting NRV (n)	Median (IQR)	NRV	% meeting NRV (n)	Median (IQR)	NRV	% meeting NRV (n)
Fat, saturated (g)	31.4 (25.3-37.5)	na	na	25.1 (18.0-35.7)	na	na	25.1 (18.0-35.7)	na	na
Energy from saturated fat (%)	14.3 (12.4-17.6)	<10% (AMDR)	0 (0)	16.0 (11.6-19.3)	<10% (AMDR)	8.6 (5)	16.0 (11.6-19.3)	<10% (AMDR)	8.6 (5)
Fat, polyunsaturated (g)	9.6 (5.4-13.9)	na	na	6.3 (4.8-9.6)	na	na	6.3 (4.8-9.6)	na	na
Fat, monounsaturated (g)	24.0 (18.3-44.4)	na	na	22.3 (13.9-31.1)	na	na	22.3 (13.9-31.1)	na	na
Dietary fibre (g)	20.1 (12.8-21.3)	30 (AI)	0 (0)	14.0 (10.1-19.0)	25 (AI)	8.6 (5)	14.0 (10.1-19.0)	25 (AI)	8.6 (5)
Folate (µg) as DFE	298.7 (188.7-346.6)	450 (EAR)	5.9 (1)	254.5 (158.5-410.9)	320 (EAR)	39.7 (23)	213.6 (139.6-371.8)	320 (EAR)	31.0 (18)
Iodine (µg)	110.2 (74.9-159.4)	190 (EAR)	5.9 (1)	86.8 (56.4-141.1)	100 (EAR)	41.4 (24)	81.4 (54.5-132.4)	100 (EAR)	37.9 (22)
Calcium (mg)	566.0 (368.0-863.0)	840 (EAR)	29.4 (5)	523.3 (255.3-781.6)	840 (EAR)	22.4 (13)	470.0 (255.3-781.6)	840 (EAR)	22.4 (13)

Nutrients	Breastfeeding ^b (n= 17)			Not breastfeeding (n= 58)					
				With vitamin/mineral supplement use (all)			Without vitamin/mineral supplement use (all)		
	Median (IQR)	NRV	% meeting NRV (n)	Median (IQR)	NRV	% meeting NRV (n)	Median (IQR)	NRV	% meeting NRV (n)
Vitamin C (mg)	65.5 (20.6-130.8)	60 (EAR)	58.8 (10)	57.3 (22.0-130.0)	30 (EAR)	65.5 (38)	42.2 (15.8-83.0)	30 (EAR)	58.6 (34)
Iron (mg)	9.3 (6.3-12.4)	6.5 (EAR)	70.6 (12)	8.4 (6.4-12.0)	8 (EAR)	51.7 (30)	7.7 (6.0-9.8)	8 (EAR)	44.8 (26)
Zinc (mg)	10.5 (6.9-13.4)	10 (EAR)	52.9 (9)	9.4 (6.9-11.6)	6.5 (EAR)	77.6 (45)	8.8 (6.5-11.3)	6.5 (EAR)	74.1 (43)
Sodium (mg)	2665.1 (2155.7-3015.3)	2300 (UL)	35.3 (6) (<2300)	2105.2 (1085.7-2930.2)	2300 (UL)	56.9 (33) (<2300)	2105.2 (1085.7-2930.2)	2300 (UL)	56.9 (33) (<2300)
Potassium (mg)	2884.8 (1636.2-3195.1)	3200 (AI)	23.5 (4)	2069.3 (1411.5-2592.9)	2800 (AI)	22.4 (13)	2069.3 (1411.5-2592.9)	2800 (AI)	22.4 (13)
Vitamin D (µg)	2.4 (1.7-4.1)	5 (AI)	0 (0)	2.3 (1.4-4.0)	5 (AI)	19.0 (11)	2.1 (1.2-3.5)	5 (AI)	12.1 (7)

IQR interquartile range; na no NRV available; AMDR acceptable macronutrient distribution range; AI adequate intake; EAR estimated average requirement; UL upper level of intake; DFE dietary folate equivalents.

^aIn all, 53 women provided at least one recall (one per study visit), repeated study visits provided a further 22 recalls.

^bNo breastfeeding participants reported taking a vitamin or mineral supplement.

Anthropometric measures of participating mothers at each postpartum study visit are summarised in Table 4.6. At every postpartum visit, the median BMI was in the overweight or obese range ($\geq 25.0 \text{ kg/m}^2$) [159], and median VFA and PBF at each study visit were higher than recommended ranges (recommended $< 100 \text{ cm}^3$ and 21-35%, respectively).

Table 4.6 Anthropometric measures of mothers in the Gomeri gaaynggal study at each study visit

Measure	Ref Ranges	Pre-pregnancy [Median (IQR)]	Last prenatal visit [Median (IQR)]	3 months [Median (IQR)]	6 months [Median (IQR)]	9 months [Median (IQR)]	12 months [Median (IQR)]	2 years [Median (IQR)]
Weight and BMI^a		n=47	n=36	n=18	n=19	n=9	n=15	n=11
Maternal weight (kg)	na	77.5 (63.0-93.3) (n=47)	90.9 (79.6 - 106.2)	81.2 (76.8 - 99.3)	80.3 (71.2 - 98.2)	83.6 (73.1 - 97.3)	77.1 (64.3 - 89.9)	72.1 (65.8 - 97.4)
Maternal BMI (kg/m ²)	18.5-24.9	29.1 (24.2-34.1) (n=44)	33.4 (29.4 - 40.6)	31.2 (28.9 - 38.4)	31.4 (27.0-38.4)	31.5 (27.8 - 34.7)	28.7 (24.0 - 33.0)	27.6 (23.2 - 35.8)
Body composition^b		nd	n=36	n=18	n=19	n=8	n=10	n=9
Maternal PBF (%)	21-35% ^[160]	nd	44.0 (37.9 - 51.3)	41.9 (35.6 - 49.7)	43.9 (35.3 - 47.9)	40.9 (39.5 - 41.7)	39.7 (34.0 - 43.2)	39.4 (34.4 - 41.9)
Maternal VFA (cm ²)	<100	nd	153.2 (119.2 - 214.3)	149.5 (114.1 - 214.5)	182.4 (132.8 - 198.0)	145.4 (112.7 - 187.5)	164.7 (103.8 - 199.4)	178.9 (106.0 - 210.2)
Maternal BFM (kg)	na	nd	39.3 (30.2 - 53.5)	34.7 (27.4 - 51.1)	35.3 (25.2 - 50.0)	35.8 (28.8 - 40.4)	32.6 (23.7 - 40.0)	32.8 (24.8 - 40.0)
Maternal SMM (kg)	na	nd	28.6 (25.7 - 31.9)	27.7 (23.5 - 30.0)	27.2 (23.6 - 28.8)	28.9 (25.7 - 32.2)	27.3 (26.1 - 27.8)	27.1 (26.2 - 29.4)

IQR interquartile range; na no reference range established; nd no data available; BMI body mass index; PBF percentage body fat; VFA, visceral fat area; BFM, body fat mass; SMM, skeletal muscle mass.

^aRural and remote cohort.

^bRural cohort only, no body composition scales at remote site.

4.6 Discussion

Several large cohort studies have made substantial contributions to our knowledge about Indigenous health in the pregnancy and postpartum periods, including the

Aboriginal Birth Cohort study, which has published extensively on birthweight, child growth and markers of chronic disease in childhood [161-163] and the Aboriginal Families Study, which explores women's experiences of antenatal care during their pregnancies [164, 165]. Participant numbers in Gomeroi gaaynggal are modest compared with these cohorts, however the study is ongoing and unique, as multiple repeated health-related measures are collected both in pregnancy and postpartum, and for both mothers and their children. The objective of the current analysis is to present cross-sectional data on dietary intakes and anthropometric measures of Indigenous women and their offspring in this cohort. The results indicate that there is a high breastfeeding initiation rate, although a short median duration of breastfeeding was observed. Mean anthropometric measures of infants indicate appropriate growth trajectories with no apparent stunting or wasting (Figure 4.2, Figure 4.3, Figure 4.4, Figure 4.5, Figure 4.6 and Figure 4.7). Maternal dietary intakes indicate a high median proportion of energy is derived from total and saturated fat, low median intakes of fibre and some micronutrients. Median anthropometric measures of women in this cohort were higher than recommended for BMI, VFA, and PBF at all postpartum time points.

The rate of breastfeeding initiation in the Gomeroi gaaynggal cohort is high (85.9%), although median (interquartile range) duration of breastfeeding (1.4 [0.5-4.0] months) did not reach National Health and Medical Research Council (NHMRC) recommendations of exclusive breastfeeding to six months and beyond. Australia-wide in 2010, breastfeeding was initiated in 96% of children [166], and the 2008 National Aboriginal and Torres Strait Islander Social Survey found that over three quarters (76%) of Indigenous Australian children (aged 0-3) had been breastfed at some point [150]. In remote areas, the median breastfeeding duration was high at 36 weeks (8.3 months), compared to 17 weeks in non-remote areas (3.9 months) [150]. Cromie *et al.* (2012) likewise described a gradient for breastfeeding by location in Western Australia, with Aboriginal children living in areas of moderate isolation 3.2 times more likely to be breastfed for ≥ 3 months compared to those in metropolitan Perth [42].

Breast milk is the optimum food for infants, providing all nutrient needs in the first months of life and providing additional short and longer term health benefits for both mother and child. Breastfeeding encourages sensory and cognitive development for infants, and is associated with reduced infant mortality, faster recovery from common childhood illnesses and reduced risk of some chronic diseases in later life [11]. In Australia, the NHMRC has set guidelines [11] which concur with the WHO recommendations [167] and call for exclusive breastfeeding until around six months of age. After six months, carers should begin introducing appropriate first foods, with continued breastfeeding to 12 months of age and beyond, as long as mother and infant desire. Cow's milk is not an appropriate drink for infants until 12 months of age [11].

The median time of introduction of solid foods in this cohort was at 5.0 (4.0–6.0) months and the introduction of cow's milk was at 12.0 (10.0–13.0) months. This is less than the recommended time points [11]. For all Australian children, the median age of introduction of solid foods is 4.7 months and cow's milk at 10.3 months [166]. Further, nearly one quarter of infants (22.6%) had been introduced to solid foods by four months [168]. For Australian Indigenous infants across the country, 35% had received solid food before six months of age and 64% had been given solid foods regularly after four months [150]. In contrast, in the Gomeroi gaaynggal cohort 28% of infants had been given solid foods regularly by their three month study visit (up to 4.5 months of age). Recent evidence suggests that very early introduction of solid foods (four months or earlier) may increase the risk of infants developing childhood obesity, especially in formula-fed infants [169, 170]. However, one systematic review concluded that the associations between timing of introduction to solid foods and weight in infancy and childhood were not clear, and that genetic and environmental factors or early rapid growth may be greater contributors to childhood obesity [171]. The Australasian Society of Clinical Immunology and Allergy recommend introducing foods around six months but not before four months, with more research needed to establish optimal time of introduction to reduce risk of food allergies [172]. Due to a dearth of longitudinal cohort studies,

the long-term health implications of early or late introduction to solid foods are not well established and there is a need for further research in this field [153].

Sweetened drinks are not recommended for infants in the first year of life and are unnecessary for a healthy diet in older children [11]. For infants ≤ 12 months, 10.1% had received sweetened drinks in the 24 hours preceding interview and, additionally, nearly a quarter (24.1%) had received fruit juice. Fruit juice may be used occasionally as a serve of fruit [47]. Although it may be perceived as a healthy drink choice, it is energy dense, and fruit juice and sugar-sweetened drinks may contribute to weight gain [173-175] and dental caries [11, 176]. In the Bibbulung Gnarnep cohort of urban Aboriginal infants ($n=274$), 69.8% of babies had received fruit juice in their bottles by 12 months and 59.8% had received cordial, established via interview with mothers and using a checklist table of foods and drinks ever consumed [43].

Early nutrition is implicated in contributing to poor health outcomes for Indigenous Australian children, with higher rates of some nutrition-related conditions compared with non-Indigenous children [177]. In NSW, Indigenous children aged 10–18 years had a significantly higher incidence of type 2 diabetes mellitus than non-Indigenous Australians (rate ratio 6:1; 95% CI, 3.9–9.7; $P<.001$) [152]. Rates of tooth decay are also higher. In 2002, Indigenous children aged 6 years had 2.6 times as many decayed, missing or filled teeth as non-Indigenous children Australia-wide [178]. A major risk factor for poor oral health is high consumption of sweetened drinks or sticky, high carbohydrate foods. Prioritising nutrition as an area for health intervention in Indigenous children as early as possible is therefore of great importance.

There is a higher rate of low birth weight babies for Indigenous Australians than non-Indigenous Australians [179]. Low birth weight has been associated with later development of childhood and adult obesity and heart disease, type 2 diabetes and stroke [2, 141, 180]. Significant weight gain in the first year is strongly associated with obesity in later life and this ‘catch-up growth’ in infants who are small for gestational age at birth is associated with increased risk of some chronic diseases,

including heart disease [180]. In a Finnish cohort of 3447 women, Forsén *et al.* (1999) found that poor prenatal nutrition, short body length and low birthweight followed by improved nutrition and catch-up growth in childhood was significantly associated with coronary heart disease in adulthood [148]. Mean anthropometric measures of infants in the Gomeri gaaynggal cohort show growth trajectories that appear appropriate with no apparent signs of short or long-term malnutrition (i.e. stunting or wasting) evident. There is some indication of catch up growth from 12 months for preterm boys, however any firm conclusion is limited by the current small sample size.

Women had dietary intakes that were low in key nutrients important during this life stage, including folate, iron, zinc, calcium and iodine. However, intakes of iodine and dietary folate equivalents may have been higher than reported here, as mandatory fortification of bread with iodised salt and folic acid came into place in Australia in 2009 [181] and this fortification was not incorporated in the AusNut 2007 food database. In comparison, findings from the Australia-wide National Nutrition and Physical Activity Survey (NNPAS), which used an updated food composition database (i.e. AUSTNUT2011-13), indicate that in women aged 19–30 years, 11.7% failed to meet the EAR for iodine, and 10.9% of women failed to meet the EAR for folate in 2011–12 [182]. It is important to note that vitamin D is also obtained through sun exposure and not solely from food, therefore these results do not imply that women were deficient in this nutrient. High proportions of energy from saturated fat were seen for both breastfeeding and non-breastfeeding women. The Nutrient Reference Values for Australia and New Zealand and the Australian Dietary Guidelines recommend limiting saturated and trans fats in the diet to 8–10% of dietary energy [183] due to the associated detrimental effects on cardiovascular disease risk markers [47, 183]. Median intake of fibre was low. High intakes of dietary fibre are associated with reduced risk of obesity, certain cancers, cardiovascular diseases and type 2 diabetes, and an adequate intake of 25g is recommended for women in Australia [47, 183]. There are significant structural barriers that may hinder ability to achieve optimum nutrition for Indigenous Australians, including financial constraints; gaps in knowledge on healthy choices,

budgeting and cooking; busy lifestyles; lack of access (including transportation) to nutritious foods; and cultural and family commitments that can inhibit regular budgeting and cooking [184]. There is a need for widespread, sustained, culturally appropriate nutrition interventions that increase demand and supply for healthy food, and also increase community capacity to achieve good nutrition [185]. Evidence-based economic interventions should also be trialled [185, 186] Brimblecombe *et al.* emphasise the importance of engaging local stakeholders to ensure nutrition strategies are culturally acceptable and appropriate, and to incorporate local knowledge, skills and experiences [187].

The high proportion of overweight and obesity and the high median PBF and VFA in this cohort of women of child-bearing age is of concern. It should be noted that VFA and PBF data are only available in the rural location of this study. Overweight and obesity are well-established risk factors in the development of many chronic diseases and retention of excess postpartum weight is considered particularly harmful, due to the central distribution of pregnancy weight [19, 20]. Retention of postpartum weight for periods of 6-12 months and longer is associated with long-term obesity [20, 188]. In this cohort 66.7% (n=10) were overweight or obese (BMI ≥ 25.0 kg/m²) at 12 months postpartum and 63.7% (n=7) at 2 years postpartum. Overweight and obesity is a major public health issue, with 42.4% of women aged 25–34 overweight or obese in the 2011–12 Australian Health Survey, including 55.3% of women aged 35-44 years [189].

There are limitations to the use of the 24-hour recall data, for example, inherent limitations due to memory and recall bias [74, 190] and under-reporting is an acknowledged issue with this method; under-reporting of energy intake was considered likely in the NNPAS [82] and in the NATSINPAS [48]. Under-reporting is likely to affect all nutrients equally. Recalls were based on one day at each time point for each woman, therefore this may not have been reflective of usual food and nutrient intakes. Further, due to the current small sample size of this cohort, plausibility of energy intake was not assessed. A standardised multiple pass method was used to collect the data, making this recall method comparable to other

studies using this method. It is unclear if this 24-h recall method is validated for reporting of dietary intake for Indigenous women and infants, although this method has been used in the most recent national nutrition survey, including the NATSINPAS. The IFR and CFP have been used in another cohort of women and children, but to our knowledge have not been previously used with Indigenous participants [131].

Another limitation is that the differences between pre-pregnancy and postpartum weight for women in this cohort may be in part due to self-reported data for pre-pregnancy weight.

While recruitment for the Gomeroi gaaynggal study commenced in 2010, funding was not received to establish postpartum data collection until late 2012, therefore there has been some natural loss to the cohort, including women who withdrew or declined to participate further (n=22). Postpartum data collection in the regional town has not been possible, due to lack of funding and demographic differences that make accessing participants from this cohort challenging. In addition, there are high rates of participants moving from the study locations, making retention and follow up difficult. Retention of participants has been challenging, possibly due to the time constraints on mothers and the lack of incentives for continued participation. There is potential for selection bias in both recruitment and retention of participants in the cohort. It is unknown what proportion of pregnant women are recruited in the study communities, and if they differ in the measures reported here from women who choose not to participate, or not to continue participation postpartum. As those demographic characteristics displayed in Table 4.1 are only collected postpartum, it is unknown what differences there may be for women who are not retained. Women are recruited from antenatal clinics, and therefore those not seeking this health service may not be recruited. There is potential for volunteer bias, as it is possible that mothers who do not continue have additional burdens on their time, shame or distrust of participating in research, or different health outcomes to those that do continue. Given the time burden of data collection and the volume of measures to be collected, it is not always possible to obtain all

measures, although attempts are made to follow up with participants at a later date, or conduct surveys over the telephone. Data presented here are preliminary, and recruitment and data collection for the Gomeroi gaaynggal study is ongoing.

The generalisability of the current findings is limited by a small sample size, lack of full retention of all women postpartum, and missing data due to the challenges of data collection at all time points. Therefore caution needs to be applied when interpreting these results. However, a number of areas for future practice and research are emerging.

Figure 4.2 Length growth trajectory of full-term male infants. Mean (filled circle) \pm SD (line) length of full-term male infants with at least one measure (n=36) in the Gomeroi gaaynggal postpartum cohort

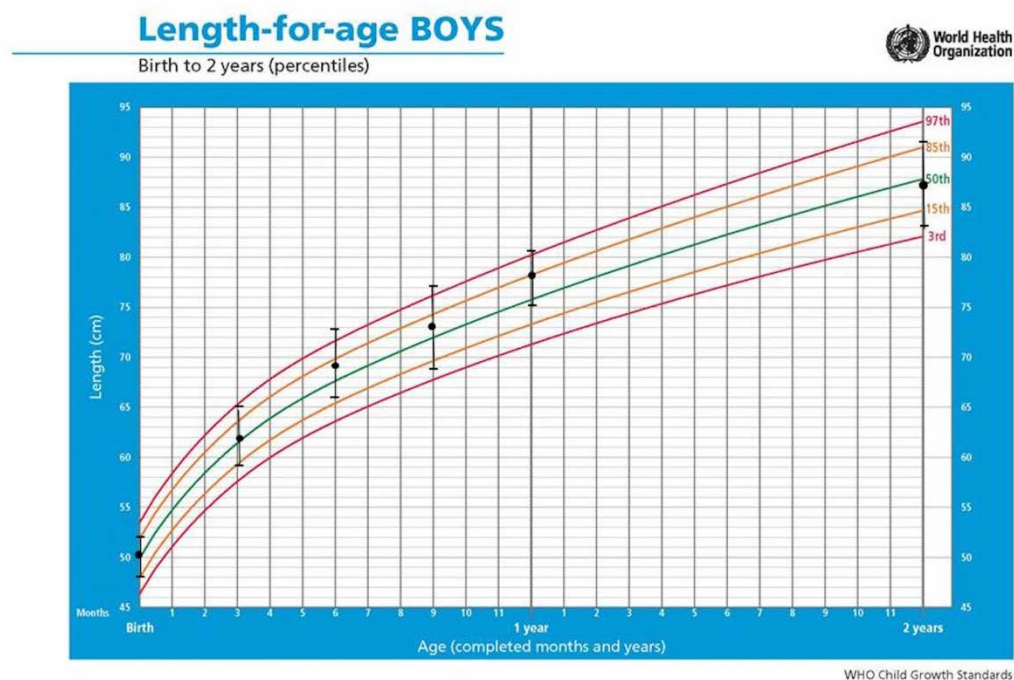


Figure 4.3 Length growth trajectory of full-term female infants. Mean (filled circle) \pm SD (line) length of full-term female infants with at least one measure (n=30) in the Gomerio gaaynggal postpartum cohort



Figure 4.4 Weight growth trajectory of full-term male infants. Mean (filled circle) \pm SD (line) weight of full-term male infants with at least one measure (n=36) in the Gomerio gaaynggal postpartum cohort

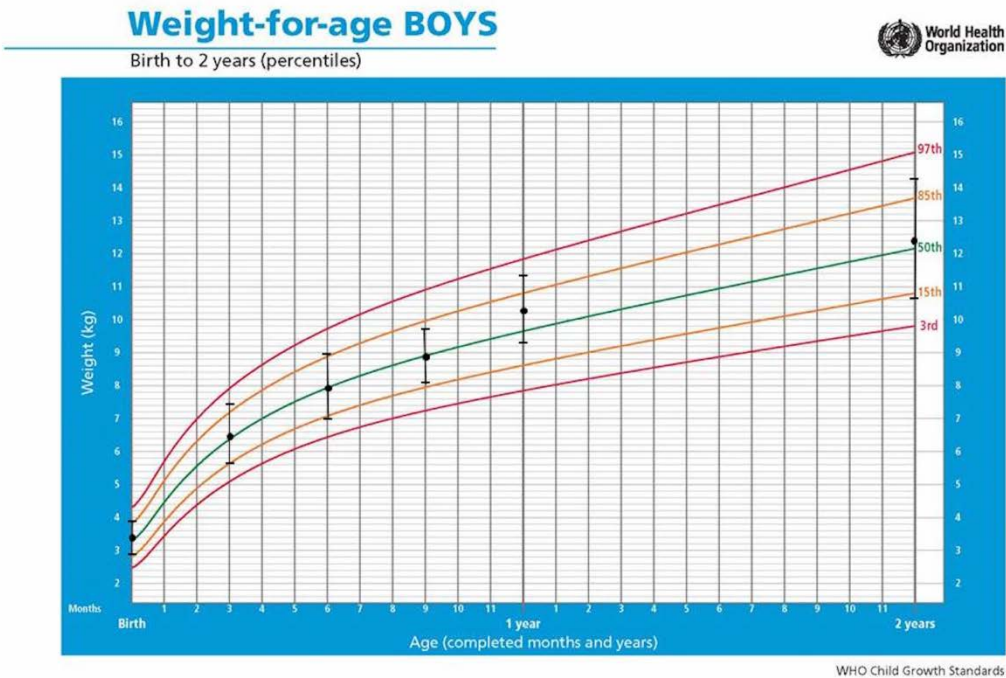


Figure 4.5 Weight growth trajectory of full-term female infants. Mean (filled circle) \pm SD (line) weight of full-term female infants with at least one measure (n=30) in the Gomeri gaaynggal postpartum cohort

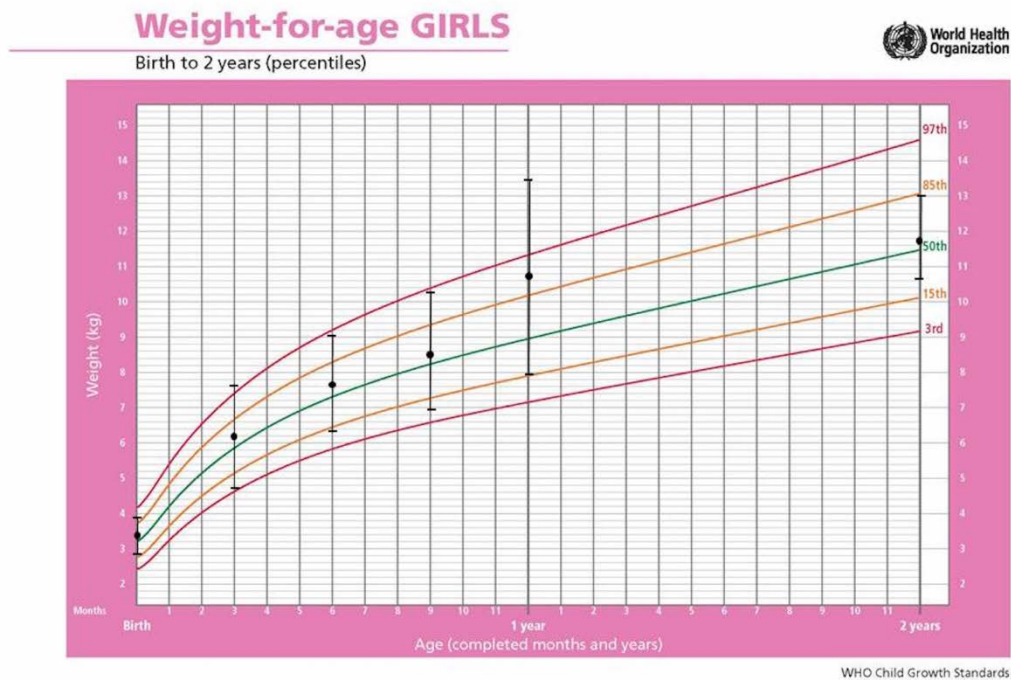


Figure 4.6 Head circumference growth trajectory of full-term male infants. Mean (filled circle) \pm SD (line) head circumference of full-term male infants with at least one measure (n=36) in the Gomeri gaaynggal postpartum cohort

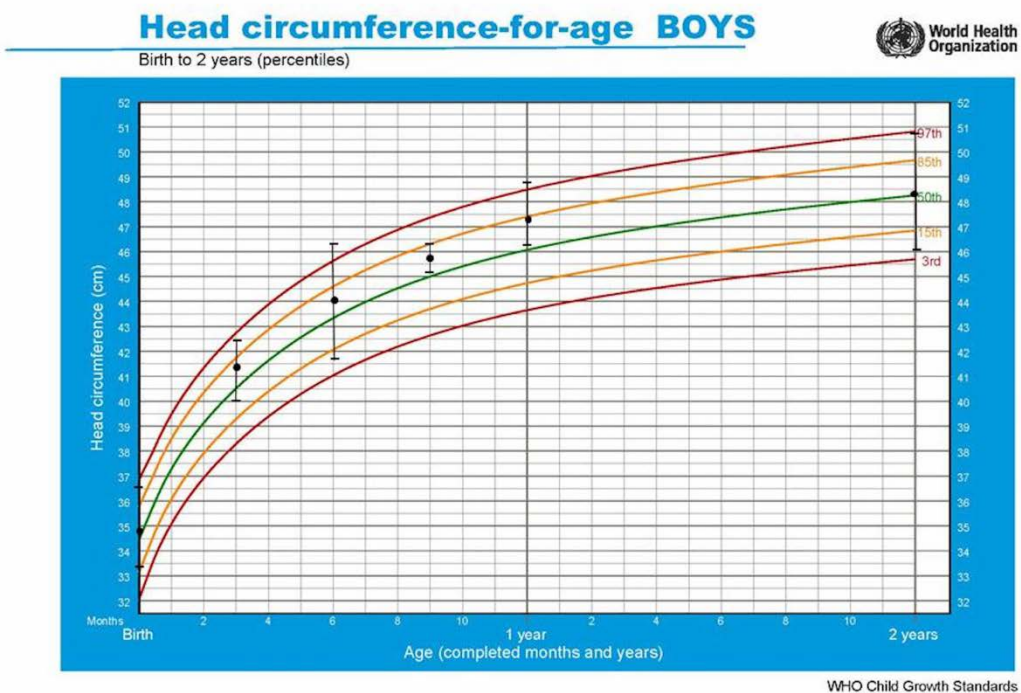
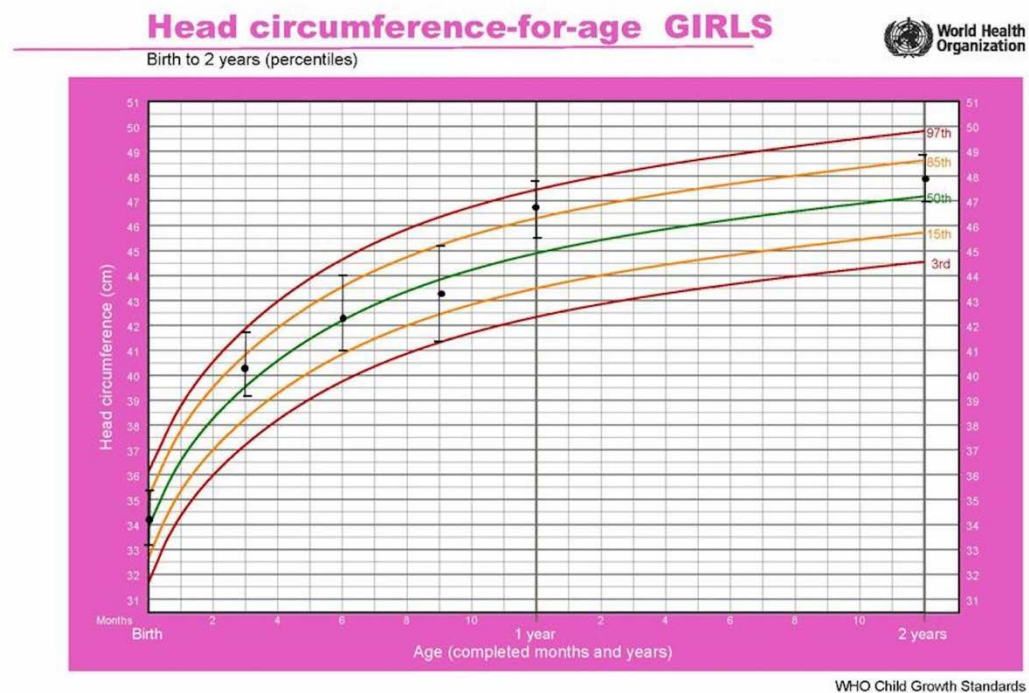


Figure 4.7 Head circumference growth trajectory of full-term female infants. Mean (filled circle) \pm SD (line) head circumference of full-term female infants with at least one measure (n=30) in the Gomeroi gaaynggal postpartum cohort



4.7 Conclusions

Some positive infant feeding practices were found including a high breastfeeding initiation rate; and continuation of these practices should be encouraged. Future research could explore the barriers and motivators to breastfeeding continuation in this cohort, and what culturally appropriate support could be utilised to extend duration. Nutrition education in these communities could focus on reducing intake of sweetened drinks and fruit juice for infants and encouraging a healthy diet for women and their children in line with the Australian Dietary Guidelines [47] and the Infant Feeding Guidelines [11]. Longer-term follow-up with a larger data set will help evaluate whether particular nutrients are specifically at risk for this population. Women of child-bearing age in this cohort may benefit from support to assist in establishing and maintaining a healthy weight before pregnancy, and to reduce pregnancy weight gain in a sustainable manner over an appropriate amount of time.

Chapter 5 A Brief Tool to Assess Image-Based Dietary Records and Guide Nutrition Counselling Among Pregnant Women: An Evaluation

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The work presented in this manuscript was completed in collaboration with the co-authors (Appendix 10.10) and permission to reproduce the published manuscript has been granted by the publishers (Appendix 10.11). This paper was published in JMIR Mhealth and Uhealth and can be reproduced in this thesis under the terms of Creative Commons Attribution License 2.0.

5.1 Overview

Dietitians may provide pregnant women with personally tailored nutrition advice but to do so they require appropriate tools for dietary assessment. Image-based dietary records, collected via smartphones, may alleviate some of the participant burden associated with capturing dietary intake records; however validated tools are required for the analysis of nutrient intakes.

The Diet Bytes and Baby Bumps (DBBB) study used a smartphone method of recording image-based dietary records of Aboriginal and non-Aboriginal women in their pregnancy. This method is used to collect dietary intake data, assess diet, and provide nutrition advice to pregnant women in Tamworth and Newcastle, New

South Wales (NSW). Participants receive individual, tailored dietary advice from an Accredited Practising Dietitian (APD). This advice is delivered to their smartphone in the form of a short video summary, followed by a telephone feedback session with the APD.

Researchers at the Gomeroi gaaynggal centre in Tamworth observed that smartphone usage amongst Aboriginal participants in the Gomeroi gaaynggal study and ArtsHealth program was high, and that many women used their smartphones frequently to take photographs. A short survey was conducted via Apple® iPad regarding smartphone usage specifically, with women attending the Gomeroi gaaynggal ArtsHealth program. Twenty-three Aboriginal women of varying ages responded. Mobile phone ownership was high at 87%. It is unclear exactly how many women owned smartphones: nine women responded that they had either an Apple® iPhone (n=7) or Samsung® galaxy (n=2), however the remaining 11 women with mobile phones stated brands only and not the type of phone. Questions regarding phone usage indicated the majority of women surveyed used their phones to take photographs (90%) and use apps (60%). Thirty percent reported using their phones to make voice recordings and 50% of respondents said they used their phone to take notes. The majority of respondents (80%) said they would be willing to take photographs of the food they ate using their mobile phone. Those that would not be willing to do this cited the following reasons; time constraints, often not having a phone, need to upgrade phone, “because I eat what I want”, and “don’t want people to know I don’t eat the right foods”. Eighty-five percent had never kept a record of their diet before or had to remember foods they ate. Thirty-five percent felt that they would be able to keep a photographic diet diary for one day, 5% said three days, and 10% said they would be able to keep the dietary record for one week. Fifty percent indicated they would be able to use their phones to keep a photographic dietary record for “as long as required”.

The results of this survey suggested that Aboriginal women attending the Gomeroi gaaynggal centre were receptive to using smartphones to participate in research

studies, and that the methodology described below for the DBBB study would be appropriate to use in this population group.

The objectives of this chapter are to assess the relative validity of a purpose-built brief tool for assessment of nutrient intake, compared with nutrient analysis software; to explore the nutrient adequacy of pregnant participants' diets; and to assess the acceptability of the DBBB method for provision of dietary feedback to participants. The manuscript commences from section 5.2.

5.2 Abstract

Background: Dietitians ideally should provide personally tailored nutrition advice to pregnant women. Provision is hampered by a lack of appropriate tools for nutrition assessment and counselling in practice settings. Smartphone technology, through the use of image-based dietary records, can address limitations of traditional methods of recording dietary intake. Feedback on these records can then be provided by the dietitian via smartphone. Efficacy and validity of these methods requires examination.

Objective: The aims of the Australian Diet Bytes and Baby Bumps Study, which used image-based dietary records and a purpose-built brief Selected Nutrient and Diet Quality (SNaQ) tool to provide tailored nutrition advice to pregnant women, were to assess relative validity of the SNaQ tool for analysing dietary intake compared with nutrient analysis software, to describe the nutritional intake adequacy of pregnant participants, and to assess acceptability of dietary feedback via smartphone.

Methods: Eligible women used a smartphone app to record everything they consumed over 3 nonconsecutive days. Records consisted of an image of the food or drink item placed next to a fiducial marker, with a voice or text description, or both, providing additional detail. We used the SNaQ tool to analyse participants' intake of daily food group servings and selected key micronutrients for pregnancy relative to Australian guideline recommendations. A visual reference guide consisting of images of foods and drinks in standard serving sizes assisted the dietitian with

quantification. Feedback on participants' diets was provided via 2 methods: (1) a short video summary sent to participants' smartphones, and (2) a follow-up telephone consultation with a dietitian. Agreement between dietary intake assessment using the SNaQ tool and nutrient analysis software was evaluated using Spearman rank correlation and Cohen kappa.

Results: We enrolled 27 women (median age 28.8 years, 8 Indigenous Australians, 15 primiparas), of whom 25 completed the image-based dietary record. Median intakes of grains, vegetables, fruit, meat, and dairy were below recommendations. Median (interquartile range) intake of energy-dense, nutrient-poor foods was 3.5 (2.4–3.9) servings/day and exceeded recommendations (0–2.5 servings /day). Positive correlations between the SNaQ tool and nutrient analysis software were observed for energy ($\rho=.898$, $P<.001$) and all selected micronutrients (iron, calcium, zinc, folate, and iodine, ρ range .510–.955, all $P<.05$), both with and without vitamin and mineral supplements included in the analysis. Cohen kappa showed moderate to substantial agreement for selected micronutrients when supplements were included (kappa range .488–.803, all $P\leq.001$) and for calcium, iodine, and zinc when excluded (kappa range .554–.632, all $P<.001$). A total of 17 women reported changing their diet as a result of the personalised nutrition advice.

Conclusions: The SNaQ tool demonstrated acceptable validity for assessing adequacy of key pregnancy nutrient intakes and preliminary evidence of utility to support dietitians in providing women with personalised advice to optimise nutrition during pregnancy.

5.3 Introduction

Dietitians can assess individual dietary needs and provide advice to clients to optimise their nutritional status [191]. In order to deliver personalised nutrition interventions, accurate information about what individuals are eating is required. For collection of such information to be feasible, the dietary data need to be collected and interpreted with a minimum burden on both the client and dietitian

[76]. Feedback should be tailored to the individual and provided in a manner that is meaningful to the recipient so as to encourage positive dietary changes.

Traditional prospective methods of dietary assessment, including weighed or estimated food records, require the recording of all food and drinks consumed. These methods can capture day-to-day variation in diets and are used commonly in research [70]. However, keeping food records is associated with a high participant burden involved in the weighing or estimating of foods, may trigger changes in usual eating behaviours [79, 80], and requires high levels of motivation to complete records accurately [70]. Reliability of written records decreases over time due to respondent fatigue, especially for recording periods of more than 4 days [77]. Keeping food records also requires literacy and numeracy skills and therefore may not be appropriate for all population groups. In clinical practice, retrospective methods of dietary assessment, such as diet histories and 24-hour food recalls, are more likely to be used. However, self-report places the onus on individuals to estimate food quantities consumed, a limitation that contributes to underreporting [81, 82].

Manual analysis of food records by dietitians or other trained individuals is often required to translate reported food intakes into nutrients and food groups. This analysis is usually undertaken using food composition tables, often embedded in food analysis software. Food composition tables provide detailed information on nutrient composition of foods and drinks, giving determined values for quantities of energy, macronutrients (carbohydrate, protein, and fat), micronutrients (vitamins and minerals), and other food components, such as fibre [192].

Once dietary intake is analysed, nutrient intakes can be compared with national recommendations. In Australia, the Nutrient Reference Values (NRVs) provide national intake recommendations for macro- and micronutrients [183]. The Australian Guide to Healthy Eating (AGTHE) is a visual food selection guide providing a representation of the proportions of food groups recommended for daily consumption [47]. The AGTHE supports the Australian Dietary Guidelines recommendation to “enjoy a wide variety of nutritious foods from these five food

groups every day:" grain and cereal foods, vegetables, fruit, meat or alternatives ("meat"), and dairy or alternatives ("dairy") [47]. The AGTHE is used as an educational and counselling tool by Australian dietitians to advise on the recommended number of daily servings from each food group and serving sizes from core nutrient-dense and noncore or discretionary energy-dense, nutrient-poor foods.

Innovative dietary assessment methods can address some of the limitations associated with current methods in order to improve the quality of data collected and ease of analysis. Image-based dietary records are a novel method for food and nutrient intake assessment [70, 76], where images of consumed food and drinks capture a dietary record from which a person's intake is determined [85]. A passive or active approach can be taken to capturing food intake. A passive approach involves wearable cameras that capture eating and drinking occasions [193, 194]. While no effort from users is needed, privacy issues associated with this technology make passive methods of image capture challenging to implement. Active methods involve recording dietary intake via stand-alone cameras or those imbedded in handheld devices, such as smartphones. Although the active method relies on participants to capture the images, the burden of estimating portion size is placed on the dietitian or skilled person performing the analysis [86]. Smartphone ownership is increasing, with 77% of Australian adults owning a smartphone in 2015 [97]. Smartphone features such as cameras, microphones, and Internet connectivity make them an ideal mode of dietary assessment, education, and counselling. With access to appropriate technologies and training, dietary intake data can be relayed between clients and dietitians in real time, transcending distance, and potentially overcoming barriers relating to literacy or numeracy skills. These assessment methods support the provision of dietary feedback over distance (e.g., through telephone or video consultation), broadening the scope of dietetic services [98]. Practical tools can support the use of image-based dietary records for both the collection of information on dietary intake and the analysis and interpretation of food and nutrient intake data. However, their use in clinical

settings is limited if these tools are not convenient, and validation is required to support manual analysis of image-based dietary records by dietitians.

Previous methods of image-based dietary assessment have been examined in healthy adult [91-93, 195, 196], adolescent [87, 90], and child [88] populations, in overweight and obese adults [94], and in type 2 diabetes [86, 95]. To our knowledge, no studies to date have examined the use of image-based dietary records in pregnant women or in Indigenous Australians. Dietary intake and nutritional status during pregnancy have important implications for foetal development and growth, and the long-term health of both mother and infant [5, 6, 197]. In Australia, women of childbearing age are at risk of not meeting targets for recommended dietary intake (RDI) [182, 198]. In particular, Indigenous women may experience structural barriers to optimal nutrition, including economic and geographical constraints to accessing food, and gaps in knowledge for choosing and preparing nutritious foods [184]. Novel lower-burden methods for dietary assessment and provision of feedback on nutrition warrant investigation and may be of benefit in these population groups.

The Diet Bytes and Baby Bumps (DBBB) study used image-based dietary records, captured via smartphone, in pregnant Indigenous and non-Indigenous women. The DBBB study sought to assess intake of AGTHE core and energy-dense, nutrient-poor food groups, total energy, and selected micronutrients, and to provide personalised feedback to these women via their smartphones, in combination with consultation with a dietitian.

The aims of this analysis were to evaluate the use of a brief approach to dietary analysis using a purpose-built Selected Nutrient and Diet Quality (SNaQ) tool to (1) assess nutrient intakes of pregnant women in the DBBB study, (2) assess the validity of the SNaQ tool for nutrient assessment, relative to analysis using nutrient analysis software, and (3) assess the acceptability of SNaQ to pregnant women for provision of feedback on dietary intake.

The DBBB study was approved by the Aboriginal Health and Medical Research Council Ethics committee (962/13), Hunter New England Human Research Ethics Committee (13/06/19/4.04) and the University of Newcastle Human Research Ethics Committee (H-2013-0185) (Appendix 10.12). The study was conducted in two locations in New South Wales (NSW), Australia: Newcastle, the second largest city in NSW, and Tamworth, a regional inland NSW town.

5.4 Methods

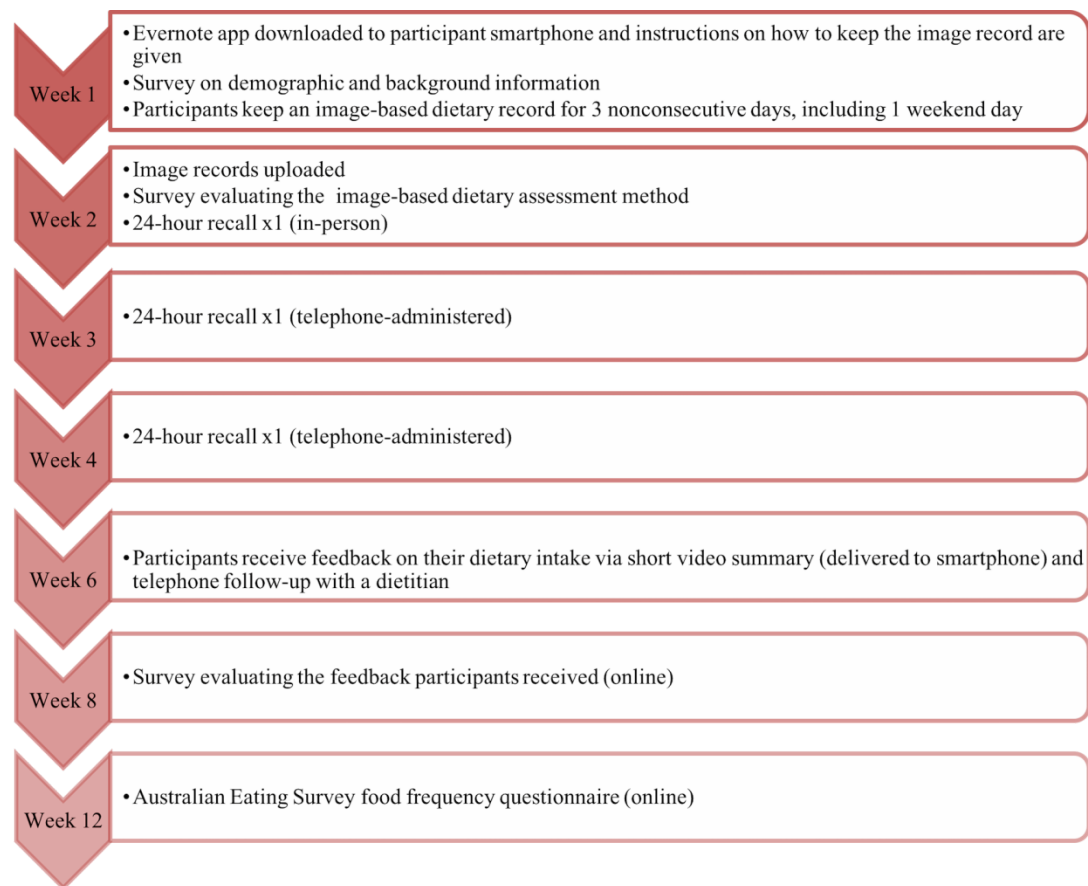
5.4.1 Participants and recruitment

We recruited participants via promotional fliers at hospital antenatal and general practitioner clinics, and the University of Newcastle, and through social media (including parenting sites), and through direct contact with pregnant women at antenatal clinics (Appendix 10.13). In Tamworth, participants were also invited to participate through the Gomeroi gaaynggal Centre [199], an Indigenous research and ArtsHealth centre. Participants were eligible if they were ≥ 18 years old, ≤ 24 weeks' gestation, lived in Newcastle or Tamworth, had no current medical conditions, owned a smartphone, and were willing to use it to record their dietary intake for 3 days (Appendices 10.14 and 10.15).

5.4.2 Surveys and study timeline

The study ran for 12 weeks (Figure 5.1). Participants collected image-based dietary records in week 1, completed three 24-hour food recalls (in weeks 2, 3, and 4), received feedback on their dietary intake in week 6, and completed the Australian Eating Survey food frequency questionnaire in week 12 [126]. Participants completed 3 online surveys over the course of the study to provide demographic and background data (week 1, in-person study visit); evaluate the image-based dietary assessment method (week 2, in-person study visit); and evaluate the feedback on dietary intake that participants received (week 8, survey link sent via email).

Figure 5.1 Diet Bytes and Baby Bumps study protocol

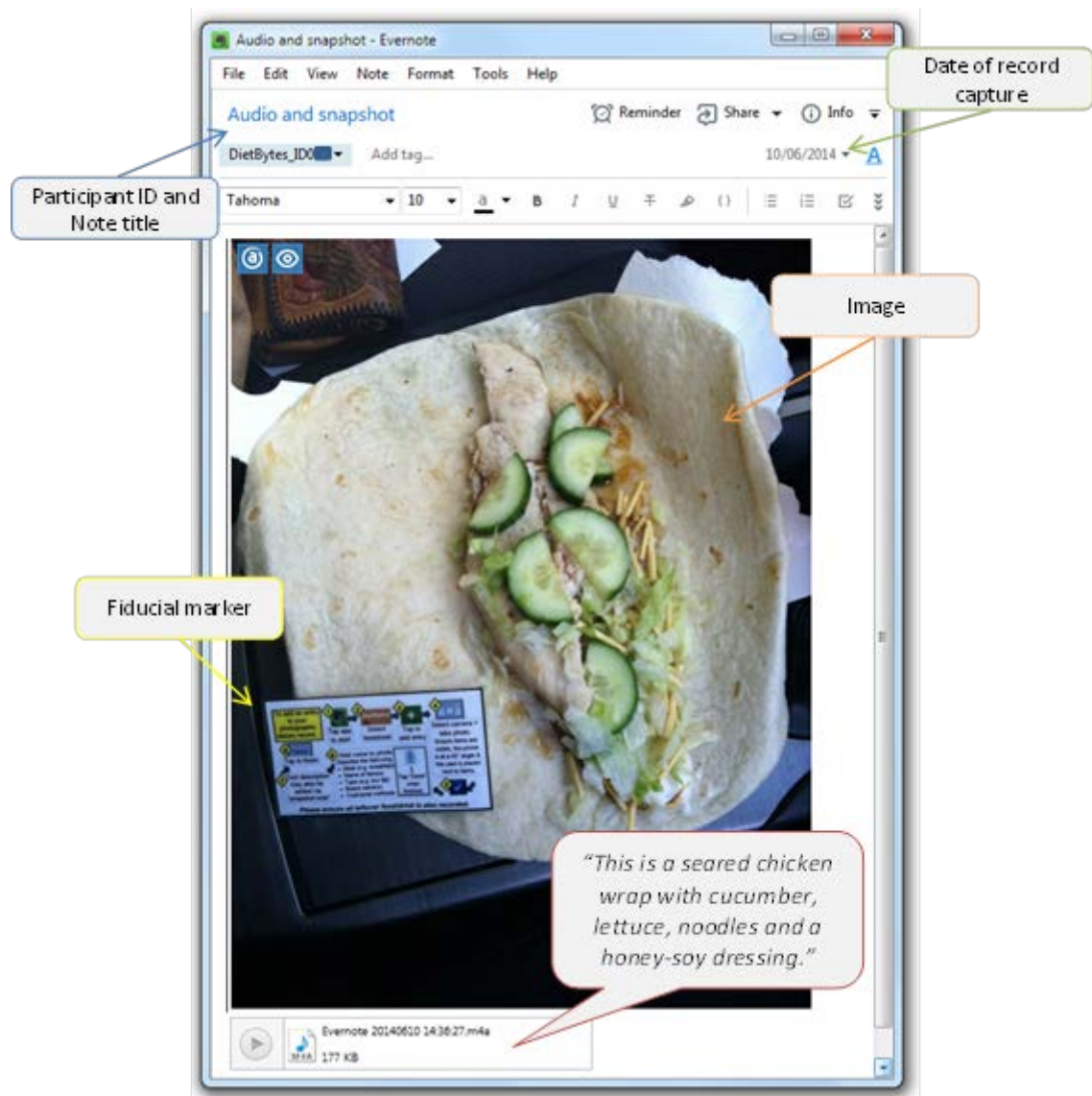


5.4.3 Diet Bytes method

We modelled the method of capturing dietary intake using image-based records on our previous validated method in adults with type 2 diabetes [86, 95]. However, in this study, to record dietary intake, participants used Evernote (Evernote Corporation, Redwood City, CA, USA), a free file-sharing and note-taking app for computers and smartphones. The Evernote app was downloaded onto participants' smartphones during the first appointment. Participants were not expected to have any prior experience using the Evernote app. They were provided with training at the first appointment on how to use the app to record dietary intake and completed a test entry. The app was used to capture each eating occasion through notes or entries into a notebook (the dietary record). For the purpose of this study, the study team set up a shared notebook to allow the entries to be recorded. This notebook could only be viewed by the individual study participant and the research team who had access to the Evernote Diet Bytes account. We adjusted settings for

Evernote so that the contents of the notebook were shared only with the research team over a Wi-Fi connection, so as not to use participants' data. Participants also had the option of disabling their home Wi-Fi connection during the collection period (week 1), with the images then transmitted during the second study appointment (week 2) over the research centre's Wi-Fi connection. Participants were asked to collect information on all food, drinks, and nutritional supplements, such as prenatal vitamin and minerals, consumed over 3 nonconsecutive days, including 1 weekend day. Each eating occasion consisted of a note taken through the app, including an image of the food or drink items for consumption, with a fiducial marker (reference object) placed next to the items. Participants were also required to annotate a text or voice description, or both, of the image's contents with information relating to cooking methods, brands, and types of foods (Figure 5.2). Any food or drink not consumed was captured using the same process. Participants were encouraged to label each eating occasion at data entry (eg "Breakfast day 1"). However, the Evernote app automatically captured the date and time when records are made, which assisted with determining when meals were consumed.

Figure 5.2 Example of an image-based dietary record in the Diet Bytes and Baby Bumps study, consisting of image, fiducial marker, and audio description of the food and drink items



5.4.4 The SNaQ tool

The SNaQ tool was developed as a brief tool to analyse participants' dietary intake relative to AGTHE daily servings of core and energy-dense, nutrient-poor foods. We estimated key nutrients important during pregnancy (folate, calcium, iron, zinc, and iodine) based on average nutrient composition of the food group servings, using the Australian Food, Supplement & Nutrient Database (AUSNUT) 2007 [157] food composition tables embedded in the SNaQ tool, plus nutrients from micronutrient supplements consumed.

A portion size estimation aid (PSEA) included in the tool assisted with portion size quantification. The PSEA contained 80 photographs of a variety of AGTHE foods and drinks displayed in recommended serving sizes. The dietitian analysing food portions compared the image from the image-based dietary record with images in the PSEA, in order to quantify portion size of the food and drink items in terms of number of AGTHE servings (see Figure 5.3). The text or voice description supplementing the image-based record further assisted with quantification. Mixed dishes and meals were broken down into their composite food groups. The image-based dietary records were first analysed separately by 2 dietitians, who later conferred to confirm participant dietary intakes. Feedback was provided to participants in week 6 of the study, via a short (1 minute) video designed to relay a simple, visual summary of food group intake compared with AGTHE recommendations. The video was transmitted to the Diet Bytes notebook, through the Evernote app on participants' smartphones. Participants were sent a text message informing them that their feedback was available to view. The video could be paused and replayed as often as desired. Participants were given a few days to view their feedback and were then contacted later in the week by a dietitian for a telephone consultation. In the telephone conversation, results were discussed in greater detail, including core and energy-dense, nutrient-poor food group results and intakes of selected nutrients, to provide practical tailored examples of foods and serving sizes to optimize the participant's pregnancy dietary intake.

Figure 5.3 The Selected Nutrient and Diet Quality (SNaQ) analysis tool and portion size estimation aid (PSEA) for analysis of image-based dietary records in the Diet Bytes and Baby Bumps study

THE UNIVERSITY OF NEWCASTLE AUSTRALIA		ID: XXX	Time of entry	Meal/Snack Occasion	Description	AGTHE Sub-Food Group and Serve Size	Approx no. of AGTHE Serve(s)
SNaQ - PSEA		Date: 1/01/14	7:30:00 AM	Meal/Snack 1	Toast, multigrain x 2 sl	BREAD: 1 slice of bread (about 40g) or 1/2 medium roll (about 40g) or 1 flatbread (about 40g)	2.0
		Day: Tuks		Meal/Snack 1	butter	BUTTER: 1 tablespoon (20g) butter	0.5
			10:00:00 AM	Meal/Snack 2	jam	JAM/HONEY: 1 tablespoons (60g) jam/honey	0.5
				Meal/Snack 2	tinned peaches	FRUIT OTHER: 150g (1 cup) diced, cooked or canned fruit	3.0
				Meal/Snack 2	yoghurt, fruit, veg fat	YOGHURT: 200g (1/2 cup or 1 small carton) yoghurt	1.0
			1:15:00 PM	Meal/Snack 3	bread, white x 2sl	BREAD: 1 slice of bread (about 40g) or 1/2 medium roll (about 40g) or 1 flatbread (about 40g)	2.0
				Meal/Snack 3	ham	PROCD MEATS: 2 slices (50-60g) processed meats, salami or mettwurst	3.0
				Meal/Snack 3	tomato	SALAD VEG: 75g (1 cup) raw salad vegetables	0.5

AGTHE Summary - Example Day	
Food Group	Day
Grain (cereal) foods	4.0
Vegetables	3.0
Fruit	3.0
Legumes, nuts and seeds	1.0
Dairy, yoghurt, cheese and alternatives	3.0
Protein foods, fish, eggs, tofu, nuts and seeds, legumes/beans	3.0
Saturated fats and oils	3.0
Alcohol	4.0
Other	2.0

Selected Nutrient Analysis - Example Day	
Nutrient	Day
Energy (kJ)	528.1
Protein (g)	625.2
Carbohydrate (g)	13.8
Fat (g)	29.9
Fibre (g)	45.5

5.4.5 Statistical analysis

We entered image-based dietary records into the nutrient composition software FoodWorks Professional version 7.0.3016 (Xyris Software [Australia] Pty Ltd) using the nutrient composition tables AUSNUT 2007 [157] (with “foods”, “brands” and “supplements” selected). The PSEA assisted with the portion size estimation of the images for the FoodWorks entry using the same approach as for the SNaQ analysis, including the use of the image and text description for clarification of quantities, types, and brands of food and cooking methods. Data entered into the SNaQ tool, including information on the estimation of portion size, were not used during the analysis of the image-based records in FoodWorks software. We developed a protocol to standardise the entry of image-based dietary records into FoodWorks, including common assumptions made. For example, if the amount of butter or margarine on a piece of bread was unspecified, we assumed 1 teaspoon per slice, and used the “not further specified” option for food types where possible when further details were not provided. Intraclass correlation coefficients for FoodWorks entries of the image-based records between 2 dietitians for a sub-sample of 10 participant records showed substantial agreement for energy and the selected micronutrients iron, folate, calcium, iodine, and zinc, in the range of .79–.99, all

$P < .05$. One dietitian subsequently entered all image records into FoodWorks. We ascertained relative validity of the SNaQ tool in estimating participants' total energy and selected nutrient intakes by comparison with the FoodWorks nutrient assessment of the image-based dietary records, and assessed by the strength of the relationship using Spearman rank correlation coefficients (ρ) and agreement between the methods using Cohen kappa. Analyses were performed using IBM SPSS statistical software version 23.0 (IBM Corporation). We took an inductive approach to analyse short qualitative responses on participants' perceived acceptability of the feedback received [109].

5.5 Results

5.5.1 Characteristics of participants

We enrolled 27 women in the DBBB study, with a median (interquartile range) age 28.8 (27.5–32.5) years, with 1 participant withdrawing due to time constraints. Of the remaining 26 participants, all were born in Australia, 8 (31%) identified as being of Indigenous descent, and all spoke only English at home. At study enrolment, 4 (15%) participants smoked tobacco products. At enrolment, participants ranged from 6 to 24 weeks gestation, with a mean (SD) of 18 (5) weeks. A total of 4 participants were in their first trimester of pregnancy, and 22 in their second trimester. For 15 (58%) participants it was the first pregnancy; 14 (54%) participants had an undergraduate or postgraduate university degree; and 2 developed health conditions (gestational diabetes and anaemia) during the study.

Over half ($n=17$, 65%) had received nutrition advice from a health professional previously, although only 5 (19%) had received advice from a dietitian. Other sources of nutrition advice came from general practitioner ($n=10$, 38%), midwife ($n=5$, 19%), obstetrician ($n=1$, 4%), or an antenatal clinic ($n=1$, 4%). Advice received focused on use of multivitamin supplements ($n=12$, 46%), managing morning sickness ($n=7$, 27%), healthy eating throughout pregnancy ($n=7$, 27%), weight gain during pregnancy ($n=5$, 19%), healthy eating during breastfeeding ($n=5$, 19%), or breastfeeding ($n=4$, 15%). Participants had also accessed pregnancy nutrition information from other sources, including friends ($n=11$, 42%), nongovernment

websites (n=11, 42%), family (n=10, 38%), government websites (n=9, 35%), smartphone apps (n=7, 27%), and community groups, including mothers' groups (n=2, 8%); 3 (12%) participants had not accessed any of these sources of information. A total of 11 (42%) participants felt they had received enough information about healthy eating for themselves and their baby at the time of enrolment, 13 (50%) were unsure, and 2 (8%) said they had not received enough information.

All participants used their smartphones for sending text messages (short message service, SMS) (n=26, 100%), and the majority for receiving SMS (n=25, 96%), searching or browsing the Internet (n=25, 96%), making voice calls (n=24, 92%), taking photos (n=24, 92%), sending or uploading photos (n=24, 92%), using apps (n=22, 85%), and taking notes (n=20, 77%). Over half (n=16, 62%) used their smartphones for taking videos and 12 (46%) to send or upload these videos. The majority of participants (n=18, 69%) had an Apple iPhone, and 8 (31%) had a Google Android phone. Only 4 (15%) had used their smartphones for making voice recordings.

5.5.2 Food group intakes of pregnant women

Of the 26 participants, 24 (92%) recorded on all 3 days of the image-based dietary record, 1 participant recorded 2 days, and 1 recorded only 1 day. The participant recording on only 1 day was subsequently excluded from further analyses, and therefore further results are for the 25 participants with dietary records adequate for analysis. We used average food group and micronutrient intakes from participants' multiple-day image records for this analyses.

Table 5.1 summarises intakes of core and energy-dense, nutrient-poor foods. Median intakes of core food groups were close to recommendations for fruit and dairy, but did not meet recommendations for grains and cereals, vegetables, or meat, and exceeded recommendations for energy-dense, nutrient-poor foods. All Indigenous participants and approximately half (n=8, 47%) of non-Indigenous participants met recommendations for 0–2.5 daily servings of unsaturated spreads and oils.

Table 5.1 Intake of core foods as assessed by the Selected Nutrient and Diet Quality (SNaQ) brief analysis tool from the Diet Bytes and Baby Bumps image-based dietary records (n=25)

Food group	Food group intake in servings/day		AGTHE ^b recommended intake during pregnancy in servings/day	Meeting recommended intake of servings	
	Mean (SD)	Median (IQR ^a)		No. of servings	n (%)
All participants combined (n=25)					
Grains and cereals	4.8 (2.0)	4.7 (3.6–6.5)	8.5	≥8.5	1 (4)
Vegetables	2.4 (1.4)	2.2 (1.2–3.5)	5	≥5	1 (4)
Fruit	1.9 (1.6)	1.7 (0.9–2.5)	2	≥2	10 (40)
Lean meat	2.0 (1.0)	1.9 (1.4–2.9)	3.5	≥3.5	2 (8)
Dairy	2.1 (1.3)	1.8 (1.3–2.7)	2.5	≥2.5	10 (40)
Unsaturated spreads and oils	1.9 (1.4)	2.0 (0.5–3.0)	0–2.5	0–2.5	16 (64)
Energy-dense, nutrient-poor foods	3.7 (1.9)	3.5 (2.4–3.9)	0–2.5	0–2.5	7 (28)
Indigenous participants (n=8)					
Grains and cereals	4.7 (2.3)	4.3 (3.4–6.1)	8.5	≥8.5	1 (13)
Vegetables	2.0 (1.4)	1.6 (1.1–3.2)	5	≥5	0 (0)
Fruit	1.4 (1.9)	0.9 (0.0–2.3)	2	≥2	2 (25)
Lean meat	1.6 (0.9)	1.5 (0.8–2.0)	3.5	≥3.5	0 (0)
Dairy	2.5 (1.9)	2.3 (1.0–3.4)	2.5	≥2.5	4 (50)
Unsaturated spreads and oils	0.8 (0.8)	0.7 (0.8–1.7)	0–2.5	0–2.5	8 (100)
Energy-dense, nutrient-poor foods	4.1 (2.9)	3.7 (1.6–7.1)	0–2.5	0–2.5	2 (25)

Non-Indigenous participants (n=17)					
Grains and cereals	4.9 (1.9)	4.9 (3.6–6.9)	8.5	≥8.5	0 (0)
Vegetables	2.6 (1.4)	2.4 (1.7–3.5)	5	≥5	1 (6)
Fruit	2.2 (1.4)	1.8 (1.4–2.7)	2	≥2	8 (47)
Lean meat	2.2 (1.0)	2.0 (1.7–3.1)	3.5	≥3.5	2 (12)
Dairy	1.9 (0.9)	1.7 (1.3–2.7)	2.5	≥2.5	6 (36)
Unsaturated spreads and oils	2.3 (1.4)	2.8 (1.0–3.3)	0–2.5	0–2.5	8 (47)
Energy-dense, nutrient-poor foods	3.5 (1.3)	3.5 (2.4–3.9)	0–2.5	0–2.5	5 (29)

^aIQR: interquartile range (25th–75th percentiles).

^bAGTHE: *Australian Guide to Healthy Eating* [47]. Examples of serving sizes of foods: grains and cereals (standard serving 500 kJ), e.g., 1 slice of bread, 0.5 cup cooked grain; vegetables (standard serving 75 g, 100–350 kJ), e.g., 0.5 cup cooked vegetables, 1 cup raw vegetables, 0.5 medium potato; fruit (standard serving 150 g, 350 kJ), e.g., 1 medium piece, 2 small pieces, 125 mL fruit juice (no added sugar, only occasionally); lean meats and alternatives (standard serving 500–600 kJ), e.g., 65 g cooked lean red meats, 80 g cooked lean poultry, 100 g cooked fish, 2 large eggs, 1 cup cooked legumes or beans; dairy and alternatives (standard serving 500–600 kJ), e.g., 1 cup milk, 2 slices (40 g) hard cheese, 0.75 cup yoghurt, 60 g sardines; unsaturated spreads and oils (standard serving 250 kJ), e.g., 10 g unsaturated spread, 7 g unsaturated oil, 10 g nuts; energy-dense, nutrient-poor foods (standard serving 600 kJ), e.g., 2 scoops ice cream, 50–60 g processed meats, 1 can soft drink, 12 hot chips, 200 mL wine.

5.5.3 Relative Validity of the SNaQ Tool for Nutrient Assessment

Table 5.2 reports the correlations (Spearman correlation coefficients) and agreement (Cohen kappa) between nutrient values assessed from the SNaQ tool and from nutrient analysis software. Agreement was not substantial between the two methods for total energy (kappa=.031, $P=.67$). Correlation coefficients for nutrient intakes assessed by the two methods of analysing the image-based dietary records ranged from $\rho = .791$ to $\rho = .955$ (all $P<.001$) for key micronutrients (iron, folate, calcium, zinc, and iodine) when supplements were included in the analysis (kappa range .488–.803, all $P\leq .001$). With supplement use excluded, correlations ranged from $\rho = .510$ to $\rho = .888$ (all $P<.05$). Agreement between the two analysis methods, ascertained via Cohen kappa, was significant for calcium (kappa=.544, $P<.001$),

iodine ($\kappa=.632$, $P<.001$), and zinc ($\kappa=.572$, $P<.001$). Agreement was poor for folate when supplement use was not included ($\kappa=-.068$, $P=.52$). Both the SNaQ tool and FoodWorks analyses identified that no participant met the estimated average requirement (EAR) for iron of 22 mg when supplement use was not included.

Table 5.2 Correlation and agreement for energy and selected nutrient intake from mean 3-day image-based dietary records in the Diet Bytes and Baby Bumps study (n=25 participants) analysed by the Selected Nutrient and Diet Quality (SNaQ) tool and FoodWorks (FW) nutrient analysis software

Nutrient	Method	Input, median (IQR ^a)	ρ (P value)	n (%) <EAR ^b	n (%) ≥EAR to <RDI ^c	n (%) ≥RDI	Cohen kappa (P value)
Intake from Food and Supplements							
Energy (kJ/day)	SNaQ	8418.33 (7755.83,10004.17)	.898 (<.001)		N/A ^d		.031 ^e (.67)
	FW	7738.89 (6329.94, 8995.05)					
Iron (mg/day)	SNaQ	11.30 (8.93, 15.08)	.812 (<.001)	21(84)	0(0)	4(16)	.533 (<.001)
	FW	13.54 (10.75, 21.47)		19 (76)	3(12)	3(12)	
Calcium (mg/day)	SNaQ	877.36 (653.74, 1181.60)	.791 (<.001)	12(48)	4(16)	9(36)	.488 (.001)
	FW	831.01 (672.39, 1000.89)		13(52)	6(24)	6(24)	
Folate, total DFE ^f (µg/day)	SNaQ	851.90 (225.15, 1156.15)	.893 (<.001)	11(44)	1(4)	13(52)	.559 (.001)
	FW	820.20 (393.53, 1383.00)		8(32)	2(8)	15(60)	
Iodine (µg/day)	SNaQ	167.00 (93.52, 311.28)	.955 (<.001)	11(44)	4(16)	10(40)	.803 (<.001)
	FW	171.42 (92.58, 300.20)		12(48)	3(12)	10(40)	
Zinc (mg/day)	SNaQ	13.09 (10.46, 19.56)	.905 (<.001)	3(12)	4(16)	18(72)	.741 (<.001)
	FW	14.66 (10.24, 21.24)		3(12)	5(20)	17(68)	
Intake from Food Only, Supplements Excluded							
Energy (kJ/day)	SNaQ	8418.33 (7755.83,10004.17)	.898 (.000)		n/a		.031 ^e (.67)
	FW	7738.89 (6329.94, 8995.05)					
Iron	SNaQ	9.50 (7.70, 10.85)	.510	25 (100)	0 (0)	0 (0)	Constants no statistics

Nutrient	Method	Input, median (IQR ^a)	ρ (<i>P</i> value)	n (%) <EAR ^b	n (%) \geq EAR to <RDI ^c	n (%) \geq RDI	Cohen kappa (<i>P</i> value)
(mg/day)	FW	11.78 (8.53, 13.73)	(.009)	25 (100)	0 (0)	0 (0)	computed
Calcium (mg/day)	SNaQ	809.90 (653.75, 1181.70)	.888	14 (56)	2 (8)	9 (36)	.554 (<.001)
	FW	736.61 (663.19, 927.37)	(<.001)	17 (68)	3 (12)	5 (20)	
Folate, total DFE ^s (µg/day)	SNaQ	319.00 (240.25, 433.35)	.600	21 (84)	4 (16)	0 (0)	-.068 (.52)
	FW	409.79 (259.74, 642.22)	(.002)	16 (64)	2 (8)	7 (28)	
Iodine (µg/day)	SNaQ	99.00 (79.80, 139.05)	.850	22 (88)	2 (8)	1 (4)	.632 (<.001)
	FW	104.25 (86.46, 130.95)	(<.001)	22 (88)	2 (8)	1 (4)	
Zinc (mg/day)	SNaQ	10.60 (8.40, 13.10)	.745	7 (28)	6 (24)	12 (48)	.572 (<.001)
	FW	10.63 (8.89, 13.47)	(<.001)	6 (24)	9 (36)	10 (40)	

^aIQR: interquartile range (25th–75th percentiles).

^bEAR: estimated average requirement. EAR is a nutrient level estimated to meet the requirements of 50% of the healthy individuals in a life stage or gender group, per day (EARs for nutrients as follows: iron 22 mg, calcium 840 mg, folate 520 µg, iodine 160 µg, zinc 9 mg) [183].

^cRDI: recommended dietary intake. RDI is the average dietary intake level sufficient to meet nutrient requirements of 97% to 98% of healthy individuals in a life stage or gender group, per day (RDIs for nutrients as follows: iron 27 mg, calcium 1000 mg, folate 600 µg, iodine 220 µg, zinc 11 mg) [183].

^dN/A: not applicable.

^eKappa for energy intake in categories of 1000 kJ.

^fDFE: dietary folate equivalents.

5.5.4 Acceptability of Receiving Feedback on Dietary Intake

Table 5.3 and Table 5.4 summarise participants' perceived acceptability of receiving nutrition feedback. Over three-quarters (n=17, 77%) of the 22 participants who responded to the final survey reported that they had made dietary changes as a result of the personalised nutrition feedback. Changes to the type of foods consumed fell into three categories: (1) food groups or individual foods, including eating more red meat, vegetables, fruit, and individual foods like Milo, yoghurt, cheese, and crackers; (2) nutrients, including consuming more foods higher in iron, calcium, and protein, or continuing or starting to take a prenatal vitamin or mineral supplement; and (3) changes to eating behaviours, including increasing snack occasions. Some participants reported eating greater quantities of foods from the core food groups, while others reported eating smaller amounts of some unspecified foods, and consuming less soft drink and "junk" foods. Some participants reported changes to cooking methods related to meat and vegetables, such as steaming vegetables, and using cooking spray rather than oil or butter to cook meat. When asked if participants had changed how they monitored their dietary intake, 1 participant reported sometimes using an app (not Evernote) to record her intake, although this was a behaviour in place prior to the study.

Table 5.3 Participant's perceived acceptability for receiving dietary counselling in the Diet Bytes and Baby Bumps (n=22^a) (survey questions with agree-disagree responses).

Questions	Strongly agree n (%)	Agree n (%)	Neutral n (%)	Disagree n (%)	Strongly disagree n (%)
I believe that the combination of the summary of my dietary intake that I received via my mobile/smartphone and the follow-up with the dietitian was helpful.	12 (55)	9 (41)	1 (5)	0 (0)	0 (0)
The summary of my dietary intake that I received via my mobile/smartphone was easy to understand on its own. I did not need to speak to a dietitian to clarify.	2 (9)	5 (23)	6 (27)	8 (36)	1 (5)
The summary of my dietary intake that I received via my mobile/smartphone was	0 (0)	2 (9)	3 (14)	13 (59)	4 (18)

difficult to understand.					
Neither the summary of the results from the analysis of my photographic dietary record that I received on my mobile/smartphone nor the advice that I received from the dietitian was helpful.	0 (0)	1 (5)	1 (5)	4 (18)	16 (73)

^an=22. Two participants did not receive the telephone counselling (1 gave birth before it could be given and 1 did not respond to contact) and 2 participants did not answer this survey.

Table 5.4 Participant's perceived acceptability for receiving dietary counselling in the Diet Bytes and Baby Bumps study (n=22^a) (survey questions with yes/no responses).

Questions	Yes, n (%)	No, n (%)
I have changed my diet as a result of the nutrition advice that I received as part of this study.	17 (77)	5 (23)
I have changed the kinds of foods I eat.	16 (73)	6 (27)
I have changed the amount of food I eat.	8 (36)	14 (64)
I have changed the cooking methods I use.	3 (14)	19 (86)
I have changed how I keep track of what I eat and drink.	5 (23)	17 (77)
I have made other changes.	1 (5)	21 (95)

^an=22. Two participants did not receive the telephone counselling (1 gave birth before it could be given and 1 did not respond to contact) and 2 participants did not answer this survey.

Some participants thought the advice from a dietitian was useful and helped to clarify the feedback provided via the video summary; for example:

"...the phone consult was very useful to me. Without this the written feedback would have been far less meaningful. I did like the visual graphs to help me understand the information." [27 years old, first baby]

Additionally, another participant commented:

"It was very detailed and thorough and easier to understand what should be done to improve my diet compared to the diet summary received on Evernote." [32 years old, first baby]

Others reported not making changes as a result of the feedback, due to already meeting requirements or not being able to fit all the recommended servings into their daily intake.

Some participants felt that DBBB could be improved by keeping the image-based records for a longer duration and by taking notes, rather than images, for certain foods such as snacks and water. More SMS reminders were requested, as some participants reported forgetting to take images. One commented that having to take an image before eating when you were hungry was inconvenient:

"It's inconvenient to take pictures of food before eating when hungry (which is most of the time), however I think this is a useful way of assessing dietary intake." [27 years old, first baby]

The majority of respondents (n=18, 82%), preferred receiving nutrition feedback via the combination of the video summary and follow-up telephone consultation with a dietitian. One indicated that she preferred the video feedback alone, and 3 preferred the consultation with the dietitian alone. Only 1 participant indicated an alternative method for receiving nutrition advice, via a printable email summary.

5.6 Discussion

We observed strong positive correlations between the SNaQ tool and the nutrient analysis software for estimates of total energy intake and all selected micronutrients (iron, calcium, zinc, folate, and iodine), both with and without micronutrient supplements included in the analysis. However, SNaQ overestimated energy intake compared with the FoodWorks analysis (8418kJ vs 7739kJ) and underestimated intakes of some micronutrients (iron, iodine, and zinc when supplements were included in the analysis; iron, folate, and iodine when supplements were excluded). The relatively minor differences in intakes were not clinically important differences, as evidenced by the comparison of classifications of nutrient intake adequacy (EAR, RDI) using Cohen kappa (in Table 5.2). Agreement is considered moderate if $.41 \leq \text{kappa} \leq .6$ and substantial if $.61 \leq \text{kappa} \leq .8$ [200]. Cohen kappa indicated moderate agreement (kappa range .488–.559, all $P \leq .001$) between the two methods for assessing adequacy of nutrient intakes of iron, calcium, and folate, and substantial agreement for iodine (kappa=.803, $P < .001$) and zinc (kappa=.741, $P < .001$), when supplements were included in the analysis. When supplements were excluded from

the analysis, there was moderate agreement for calcium ($\kappa=.554$, $P<.001$) and zinc ($\kappa=.572$, $P<.001$), and substantial agreement for iodine ($\kappa=.632$, $P<.001$). Future estimation of bias could be explored through criterion validity (i.e. comparison with objective measures of dietary intake such as nutritional biomarkers). However, this was beyond the scope of our study, which aimed to assess the relative validity of the SNaQ tool compared to nutrient intakes assessed using dietary composition software.

Specifically designed as a brief tool, the SNaQ tool therefore did not include all foods within the food composition database, and as such may have underestimated some micronutrients. When we removed supplements from the analysis, the SNaQ tool did not show significant agreement with the nutrient software analysis for folate ($\kappa=-.068$, $P=.52$). While the nutrient software analysis indicated that 9 participants had nutrient intakes meeting or greater than the EAR of 520 μg , SNaQ showed that only 4 participants had intakes that met the EAR. This may be related to the inclusion of Vegemite (a yeast-based spread) in the image-based records of 7 participants (28%) who ate this food on at least 1 record day. A serving (5g) of Vegemite provides 100 μg folate (19% of the pregnancy EAR) [201], and so pregnant women may be able to meet their requirements without supplements on certain days, if they consume specific folate-rich foods. As the aim of the SNaQ tool was to also provide a food group analysis of participant diets, we did not include some foods that do not fall into food group categories in the SNaQ (eg, gravy, Vegemite, tomato sauce and some other condiments, salt, and fortified foods like Nestlé Milo). This has highlighted that future modifications to SNaQ may be required to better reflect foods commonly consumed by pregnant women.

The majority of pregnant women in the DBBB study did not meet the recommended AGTHE target for daily servings of grain and cereal foods, vegetables, fruit, meat, and dairy. The median daily servings of unsaturated spreads and oils met recommendations, while median intakes of energy-dense, nutrient-poor foods exceeded recommendations, with less than a third of participants consuming within the target 0–2.5 servings per day. When we

evaluated food intakes excluding micronutrient supplements, both the SNaQ and nutrient composition software showed that median intakes of selected key micronutrients important in pregnancy were lower than the EAR for iron, calcium, folate, and iodine. When we included vitamin and mineral supplements use, the median intake of iron was still below the EAR.

Intakes of energy-dense, nutrient-poor foods were high, with the majority (n=18, 72%) exceeding the maximum target of 2.5 servings/day. In other cohorts of pregnant Australian women, it has been reported that meeting AGTHE and NRV targets is challenging [202]. Pregnant women have higher requirements for some nutrients, including folate, iron, zinc, and iodine [183]. Australia-wide in 2011–2012, 11.7% of non-pregnant women aged 19–30 years did not meet the EAR for iodine, 10.9% for folate, 13.5% for zinc, 37.5% for iron, and 71.3% for calcium [182]. In addition, within the Australian Longitudinal Study on Women's Health (ALSWH) cohort, sub-optimal intakes of core foods and nutrients in pregnant women were common [202, 203]. Only 1.5% of the 606 pregnant participants achieved the NRVs for key micronutrients, with no pregnant woman meeting AGTHE target intakes for all food groups and median intakes of energy-dense, nutrient-poor choices exceeding recommendations [202]. However, ALSWH highlighted that women who consumed more daily servings of fruit and dairy than the AGTHE targets met pregnancy NRVs, as did consuming more than the 2.5 daily servings of energy-dense, nutrient-poor foods, although this was associated with higher total energy and saturated fat intakes [202]. This indicates that provision of personalised nutrition advice to optimise diet quality and nutrient intake in pregnancy is warranted. While AGTHE serving sizes and recommended numbers of servings have been revised since this time, including an increase in recommendations from 1.5 to 3.5 servings of meat, and an additional half serving of dairy foods, dietary intakes are still of concern. In the DBBB cohort the median intake from AGTHE food groups did not meet the revised targets for non-pregnant women, with less than 10% meeting targets for daily servings of meat (n=2, 8%), vegetables (n=1, 4%), and grain foods (n=1, 4%), and less than half meeting targets for fruit (n=10, 40%) and dairy (n=10, 40%).

Prior to being in the study, less than half (n=12, 46%) of participants had received information on prenatal nutrient supplements (including folic acid and iron) during their pregnancy, although the results of this study imply that micronutrient supplementation use may help women meet pregnancy EARs, particularly for iron, folate, and iodine. Only approximately a quarter of participants (n=7, 27%) had received advice on healthy eating during pregnancy prior to the study. Nutrition knowledge among pregnant women in Australia is suboptimal, with one cross-sectional study of 400 pregnant women showing that over half (65%) of participants were not familiar with AGTHE recommendations [204, 205]. However, high motivation among pregnant women to adopt healthy eating behaviours [205] and increased awareness of nutrition during pregnancy [206] imply that pregnancy may be an opportune time for health professionals to intervene to improve women's nutrition-related knowledge. The results from the DBBB study further suggest that pregnant women could potentially benefit from receiving personalised nutrient intake assessment and provision of information. This was supported by the less than half (n=11, 42%) of participants who reported they felt they had received enough information about healthy eating for themselves and their baby at the time of enrolment, and a high proportion of participants who reported changes to their dietary intake in response to receiving tailored feedback.

The majority (n=17, 77%) of participants who completed the final survey reported that they had made changes to their dietary intake as a result of receiving the personalised feedback, which consisted of the video summary and the telephone consultation with the dietitian. The preferred method of receiving dietary advice was from the video summary and the dietitian consultation combined, with 95% (n=21) of participants agreeing that this combined way of receiving feedback was helpful. Previous research in the area of apps for dietary feedback during pregnancy supports our findings in this study. A recent evaluation of a Dutch online coaching program delivered by a mobile health platform (called Smarter Pregnancy) resulted in improvements in vegetable, fruit, and folic acid intake in pregnant women, although these were not statistically significant, and high compliance with positive feedback from participants was reported [207]. Likewise,

results from the pilot study of the Eating4two app, to monitor gestational weight, was viewed favourably by participants as a method to assist in supporting healthy pregnancy dietary behaviours [208]. Dietary advice during pregnancy can come from multiple sources (as reported by DBBB participants), and can be confusing and contradictory [209], and it is therefore promising that this method was perceived as acceptable by participants. Furthermore, the feedback received indicates that the Diet Bytes method is promising and warrants future testing in randomised controlled studies to establish the efficacy of using a personalised smartphone method for improving pregnancy food and nutrient intakes [210].

5.6.1 Limitations

Limitations of our study include the small sample size of 25 participants completing the study protocol. A review [85] of image-based dietary assessment methods found that validation studies using this method to date have been conducted in sample sizes ranging from 9 [211] to 75 [92] participants. Given the small sample size and the wide variety of foods available in the Australian food supply, more days of recorded dietary intake may have been required to optimise accuracy of estimated food intake. In relation to the quantification of food portions contained in the image-based records, we attempted to reduce the introduction of bias during the analysis. Coding and entry of the records using the SNaQ tool and FoodWorks were performed independently at separate time points, and information on the estimations of portion size made using the SNaQ tool was not available to the dietitian during the FoodWorks analysis. Despite this, it is possible that estimations of portion size made using the SNaQ tool may have influenced the FoodWorks analysis for the first dietitian. However, the subsample (10 participants) analysis of the image-based records by a second dietitian (using FoodWorks only) showed high agreement with the analysis of the first dietitian, suggesting that any impact may have been small. At the time of developing the SNaQ tool, AUSNUT2007 was the most recent nutrient composition database available, and this was embedded in the SNaQ tool and also used for the FoodWorks analysis. This database does not contain food group equivalents for each of the food items, and we therefore could

not establish intakes of AGHE food groups from FoodWorks. It is therefore a limitation of this study that we were unable to compare estimates of food group intakes between the two methods.

Participants in the DBBB study may not be representative of all Australian women. Those without smartphones were excluded from participating, and therefore these results may not be representative of women who are economically vulnerable or who have other reasons for not owning a smartphone. We did not collect data on prepregnancy weight and weight gain during pregnancy, and therefore we do not know whether study participants were achieving recommendations for appropriate pregnancy weight gain. The median age of DBBB study participants (28.8 years) was slightly lower than the NSW state median age of women giving birth in 2014 (31.2 years) [212] and may be indicative of the number of rural and Indigenous women in this study, who tend to have their children at a younger age [213]. Over half the participants had completed a university degree, compared with 29% of all women Australia-wide of working age (15–64 years) in 2015 [214]. However, this study purposively recruited Indigenous participants (n=8, 31%), to ensure their representation in the study was adequate for separate analyses. It should be noted that Australia-wide it is estimated that 3% of the population is Aboriginal or Torres Strait Islander [54]. Given that one of the recruitment avenues was through an Indigenous birth cohort to specifically target this population group, the high representation of Indigenous participants in this study is to be expected and is desirable given that the use of image-based dietary records has not been previously evaluated in this population.

5.7 Conclusions

To our knowledge, this study is the first to evaluate the use of image-based dietary records for dietary assessment in pregnant women, including Indigenous Australian women, and demonstrated that the SNaQ tool can adequately assess key nutrient intakes during pregnancy. With training and practice, the SNaQ tool has the potential to be both time and resource saving as a dietary assessment tool for dietitians, while reducing the burden of recording associated with traditional

methods for participants. Importantly this study highlights that using an image-based dietary record in combination with individual phone consultation with a dietitian for the provision of dietary feedback during pregnancy is acceptable. The Diet Bytes method for nutrition assessment and provision of personally tailored feedback may be a useful method for dietitians to assist women in optimising their food and nutrient intakes during pregnancy.

Chapter 6 Validation of a smartphone image-based dietary assessment method for pregnant women

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The work presented in this manuscript was completed in collaboration with the co-authors (Appendix 10.16) and permission to reproduce the published manuscript has been granted by the publishers (Appendix 10.17).

6.1 Overview

As discussed in section 1.4.4, image-based dietary assessment may limit some of the participant burden associated with traditional dietary records. The previous chapter demonstrated the validity of a brief tool for the analysis of nutrient intake adequacy of pregnant women, based on image-based dietary records. In this chapter, the relative validity of the image-based dietary assessment method against 24-hour food recalls is evaluated. The manuscript commences from section 6.2.

6.2 Abstract

Image-based dietary records could lower participant burden associated with traditional prospective methods of dietary assessment. They have been used in children, adolescents and adults, but have not been evaluated in pregnant women. The current study evaluated relative validity of the DietBytes image-based dietary assessment method for assessing energy and nutrient intakes. Pregnant women collected image-based dietary records (via a smartphone app) of all food, drinks and supplements consumed over three non-consecutive days. Intakes from the image-based method were compared to intakes collected from three 24-hour recalls,

taken on random days; once per week, in the weeks following the image-based record. Data were analysed using nutrient analysis software. Agreement between methods was ascertained using Pearson correlations and Bland-Altman plots. Twenty-five women (27 recruited, one withdrew, one incomplete), median age 29 years, 15 primiparas, eight Aboriginal Australians, completed image-based records for analysis. Significant correlations between the two methods were observed for energy, macronutrients and fibre ($r=0.58-0.84$, all $P<.05$), and for micronutrients both including ($r=0.47-0.94$, all $P<.05$) and excluding ($r=0.40-0.85$, all $P<.05$) supplements in the analysis. Bland-Altman plots confirmed acceptable agreement with no systematic bias. The DietBytes method demonstrated acceptable relative validity for assessment of nutrient intakes of pregnant women.

6.3 Introduction

Pregnant women have unique nutrition requirements for growth and development of the foetus, and health of both mother and child [5, 47, 183]. However, in Australia women of childbearing age may be at risk of not meeting these recommendations during this period [182, 198, 202]. In order to assist pregnant women with optimising their dietary intake it is imperative to first ascertain what they are currently eating and drinking. Dietitians in all areas of practice depend on validated, reliable tools for the assessment of dietary intake [215]. Self-reported dietary intake is a feasible and practical way to establish intake in both clinical practice and research settings, although there are challenges associated with this method. Diet is complex, affected by food availability and personal preferences, and intake can vary on a day-to-day basis. Dietary assessment methods may be susceptible to bias, including under-reporting of energy intake [81, 82]. Prospective methods, including weighed and estimated food records, require the reporting of all food and drinks consumed. Weighing or estimating all foods may be burdensome for individuals, requiring high levels of motivation to keep accurate records [70], and accuracy can decrease if records need to be kept for more than four days [77]. The process of keeping records may result in changes to usual intake

[79, 80], and the act of keeping the records themselves requires a degree of numeracy and/or literacy skill from individuals [74, 216].

Image-based dietary records are emerging as a novel method for dietary assessment, and may be able to address some of the participant burden associated with traditional prospective methods such as weighed records. Their use involves capturing images of food and drinks consumed in order to support paper dietary records, or to act as standalone dietary records. Images can be transferred to a dietitian or other trained individual for analysis and interpretation, shifting the onus of estimating portion size from the individual to the dietitian [86]. Advancements in smartphone technology have resulted in a unique platform for the capture and relaying of image-based dietary records in real time. Smartphone ownership is prevalent, with 77% of Australian adults owning smartphones, and ownership is on the rise [97]. Smartphone features such as internet connectivity and built-in cameras support the use of this platform for collection of image-based dietary records. While the use of image-based or image-assisted dietary assessment has been explored in populations of healthy adults [91-94], children and adolescents [87, 88, 90], overweight and obese adults [94], and adults with type 2 diabetes [86, 95], their use has not been evaluated in pregnant women, warranting further investigation.

Importantly, the use of novel dietary assessment methods in new population groups requires validation in order for them to be utilised in a variety of research and clinical practice settings. The current study therefore reports on the evaluation of the DietBytes image-based dietary assessment method in a group of pregnant women, with a focus on Indigenous women. In the Diet Bytes and Baby Bumps study (DBBB) pregnant women used a smartphone application (app) to capture three-day image-based dietary records (the DietBytes method). The study aimed to: (1) assess the relative validity of image-based dietary records for assessment of intake of Indigenous and non-Indigenous Australian pregnant women, against three 24 hour (24-R) food recalls; (2) assess the inter-rater reliability between two independent dietitians in assessing 3-day image-based dietary records and 24-R

recalls in a sub-sample of participants (n=10); (3) assess the quality of image-based dietary records and voice/text description for analysis; (4) assess the perceived usability and acceptability of the image-based dietary assessment method by the pregnant women.

6.4 Materials and Methods

6.4.1 Ethics

DBBB was approved by the following ethics committees; Aboriginal Health and Medical Research Council Ethics Committee (Reference No. 962/13), Hunter New England Human Research Ethics Committee (HREC Reference No. 13/06/19/4.04) and the University of Newcastle Human Research Ethics Committee (Reference No. H-2013-0185).

6.4.2 Eligibility

Women were eligible for inclusion if they met the following criteria: ≤ 24 weeks gestation, aged ≥ 18 years, no current medical conditions (including gestational diabetes), ownership of or access to a smartphone capable of using the freely downloadable app Evernote® for smartphones and computers (Mobile and desktop application software, 2016 Evernote Corporation, Redwood City, CA, USA) and willingness to attend two in-person sessions. All participants gave written, informed consent.

6.4.3 Recruitment and Setting

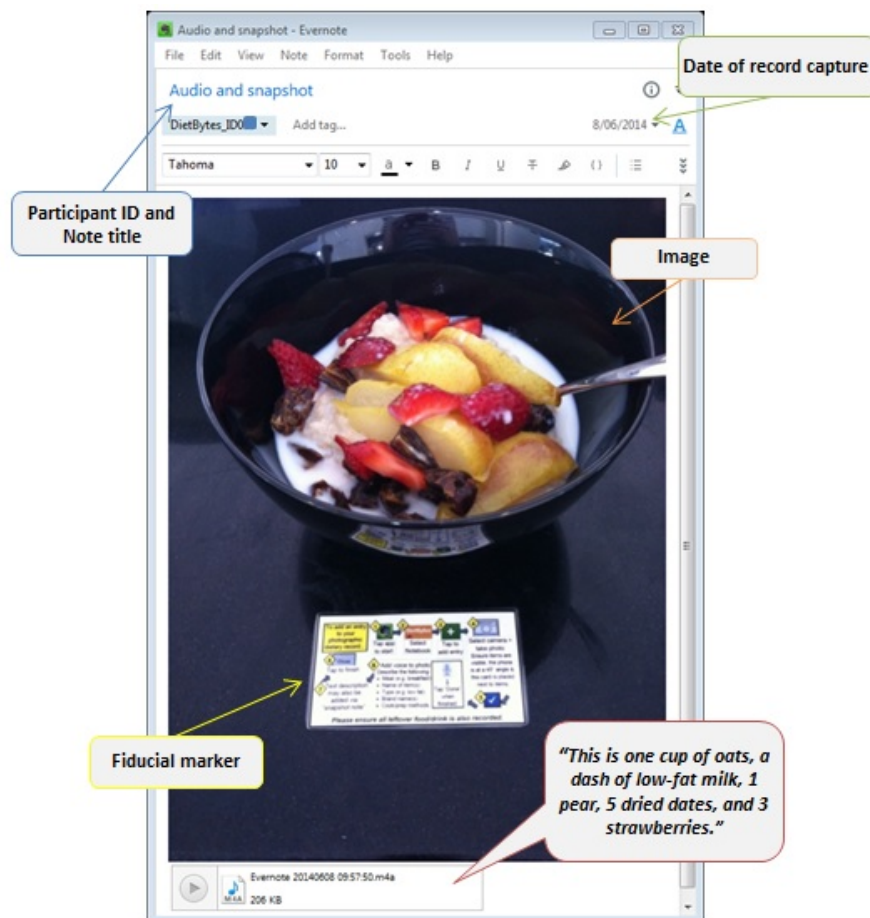
Recruitment for DBBB was conducted in Tamworth, a regional inland town in New South Wales (NSW), and Newcastle, the second largest city in NSW, Australia. Participants were recruited at antenatal clinics by members of the research team at both sites. In addition, the study was advertised via promotional fliers at hospital antenatal and general practitioner clinics and at the University of Newcastle campus, as well as through social media. In Tamworth, members of the research team, including an Indigenous research assistant, recruited through the Gomeroi gaaynggal Centre [199]. While no specific sample calculation was performed, a

target of 25 pregnant women with adequate image-based records was set given the substantial participant burden on pregnant women to collect the data.

6.4.4 DietBytes dietary assessment method

Dietary assessment in DBBB was modelled on methods previously used in adults with Type 2 diabetes [86, 95]. In week one of the study, participants used the Evernote® app to record all eating and drinking occasions (including vitamin and mineral supplement use) for three non-consecutive days, including a weekend day (the DietBytes method). Records consisted of taking a phone image of the consumed item(s) placed next to a fiducial marker (reference object of known dimensions). Text and/or voice descriptions were added to the image to support the identification of items in the image, and included detailing brands, types, and cooking methods of foods consumed, where applicable (Figure 6.1). Participants were instructed to record images of all food and drink leftover, and any second servings consumed. No prior familiarity with the Evernote® app, or experience with recording dietary intake, was required. Training was provided in the first in-person session (week one) and participants created a practice record. Records could only be viewed by the participant and members of the research team who had access to the DietBytes Evernote® account. Settings on the app were selected so that records could only be shared with the research team over a Wi-Fi connection and/or were uploaded to the DietBytes Evernote® account during the second in-person session (week two). Participants were encouraged to label their records (e.g. Snack), however the Evernote® app automatically notes the date and time a record is made, which assisted the research team with establishing when items were consumed.

Figure 6.1 Example of an eating occasion recorded in the image-based dietary records in the Diet Bytes and Baby Bumps study, including supporting voice description, fiducial marker, and date and title of record



6.4.5 24-Hour Recall (24-R)

In weeks two, three and four, participants were asked to complete a dietitian-administered 24-R (one per week). Diet recalls in week two were conducted at the in-person study session, while the recalls in week three and week four were collected over the telephone. The three collection days were varied across the week and consisted of one weekend day. A multiple-pass method was used: 1) participants reported a quick list of all items consumed in the previous 24-h period; 2) followed by a checklist for forgotten foods; and 3) probing for detail (i.e. amounts, type, cooking/preparation methods) on foods listed (based on standardised protocols for multiple-pass 24-R) and review [155, 156]. To assist with estimating portion size of foods consumed, participants were given a visual aid

(booklet), the Dietary Estimation and Assessment Tool (DEAT) [86, 95]. The DEAT consisted of images of foods and drinks in varying portion sizes, serving vessels, amorphous mounds and geometric shapes and was based on similar food model booklets [217, 218]. Participants used the DEAT to quantify amounts of foods and drinks consumed, by indicating which portion size they consumed.

6.4.6 Nutrient Analysis

For the current study, energy, macronutrient and micronutrient intakes from the image-based dietary records and 24-R were assessed using FoodWorks® (Xyris Software, Pty Ltd., Brisbane, Queensland, Australia) nutrient composition software, with AUSNUT 2007 [157] selected as the nutrient composition table ('foods', 'brands', and 'supplements' selected). A protocol was developed to standardise entries into FoodWorks®, including common assumptions made (for example, the 'not further specified' option was used when detail was lacking; specific brands were not chosen unless they were explicitly stated). Two portion size estimation aids were used to assist in the quantification of items contained in image-based dietary records. In addition to the DEAT (where quantities of foods and serving vessels were displayed), a separate visual guide consisting of 80 images of a variety of food and drinks, photographed in serving size amounts recommended in the Australian Dietary Guidelines [47] was developed. One dietitian performed the analysis of the image-based dietary records and 24-R for all (n=25) participants. In order to determine the inter-rater reliability, a second dietitian analysed the image and 24-R records for a sub-sample of 10 participants.

6.4.7 Quality assessment of image-based dietary records

The quality of the image-based dietary records was established by examining records against the following pre-defined set of criteria using a "yes" or "no" response. Each record (eating and/or drinking occasion) was evaluated against a checklist for the following components: an image; text description; and voice record description providing additional details.

6.4.8 Surveys

Participants completed online surveys over the course of the study. The week one survey asked questions on demographics, usual use of smartphones, and on nutrition information received prior to study enrolment. The week two survey asked about participants' perceived usability and acceptability of the DietBytes method for dietary assessment using Likert scale, multiple-choice, and yes/no responses; and open-ended questions providing an opportunity to record qualitative responses.

6.4.9 Statistical Methods

Variables were assessed for normality of distribution graphically and via the Shapiro-Wilk test. Inter-rater reliability between two independent dietitians who assessed the image-based dietary records and 24-R in FoodWorks® was assessed via intra-class correlation coefficients for energy and nutrient intakes of the sub-sample of participants (n=10). Relative validity was assessed from one dietitian's analysis of the image-based dietary records compared with the 24-R recalls for all participants (n=25). The strength of linear relationships between the two methods was evaluated using Pearson correlations, one-sample *t*-tests exploring differences between the two measures, and agreement assessment using Bland-Altman plots and to assess any systematic bias between methods. Descriptive statistics and frequencies are provided for demographic data. Analyses were performed using IBM SPSS statistical software (Version 23.0, IBM Corp., Armonk, NY, USA). Statistical significance was set at $P \leq 0.05$. Results from the quality assessment of the image-records are reported as counts and percentages. A general inductive approach was used to analyse the qualitative responses to the open-ended survey questions about usability and acceptability (week two survey) [109]. This approach involved close reading of the qualitative text, creation of categories, coding of data into categories, revision and refinement of categories. The categories capture key aspects of themes present within the raw data.

6.5 Results

6.5.1 Participant characteristics

Twenty-seven women enrolled in the DBBB study, with one withdrawal. Of the 26 participants who completed DBBB, one participant completed two days of the image-based dietary record and one completed one day. The participant completing only one day was excluded from all analyses. Therefore results reported here are for n=25 participants. Of these 25 participants, 17 were recruited from the Tamworth recruitment sites, and eight from the Newcastle sites; eight identified as Indigenous Australians (all identified as Aboriginal), and 17 as non-Indigenous. The median age of participants at recruitment was 28.8 years (range: 20.4–50.4 years). Gestation at the time of recruitment ranged from 6–24 weeks, with four participants in their first trimester of pregnancy and 21 in the second trimester. Twelve participants (48%) had measured or kept a record of their diet previously (e.g. for previous health condition or for a previous research study) and the remaining participants had not kept a dietary record before participation in DBBB. The most commonly used apps that participants used on their smartphones were social media apps (n=32 responses), games (n=12), banking (n=9), baby/pregnancy-related app (n=9) and emails (n=5). Further characteristics of DBBB study participants and smartphone uses are summarised in Table 6.1.

Table 6.1 Demographic characteristics of participants in the Diet Bytes and Baby Bumps study (n=25)

Characteristic	n (%)
<i>Aboriginal or Torres Strait Islander origin</i>	8 (32)
<i>Born in Australia</i>	25 (100)
<i>Speaks only English at home</i>	25 (100)
<i>Currently smokes tobacco products</i>	4 (16)
<i>Ever had to measure or keep a record of diet or been asked to recall foods eaten</i>	12 (48)
<i>Type of smartphone currently used:</i>	
iPhone	18 (72)
Android	7 (28)
<i>Highest qualification completed:</i>	
No formal qualifications	1 (4)
School certificate (year 10 or equivalent)	1 (4)
Higher school certificate (year 12 or equivalent)	3 (12)
Certificate/ Diploma (e.g. childcare, technician)	6 (24)

University Degree	6 (24)
Higher University Degree	8 (32)
<i>Present marital status:</i>	
Never married	2 (8)
Defacto	8 (32)
Married	14 (56)
Separated, but not divorced	1 (4)
<i>Number of children:</i>	
This will be my first baby	15 (60)
1	4 (16)
2	3 (12)
≥3	3 (12)
<i>Average annual gross (before tax) household income</i>	
No income	0 (0)
\$1-\$31,199	0 (0)
\$31,200-51,999	2 (8)
\$52,000-77,999	6 (24)
\$78,000-103,999	2 (8)
\$104,000 or more	10 (40)
Don't know	2 (8)
No response	3 (12)
<i>How do you manage on the income you have available?</i>	
It is easy	4 (16)
It is not too bad	12 (48)
It is difficult some of the time	7 (28)
It is difficult all of the time	1 (4)
It is impossible	1 (4)
<i>Smartphone activities</i>	
Sending SMS (text messages)	25 (100)
Receiving SMS (text messages)	24 (96)
Making voice calls	23 (92)
Making video calls	11 (44)
Taking photos	23 (92)
Sending and/or uploading photos	23 (92)
Taking videos	15 (60)
Sending and/or uploading videos	11 (44)
Searching or browsing the internet	24 (96)
Directors, maps and/or GPS functions	22 (88)
Taking notes	20 (80)
Playing games	13 (52)
Calendar or diary function	17 (68)
Playing music	18 (72)
Making voice recordings	4 (16)
Using apps	21 (84)

6.5.2 Relative validity of the DietBytes method

Results of Pearson correlations, mean difference between methods, and one-sample *t*-tests are summarised in Table 6.2. There was no significant difference between dietary assessment methods for intakes of energy (mean difference 517 ± 1461 kJ/day, $t^{(df)} = 1.77^{(24)}$, $P=.089$), or carbohydrate and protein intakes, although the mean difference of 7.8 ± 18.7 g fat/day was statistically significant ($t^{(df)} = 2.08^{(24)}$, $P=.049$). There was no significant difference for daily micronutrients iron, iodine, folate, zinc and calcium, either with or without supplements included in the analysis.

Bland-Altman plots were constructed for energy, macronutrients, and micronutrients (see Figure 6.2 for plots of energy and macronutrients). Bland-Altman plots comparing mean intakes versus the difference between the image-based dietary records and 24-R methods for daily energy and macronutrient intakes indicates the majority of values were within the acceptable limits of agreement.

Table 6.2 Comparison of energy and nutrient intake between the DietBytes image-based dietary records and 24-h food recall methods (n=25)

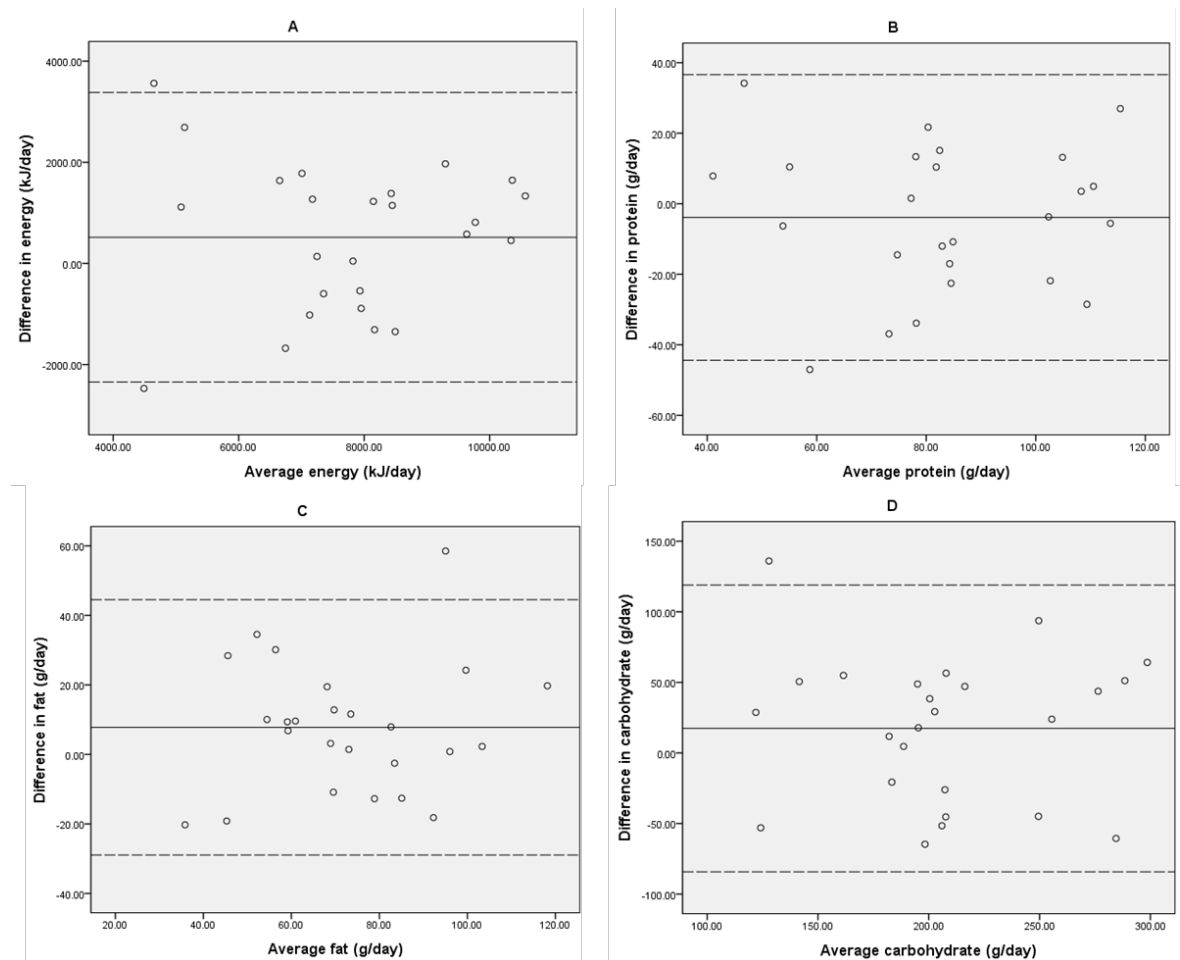
Nutrient	Method	Mean±SD ¹ Intake ²	Pearson Correlation between methods	Mean difference ³ ± SD	One-sample <i>t</i> -test (DF ⁴), <i>P</i>
Energy (kJ/day)	DBBB ⁵	7503±1864	0.696 (<i>P</i> <.001)	517±1461	1.77(24), <i>P</i> =.089
	24-R ⁶	8020±1884			
Protein (g/day)	DBBB	85.4±23.8	0.619 (<i>P</i> =.001)	-3.9±20.7	-0.94(24), <i>P</i> =.355
	24-R	81.5±23.6			
Fat, total (g/day)	DBBB	69.2±21.5	0.654 (<i>P</i> <.001)	7.8±18.7	2.08(24), <i>P</i> =.049
	24-R	77.0±23.4			
Fat, saturated (g/day)	DBBB	26.7±8.1	0.745 (<i>P</i> <.001)	4.8±8.3	2.901(24), <i>P</i> =.008
	24-R	31.5±12.4			
Carbohydrate (g/day)	DBBB	198.1±57.6	0.580 (<i>P</i> =.002)	17.4±51.8	1.68(24), <i>P</i> =.107
	24-R	215.5±55.4			
Fibre (g/day)	DBBB	22.2±8.7	0.844 (<i>P</i> <.001)	0.6±4.8	0.66(24), <i>P</i> =.516
	24-R	22.8±8.4			
Supplements included: Food and supplements					
Iron (mg/day)	DBBB	19.1±16.7	0.622 (<i>P</i> =.001)	4.4±17.5	1.25(24), <i>P</i> =.224
	24-R	23.5±22.1			
Vitamin C (mg/day)	DBBB	156.3±180.8	0.549 (<i>P</i> =.004)	15.0±151.6	.50(24), <i>P</i> =.624
	24-R	171.3±112.3			
Folate ⁷ (µg/day)	DBBB	1210.6±1693.2	0.937 (<i>P</i> <.001)	40.3±735.5	0.27(24), <i>P</i> =.787
	24-R	1250.8±1149.7			

Zinc (mg/day)	DBBB 24-R	15.8±7.6 16.3±6.6	0.805 (<i>P</i> <.001)	0.5±4.5	0.51(24), <i>P</i> =.616
Iodine (mg/day)	DBBB 24-R	198.3±126.9 216.6±110.6	0.669 (<i>P</i> <.001)	18.3±97.8	0.94(24), <i>P</i> =.359
Calcium (mg/day)	DBBB 24-R	875.9±351.8 862.9±261.0	0.473 (<i>P</i> =.017)	-13.0±324.2	-0.20(24), <i>P</i> =.843
Vitamin D (µg/day)	DBBB 24-R	7.6±9.5 7.3±7.3	0.870 (<i>P</i> <.001)	-0.3±4.8	-0.31(24), <i>P</i> =.756
Vitamin E (mg/day)	DBBB 24-R	11.5±8.7 12.7±8.5	0.725 (<i>P</i> <.001)	1.2±6.4	0.95(24), <i>P</i> =.354
Sodium (mg/day)	DBBB 24-R	2269.9±825.6 2448.7±894.2	0.687 (<i>P</i> <.001)	178.9±683.5	1.31(24), <i>P</i> =.203
Potassium (mg/day)	DBBB 24-R	2848.2±813.1 3057.3±919.1	0.659 (<i>P</i> <.001)	209.1±722.0	1.45(24), <i>P</i> =.161
Magnesium (mg/day)	DBBB 24-R	345.9±149.0 344.2±121.5	0.842 (<i>P</i> <.001)	-1.76±80.4	-0.109(24), <i>P</i> =.914
Supplements excluded: Food only					
Iron (mg/day)	DBBB 24-R	11.5±4.0 11.3±3.4	0.562 (<i>P</i> =.003)	-0.24±3.5	-0.341(24), <i>P</i> =.736
Vitamin C (mg/day)	DBBB 24-R	109.7±70.5 131.0±98.5	0.502 (<i>P</i> =.011)	21.2±87.8	1.209(24), <i>P</i> =.238
Folate ⁷ (µg/day)	DBBB 24-R	487.4±286.2 527.3±214.5	0.404 (<i>P</i> =.045)	40.0±279.9	0.714(24), <i>P</i> =.482
Zinc (mg/day)	DBBB 24-R	10.7±3.1 10.7±2.5	0.513 (<i>P</i> =.009)	0.1±2.8	0.103(24), <i>P</i> =.918
Iodine (mg/day)	DBBB 24-R	113.0±51.4 122.4±43.6	0.575 (<i>P</i> =.003)	9.4±44.3	1.055(24), <i>P</i> =.302
Calcium (mg/day)	DBBB 24-R	812.7±310.7 812.1±258.5	0.466 (<i>P</i> =.019)	-0.6±297.5	-0.010(24), <i>P</i> =.992
Vitamin D (µg/day)	DBBB 24-R	2.8±1.3 3.1±1.9	0.615 (<i>P</i> =.001)	0.3±1.5	0.979(24), <i>P</i> =.337
Vitamin E (mg/day)	DBBB 24-R	8.9±5.5 8.6±4.3	0.766 (<i>P</i> <.001)	-0.4±3.5	-0.515(24), <i>P</i> =.611
Sodium (mg/day)	DBBB 24-R	2269.8±825.7 2448.5±894.2	0.687 (<i>P</i> <.001)	178.8±683.6	1.308(24), <i>P</i> =.203
Potassium (mg/day)	DBBB 24-R	2844.5±806.1 3054.0±911.2	0.652 (<i>P</i> <.001)	209.6±722.5	1.450(24), <i>P</i> =.160
Magnesium (mg/day)	DBBB 24-R	318.1±101.8 313.8±102.4	0.846 (<i>P</i> <.001)	-4.3±56.6	-0.382(24), <i>P</i> =.706

¹SD Standard Deviation; ²Mean (±SD) of three-day records for each method as assessed by Dietitian 1; ³Mean difference (24-hour recall intake – image record intake) calculated for each participant; ⁴Degrees of freedom; ⁵DBBB Analysis based on Diet Bytes & Baby Bumps image-based dietary records; ⁶24-R Analysis based on 24-hour recall; ⁷Folate as dietary folate equivalents.

Figure 6.2 Bland-Altman plots showing mean difference (24-R–DietBytes, solid line) vs. mean intakes ((24-R + DietBytes)/2) between the DietBytes image-based dietary records and the 24-R nutrient intakes, and two standard deviations of the difference (limits of

agreement, dotted lines), for the following: (A) Energy (kilojoules per day); (B) Protein (grams per day); (C) Fat (grams per day); (D) Carbohydrate (grams per day)



6.5.3 Inter-rater reliability

Results of the nutrient analysis performed by two dietitians using the two dietary assessment methods, for a sub-sample of $n=10$ participants are summarised in Table 6.3. Intra-class correlation coefficients between the two dietitians for the analysis of the image-based dietary records was 0.929 ($P<.001$) for energy, 0.865–0.932 (all $P<.05$) for macronutrients carbohydrate, protein, and fat; and ranged from 0.794–0.988 (all $P<.05$) for selected key micronutrients (folate, iron, iodine, calcium and zinc). Intra-class correlation coefficients between the two dietitians for the analysis of the 24-Rs was 0.973 ($P<.001$) for energy, 0.952–0.978 (all $P<.001$) for macronutrients, and 0.921–0.989 (all $P\leq.001$) for the aforementioned micronutrients.

Table 6.3 Inter-rater reliability of energy and nutrient intake from the Diet Bytes and Baby Bumps image-based dietary records and 24-h recalls between two dietitians (for n=10 participants)

Nutrient	Method	Mean±SD ¹ intake as assessed by each dietitian		ICC ² (95% CI) between Dietitians 1&2	P
		Dietitian 1	Dietitian 2		
Energy (kJ/day)	DBBB ³	7665±1795	7786±2654	0.929 (0.710—0.982)	<.001
	24-R ⁴	7966±2387	7728±2539	0.973 (0.897—0.993)	<.001
Protein (g/day)	DBBB	86.6±19.0	90.7±29.3	0.865 (0.471—0.966)	.004
	24-R	79.5±24.1	76.7±25.4	0.978 (0.915—0.994)	<.001
Fat, total (g/day)	DBBB	75.2±21.9	78.7±29.1	0.932 (0.738—0.983)	<.001
	24-R	77.6±28.0	71.0±29.9	0.952 (0.790—0.988)	<.001
Fat, saturated (g/day)	DBBB	28.9±8.4	30.1±12.2	0.886 (0.544—0.972)	.002
	24-R	34.2±13.7	31.1±14.0	0.949 (0.786—0.987)	<.001
Carbohydrate (g/day)	DBBB	193.9±48.3	189.6±73.1	0.930 (0.718—0.983)	<.001
	24-R	213.4±68.2	217.0±69.7	0.975 (0.904—0.994)	<.001
Fibre (g/day)	DBBB	20.1±8.3	19.5±6.9	0.923 (0.694—0.981)	<.001
	24-R	21.5±7.5	20.6±7.0	0.983 (0.929—0.996)	<.001
Iron (mg/day)	DBBB	12.2±3.5	12.1±3.3	0.810 (0.185—0.954)	.014
	24-R	11.9±4.1	11.4±4.1	0.977 (0.912—0.994)	<.001
Vitamin C (mg/day)	DBBB	96.3±57.8	96.6±89.0	0.893 (0.551—0.974)	.002
	24-R	130.0±80.2	117.9±59.6	0.945 (0.793—0.986)	<.001
Folate ⁵ (µg/day)	DBBB	644.2±546.6	676.9±400.1	0.954 (0.816—0.988)	<.001
	24-R	737.0±320.4	751.1±346.5	0.988 (0.953—0.997)	<.001
Zinc (mg/day)	DBBB	12.0±3.6	12.8±4.2	0.899 (0.618—0.974)	.001
	24-R	12.4±4.3	12.9±6.1	0.921 (0.687—0.980)	.001
Iodine (mg/day)	DBBB	142.3±90.1	149.5±83.6	0.988 (0.953—0.997)	<.001
	24-R	154.7±75.5	158.0±78.2	0.989 (0.958—0.997)	<.001
Calcium (mg/day)	DBBB	819.2±220.3	862.7±331.8	0.794 (0.158—0.949)	.017
	24-R	840.7±276.1	814.2±323.4	0.969 (0.883—0.992)	<.001
Vitamin D (µg/day)	DBBB	3.7±1.9	4.0±2.4	0.879 (0.511—0.970)	.003
	24-R	4.7±3.2	3.8±2.9	0.883 (0.559—0.971)	.001
Vitamin E (mg/day)	DBBB	9.7±4.6	9.7±4.5	0.851 (0.366—0.963)	.006
	24-R	9.3±3.9	12.1±10.2	0.325 (-1.73—0.833)	.287
Sodium (mg/day)	DBBB	2580.0±894.9	2869.1±1393.5	0.875 (0.532—0.968)	.002
	24-R	2632.1±1106.7	2524.1±1042.9	0.976 (0.908—0.994)	<.001
Potassium (mg/day)	DBBB	2724.0±832.0	2543.2±849.4	0.852 (0.435—0.963)	.005
	24-R	2750.7±844.8	2679.1±816.1	0.961 (0.849—0.990)	<.001
Magnesium (mg/day)	DBBB	301.4±65.1	274.0±77.7	0.741 (0.069—0.934)	.024
	24-R	297.8±88.0	282.3±86.3	0.959 (0.839—0.990)	<.001

¹SD standard deviation; ²ICC Intra-class Correlation Coefficient; ³DBBB Analysis based on DietBytes image-based dietary records; ⁴24-R Analysis based on 24-h recall; ⁵Folate as dietary folate equivalents.

6.5.4 Quality assessment of the image-based dietary record entries

There were a total of 517 record entries (recorded eating and/or drinking occasions, consisting of image and/or voice record and/or text description) for the 25

participants (20.7 ± 9.2 entries per participant). The majority of entries included an image ($n=496$, 96%), over half of the entries included text description providing additional details ($n=312$, 60%), and around one third of entries included voice description to provide additional detail ($n=158$, 31%). A small proportion of entries contained an image, text description, and a voice record ($n=15$, 3%). Further details of results from the quality assessment are displayed in Table 6.4.

Table 6.4 Quality assessment of the DietBytes image-based dietary record entries ($n=517$ entries for $n=25$ participants)

	Yes (n)	Yes (%)
Images		
Is there an image in the record?	496	95.94
<i>If yes, is the reference card visible?</i>	439	88.51
<i>If yes, can all food items be clearly seen?</i>	430	86.69
<i>If yes, is the image sufficient to quantify items?</i>	439	88.51
Voice Records		
Is there a voice record present?	158	30.56
<i>If yes, does the voice record include the item name?</i>	157	99.37
<i>If yes, does the voice record include the item type?</i>	117	74.05
<i>If yes, does the voice record include the item brand/product name?</i>	50	31.65
<i>If yes, does the voice record include item preparation /cooking methods?</i>	48	30.38
<i>If yes, is the voice record sufficient to identify items?</i>	140	88.61
Text Description		
Is there text description present?	312	60.35
<i>If yes, does the text description include the item name?</i>	307	98.40
<i>If yes, does the text description include the item type?</i>	177	56.73
<i>If yes, does the text description include the item brand/product name?</i>	83	26.60
<i>If yes, does the text description include preparation /cooking methods?</i>	50	16.03
<i>If yes, is the text description sufficient to identify the item?</i>	225	72.12
Is there an image and a voice record?	155	29.98
Is there an image and a text description?	297	57.45
Is there an image, voice record, and text description?	15	2.90

6.5.5 Perceived usability and acceptability of using the DietBytes method

In the week two survey, participants ($n=25$) were asked about the usability and acceptability of the dietary assessment methods used in DBBB. Overall, 22 participants (88%) said they would be willing to use the DietBytes method again, including all Aboriginal participants. Of these women, nine reported they would use the image-based method again for up to one week, with five expressing they

would use the method for one month or more, while others would use it for three days or less (n=8). The majority of participants (n=21, 84%) rated their satisfaction with the Evernote® app as 'satisfied' (n=15) or 'very satisfied' (n=6). Further quantitative responses to the week two survey are summarised in Table 6.5.

Table 6.5 Participants' perceived usability and acceptability of using the Diet Bytes method for dietary assessment (n=25)

Perceived usability and acceptability ¹	Count (%)				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
It was easy to use the Evernote app to collect my photographic dietary record	9 (36)	15 (60)	1 (4)	0 (0)	0 (0)
It was difficult to take photographs of my food and drinks	0 (0)	3 (12)	1 (4)	13 (52)	8 (32)
I found using the voice record annoying	4 (16)	4 (16)	8 (32)	7 (28)	2 (8)
I found it difficult to remember to collect a photographic dietary record	1 (4)	3 (12)	6 (24)	11 (44)	4 (16)
The text message reminders helped me to remember to use the app	4 (16)	17 (68)	3 (12)	0 (0)	1 (4)
I found the prompt card helpful	6 (24)	11 (44)	7 (28)	1 (4)	0 (0)
	Yes n (%)		No n (%)		
Did the way you used the app in private and in public differ?	15 (60)		10 (40)		
Did you record all food and drink items that you consumed during the period that you collected a photographic dietary record?	17 (68)		8 (32)		
Would you use the smartphone photographic dietary record method again?	22 (88)		5 (20) ²		
If yes, would you want to use the photographic dietary record to do any of the following: n (%)					
Share it with a Dietitian for feedback	18 (72)				
Share with friends	4 (16)				
For your own feedback or tracking of your diet	16 (64)				
Did you prefer to record details of your food and drink using:					
Text description; n (%)	20 (80)				
Voice record; n (%)	5 (20)				
As a result of collecting a photographic dietary record did you do any of the following:	Yes; n (%)		No; n (%)		
Change the types of food you ate	7 (28)		18 (72)		
Change how often you ate	6 (24)		19 (76)		
Change the amount of food you ate	3 (12)		22 (88)		
Change where you ate	2 (8)		23 (92)		
Change who you ate with	0 (0)		25 (100)		
Change your cooking habits	1 (4)		24 (96)		

¹Questions as posed to participants; ²Two participants responded both yes and no for this question

The qualitative data participants provided on the acceptability and usability of the DietBytes method revealed two key themes (i) Process and perceptions of using the image-based dietary record; and (ii) Changes to dietary intake due to increased awareness and external influences.

Under the first theme 'Process and perceptions of using the image-based dietary record' participants commented about the process of using the image based dietary record, and external perceptions of the DietBytes method. Participants commented that keeping the dietary record involved memory, i.e. remembering (or forgetting) to record items, or remembering to place the fiducial marker in the images. This was cited as a reason for not recording all food and drink items, and also as something participants found to be a barrier to completing the record.

"It was often difficult to remember to take the pictures and to put the prompt card in the pictures" [Age 27, first baby, non-Indigenous participant]

Some participants also reported that having to keep the dietary record could be inconvenient, e.g. having to have their phone with them before they could eat, or avoiding shared meals that were complicated to record. Some felt self-conscious or embarrassed to record intake using the image-based dietary record, as illustrated in the following survey quote:

"I didn't like to eat out during this time due to not being comfortable photographing my food in front of others." [Age 33, first baby, Aboriginal participant]

In particular, there were some negative responses to using the voice record in public:

"[I] was more self-conscious to use the voice recording if other people were around so tended to use the text instead." [Age 35, first baby, non-Indigenous participant]

Some participants commented on the process being "quick" and "easy" to use, and that using the DietBytes method was preferable to other dietary assessment methods:

"It didn't require me to measure and log each ingredient, something which has discouraged me from using food diaries in the past" [Age 30, first baby, non-Indigenous participant]

Under the second theme, a sub-theme arose of 'increasing awareness': participants indicated that keeping an image-based dietary record increased their awareness of their dietary intake. Some participants commented that the act of collecting the image-based record had a positive influence on their eating behaviors, including choosing healthier food options:

"Seeing pictures of dietary intake is a good motivator to make good choices!"
[Age 27, first baby, non-Indigenous participant]

Other changes to intake as a result of having to keep the dietary record, included "[choosing] foods that were easier to record" eating less; and "[a] combination of eating more at some meals [and] less at others"; and not eating out as often. Other influences on participants' dietary intake included the impact of someone else being able to see what they were eating:

"[I] used the fact someone else would see what I ate to break a bad habit that formed in the last month of having something sweet at 3:00pm. Didn't want to have it any more so used it for self-motivation to break habit." [Age 35, first baby, non-Indigenous participant]

Some negative responses arose from the influence of others observing participants' dietary intake (including the dietitian performing the analysis, and family members). One participant reported guilty feelings around taking images of sweets, biscuits and chocolates. Another commented:

"With family around me adding their own input for anything that I had forgotten I found it very distracting" [Age 36, second baby, Aboriginal participant]

6.6 Discussion

The first aim of the current study was to establish the relative validity of the image-based records against the 24-R. Pearson correlations comparing estimated nutrient intakes between the two methods were moderate to substantial for energy, macronutrients and fibre ($r=0.58-0.84$, all $P<.05$), and for micronutrients both with

supplement use included ($r=0.47-0.94$, all $P<.05$) and without supplement use included ($r=0.40-0.85$, all $P<.05$). In addition, there were no significant mean differences in nutrients between the two dietary assessment methods, with the exception of total fat (borderline at $P=.049$) and saturated fat ($P=.008$). However, mean differences were small and not clinically important for any nutrient. The 95% Confidence Intervals (limits of agreement) are relatively wide in the Bland-Altman plots for energy and macronutrients, which shows variability between methods for individuals. However, most data points are within the limits of agreement with only one or two outliers, and the pattern of data distribution in the Bland-Altman plots does not indicate evidence of systematic bias at high or low intakes. The second aim was to establish the inter-rater reliability between two dietitians for assessing the image-based dietary records and 24-R. Intra-class correlation coefficient test statistics for macronutrients and major micronutrients that are particularly important during pregnancy (iron, calcium, zinc, iodine and folate) were in the excellent range (0.75–1 is considered excellent agreement) [219] and one dietitian subsequently analysed records for all ($n=25$) participants.

The results of DBBB are very encouraging, and demonstrate acceptable validity of the DietBytes method for dietary assessment of pregnant women. In a previous study in Japan by Wang and colleagues, $n=20$ female college students studying food and nutrition recorded one day of dietary intake through both a weighed food record and by capturing images of the same meals. Images were captured via handheld personal digital assistant with camera and mobile 'phone card (the Wellnavi method). Resulting Spearman's rank correlation coefficients of $r=0.46-0.93$ (median $r=0.77$) were deemed acceptable for demonstrating the use of the image-based dietary record [91]. In a follow up study of $n=28$ participants there was a median correlation coefficient of $r=.066$ for nutrients between the two dietary assessment methods, with 57% of participants reporting the Wellnavi method as less burdensome and less time-consuming compared to weighed food records or 24-R [196]. This suggests that the results of the current DBBB study are comparable with this previous study examining the use of image-based dietary records in young women, and have provided further support for their use.

The current study sought to assess the quality of the image-based dietary records, in order to establish if these could feasibly be analysed. While two-thirds of the record entries included text description (n=312, 60%), only one third included voice description (n=158, 31%). This was reflected in survey responses, with only 20% (n=5) of participants favouring the voice description over text. Participants reported feeling self-conscious or embarrassed when using the voice record in public. Although the voice records can provide more detailed description to support images, this is an important issue to acknowledge. Of interest was that for 89% of entries containing an image, the image alone was sufficient to quantify items. A recommendation for future use of the DietBytes method is to reinforce to participants that records can be amended at a later time point, and additional description, whether text or voice, can be added to entries when in a quiet and private space.

The DietBytes method was well-received by pregnant women in this study; all but one reported that the Evernote® app was easy to use, 84% (n=21) were satisfied with the app, and 88% (n=22) stated that they would use the image-based dietary record method again. Importantly, all Aboriginal participants were willing to use the method again. Aboriginal and Torres Strait Islander Australian women face socio-economic barriers to nutrition, including disadvantages in education, employment and income. In addition, there are geographic limitations to accessing nutritious foods in rural and remote areas [23], where nearly two thirds (65%) of Australia's Indigenous Australians reside [54]. Indigenous Australian women may therefore be at higher risk for food insecurity [184] and have dietary intakes that differ from their non-Indigenous counterparts. That the DietBytes method was well-received may be a consideration for researchers working in the field of Aboriginal nutrition, as a potential method for dietary assessment which has demonstrated acceptability by this group of pregnant women.

The DietBytes method may have been particularly acceptable for this cohort of women of childbearing age, as 92% (n=23) of participants reported that they use their phones for taking, sending, and uploading photographs at the time of

recruitment. Our previous study demonstrated that providing feedback on the image-based dietary records via the smartphone in combination with consultation with a dietitian was well-received by participants [220]. The majority of women in the current study (n=18, 72%) indicated they would use the DietBytes method again to obtain feedback from a dietitian, but interestingly, over half (n=16, 64%) would use it for their own feedback or tracking of their diet (i.e. self-monitoring). Previous research with young women demonstrated that computer and smartphone food records were as accurate as paper-based records for dietary self-monitoring, and that these methods were preferred over the paper-based records [221].

A sub-theme that arose from survey responses was that the act of keeping a dietary record increased participants' awareness of the food they ate. The findings of DBBB are mirrored in other studies where participants have reported increased awareness of foods or portion sizes consumed as a result of capturing images of food intake [222]. Participation in the DietBytes study may have created a teachable moment, by motivating women to consider dietary changes, and previous research has demonstrated that pregnancy is a time period when women may gain an increased awareness of their dietary intake [206] and be more receptive towards engaging in healthy eating behaviours [205]. The downside of this phenomenon is that having to record dietary intake may cause people to change their usual eating behaviours: this is a common limitation of dietary assessment methods and is not unique to the DietBytes method [79, 80]. However, this was unlikely to have had a major influence on the validity of the DietBytes method, as only a small proportion of participants reported that they changed the type (n=7, 28%), frequency (n=6, 24%) or amount (n=3, 12%) of food they ate when they used the DietBytes method, with even fewer reporting changes to where they ate, who they ate with, or to their cooking habits. This is reflected in the high agreement between the DietBytes method and 24-R.

The two methods of dietary assessment used (DietBytes and the 24-R) were chosen as they had theoretical errors independent of one another: DietBytes is a prospective method that puts the onus of portion size estimation on the dietitian,

and the 24-R method is retrospective and requires participants to estimate and report portion sizes. Choosing two different methods reduces the chance of correlations between nutrient intakes due to similar errors, however both methods have the potential for participants to misreport dietary intake [223].

There are limitations to the current study that should be acknowledged. DBBB participants may not be representative of all pregnant women in Australia. All participants were born in Australia (Australia-wide, 28.2% of the resident population were born overseas [224]), and all spoke only English at home; so language did not act as a barrier to study participation or accessing antenatal care in general. Over half (n=14, 56%) of participants held a university or higher university degree, compared with 29% of Australian women aged 15-64 years [214], which is likely attributed to the fact that a major source of recruiting was via a university campus. DBBB excluded women who did not own a smartphone, and depended on women having their smartphone on hand during eating and drinking occasions. Therefore women who did not have regular access to a smartphone could not participate. While smartphone ownership is high in Australia (77%) [97], the study design may have excluded economically vulnerable women. However, there was a broad distribution of income represented. Finally, previous research has shown that three days may be adequate for establishing mean energy intakes of groups, however may not be a long enough duration to accurately measure intake of macro- and micro-nutrients [78]. More days of recording may therefore have been required. Eight of the 22 participants in DBBB who reported that they would be willing to use the DietBytes method again would use it for three days or less. However, the remaining 14 participants would be willing to use the method for longer recording times, the majority of whom reported a maximum of one week. Therefore, there is potential for future research to explore the use of the DietBytes method over longer recording periods.

6.7 Conclusions

The DietBytes method of image-based dietary assessment demonstrated acceptable relative validity for establishing energy and nutrient intakes of pregnant Aboriginal and non-Aboriginal Australian women. The use of image-based dietary records was well-received by participants, the majority of whom would be willing to use the method again. The DietBytes method of dietary assessment via image-based records may therefore be a useful and feasible way for dietitians in research or practice settings to establish dietary intakes of pregnant women.

Chapter 7 Factors associated with effective nutrition interventions for pregnant Indigenous women: A systematic review

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The work presented in this manuscript was completed in collaboration with the co-authors (Appendix 10.18) and permission to reproduce the published manuscript has been granted by the publishers (Appendix 10.19).

7.1 Overview

Health promotion activities and interventions which aim to optimise nutrition for Aboriginal women and their children should be based on best practice evidence. A systematic review on factors associated with effective nutrition interventions for pregnant Indigenous women was conducted to identify what intervention characteristics have been successfully implemented in countries with Indigenous populations. The results of this review may inform the development of intervention programs and health promotion activities which aim to optimise nutrition-related outcomes for Indigenous women and their children.

The objectives of this review were to identify pre-existing programs which aimed to improve nutrition-related outcomes for pregnant Indigenous women and/or their children; and to identify the factors associated with programs that resulted in positive outcomes. The manuscript for this systematic review, as submitted for publication, commences from section 7.2.

7.2 Abstract

Introduction: Indigenous people continue to experience health disparities relative to non-Indigenous populations. Interventions to improve nutrition during pregnancy in these groups may improve health outcomes for mothers and their infants. The effectiveness of existing nutrition intervention programs has not been reviewed previously.

Objective: The objective was to identify interventions targeting improving nutrition-related outcomes for pregnant Indigenous women residing in Organisation for Economic Co-operation and Development countries, and to identify positive factors contributing to successful programs.

Methods: Thirteen electronic databases were searched up until October 2015. Key words identified studies intervening to improve nutrition-related outcomes for pregnant Indigenous women. Two reviewers assessed articles for inclusion and study quality and extracted data. Only studies published in English were included. Data were summarised narratively.

Results: Abstracts and titles were screened (n=2566) and 315 full texts were reviewed for eligibility. This review included 27 articles from 20 intervention programs from Australia, Canada or the United States. The most prevalent measurable outcomes were birth weight (n=9) and breastfeeding initiation/duration (n=11). Programs with statistically significant results for these outcomes employed the following nutrition activities: individual counselling/education (n=8); delivery by senior Indigenous woman (n=2), peer counsellor (n=3) or other Indigenous health worker (n=4); community-wide interventions (n=2); media campaigns (n=2), delivery by non-Indigenous health professional (n=3); and home visits (n=3).

Conclusions: Heterogeneity of included studies made it challenging to make firm recommendations regarding program success. Authors of included studies recommended community consultation be included when designing studies and working with communities at all stages of the research process. Individualised counselling/education can contribute to successful program outcomes, as can the

use of Indigenous workers to deliver program content. Limitations of some studies included a lack of details on interventions and the use of non-random control groups. Future studies should include detailed descriptions of intervention components and include appropriate evaluation protocols.

7.3 Introduction

There are an estimated 370 million people worldwide who self-identify as Indigenous, including Aboriginal and Torres Strait Islander people of Australia, Maori people of New Zealand, and Indigenous people of the Americas [25, 110]. These groups have separate cultural, economic, political and social characteristics to the dominant societies where they live, and are the descendants of those inhabitants of a region at the time when people of different cultures or ethnic origins arrived. While no official definition for 'Indigenous' has been determined, an important understanding of the term includes self-identification as an Indigenous person [25].

Disparities between Indigenous and non-Indigenous peoples in terms of morbidity and mortality, and social, economic and political equity continue wherever Indigenous peoples reside, as does a lasting legacy of colonisation, oppression and systemic disadvantage [110]. Health disparities have been well-documented, particularly for Indigenous populations residing in Australia, Canada and the United States. In 2012 to 13, Indigenous Australians were three times more likely to have diabetes (rate ratio 3.3) than non-Indigenous Australians, and twice as likely to have indicators of chronic kidney disease (rate ratio 2.1) [32]. More than half of Indigenous Australian adults (65%) had at least one risk factor for cardiovascular disease and 11% had diabetes [32]. In Canada, approximately 43% of Inuit people have been diagnosed with a chronic condition by a health professional [225]. In the USA between 2012 and 2014, 15.4% of American Indian/Alaska Native women aged 18 years and older reported ever having been diagnosed with diabetes, and 3.5% reported ever having had a stroke, compared with 8.1% and 2.5% respectively for all American women [226].

Improving nutrition in pregnancy and early infancy could set the scene for positive long-term health trajectories for Indigenous people. Optimal nutrition during pregnancy has important implications for fetal development and growth and may be protective for maternal and child long-term health outcomes [180]. Maternal diet during pregnancy must provide adequate energy and nutrients to meet nutritional needs of both the mother and foetus. In addition, appropriate weight gain during pregnancy is important, as excessive gestational weight gain increases both the risk of maternal postpartum overweight and obesity [19, 20, 188] and risk of having a low birth weight (LBW) infant (<2500g) increases with low gestational weight gain [227]. The Barker hypothesis provided evidence that LBW is associated with an increased risk of cardiovascular disease, hypertension, stroke and type 2 diabetes mellitus in the future life of the infant [2, 140, 141]. In Australia and the United States, Indigenous infants are more likely to be of LBW [112], with the proportion of LBW babies born to Indigenous mothers in Australia twice the proportion (12.5%) born to non-Indigenous mothers (5.7%) [179].

Research on dietary practices of Indigenous women during pregnancy is scarce. A recent examination of remote and urban-dwelling First Nations women in Manitoba, Canada explored the reasons for increased prevalence of gestational diabetes [228]. This study found significantly lower intakes of vegetables and higher consumption of cholesterol in First Nations women in remote areas (n=24) compared to white women (n=22) in urban areas, and significantly lower intakes of nonfat milk for all First Nations women (n=41) compared to the white women [228]. The authors concluded that there was a need for improvements in nutritional intake during pregnancy for First Nations women, especially among those residing in rural or remote communities [228]. In Australia, disparity in income is a determinant of health disadvantage for Indigenous people [115]. Lee (2009) and Brimblecombe (2015) have advocated for an improvement in Aboriginal and Torres Strait Islander nutritional health, and suggested exploring economic interventions, including food supplementation for women, infants and children [187] [185].

Optimal infant feeding practices are essential for the health of infants. Breast milk is the ideal food, imparting physiological benefits to both mother and child [11]. The World Health Organization recommends exclusive breastfeeding to six months of age, continuing alongside complementary infant feeding up until the infant is two years of age, or as long as mother and child desire [167]. Breastfeeding initiation and duration for Indigenous peoples appears to be affected by a number of factors, including residential rurality [42]. Rates of breastfeeding are influenced by rural or urban locality for Indigenous Australians, with those living in rural areas more likely to initiate breastfeeding, and have a longer duration [42]. Significantly fewer Canadian Aboriginal mothers living off-reserve reported exclusively breastfeeding their last child for six months or more (17%) compared to non-Aboriginal mothers (27%) [229]. Overall, 78% of Canadian Aboriginal women and 88% of non-Aboriginal Canadian women initiated breastfeeding [229]. In Hawaii, overall breastfeeding initiation rates are high (89%), but amongst Native Hawaiian women rates are relatively low (64%) [230].

It is clear that maternal and infant nutrition should continue to be a priority for health policy implementation, health promotion activities, and intervention. However, factors associated with the effectiveness of interventions to improve nutrition-related outcomes for the target demographic of pregnant Indigenous women has not been reviewed previously. Lessons learned from existing research in this field are likely to be of great value for future direction to optimise dietary intake and nutrition-related health for the world's Indigenous women and their infants. The objectives of this review are:

1. To identify existing programs where a nutrition intervention conducted with the target group of pregnant Indigenous women aimed to improve nutrition-related outcomes for these women and/or their children. Any outcome related to, or affected by nutrition, was included as long as outcomes were compared with a control group or other comparisons were made.

2. To identify factors associated with nutrition interventions that resulted in positive nutrition-related outcomes for pregnant Indigenous women and/or their children when compared with a comparison group.

7.4 Methods

7.4.1 Methods for the selection of literature reviewed

The protocol for this systematic review was registered with Prospero (University of York Centre for Reviews and Dissemination) (registration ID CRD42014012984, 2014).

Databases were searched using selected key terms relating to diet/nutrition, pregnancy, and Indigenous status. Articles meeting inclusion criteria were assessed for study quality using the Academy of Nutrition and Dietetics Quality Criteria Checklist for Primary Research standardised tool [231]. Data were extracted and facets of studies resulting in statistically significant outcomes were identified and summarised narratively.

7.4.2 Eligibility criteria

7.4.2.1 Participants/population

Studies were included where the target population was pregnant women who self-identified as Indigenous; and who resided in one of the 34 member countries* of the Organisation for Economic Co-Operation and Development (OECD) [232]. There was no maternal age restriction.

* The member countries of the Organisation for Economic Co-operation and Development are: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel , Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

7.4.2.2 Interventions

This review included any study where an intervention component was aimed at changing a nutrition-related outcome. Studies were included if nutrition interventions were implemented alone or in combination with other health-related interventions (e.g. tobacco cessation). Any intervention study design (e.g. randomised or pseudo-randomised controlled trial, pre-/post-test or other study design) reporting quantitative results were considered.

7.4.2.3 Comparators

Any study design that included a comparison group was considered for inclusion, such as a control group from the same population not receiving intervention, comparison with another population group or another Indigenous community, or a pre-/post-test study design.

7.4.2.4 Outcome Measures

Studies that reported any of the following outcome measures were considered for inclusion: infant birth weight; breastfeeding initiation or duration (primary outcomes); maternal dietary intake during pregnancy; anthropometric outcomes of mothers (e.g. gestational weight gain); child overweight; infant dietary intake (other than breastfeeding); infant health outcome affected by maternal dietary intake (e.g. presence of foetal alcohol syndrome); maternal nutrition knowledge; changes to the food environment; biomarkers of maternal or infant food intake; or nutrition-related health status of mothers or infant (e.g. improvements in cholesterol or blood glucose) (secondary outcomes).

Studies were excluded if they met any of the following; pregnant Indigenous women were not the focus of the intervention, studies targeted populations in non-OECD member countries, there was no intervention component (e.g. observational studies), there were no published results (e.g. protocols for ongoing studies), if studies were not published in English, no nutrition-related outcomes were reported, or the target groups for intervention had rare or serious medical conditions (e.g. cancer). Studies where participants had conditions requiring dietary

management (e.g. gestational diabetes) were considered for inclusion. Studies were not eligible for inclusion if the intervention occurred postnatally only, even if outcome variables were the same as those examined in this review (e.g. breastfeeding duration).

7.4.3 Search Strategy

The following databases were searched: Medline/Premedline; the Cochrane Library, Embase, CINAHL, Scopus, PsychInfo, Dissertation & Thesis, Maternity and Infant Care, PubMed (using the Lowitja Institute 'Lit.search tool' [233]), Aboriginal and Torres Strait Islander Health Bibliography; Australian Family & Society Abstracts Database- Aboriginal and Torres Strait Islander Subset; Rural and Remote Health Database. This search was conducted in October 2014 with no date restrictions, and updated in October 2015. The reference lists of included studies were also examined and appropriate papers retrieved and checked for eligibility. Search terms were divided into three groups: 1) Aboriginal, Torres Strait Islander, Indigenous, Native American, Native Canadian, Inuit, Eskimo, First Nations, Maori, Sami, Lapp; 2) pregnancy/pregnant; and 3) diet, nutrition, breastfeeding/lactation, infant feeding/weaning, infant nutrition, eating behaviors, food habits, food intake, healthy eating, nutrition education. The Boolean operator *AND* was used to combine groups and *OR* was used within groups. Truncation of words was used where necessary (see Appendix 10.20 for example search strategy).

7.4.4 Study selection

All studies identified by the databases searched were retrieved and duplicates were removed. Two reviewers independently assessed relevance by a review of the title and abstract against inclusion and exclusion criteria to determine if full texts should be retrieved. If either reviewer identified a record that was potentially eligible for inclusion in the review, the full text of the article was retrieved. The full texts of retrieved studies were assessed by two independent reviewers to determine if they met inclusion and exclusion criteria. Where reviewers disagreed, a third reviewer was consulted to determine whether the study met the inclusion criteria.

7.4.5 Data Extraction

Data were extracted from included studies using a tool developed by the authors with key data reported as follows: setting; participants; intervention description and delivery; outcomes; comparison group; and key findings. The first reviewer extracted the data, which was cross-checked by a second reviewer.

7.4.6 Quality Assessment

Study quality was assessed by two independent reviewers using a standardised checklist and protocol (The Academy of Nutrition and Dietetics Quality Criteria Checklist for Primary Research) [231].

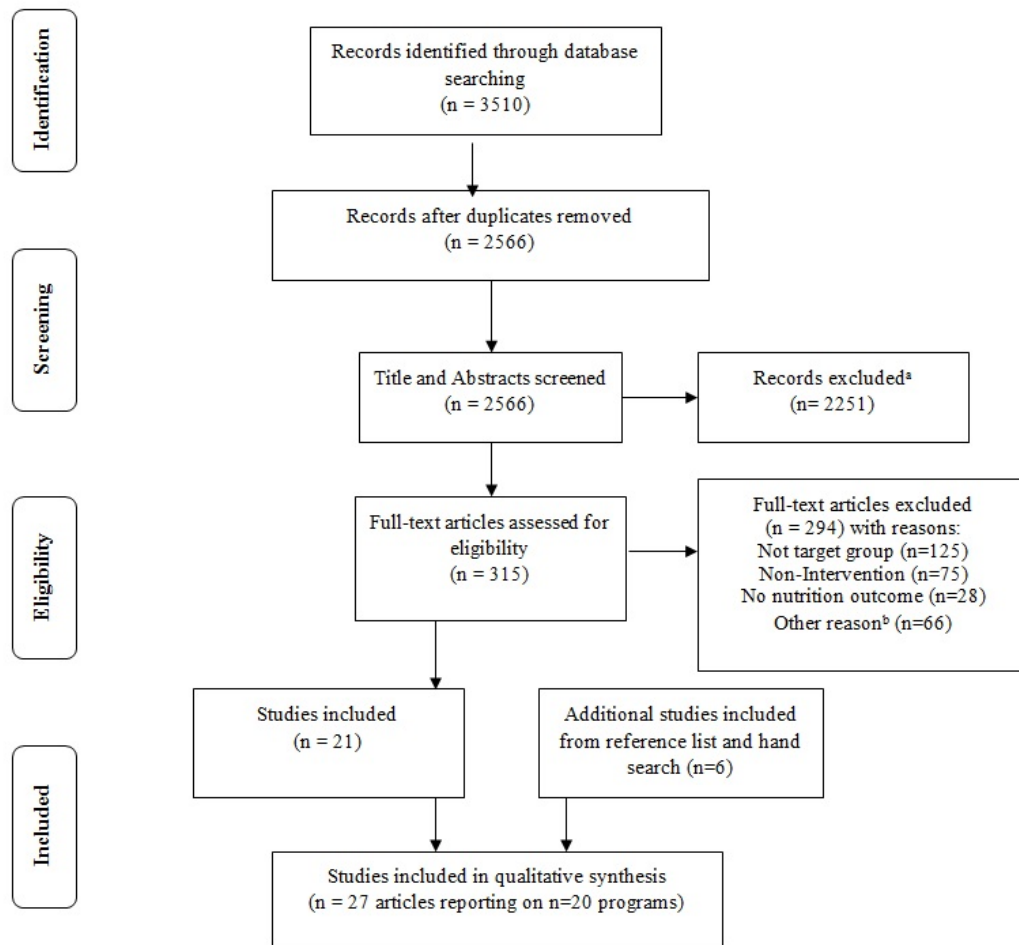
7.5 Results

In order to explore the efficacy of programs implemented to improve nutrition-related outcomes for pregnant Indigenous women, a descriptive summary of results and quality assessment of included studies are presented.

7.5.1 Description of Interventions

Twenty-seven articles reported on 20 intervention programs that met inclusion criteria (see Figure 7.1) [234]). Five programs were set in Australia (Northern Territory, New South Wales, Queensland, and Western Australia), 10 in the United States (Oklahoma, Idaho, Oregon, Washington, Utah, Northern Plains States, South Dakota, New Mexico, Arizona and Michigan), and five in Canada (Quebec, Manitoba, Ontario, Saskatchewan and Canada-wide). Indigenous groups represented included: Cree, Chikasaw Nation, Choctaw Nation, Sagkeeng First Nations, Alaska Natives, Rosebud Tribe, Cheyenne River Tribe, Navajo, Apache, Metis, and Aboriginal and Torres Strait Islander Australians. All participants were pregnant Indigenous women, and two programs were aimed specifically at adolescent and young adult Indigenous women, aged 13 to 19 years [235] and 12 to 22 years [236, 237].

Figure 7.1 Flow chart to show studies included in systematic review and review process



^aRecords were excluded by screening titles and articles for relevance against inclusion and exclusion criteria; ^bOther reasons include no results reported, study not available in English, review, no comparison group.

Descriptions of included interventions are presented in Table 7.1, including target group and setting, sample size, comparison groups and details of interventions. Study activities included nutrition or other health education or counselling (n=20), antenatal care services (n=4) and food supplementation or food vouchers (n=3). Table 7.2 summarises the modes of delivery and individuals delivering included programs. The majority of programs utilised individual counselling or education (n=16). Ten programs included home visits. Programs were most commonly delivered by non-Indigenous health/other trained worker (n=11) or by Indigenous health workers, researchers, or para-professionals (n=10). Three programs used senior Indigenous women to help deliver the program and four used peer

counsellors. Only one program used nutritionists [238]. Four programs involved interaction with the wider community and five used media campaigns.

Nutrition-related outcomes for the programs are presented Table 7.3. The most common outcomes measured were birth weight and proportion of LBW babies (n=9 programs), breastfeeding initiation (n=8) and duration (n=10), alcohol intake (n=5), and changes in parental knowledges, attitudes, and/or skills (n=6)

Table 7.1 Program target groups, setting, sample size, comparison group and intervention description of intervention programs aimed at improving nutrition-related outcomes for pregnant Indigenous women residing in OECD^a countries

<i>Program name</i> First Author, date	Target group and Setting	Sample size	Comparison group	Intervention description
<i>The Aboriginal Maternal and Infant Health Service (AMIHS)</i> Murphy et al., 2012	Pregnant Aboriginal women, Various locations, NSW ^b , Australia	sample size not provided	Pre-/Post-test design	Maternity service. Women-centered care, delivered by midwives and Aboriginal Health Workers. Continuity-of-care model from conception to 8-weeks postpartum Duration: 10-12 months
<i>The Aboriginal Maternity Group Practice Program</i> Bertilone et al., 2015	Pregnant Aboriginal women in South Metropolitan Perth, WA ^c , Australia	n=343	Historical/geographical control: Delivered between 1/1/2009 and 30/06/2011 (n=353 babies born) Contemporary control: Delivered in intervention time period in the north metropolitan area (n=353 babies born)	Community-based antenatal program with a focus on early access to antenatal care, Indigenous staff, holistic care, and awareness of social determinants of health. Women received standard antenatal care alongside culturally appropriate interventions for smoking and alcohol cessation, delivery of antenatal education including information on nutrition and alcohol use Duration: information not provided
<i>Baby Basket</i> McCalman et al., 2014	Indigenous women who are pregnant or recently given birth, Cape York, Queensland, Australia	n=170	Apunipima Cape York Health Council compared with control sites who did not receive the intervention	Pregnancy basket includes information on a healthy pregnancy including drinking, healthy diet, baby toiletries, a safe baby sleeper, a booklet written by Indigenous health workers, and five fresh fruit and vegetable food vouchers Duration: Baskets are delivered in first trimester, immediately prior to birth and postpartum

<i>Program name</i> First Author, date	Target group and Setting	Sample size	Comparison group	Intervention description
<i>Canada Prenatal Nutrition Program</i> Muhajarine et al., 2012	Pregnant women, Canada-wide, Canada	n= 48184 23% of sample are Indigenous women	'High' program exposure compared to 'low' exposure. An index for determining high or low exposure was developed based on time of program initiation, intensity and duration	330 projects across 2000 communities, including; food supplements, dietary assessments, individual and group nutrition education sessions, BF ^d preparation Duration: information not provided
<i>Family Spirit</i> Walkup et al., 2009 Barlow et al., 2013 Barlow et al., 2015	Pregnant American Indian adolescents aged 12-22 living on Navajo and White Mountain Apache reservations, New Mexico and Arizona, USA^e	n=81 (in 2002-2004) n=159 (in 2006-2011)	Active control (n=86) randomized to 23-visit BF and nutrition education program (in 2002-2004) Family Spirit + optimized care (n=159) compared to optimized standard care alone (n=163). Optimized standard care is transportation to recommended prenatal and well-baby visits,	Paraprofessional-delivered home visit pregnancy and early-childhood intervention. 25-visits addressing prenatal and newborn care and maternal life skills. Lessons (approx. 1 hour each) utilize flip-charts. Nutrition-related curriculum topics were: healthy pregnancy, harmful substances, diabetes, BF, formula, nutrition and disease, substance abuse. Increased to 43 lessons in 2006-2011 Duration: Intervention from 28 weeks gestation-6 months postpartum (Walkup., 2009). Increased duration to weekly visits during pregnancy, with ongoing visits to 36 months postpartum in 2006-2011

<i>Program name</i> First Author, date	Target group and Setting	Sample size	Comparison group	Intervention description
			pamphlets on child care and community resources, referrals to local services as needed (in 2006-2011)	
<i>Healthy Start</i> Coughlin et al., 2013	Pregnant American Indian women in Inter-Tribal Council of Michigan locations, Michigan, USA	n=872	Stratified by county (Medically Underserved Area [MUA] vs non-MUA)	Home-visiting program with five core services: direct outreach and client recruitment, case management, health education, screening and referrals for maternal depression, interconceptual continuity of care Duration: monthly visits during pregnancy plus individually-tailored education and referrals to needed services
<i>The Mums and Babies Program</i> Panaretto et al., 2005 Panaretto et al., 2007	Women with Indigenous singleton births attending Townsville Aboriginal and Islander Health Service (TAIHS) for antenatal care, Townsville, Queensland, Australia	n=456 (Panaretto et al. 2005) and n=781 (Panaretto et al. 2007)	1) Historical control attending antenatal care before the intervention (n=84) 2) Contemporary control who had singleton birth between January 2000 and June 2003 but who did not attend Townsville Aboriginal and Islander Health Service (TAIHS) for antenatal care (n=540)	Integration of previously autonomous service providers to deliver shared antenatal care run through the TAIHS. This integrated program includes a brief intervention for risk factors, including smoking cessation, nutrition including nutritional supplementation, antenatal education, BF Duration: information not provided

<i>Program name</i> First Author, date	Target group and Setting	Sample size	Comparison group	Intervention description
<i>Navajo Breastfeeding Intervention Program</i> Wright et al., 1997 Wright et al., 1998	Native American infants born year after intervention in a Navajo Reservation, Shiprock, New Mexico, USA	n=870 (Wright 1997) n=858 (Wright 1998)	Historical control: All infants born in Navajo community the year before the intervention (n=988)	Culturally appropriate BF promotion program with three components; 1) Community public service announcements, video, billboard, infant-shirts, 2) Health care system: including education of health care providers, creation of BF policy, 3) Individual level; video on BF, prenatal brochure, tribal Foster Grandparent program (bilingual women who would visit women in maternity ward to discuss BF) Based on community empowerment and social marketing techniques. Duration: information not provided
<i>Strong Women Strong Babies Strong Culture</i> Smith., 2000 Mackerras., 2001 d'Espaignet et al., 2003	Pregnant Aboriginal women in rural and remote communities, Top End, Northern Territory, Australia	Intervention group n=1151 (d'Espaignet et al., 2003)	1) Antenatal charts for births in 1990/1 2) Other communities in the Northern Territories using Midwives Collection, 3) Same communities 5 years prior to intervention	Supporting pregnant Aboriginal women by encouraging antenatal clinic visits, providing advice and encouragement about healthy nutrition in pregnancy (including greater use of bush foods), promoting safe practice (avoidance of smoking and alcohol), reinforcing need to seek appropriate medical assistance Duration: Fluid, determined by circumstances of the participant and availability of workers delivering the intervention

<i>Program name</i> First Author, date	Target group and Setting	Sample size	Comparison group	Intervention description
<i>Toddler overweight and tooth decay prevention study (TOTS)</i> Karanja et al., 2010	Pregnant women and their families from three American Indian tribes, Northwest Portland Area Indian Health Board (Idaho, Oregon, Washington), USA	n=205 families	Pre/Post-test design (children born 2 years earlier in the same tribes) and comparison to national BF rates	Community-wide intervention involved raising awareness, providing health education, facilitating individual behavior change, augmenting public health practice, modifying environments and/or policies related to BF, sugar-sweetened beverages and water consumption. Community interventions included water, milk or 100% fruit juice at community events, TOTS mothers with information about withholding sugar-sweetened beverages, promotional items containing BF information, mothers supporting other mothers BF Family Interventions delivered in 8 home-visit clusters via face-to-face contact or phone. Tribe A received a community-wide intervention alone and Tribes B and C received the community-wide intervention with a family component Duration: First during pregnancy, then further visits (7-21 total) postpartum
Program name not provided Glor et al., 1987	Pregnant Native Canadian women, Saskatchewan, Canada	n=98	Comparison to general population, Native population, high risk groups, pre-/post-test for diet	Prenatal education, birth coaching, postnatal counseling Duration: information not provided
Gray-Donald et al., 2000	Pregnant Cree women in four Cree communities, James Bay, Quebec,	Intervention group n=112	Control period of no intervention, followed by intervention	Strategies such as modelling, skill training, contracting, self-monitoring. Activities: local radio about healthy eating during pregnancy, pamphlets about nutritional choices and

<i>Program name</i> First Author, date	Target group and Setting	Sample size	Comparison group	Intervention description
	Canada		Control group n=107	BF, supermarket tours, cooking demonstrations, exercise/walking groups, individual dietary counseling. Dietary advice related to increasing dairy, fruit, vegetables, decreasing high-energy, low-nutrient foods, guidelines for pregnancy weight gain. Duration: women seen at least monthly for the duration of their pregnancy
Hermann et al., 2001	Pregnant adolescents, Chikasaw Nation and Choctaw Nation, Oklahoma, USA	n=336, 22% Native American and 78% Caucasian	Pre-nutrition education for food serves, national and state-wide rates for weight gain and birth weight	Nutrition education program based on "Have a Healthy Baby" curriculum. Sessions were delivered to small groups (2-4 participants per group). Sessions were conducted at public schools where participants were enrolled, or at participants' homes Duration: program was 8 sessions, unclear time period
Hoffhines et al., 2014	Pregnant women in an American Indian community, Oklahoma, USA	Sample size not provided	Pre-/post-test design for dietary intake, compared with survey of feeding practices of n=94 toddlers and national BF rates	Class for pregnant women covering benefits of BF, BF myths and problem-solving, latching techniques, BF positions, use of breast pumps, healthy toddler feeding practices. Note: breast pumps were provided free of charge. Duration: Unclear how many visits during pregnancy, but seen for educational follow-up at 2 and 6 weeks, 4, 6, 9, 12, 15, 18 and 24 months following delivery and provided with nutritional guidance at visits.
Lawrence et al. 2004	Pregnant women and carers living on First Nations Reserves in Sioux	Program delivered to n=28 communities.	High intervention group (n=8 communities) compared with low-	Education program delivered during home visits providing dental preventive education to pregnant women, new mothers, carers. Prenatal women are instructed on

<i>Program name</i> First Author, date	Target group and Setting	Sample size	Comparison group	Intervention description
	Lookout Zone, Ontario, Canada	Study reports on a cross-sectional representative sample of survey respondents (n=471 in 2001, n=705 in 2002) from n=16 communities	intervention group (n=8 communities). Determined by level of community participation (number of home visits, distribution of educational materials)	importance of healthy infant nutrition using visual aids. Educators focus on implementing behaviors in follow up visits. Other aspects include postnatal education package including tippi-cups, promotion of healthy food choices during food store visits, optimal oral hygiene practices taught to parents, children and carers, reinforcement of messages by nurses during well child clinics, bi-annual media campaigns. Duration: information not provided
Long et al., 1995	Pregnant women, Salt Lake Indian Health Care Centre, Utah, USA	Intervention group n=63 (n=60 Native American)	Historical control group of women (n=78 [Native American n=72] giving birth the year prior to the program)	Peer counsellors provided information, support and counselling on BF. Referrals to doctors and nutritionists were made where required. Duration: Peer counsellors contacted subjects prenatally (last month of pregnancy) and at 1, 2, and 4-6 weeks postpartum, via telephone, home visits, or clinic visits
Martens et al., 2002	Pregnant and breastfeeding First Nations women, Sagkeeng First Nation, Manitoba, Canada	n=283 newborn charts audited	Chart audit of community BF initiation from 1992-1997 compared with historical control Peer Counselor clients compared with non-clients	1) Prenatal instruction by community health nurse in home or clinic. Resources included video and booklet discussing BF. Addressed importance of BF, instruction on how to breastfeed, overcoming barriers. 2) Postpartum Peer Counsellor program if BF had been initiated. Duration: Unclear duration of prenatal component. Peer Counsellor's initiated calls to mothers once per week for first month and once every 2 weeks for months 2 and 3

<i>Program name</i> First Author, date	Target group and Setting	Sample size	Comparison group	Intervention description
May et al., 1989 May et al., 2008	Primagravidas, school children, and community in American Indian communities in Northern Plains States (Montana, South Dakota, North Dakota), USA	n=131 for case management	Pre-/Post-test study design	Macro-level Fetal Alcohol Syndrome (FAS) prevention program funded by Indian Health Service. FAS education and training utilized pamphlets, posters, fact sheets, a movie and a basic slide show (not all resources used in all training). Use of illustrations on same to attract attention of specific Native American cultural groups. Women identified as at high risk for drinking during pregnancy were provided with case management based on motivational interviewing. Duration: information not provided.
Mehl-Madrona et al., 2000	Native American, African American and Hispanic women in Arizona and New Mexico, USA	n=320	Historical control group, matched for age, parity, marital status, race and socioeconomic status	A Native American talking circle was used as the setting to deliver the intervention. Talking circle helps participants to open up and determine when to speak. Specific sessions of the intervention were 1) addressing fears 2) getting support 3) how we cope with stress 4) attachment to the unborn child 5) and 6) preparation for birth I and II 7) environmental awareness. Some skills used were visualisation, learning coping skills, learning where to get support. Incentives to participate in the program were provided. Duration: Classes started at 16-20 weeks pregnant and continued every 2-3 weeks until women were 36-40 weeks
Wilhelm et al., 2012	Mother infant dyads from the Rosebud Tribe and Cheyenne River Tribe,	Rosebud Tribe (Motivational Interviewing) n=8	Motivational Interviewing group compared with	Motivational Interviewing: Patient-centered counselling approach centered on decreasing ambivalence towards BF. Included BF test weights to validate BF volume and

<i>Program name</i> First Author, date	Target group and Setting	Sample size	Comparison group	Intervention description
	South Dakota, USA	dyads, Cheyenne River Tribe (Attention Intervention) n=4 dyads	Attention Intervention group	promote confidence in women over their milk supply. Duration: information not provided.

^aOECD Organisation for Economic Co-operation and Development; ^bNSW New South Wales; ^cWA Western Australia; ^dBF breastfeeding; ^eUSA United States of America

Table 7.2 Mode of delivery and personnel delivering nutrition intervention programs aimed at improving nutrition-related outcomes for pregnant Indigenous women residing in OECD^a countries

Program name First Author, date	Person/people delivering intervention						Mode of delivery					
	Indigenous Health worker/ Researcher/ paraprofessional	Other health worker or professional/ trained worker	Senior Indigenous women	Nutritionist/ Dietitian	Peer Counselor		Home visits	Telephone	Group counseling/ education	Inclusion of other community members	Individual counseling/ education	Media Campaign
The Aboriginal Maternal and Infant Health Service Murphy et al., 2012	✓	✓									✓	
The Aboriginal Maternity Group Practice Program Bertilone et al., 2015	✓	✓	✓				✓				✓	

Program name First Author, date	Person/people delivering intervention						Mode of delivery					
	Indigenous Health worker/ Researcher/ paraprofessional	Other health worker or professional/ trained worker	Senior Indigenous women	Nutritionist/ Dietitian	Peer Counselor		Home visits	Telephone	Group counseling/ education	Inclusion of other community members	Individual counseling/ education	Media Campaign
<i>Baby Basket</i> McCalman et al., 2014							✓					
<i>Canada Prenatal Nutrition Program</i> Muhajarine et al., 2012									✓		✓	
<i>Family Spirit</i> Walkup et al., 2009 Barlow et al., 2013 Barlow et al., 2015	✓						✓				✓	
<i>Healthy Start</i> Coughlin et al., 2013		✓					✓				✓	
<i>The Mums and Babies Program</i> Panaretto et al., 2005 Panaretto et al., 2007	✓	✓									✓	
<i>Navajo Breastfeeding Intervention Program</i> Wright et al., 1997 Wright et al., 1998	✓		✓							✓	✓	✓
<i>Strong Women Strong Babies Strong Culture</i> Smith et al., 2000 Mackerras et al., 2001 d'Espaignet et al., 2003			✓								✓	
<i>Toddler overweight and tooth decay prevention</i>		✓					✓	✓	✓	✓		✓

Program name First Author, date	Person/people delivering intervention						Mode of delivery					
	Indigenous Health worker/ Researcher/ paraprofessional	Other health worker or professional/ trained worker	Senior Indigenous women	Nutritionist/ Dietitian	Peer Counselor		Home visits	Telephone	Group counseling/ education	Inclusion of other community members	Individual counseling/ education	Media Campaign
study (TOTS)												
Karanja et al., 2010												
Program name not provided												
Glor et al., 1987	✓				✓		✓		✓		✓	
Gray-Donald et al., 2000	✓			✓					✓	✓	✓	✓
Hermann et al., 2001	✓	✓					✓		✓		✓	
Hoffhines et al., 2014		✓							✓			
Lawrence et al. 2004	✓	✓			✓		✓			✓	✓	✓
Long et al., 1995					✓		✓	✓			✓	
Martens et al., 2002		✓			✓		✓				✓	
May et al., 1989		✓									✓	✓
May et al., 2008												
Mehl-Madrona et al., 2000		✓							✓			
Wilhelm et al., 2012	✓										✓	

^aOECD Organisation for Economic Co-operation and Development

Table 7.3 Outcomes of nutrition-related interventions for pregnant Indigenous women residing in OECD^a countries

Type of outcome	Specific outcome	Program name First Author, date ^b	Sample size	Statistical tests utilized	Results
Maternal Outcomes	Maternal dietary intake	Glor et al., 1987	n=98	Binomial, normal approximation of the binomial, Fisher's exact test and t-test	7 out of 15 women counselled before 8 months gestation improved their diet scores, 5 to an "excellent" score (categories based on adherence to the Canada Food Guide). Significance unclear
		Gray-Donald et al., 2000	Intervention group n=112	Independent t-tests for comparison of mean nutrient intake. Where warranted, data were pre-adjusted for normality before test was performed. Sample size sufficient for 80% power, using a 2-sided t-test to detect differences in energy intake of 1396 kJ (12.6%)	NS ^c differences in macro- and micro-nutrient intake between control and intervention groups (measured by 24-hour food recall), except for a mean (\pm SD ^d) decrease in caffeine (160 \pm 180 mg vs. 210 \pm 147 mg) at 24–30 weeks gestation and increase in folate (373 \pm 27.2 μ g vs. 304 \pm 19.9 μ g) at 6 weeks postpartum for the IG ^e vs CG ^f (both P <0.05)
		Hermann et al., 2001	n=336, 22% Native American and 78% Caucasian	Statistical Analysis Systems Analysis of Variance and Least Squared Means	Increases in servings of breads, cereal, rice and pasta, vegetables, dairy foods, and meat and protein alternatives foods after education for Native American participants whose initial number of servings were below minimum recommendations. Decrease in number of servings of all food groups except for vegetables and dairy foods for participants whose initial servings were at least the minimum recommended (all P <0.05)

	Canada Prenatal Nutrition Program (Muhajarine et al., 2012)	n= 48184 23% of sample are Indigenous women	ORs (95% CI ^b) specific to Aboriginal participants (from stratified analysis) between high and low exposure groups	Change in vitamin use from never to daily (OR: 3.34, CI: 2.22–5.01, $P \leq 0.05$)
Gestational weight gain	Canada Prenatal Nutrition Program	n= 48184 23% of sample are Indigenous women	OR (95% CI) specific to Aboriginal participants (from stratified analysis) between high and low exposure groups	Maternal weight gain greater than recommended (OR: 1.09, CI: 1.01–1.17, $P \leq 0.05$)
	Glor et al., 1987	n=98	Binomial, normal approximation of the binomial, Fisher's exact test and t-test	Mean (SD) weight gain was 11.7kg \pm 4.9 (n=32) (14.5kg in another Saskatchewan program, 16.8kg in a “young group”). NS program impact on weight gain.
	Gray-Donald et al., 2000	Intervention group n=112	Independent t-tests for comparison of mean rate of weight gain. Where warranted, data were pre-adjusted for normality before test was performed. Sample size sufficient for 80% power, using a 2-sided t-test to detect differences in rate of weight gain of 0.10 kg per week	NS difference in rate of gestational weight gain
	Hermann et al., 2001	n=336, 22% Native American and 78% white	Statistical Analysis Systems Analysis of Variance and Least Squared Means	5.7% of Native American participants gained <21 pounds compared to national average for pregnant adolescents of 23% gaining <21 pounds (statistical significance unclear)

	Postpartum weight	Gray-Donald et al., 2000	Intervention group n=112	Independent t-tests for comparison of mean postpartum weight retention. Where warranted, data were pre-adjusted for normality before test was performed. Sample size sufficient for 80% power, using a 2-sided t-test to detect differences in postpartum weight retention of 1.9 kg	NS difference in maternal weight at 6 weeks postpartum
	Nutrition-related Biomarkers	Baby Basket (McCalman et al., 2014)	n=170	Unclear	Lower reports of deficient iron levels in this setting compared to control sites (no further details provided)
		Gray-Donald et al., 2000	Intervention group n=112	Independent t-tests for comparison of mean glycemic level on the glucose screen. Where warranted, data were pre-adjusted for normality before test was performed. Sample size sufficient for 80% power, using a 2-sided t-test to detect differences in plasma glucose level of 0.74 (10%) mmol/L	NS difference in plasma glucose levels
	Breastfeeding initiation	The Aboriginal Maternal and Infant Health	sample size not provided	None. Direct comparison of BF ⁱ initiation rates	Increased BF initiation (67% to 70%) (statistical significance unclear)

	Service (Murphy et al., 2012)			
	Canada Prenatal Nutrition Program	n= 48184 23% of sample are Indigenous women	OR (95% CI) specific to Aboriginal participants (from stratified analysis) between high and low exposure groups	BF initiation OR: 1.27 (CI: 1.11–1.46, $P \leq 0.05$)
	Navajo Breastfeeding Intervention Program (Wright et al., 1997, Wright et al., 1998)	n=870 (Wright 1997) n=858 (Wright 1998)	t-tests for differences between means	-Increase in %BF in hospital (64.2% to 77.8%, $P < 0.00001$) -Decrease in % receiving formula in hospital (84.6 to 45.4%, $P < 0.00001$) -Increase in BF initiation (71.1% to 81.1% $P < 0.00001$) (compared to historical controls)
	Toddler overweight and tooth decay prevention study (Karanja et al., 2010)	n=205 families	None. Direct comparison of BF initiation rates	14% points increase in BF initiation in all tribes (74%) compared to national rates for American Indians (60%) (statistical significance unclear)
	Glor et al., 1987	n=98	Binomial, normal approximation the binomial, Fisher's exact test and t-test	89% BF initiation rate in year one of the program, 47% in year two. General population is 72% and Saskatchewan reserve Indian rate is 68.7% (statistical significance unclear)
	Hoffhines et al., 2014	Sample size not provided	None. Direct comparison of BF initiation rates	BF initiation rate was successfully increased from survey rate of 59% to 89% in the intervention group (statistical significance)

					unclear)
	Long et al., 1995	Intervention group n=63 (n=60 Native American)	Chi-squared likelihood ratio test to determine differences between intervention and control group		BF initiation higher in intervention group (84%) versus control group (70%) ($P=0.07$)
	Martens et al., 2002	n=283 newborn charts audited	Unclear		BF initiation rates increased from 38% in 1995 to 60% in 1997 (statistical significance unclear)
Breastfeeding duration	The Aboriginal Maternal and Infant Health Service	sample size not provided	None. Direct comparison of BF rates at 6 weeks		Increased BF at 6 weeks (59% to 62%), unclear if significant
	Canada Prenatal Nutrition Program	n= 48184 23% of sample are Indigenous women	OR (95% CI) specific to Aboriginal participants (from stratified analysis) between high and low exposure groups		BF duration OR: 2.97 (CI: 1.01-8.76, $P\leq 0.05$)
	Navajo Breastfeeding Intervention Program	n=870 (Wright 1997) n=858 (Wright 1998)	t-tests for differences between means		-Increase in mean age (days) at starting formula (11.7 to 48.5, $P<0.001$) -Increase in mean (days) BF duration (100.6 to 131.6, $P<.001$)
	Toddler overweight and tooth decay prevention study	n=205 families	None. Direct comparison of BF rates at 6 months		15% points increase in 6-month BF duration in all tribes (38%) compared to national rates for American Indians (23%) (statistical significance unclear)

	Gray-Donald et al., 2000	Intervention group n=112	None. Direct comparison of BF rates at 6 weeks	BF at 6 weeks postpartum prevalent in intervention group (87%) and control group (83%) (statistical significance unclear)
	Hoffhines et al., 2014	Sample size not provided	None. Direct comparison of BF rates at 6 weeks and 12 months	BF at 6 weeks and 12 months postpartum rose from 23% and 13%, respectively (statistical significance unclear), before the study to 35% and 12% in the intervention group after the study, compared to national rates of 43% at 6 months and 7% at 12 months
	Lawrence et al. 2004	Program delivered to n=28 communities. Study reports on a cross-sectional representative sample of survey respondents (n=471 in 2001, n=705 in 2002) from n=16 communities	Chi-squared test to assess differences in proportions	BF duration was longer in high intervention group in 2001 (age of weaning: mean \pm standard error 12.6 \pm 1.00 months in high intervention group vs 10.1 \pm 0.88 months in low intervention, $\chi^2 = 4.69$, $P=0.030$) and in 2002 (8.5 \pm 0.83 vs 7.68 \pm 0.79 months, statistical significance unclear)
	Long et al., 1995	Intervention group n=63 (n=60 Native	Mann-Whitney U test	BF duration at 3 months postpartum higher for IG (49%) v. CG (36%) ($P=0.08$). BF duration at 6 months postpartum similar for IG (21%) and CG

		American)		(31%) (NS)
	Martens et al., 2002	n=283 newborn charts audited	Cox Proportional Hazards regression model	Peer counselor clients half as likely to wean at any given point as non-clients (OR=0.5, 95% CI 0.25-0.98, P<0.02) and more peer counselor clients BF at 2 and at 6 months than non-peer counselor clients.
	Wilhelm et al., 2012	Rosebud Tribe (Motivational Interviewing) n=8 dyads, Cheyenne River Tribe (Attention Intervention) n=4 dyads	Mann-Whitney U test	Motivational interviewing (MI) group (mean±SD =142.5±58) BF for more days than Attention Intervention (AI) group (21.3±16.5), 5/8 mothers in MI group BF for 6 months, no mother in AI group breastfed >1.5 months. Significant group differences for days BF (P=0.005)
Parental Knowledge, Attitudes and/ or Skills related to nutrition	Family Spirit (Walkup et al., 2009, Barlow et al., 2013, Barlow et al., 2015)	n=81 (in 2002-2004) n=159 (in 2006-2011)	Unstandardized β regression coefficient representing mean difference in outcome value between groups (Walkup 2009) Repeated measures analysis of covariance models for scalar outcomes and logistic regression for binary outcomes (Barlow 2013) and odds ratios (Barlow 2015)	-Greater parenting knowledge gains at 6 (β =13.5, P<0.01) and 12 (β =13.9, P<0.01) months postpartum for mothers in Family Spirit group compared to active control mothers (Walkup 2009) -12 months postpartum, mothers in Family Spirit group had higher parenting knowledge than control group (effect size 0.33, P=0.001) (Barlow 2013) -At 36 months postpartum, mothers in intervention group has significantly greater parenting knowledge (adjusted mean score 15.94 in intervention, 14.66 in control, effect

			size= 0.42, $P<0.001$) (Barlow 2015) (Parenting knowledge includes nutrition-related questions)
Toddler overweight and tooth decay prevention study	n=205 families	Unclear	60% of parents expressed high confidence in abilities to implement study recommendations for all interventions except for breastfeeding (statistical significance unclear)
Lawrence et al. 2004	Program delivered to n=28 communities. Study reports on a cross-sectional representative sample of survey respondents (n=471 in 2001, n=705 in 2002) from n=16 communities	Independent sample t-test for difference in mean scores between groups, The Mann Whitney U test was used when data were not normally distributed. Chi-squared test for differences in proportions	Caregiver knowledge, behaviors and attitudes (including nutrition questions) score (mean \pm standard error) significantly higher in high-intervention versus low-intervention groups (8.62 ± 0.14 v 7.73 ± 0.18 in 2001, $P<0.001$, and 9.07 ± 0.18 v 8.55 ± 0.20 in 2002, $P<0.05$). Significant difference in proportion who chewed food before giving it to child between high intervention (33.3%) and low intervention (44.0%) in 2001 ($X^2=3.67$, $P=0.054$) but NS in 2002. Fewer carers put sugar or sweeteners in child's bottle in high intervention communities (34.5%) vs low intervention communities (55.4%) ($X^2=12.6$, $P<0.001$) in 2002 (data not collected in 2001).
May et al., 1989	n=131 for case management	Difference of mean test (either Z or t test)	Knowledge score gains post-test after Fetal Alcohol Syndrome (FAS) training sessions were statistically significant in 10/14 community groups who received FAS training ($P\leq0.05$) (not all participants were pregnant women). In

				group of prenatal patients (n=10), knowledge scores rose from mean 85.0 ± 15.1 pre-test to 98.8 ± 11.3 post-test, NS
	Wilhelm et al., 2012	Rosebud Tribe (Motivational Interviewing) n=8 dyads, Cheyenne River Tribe (Attention Intervention) n=4 dyads	Unclear	Case managers perceived MI to motivate women to breastfeed longer and breastfeeding test weights to give mothers confidence
	Martens et al., 2002	n=283 newborn charts audited	One-tailed independent t-test and Mann-Whitney U test	Peer counsellor clients had fewer problems BF ($P<0.05$), greater satisfaction with BF ($P<0.10$), and less favourable bottle-feeding beliefs ($P<.10$) than non-PC clients
Alcohol intake	Baby Basket	n=170	Unclear	Trend decrease in women who consumed alcohol in pregnancy (statistical significance unclear)
	Canada Prenatal Nutrition Program	n= 48184 23% of sample are Indigenous women	OR (95% CI) specific to Aboriginal participants (from stratified analysis) between high and low exposure groups	Drinking cessation OR: 1.44 (CI: 1.22-1.70, $P\leq 0.05$)
	Family Spirit	n=81 (in 2002-2004)	OR (95% CI) (Walkup 2009) Repeated measures analysis of	-No between group differences for alcohol use (Walkup 2009)

			n=159 (in 2006-2011)	covariance models for scalar outcomes and logistic regression for binary outcomes (Barlow 2013) and odds ratios (Barlow 2015)	-NS difference between groups for substance use (Barlow 2013) -NS difference in alcohol use in last 30 days between groups (Barlow 2015)
		May et al., 2008	n=131 for case management	Chi-squared test, t-test, and one-way analyses of variance	NS difference in number of drinks on typical drinking day over last 30 days, increase in proportion of women having 0 drinking days in a typical week from 69.5% at baseline to 80% at 6 months (NS), then decrease to 40% at 12 months ($P<0.001$)
		Mehl-Madrona et al., 2000	n=320	Chi-squared test for group differences	Reduction in drinking for heavy drinkers in the intervention group (100%) compared to comparison group (36.4%) ($P<0.02$)
Child Outcomes	Pre-term birth	The Aboriginal Maternal and Infant Health Service	sample size not provided	OR (95% CI)	Decreased proportion preterm births (20% vs 11%, OR 0.5, 95% CI 0.4-0.8, $P<0.001$)
		Canada Prenatal Nutrition Program	n= 48184 23% of sample are Indigenous women	OR (95% CI) specific to Aboriginal participants (from stratified analysis) between high and low exposure groups	Pre-term birth OR: 0.72 (CI: 0.57-0.92, $P\leq 0.05$)
		The Mums and Babies Program (Panaretto et al.,	n=456 (Panaretto et al. 2005) and	Chi-squared, Kruskal-Wallis and t-tests (as appropriate).	Significant reduction in preterm birth in intervention group (8.7%) compared with contemporary control group (14.3%, $P<0.01$) and

	2005, Panaretto et al., 2007)	n=781 (Panaretto et al. 2007)		historical control (16.7%, $P<0.05$) (Panaretto et al., 2005). Significant reduction in preterm birth in intervention group (9.5%) compared with Queensland Indigenous births (13.0%) ($P<0.05$) in updated results (Panaretto et al., 2007).
	Baby Basket	n=170	Unclear	Improvements in trend of failure to thrive, from 26% in 2010 showing evidence of faltering growth to 5% in 2013 (statistical significance unclear)
Child anthropometrics	Toddler overweight and tooth decay prevention study	n=205 families	Changes in z-scores (for age) of BMI, weight, and height, from birth to 24 months. Due to the disparity of z-score distributions between tribes, an adjustment was made using historical control data	BMI Z-scores decreased by 0.75 in Tribes B and C (receiving both community-wide and family interventions) combined ($P=0.016$)
	Lawrence et al. 2004	Program delivered to n=28 communities. Study reports on a cross-sectional representative sample of survey	Chi-squared test for differences in proportions	Lower proportion of overweight 2–5 year olds in high intervention than low intervention communities (20.2% vs 20.7% in 2001, statistical significance unclear, 25.8% vs 31.8%, $X^2=9.534$, $P=0.023$ in 2002)

		respondents (n=471 in 2001, n=705 in 2002) from n=16 communities			
	The Aboriginal Maternal and Infant Health Service	sample size not provided	Unclear		Decreased rate LBW babies (13% pre-service, 12% after service), NS
	The Aboriginal Maternity Group Practice Program (Bertilone et al., 2015)	n=343	Mann-Whitney U test		NS between-group difference in proportion of low birth weight babies found (10.8% in intervention group, 14.4% in historical control, 15.9% in contemporary control)
Birthweight/ proportion LBW^k	Canada Prenatal Nutrition Program	n= 48184 23% of sample are Indigenous women	OR (95% CI) specific to Aboriginal participants (from stratified analysis) between high and low exposure groups		LBW OR: 0.65 (CI: 0.53-0.81, $P \leq 0.05$)
	Healthy Start (Coughlin et al., 2013)	n=872	OR (95% CI)		When stratified by county (Medically Underserved Area [MUA] vs non-MUA) Healthy Start participants from MUA counties had lower adjusted odds of LBW (OR=0.37, 95% CI =0.14, 0.96) than non-Healthy Start participants
	The Mums and Babies Program	n=456 (Panaretto et	Chi-squared, Kruskal-Wallis and t-tests (as appropriate).		Increase in mean birthweight in intervention (3239g) vs historical control (3043g) was

		al. 2005) and n=781 (Panaretto et al. 2007)		significant ($P=0.027$) but NS different to contemporary control (3188g) ($P=0.28$) (Panaretto et al., 2005). NS difference in updated results (Panaretto et al., 2007).
Strong Women Strong Babies Strong Culture (Smith et al. 2000, Mackerras et al., 2001, d'Espaignet et al., 2003)	Intervention group n=1151 (d'Espaignet et al., 2003)	Linear regression, Student's t and X^2 tests for trend in average birthweight and proportion low birth weight between intervention and control groups		Decrease in proportion of LBW babies and increase in birth weight amongst intervention group, however results were NS for all groups
Glor et al., 1987	n=98	Binomial, normal approximation the binomial, Fisher's exact test and t-test		Mean birth weight $3302g \pm 488$ (3405g for Saskatchewan, 3410g for all British Columbia Indians, NS difference between groups)
Gray-Donald et al., 2000	Intervention group n=112	Independent t-tests for comparison of mean birth weight. Where warranted, data were pre- adjusted for normality before test was performed. Sample size sufficient for 80% power, using a 2-sided t-test to detect differences in birth weight of 215g		NS difference in mean birth weight
Hermann et al., 2001	n=336, 22% Native American and 78% Caucasian	Statistical Analysis Systems Analysis of Variance and Least Squared Means		Rate of LBW was 7.5% for Native American participants, compared to state-wide low birth weight rates of 11.1% for Native American adolescents (statistical significance unclear)

	Child dietary intake	Hoffhines et al., 2014	Sample size not provided	None. Direct comparison of caloric intake, energy requirements, and nutrient intake	NS changes to caloric intake or estimated energy requirements, or macronutrient or micronutrient intake (statistical significance unclear)
		Navajo Breastfeeding Intervention Program	n=870 (Wright 1997) n=858 (Wright 1998)	t-tests for differences between means and Chi-squared tests for comparison of incidence figures	-Reduction in proportion of children having pneumonia (-32.2%, <i>P</i> =0.04), gastroenteritis (-14.6%, <i>P</i> =0.02) or bronchitis (-71.9%, <i>P</i> =0.02) -Increased rates of croup and bronchiolitis among formula-fed infants who were never exclusively breastfed -Decline in sepsis in both formula and breast-fed infants
	Rates of childhood illnesses/ infections/ dental caries	Lawrence et al. 2004	Program delivered to n=28 communities. Study reports on a cross-sectional representative sample of survey respondents (n=471 in 2001, n=705 in 2002) from n=16 communities	Chi-squared test for differences in proportions	Children in high intervention communities less likely to have abscessed teeth and untreated dental decay

Other	Nutrition-related Changes to environment/policies	Toddler overweight and tooth decay prevention study	n=205 families	None reported	Environmental/Policy changes implemented included baby-friendly hospitals, longer breaks for lactating mothers returning to work, vending machines selling water, replacing sweetened beverages for water at child events, passing tribal resolutions to not use tribal government dollars for purchase of sweetened drinks (effect or statistical significance unclear)
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^aOECD Organisation for Economic Co-operation and Development; ^bWhere a program has more than one publication associated with it, authors and dates are only listed at the first mention of the program; ^cNS not statistically significant; ^dSD Standard deviation; ^eIG Intervention Group; ^fCG Control Group; ^gOR Odds Ratio; ^hCI Confidence Intervals; ⁱBF breastfeeding; ^jBMI Body Mass Index; ^kLBW Low Birth Weight

7.5.2 Quality Assessment and Change in Outcome Measures

Using the Quality Criteria Checklist for Primary Research, 13 studies scored a positive quality rating, 14 scored a neutral rating, and none of the studies scored a negative quality rating. Details of study scores by criteria are outlined in Appendix 10.21.

7.5.2.1 Changes in breastfeeding initiation and/or duration

Eleven programs (12 articles) investigated changes in breastfeeding initiation and/or duration resulting from the implemented intervention. Five of the articles received a positive quality rating, and seven received a neutral rating (Appendix 10.21). All of the programs reported positive outcomes in increasing rates of breastfeeding initiation. Long et al (1995) observed a non-statistically significant higher rate of breastfeeding initiation in the experimental group (84%, n=45) compared to the control group (70%, n=77) for all women in the experiment ($P=.07$; chi-square, likelihood ratio test). The researchers considered $P\leq.08$ to be an acceptable level of significance owing to high breastfeeding rates in the control group [239]. Wright et al (1997 and 1998) observed an increase in women who ever breastfed from 71.1% to 81.1% ($P<.001$) [240, 241]. In the Canada Prenatal Nutrition Program, there was an association between program participation and increased likelihood of breastfeeding initiation for Aboriginal women (OR: 1.27, 95% CI 1.11-1.46, $P\leq.05$) [242]. Two of these articles received a positive rating and two a neutral rating. The remainder of studies did not report on statistical significance. All but two programs [238, 243] reported positive outcomes in terms of breastfeeding duration with six programs reporting statistically significant improvements [239-242, 244-246], and four articles receiving a positive quality rating. Four programs did not report on statistical significance [238, 243, 247, 248].

Nutrition activities utilised in programs resulting in statistically significant improvements in breastfeeding initiation and/or duration included; provision of nutrition education (n=6), food supplementation/food vouchers (n=1), modification to the food environment (n=1), and supermarket tours (n=1) (details of program activities are in Table 7.1). Modes of delivery associated with significant

improvements in breastfeeding outcomes included: individual (n=6) or group (n=1 program) counselling or education; peer counselling (n=3); home visits (n=3); delivery by Indigenous health workers (n=3), health professionals (n=2), and senior Indigenous women (n=1); interventions that involve other community members (n=2); and media campaigns (n=2) (Table 7.2).

7.5.2.2 Changes in birthweight and/or proportion of LBW babies

Nine programs (twelve articles) investigated changes in infant birth weight and proportion of LBW. Four studies received a positive quality rating and eight received a neutral rating. Five of the programs reported positive outcomes in improving birthweight and/or proportion of LBW, however results were only statistically significant for three programs [242, 249-251], of which two of the six articles received a positive quality rating. For the other programs, there were either no significant changes seen [238, 248, 252, 253] or statistical significance was not reported [235, 254].

Nutrition activities employed by programs that reported statistically significant results included: individual counselling or education (n=3); group education or counselling (in n=1 program); use of traditional practices (n=1); provision of food supplementation or food vouchers (n=2); and delivery by senior Indigenous women (n=1).

7.5.2.3 Changes in other nutrition-related outcomes

Of the five programs [236, 237, 242, 255-258] that examined alcohol use as an outcome, three were successful in reducing alcohol intake [242, 255, 259]. In the program described by Mehl-Madrona *et al.* participation in the experimental group was associated with an odds ratio of 1.22 for reducing alcohol intake, which was not statistically significant. However, the odds of reducing heavy drinking were 2.26 (chi-square 5.83 ($P=.02$) [259]. The Canada Prenatal Nutrition Program observed an odds ratio of 1.44 ($P\leq.05$) for drinking cessation amongst Aboriginal participants with high program exposure [242]. Finally, the Baby Basket program reported a trend for a decrease in the number of women consuming alcohol in

pregnancy, but it is not reported whether this was statistically significant [255]. Significant changes in dietary intake in terms of increases in daily food group servings was achieved in one intervention program ($P<.05$) [235], while no significant differences in macro- or micro-nutrient intake were seen in another program [238]. A third program found improvements in a diet score, though it is unclear if these were statistically significant [253]. Several studies aimed to improve infant health outcomes, including rates of childhood illness [241], dental caries [244], childhood obesity [244, 247] and failure to thrive [255]. While all reported positive outcomes, not all were statistically significant. For example, the Toddler Overweight and Tooth decay prevention study (TOTS) reported a decrease in Body Mass Index Z-score by 0.75 ($P=.016$) for 18-24 month olds whose families had participated in a community intervention alongside additional family support [247]. This program also aimed to prevent toddler tooth decay and reported policy changes implemented to reduce access to sweetened beverages, although data on tooth decay was not reported.

7.6 Discussion

This review identified several studies that were successful in improving nutrition-related outcomes for pregnant Indigenous women and their infants. There was major variation in study design and/or outcome reporting, combined with the broad range of outcomes and activities covered by programs. Heterogeneity of the included studies means it is challenging to determine which factors have contributed to statistically significant improvements in nutrition-related outcomes; however, features of successful outcomes are discussed below.

7.6.1 Individual counselling or education

Individual counselling or education was provided in six programs resulting in statistically significant outcomes for breastfeeding, and in all programs that resulted in significant outcomes for birth weight. Generalised advice on nutrition during pregnancy is available from a number of sources, including dietary guidelines, health professionals, and friends and family, which may cause confusion for pregnant women [209], and knowledge gaps exist for pregnant

women's awareness of the recommendations for dietary intake during pregnancy [204]. Pregnant women may therefore benefit from individualised nutrition education and counselling to optimise their intake.

7.6.2 Community collaboration

Studies in this review highlight that interventions aimed at changing nutrition-related behaviours must be developed with cultural appropriateness as a high priority. Working with Indigenous peoples requires patience and time in order to build trust and rapport [124]. Ethical research with Indigenous peoples must be culturally appropriate, involving communities in all aspects of the research process and developed in close collaboration with Indigenous workers and communities [105, 260, 261]. Ten of the authors of studies included in the current review placed a strong emphasis on using community consultation in the development of the study design and investing extensive time into ensuring studies are developed in collaboration with the intended target population to ensure the program represents the interests of the community [235, 236, 238, 240, 241, 246-249, 259]. Several studies attribute success to having strong collaborations with the target population group, incorporating local practices into the intervention, and/or effective local Indigenous partnerships [236, 240, 241, 246-248, 259]. Wilhelm et al (2012) made several major recommendations for researchers working in Indigenous health promotion, including ensuring the community is involved in all stages of the research project, demonstrating a long-term commitment to the health of the community, and placing the needs of the community above the research project goals [246].

An example of community collaboration is the Strong Women Strong Babies Strong Culture program, which aimed to improve birth weights of Aboriginal Australian children in communities in the Northern Territory, by culturally appropriate means. The intervention involved periodic nutrition assessment and counselling of pregnant women, alongside a community-based education and support program. Women were supported to attend antenatal visits and were provided with advice by senior Aboriginal women, who were well-respected in the community, on healthy nutrition in pregnancy (including greater use of traditional foods) and the

avoidance of alcohol [249, 262, 263]. Communities where the interventions were not in place were used as the control group. In the pilot communities, prevalence of LBW declined from 21% to 13% ($P=.03$) and mean birth weight increased by 108g ($P=.046$) [262]. D'Espaignet et al. (2003) reported increases in birth weight in intervention communities in the Top End of the Northern Territory, compared to historical controls and non-intervention communities ($P<.0001$), although results were not statistically significant for all groups [249].

7.6.3 Delivery by Indigenous program workers

Thirteen programs in this review used Indigenous health workers, researchers, paraprofessionals, peer counsellors, or Senior Indigenous women to deliver program content. Senior Aboriginal women for example, were engaged in delivering the nutrition education for the Strong Women Strong Babies Strong Culture program, which achieved some significant improvements in birth weights. Mackerras (2001) attributed this to the intervention being dependent on the traditional authority of the female elders in the community [262]. The Navajo Breastfeeding Program employed a comprehensive approach to improving rates of breastfeeding, including incorporating an existing tribal Foster Grandparent program, where a bilingual foster grandmother provided individual counselling and lactation support to woman [240, 241]. This may have contributed to the statistically significant improvements in breastfeeding initiation and duration. Mehl-Madrona (2000) et al. suggests that a strength of their program was allowing mothers and grandmothers to attend prenatal classes with pregnant women, and this helped gain community acceptance [259]. Finally, although the program described by Bertilone et al. did not show significant differences in proportion with LBW, the authors refer to the importance of recruitment by Aboriginal "grandmothers", who were respected women in the community, as key to increasing referrals to the program and reducing risk of selection bias [252].

7.6.4 Home-visiting interventions

Home-visiting interventions show promise as effective methods of delivering nutrition intervention programs. American Indian and Australian Aboriginal

women receive fewer antenatal care visits and therefore have less face-to-face contact time within which health professionals and care providers can deliver information, including education on nutrition for pregnancy and infancy. Home visits can help overcome the barrier of transportation, and other cultural barriers that can prevent women from accessing health education at mainstream service providers. There was strong tribal support for the intervention described by Walkup and colleagues, because home-based interventions fit well within a health-care framework that favors a family-centered approach to healthcare [236]. Karanja and colleagues highlight the strength of the home visit intervention was allowing greater flexibility and tailoring of the intervention to meet the specific needs of the participating family [247]. Of the 20 programs included in this review, 10 programs reported offering home visits. All of these programs reported improvements in at least one outcome, although the direct impact of offering home-visits on study success is unclear. Home-visiting interventions delivered by peers have the advantage of being “inherently more culturally competent” programs, and allow for research capacity-building within the Indigenous community [236]. They may be conducted in native languages and/or incorporate more culturally appropriate content. However, this delivery method is not always possible due to finite resources, unavailability of suitable peers, and potential logistical difficulties relating to geography. The use of telehealth services has great potential to overcome some of these barriers.

7.6.5 Multi-faceted interventions

Several articles suggested that a multi-faceted approach may be beneficial. The Toddler Overweight and Tooth decay prevention Study tested a multi-faceted intervention to promote breastfeeding and decrease sweetened drink intakes with the aim of preventing toddler overweight and improving oral health. Study design was a community-wide trial compared with the same community trial plus an additional family intervention [247]. Individual and family counselling were combined with community efforts to raise awareness of breastfeeding and modify environments and policies to facilitate improved breastfeeding rates. A baby-

friendly hospital initiative was introduced, and longer breaks for breastfeeding women returning to work were implemented. Among all participating tribes, breastfeeding initiation and breastfeeding duration up to six months were 14% and 15% higher than national rates for American Indians, respectively. There was a combined decrease in body mass index z score at 24 months for the two communities that received both community-wide and family-based interventions [247]. Wright and colleagues (1997, 1998) took a similar multi-faceted approach with the Navajo Breastfeeding Intervention Program. They evaluated a culturally appropriate breastfeeding promotion program involving a community-wide media campaign, an intervention within the health care system, including creation of breastfeeding policy and educating health care providers, and individual and family-based counselling. There were improved rates of breastfeeding; an increase in initiation from 71.1% to 81.1% and an increase in mean breastfeeding duration by 31 days (both $P<.001$) [240, 241].

7.6.6 Other factors

Other factors that may be associated with program success included having services based in, or easily accessible to, the community [248], flexibility of service delivery [248], provision of transport [248], effective local health partnerships [248], collaboration with other services [248], regular and long-term follow up of participants [236, 237, 256], use of an active control group connecting participants to antenatal and pediatric care to ensure all participants receive appropriate services [236, 237, 256]; flexibility in terms of where programs are delivered (e.g. in schools, in homes) [235-237, 247, 248]; and flexibility in terms of giving participants a choice of how they want the intervention delivered, e.g. language and emphasis on traditional or Western practices [236]. In the study described by Gray-Donald et al. (2000), the addition of two nutritionists who were based in the community and delivering the interventions was viewed favorably by the communities, even though the program was not successful at meeting outcomes [238]. Interestingly, this was the only program delivered by nutritionists or dietitians, although the

Senior Aboriginal women working in the Strong Women Strong Babies Strong Culture program were supported by community nutritionists [262].

Provision of nutrition support, through food vouchers, and food and nutritional supplementation, was employed by few programs (n=3). However, evidence from the wider literature suggests that combining nutrition education and counselling with nutrition support may be more effective in improving gestational weight gain, reducing risk of anemia, and increasing birth weight [264].

7.6.7 Quality of included studies

Several limitations of study quality and/or reporting of results have made assessing the true impact of some of these interventions challenging. The majority of articles had clearly stated research questions (n=27), clearly defined outcomes (n=27), appropriate statistical methods (n=25), and had considered bias and limitations (n=26). Bias due to funding sources was unlikely in 24 articles (funding was unclear in the remaining three). However, there were some limitations in study design, including controls used. When there was no strictly defined control group, it was difficult to assess if changes to outcome measures were the result of the intervention, or natural changes and shifts in behaviors over time. Only one randomised controlled trial was conducted and this was the only study to report blinding of evaluators, though not participants [236, 237, 256]. Mehl-Madrona (2000) [259] and colleagues state that size and closeness of communities may make randomisation not feasible for some interventions delivered in this context, and imply that a randomised study design would not be acceptable to participants. This was supported by Gray-Donald et al. (2000), who asserted that randomising individuals in small communities might lead to treatment contamination, and randomisation of whole communities was unfeasible, due to key differences between communities [238]. A matched historical control group or pre-/post-test design was a common comparison group across studies included in this review. Other studies made comparisons with other contemporary groups not receiving the intervention [245, 246, 255], or high versus low exposure to the program [242, 244, 254]. Several researchers compared results to appropriate population-level data, e.g.

national, state and/or local statistics, at least for some outcomes [235, 243, 247, 252-254]. The Family Spirit program used an active control group who also received antenatal support through breastfeeding education and optimised care [236, 237, 256]. Heterogeneity hindered the ability of this review to draw any conclusions regarding appropriate study designs for interventions of this type.

In many studies, the descriptions of the interventions lacked detail relating to nutrition components [242, 248, 254, 262], for example, the nature of the nutrition intervention, who delivered it, or the specific content. It is challenging to identify which aspects of the program may or may not have led to improvements in outcomes when there is limited description of the nutrition interventions. In addition, for many of the included studies, nutrition was not the sole focus of the intervention, with other aspects of antenatal care often included (e.g. support for smoking cessation, midwife services, antenatal education). This makes it difficult to assert if improvements in study outcomes were related to nutrition intervention. There is a need for interventions to be designed with clear evaluation protocols and for the use of validated tools to determine intervention causation in nutrition-related outcomes.

7.6.8 Strengths and limitations of the review

There are several limitations of this review that should be acknowledged. Publication bias is a consideration, as only those studies with published results (before October 2015) have been included. Therefore ongoing programs, or those without published evaluations, will have been missed. Studies published more recently or those not published in English will also have been missed. Studies without statistically significant results may not be published, and therefore this review likely presents a best-case scenario. Data extraction for this review was conducted by one person and checked by a second, rather than extracted separately by two people followed by comparison of results. This is therefore a potential source of bias in this review. Most of the intervention programs included in this review utilised a multi-faceted approach to intervention activities and delivery, and statistical significance was not reported for all studies. Outcomes such as

birthweight may be influenced by a variety of factors beyond nutrition, such as tobacco smoking. These considerations make it difficult to definitively ascertain if programs were directly associated with changes in the outcomes, and if so, which components of programs are most responsible for facilitating improved outcomes. It should be acknowledged that every Indigenous group is unique, and that tailored intervention strategies are required to meet the diverse needs of different groups. Finally, this review did not identify any studies from OECD countries other than Australia, the United States, or Canada. It is therefore unknown whether intervention programs within other populations of pregnant Indigenous women have been conducted and evaluated or have achieved favorable nutrition outcomes, and if so, what lessons can be learned from these.

The strengths of this review include the systematic and comprehensive search strategy, and use of two independent reviewers for assessing study inclusion and quality assessment, which improves objectivity.

7.7 Conclusions

The aims of this review were to identify existing interventions and the factors associated with positive outcomes. It was not possible to draw any firm conclusions on the direct impact of individual program components on successful nutrition-related outcomes. However, the importance of community collaboration has been highlighted based on the characteristics of the majority of included programs. Individual education or counselling may be associated with positive outcomes. Indigenous workers may be a valuable asset for program recruitment and delivery, and offering home-visits may facilitate program success. In order to improve the quality of reporting of future studies, details of interventions and measurement tools used should be provided in appendices, via website links, or by establishment of an international repository. There is a need for more studies using robust study designs incorporating appropriate comparison data, in order to standardise evaluations and inform best practice. Future studies need to include more comprehensive description of nutrition interventions in order to adequately

identify the impact of interventions on nutrition-related pregnancy outcomes for Indigenous women.

Chapter 8 Discussion and recommendations

8.1 Overview

While the preceding chapters (2-7) outline the findings from each individual study in detail, this chapter summarises the key findings of these studies in the context of the overall aims of the research thesis. In section 8.2, a summary of findings from each study is presented. Strengths and limitations of each study are discussed in section 8.3. In section 8.4, the overall findings of the research thesis are summarised. A discussion of findings is outlined in section 8.5. Implications of the body of research on practice and implications for further research and for Aboriginal communities are presented in sections 8.6 , 8.7, and 8.8, respectively. The research thesis closes with concluding remarks, presented in section 8.9.

8.2 Summary of findings

In this section the findings from each study that forms this thesis are summarised.

8.2.1 Summary of findings from the quality assurance project

The aim of the quality assurance project was to evaluate the cultural experiences of student and new-graduate dietitians working with Aboriginal women and infants in an ArtsHealth setting. The student and new-graduate dietitians who participated discovered the importance of building rapport with Aboriginal women before the topics of nutrition and health could be addressed. They cited art as a useful medium through which to 'break the ice' and facilitate conversation. Some participants described the experience of working in the ArtsHealth centre as eye-opening, and as having increased their understanding around the greater context of the disparity in health for Aboriginal Australians, with one participant stating:

"Yes we've been told about the disparities but there's no explaining why there's this difference...it's almost accepted." [second-year Nutrition & Dietetics student]

The participants placed value on working directly with Aboriginal communities in order to develop cultural understanding, with one participant stating *"nothing beats first-hand experience"* [fourth-year Nutrition & Dietetics student]. Working in-person

with Aboriginal women in a safe space appeared to be an effective environment in which to assist with building the cultural competency skills required for ideal practice as a dietitian. This is an important finding, as cultural competency plays a significant role in reducing health inequalities for Indigenous people, including improving healthcare access and quality of care [65]. Education of health professional students should include cultural experiences to help prepare students for the workforce, and to drive their commitment to work towards closing the gap in health disparity [65].

With only 20 weeks of practical placement experience, the opportunity for in-person cultural training is not available for all Nutrition and Dietetics students. Recommendations from this quality assurance activity were to encourage students to engage with volunteer activities in their undergraduate degrees, which would provide them with additional opportunities to build upon their cultural competency skills. While in-person practical experiences may be ideal, this will not be feasible for all students. Undergraduate Nutrition & Dietetics curriculums should provide a more detailed background to the greater historical and contemporary context surrounding Aboriginal nutrition, and include practical advice to ease the transition for student dietitians from the lecture room to the real world.

8.2.2 Summary of findings from the Gomeroi gaaynggal study

To optimise nutrition for Aboriginal women and their infants, current dietary intakes need to be established. The objective of this study was to provide cross-sectional data on diet, anthropometric measures, and body composition of Aboriginal women and their infants (n=73 mother-child dyads) who are part of the longitudinal birth cohort, the Gomeroi gaaynggal study.

The rate of breastfeeding initiation in this cohort was 85.9% (women who had ever breastfed), however a number of these mothers may have only breastfed on a single occasion. The median (interquartile range) duration of breastfeeding was 1.4 (0.5–4.0) months. Median age of introduction to solid foods was at 5.0 (4.0–6.0) months and introduction to cow's milk was at 12.0 (10.0–13.0) months. Reported

postpartum nutrient intakes from 24-R for mothers indicated they were low in folate, iodine, calcium, and potassium compared with estimated average requirements (EAR), low in fibre compared with the adequate intake (AI), and high in the proportion of energy from saturated fat. No lactating women, and only five non-lactating women, reported consuming alcohol in the 24 hours preceding the study session.

At one and two years postpartum, the proportion of women who were overweight or obese (body mass index [BMI] $\geq 25.0 \text{ kg/m}^2$) was 66.7% and 63.7%, respectively. At every postpartum study time-point, the median BMI was in the overweight to obese range. Median visceral fat area and percentage body fat were also higher than recommended of the cohort (recommended ranges $<100 \text{ cm}^3$ and 21–35%, respectively). Mean growth trajectories of infants, plotted on growth charts, appeared appropriate with no identified signs of systemic stunting or wasting.

8.2.3 Summary of findings from the Diet Bytes and Baby Bumps study

The Diet Bytes and Baby Bumps (DBBB) study had five parts. It (1) evaluated the purpose-built Selected Nutrient and Diet Quality (SNaQ) tool for dietary assessment of image-based dietary records and provision of nutrition feedback, (2) assessed the relative validity of the DietBytes method of dietary assessment against 3x 24-R, (3) examined intakes of food groups and selected micronutrients of pregnant participants, (4) assessed the quality of the image-based dietary records, and (5) evaluated participants' perceived acceptability and useability of the DietBytes method for collection of an image-based dietary record and the receipt of feedback on dietary intake.

There were strong positive correlations between the SNaQ tool and the nutrient analysis software for estimating median daily intakes of energy and iron, calcium, zinc, folate and iodine, both with and without supplements included in the analysis. While there were some differences in intakes for energy and some micronutrients between the two methods, these were not clinically important for micronutrients, as demonstrated by Cohen kappa results. Results indicated

moderate to substantial agreement between the two methods for estimating adequacy of most nutrient intakes relative to meeting EARs. In the validation analysis, one-sample t-tests demonstrated that there were no significant mean differences between nutrients estimated from the image-based dietary records and 24-R. There was variability between methods, as illustrated by the wide limits of agreement in Bland-Altman plots of macronutrients. However, most data points fell within the limits of agreement and the mean difference was close to zero for energy and all nutrients, demonstrating insufficient evidence of systematic bias at high or low levels of intake for the two dietary assessment methods.

The majority of participants found the nutrition feedback they received to be helpful (96%, n=21 out of 22 participants who responded to the final survey). The preferred method of receiving feedback was via the video summary and the combined telephone consultation with a dietitian (83%, n=18/22, preferred this method). Over three quarters of participants (77%, n=17/22) reported making dietary changes as a result of the nutrition feedback they had received. All participants (n=25) responded to survey questions regarding their perceptions of the usability and acceptability of the DietBytes method for collection of an image-based dietary record. Twenty-four participants (96%) agreed or strongly agreed that it was easy to use the Evernote app to collect the image record, although eight participants (32%) found using the voice record to capture additional details annoying, and four participants (16%) found it difficult to remember to collect the record. Despite this, 22 women (88%) agreed that they would use the smartphone image-based dietary record again, including all Aboriginal participants (n=8).

The DBBB study has demonstrated relative validity for both the image-based dietary assessment method and the purpose-built brief SNaQ tool for the assessment of core and non-core food group and nutrient intakes. In addition, the study has shown the acceptability of image-based dietary records for dietary assessment and to guide nutrition counselling of pregnant women of different ethnicities.

8.2.4 Summary of findings from the systematic review

A systematic review on factors associated with effective nutrition interventions for pregnant Indigenous women was conducted. The objectives of this review were to identify pre-existing programs which aimed to improve nutrition-related outcomes for pregnant Indigenous women and/or their infants, and to identify the factors associated with programs that resulted in positive outcomes. The results of this review may inform the development of intervention programs and health promotion activities which aim to optimise nutrition-related outcomes for Aboriginal Australian women and their infants in the future.

The review identified 27 articles from 20 programs in Australia, Canada, and the USA. The outcomes most commonly evaluated were breastfeeding (initiation and/or duration, in n=11 programs) and birth weight (in n=9 programs). Other outcomes included alcohol intake (n=5), and changes in parental knowledge, attitudes and/or skills (n=6). Programs that had statistically significant improvements in outcomes included nutrition activities in program design: individual counselling/education (n=8 programs); interventions involving community members beyond the target group (n=2); media campaigns (n=2); and delivery by senior Indigenous women (n=2), peer-counsellors (n=3), or other Indigenous health worker (n=4). In addition, authors of included studies stressed the importance of working in collaboration with Indigenous communities at all stages of the research process.

8.3 Strengths and limitations of the research project

8.3.1 Strengths and limitations of the quality assurance project

A limitation of the quality assurance activity was the small sample of student (n=5) and new-graduate (n=1) dietitians from one university program that were interviewed for this project. The number interviewed was limited by the number of dietitians who had experienced working with rural Aboriginal women attending ArtsHealth for a significant amount of time (equivalent to a placement of four weeks or longer), which at the time of conducting the interviews was a potential

pool of seven students on rural placement and one new-graduate dietitian. With this small sample size it cannot be guaranteed that data saturation was achieved. This quality assurance project focused on the experiences of the dietitians, and as such a limitation is that the perspectives of the Aboriginal women who attended ArtsHealth were not included. Future quality assurance activities could therefore include the perspectives of the Aboriginal ArtsHealth participants. The students and new-graduate interviewed provided important feedback on their experiences, which has demonstrated the value of placements at the Aboriginal ArtsHealth centre. Ongoing quality assurance activities are recommended with future student groups to ensure the continuing quality of these placement experiences.

8.3.2 Strengths and limitations of the Gomeroi gaaynggal study

There are inherent limitations associated with all methods of dietary assessment, including 24-R, as discussed in section 1.4.3. In chapter 4 the nutrient intakes of participating women are reported. On the day surveyed, women had dietary intakes that were low in some key nutrients. A single 24-R is not sufficient to establish nutrient intakes of individuals, with for example a minimum of 14 days required to estimate true average intake for women for energy, 28 days for iron, and 35 days for calcium [78]. However, 24-R are appropriate for use in estimations of population dietary intakes, and have been used in nation-wide surveys including the National Nutrition and Physical Activity Survey [82] and the National Aboriginal and Torres Strait Islander Nutrition and Physical Activity Survey [48].

Due to a small sample size, and incomplete data sets for all mother-child dyads, caution is needed when interpreting the results reported in this chapter. Retention of participants in a longitudinal study with multiple data collection points is challenging, and a further limitation of these results is the potential for selection bias in both the recruitment and retainment of women in this cohort. The characteristics of women and their infants who did not participate in this study, or who did not attend all data collection sessions, is unknown. Women who did not participate or ceased to continue participation may have had different characteristics affecting health outcomes than those who did participate or those

who were retained. It is possible that the results presented in chapter 4 therefore present a 'best-case' scenario.

A further limitation is that findings from this study may not be generalisable to other populations of Aboriginal women and infants. Every Aboriginal community is unique and health is influenced by myriad social, cultural, economic and geographical factors. Therefore results from this cohort living in a regional and a remote location of New South Wales (NSW) are not necessarily representative of all Aboriginal women and infants.

At the time of preparation of chapters 3 and 4, the number of participants in the Gomeroi gaaynggal study was modest. However, this study is ongoing and at the time of thesis preparation the study has recruited 313 women during their pregnancies. To date, 38% of the cohort is retained into the follow-up study and the research team are constantly re-assessing their procedures to improve this retention.

A large number of variables are measured in the Gomeroi gaaynggal study, including measures of anthropometry, body composition and dietary intake. While this allows for exploration of many research questions, collection of multiple variables increases the burden on participants. The results reported in chapter 4 have provided preliminary evidence of areas to target for future research and health promotion activities that aim to improve the diets and nutrition-related outcomes in this target group of Aboriginal women and infants.

8.3.3 Strengths and limitations of the Diet Bytes and Baby Bumps study

All dietary records have inherent limitations, as discussed in detail in section 1.4.3. These include a dependence on the respondent being motivated to keep accurate records. There is therefore potential for bias in the selection of the study sample (i.e. participation was voluntary, and the study may have appealed to women with an interest in nutrition and/or research). There is also potential for bias in the completion of records, as those who were more motivated may have completed

records more thoroughly and accurately. It is therefore possible that results from DBBB are not generalisable to all pregnant women.

A further limitation of all food records is that individuals may alter their intakes as a result of having to record items consumed. In the classic study by Mela et al. (1997), participants believed they would record all dietary intake honestly, though some sub-groups accurately predicted that they would alter their intake during the recording period. People who felt embarrassment over their weight were more likely to keep records that did not accurately reflect their usual diet (even if they were of a healthy weight) [79]. While this is a disadvantage to dietary assessment methodology, it is not unique to the DietBytes method. Some women reported making changes to the type (28% of participants) or amounts (12%) of foods consumed, or frequency of consumption (24%). An independent objective biomarker was not used to see if this affected the validity of results, however given the high agreement between the DietBytes and 24-R methods, this is unlikely to have affected study outcomes.

The DBBB study had a sample size of 27 recruited participants, with 25 completing image-based dietary records suitable for analysis. While this is a small sample, other studies evaluating the use of image-based dietary records have reported similarly small sample sizes ranging from 9 [211] to 75 [92] participants. Liberato and colleagues (2016) collected dietary intake data from eight Aboriginal infants and children, with around one third of meals recorded electronically via photograph or video [89]. With a small number of Aboriginal Australian participants in the DBBB study (n=8), it is unclear how generalisable the results are to other populations of Aboriginal Australians or pregnant women. However, given this a relatively new area of research the results of the DBBB study are very promising.

Despite limitations, the DBBB study has contributed valuable findings to the knowledge base on novel dietary assessment methods, and has demonstrated strengths. With training, the SNaQ tool may be time and resource-saving as a tool to assess dietary intakes; the method may reduce participant burden associated

with traditional methods of dietary assessment, and the study is the first to evaluate the use of image-based dietary records in pregnant women.

8.3.4 Strengths and limitations of the systematic review

This review was the first to investigate interventions that target all nutrition-related outcomes for pregnant Indigenous women residing in Australia, Canada and the USA. It showed that targeted interventions with pregnant Indigenous women can have positive effects on a number of nutrition-related outcomes, including improvements in birth weight and breastfeeding rates. The reviewers employed a systematic search strategy, including the use of two reviewers for the identification of studies for inclusion and for assessment of study quality.

Only studies with published results were eligible for inclusion. Publication bias exists when studies with unfavourable results are not published, and it is therefore possible that the outcomes from this review are representative of a ‘best-case’ scenario. This review focused on factors associated with successful nutrition intervention programs; however factors associated with unsuccessful programs were not likewise explored. There may therefore be similarities in features of programs resulting in positive outcomes and those that did not result in positive outcomes. Included studies were heterogeneous for both intervention activities and nutrition-related outcomes, and therefore it was not possible to conduct a meta-analysis. Finally, where included programs used multi-faceted strategies to meet outcomes, it could not be definitively determined what aspects of interventions resulted in changes to nutrition-related outcomes.

8.4 Overall findings from the research thesis

Key findings of the research thesis are summarised in bullet points below:

- ❖ While a high rate of breastfeeding initiation was found in a cohort of regional and remote-dwelling Aboriginal women in the Gomeroi gaaynggal study, there is room for improvement in rates of breastfeeding duration and timing of introduction to solid foods and cow’s milk for infants. For infants

less than 12 months old, 10% had received sweetened drinks and 24% had received fruit juice in the 24 hours preceding interview.

- ❖ Pregnant Aboriginal women in the DBBB cohort did not meet intakes of core food groups relative to recommended servings in the AGTHE for pregnant women, for the grain and cereals, vegetables, fruit, and lean meat and alternatives food groups. Intakes of discretionary food groups exceeded recommendations.
- ❖ Around two thirds of postpartum women in the Gomeroi gaaynggal study were overweight or obese at 12 months (67%) and two years (64%) postpartum.
- ❖ Use of image-based dietary records is a valid method of dietary assessment of pregnant women, relative to 24-R.
- ❖ The SNaQ analysis tool is a valid tool for estimating intakes of core and non-core food groups and selected micronutrients of pregnant women from image-based dietary records.
- ❖ Pregnant women may benefit from personalised nutrition counselling. Feedback delivered via short video summary in contribution with telephone feedback from a dietitian was considered acceptable by DBBB participants, and 77% of women in this cohort reported that they had made changes to their dietary intake as a result of this feedback.
- ❖ Capturing of dietary intake via image-based dietary records was perceived to be an acceptable and usable method of dietary assessment by pregnant Aboriginal and non-Aboriginal women.
- ❖ Student dietitians may require greater education at the undergraduate level on the historical context of health for Aboriginal Australians.
- ❖ From the perspective of student and new-graduate dietitians, art may be a useful medium through which to “break the ice”, and may act as a tool to help build rapport when working with Aboriginal people.
- ❖ Real-world experiences of working with Aboriginal communities are valued by student and new-graduate dietitians as a means to develop the skills required to demonstrate a level of cultural competence.

- ❖ The importance of collaboration with Aboriginal communities in the development of research activities was highlighted by authors of many studies included in the systematic review, as well as by the researchers who established the Gomeroi gaaynggal study.
- ❖ Individual education or counselling may be associated with positive nutrition-related outcomes for pregnant women, as demonstrated in the systematic review.
- ❖ The systematic review found that Indigenous workers (e.g. peer counsellors, senior Indigenous women), provision of home-visits, and trialling multifaceted interventions may be key features contributing to positive outcomes for nutrition intervention programs.

8.5 Discussion of key findings

8.5.1 Breastfeeding: findings and implications

The rate of breastfeeding initiation in the Gomeroi gaaynggal cohort was high at 85.9%, however the median (interquartile range) duration of breastfeeding was 1.4 (0.5–4.0) months. These results are on par with national figures: in 2012–13, 83% of Indigenous Australian infants (and 93% of non-Indigenous infants) aged 0–3 years old had been breastfed at some point [22]. The National Health and Medical Research Council recommends exclusive breastfeeding to six months of age, continuing to 12 months and beyond with the introduction of complementary foods at around six months [11]. In the Gomeroi gaaynggal cohort, 29.4% of infants (n=5 out of 17 infants who attended this data collection time point) were breastfed to ≥6 months, and 8.7% (n=2/23 infants) were breastfed for ≥12 months. Nationally in 2012–13, 12% of Indigenous infants and 21% of non-Indigenous infants had been breastfed to 12 months or more [22].

As discussed in section 1.3.4, rates of breastfeeding vary by locality, and the results from the Gomeroi gaaynggal study may be specific to the women and infants in these rural and remote locations of NSW. With no two communities the same, dietitians and policy-makers alike should adopt a localised approach to optimising breastfeeding rates. However, some recommendations for programs may be made

from the results outlined in the systematic review of factors associated with nutrition interventions for pregnant Indigenous women. Eleven programs from Australia, Canada, and the USA investigated changes in breastfeeding initiation and/or duration (all reported positive outcomes, though not all studies reported statistical significance). The nutrition activities associated with statistically significant improvements in breastfeeding initiation and duration included provision of nutrition education or counselling (used in n=6 programs) delivered individually (n=6 programs) or in groups (n=1); food supplementation or food vouchers (n=1); modifications to the wider environment (n=1); interventions that involve other community members (n=2); media campaigns (n=2); and delivery by Indigenous health workers (n=3), health professionals (n=2), or senior Indigenous women (n=1).

8.5.2 Introduction to solids, cow's milk and sweetened drinks: findings and implications

In the Gomeroi gaaynggal cohort, the median time of introduction of solid foods was at 5.0 (4.0–6.0) months, and the timing of introduction to cow's milk was at 12.0 (10.0–13.0) months. Recommendations are for the introduction to solid foods at around six months, and cow's milk is not a suitable drink for infants under 12 months of age [11]. By the three month visit (range up to 4.5 months old), 28% of infants in the Gomeroi gaaynggal cohort had been given solid foods regularly. Nationally, in 2010 64% of Indigenous Australian infants had been given solid foods regularly after four months of age [150]. Early introduction to solid foods (by four months) may be associated with increased risk of childhood obesity (particularly in formula-fed infants) [169, 170], although the evidence is not conclusive, and genetic and environmental factors influencing rapid growth in early childhood may play a causal role [171]. There is more research needed into the optimal timing of introduction to solid food and the risk of developing food allergies.

Sugar-sweetened drinks are not recommended for infants ≤ 12 months old [11]. In the Gomeroi gaaynggal cohort, 10% of infants ≤ 12 months had received sugar-

sweetened drinks in the 24 hours preceding data collection, and 24% had received fruit juice. Sweetened drinks contribute to weight gain and poor oral health, and there are higher rates of overweight [46] and dental caries [178] for Indigenous children than non-Indigenous children. Healthy habits set in childhood can track into adulthood; soft drinks, sports drinks, and energy drinks accounted for 28% of intake of free sugars for Indigenous Australians in 2012–13 [50]. Discouraging consumption of sweetened drinks for infants is therefore a priority for nutrition promotion.

8.5.3 Food group and nutrient intakes of pregnant and postpartum Aboriginal women and their infants: findings and implications

In the Gomeri gaaynggal cohort, postpartum women had intakes of several key micronutrients (including folate, iron, zinc, calcium and iodine) that were lower than recommendations set out in the Nutrient Reference Values [183] (established by 24-R). Fibre intake was low (recommended AI of 25g, 8.6% of non-breastfeeding participants met the AI) and there was a high intake of saturated fat (median intake in non-breastfeeding women was 25.1g [18.0–35.7]). In the DBBB study, pregnant women did not meet the recommended number of AGTHE servings for grain and cereal foods, vegetables, fruit and meat. The split analysis revealed that this was true for both Aboriginal and non-Aboriginal participants, although Aboriginal participants in this cohort did meet recommendations for intakes of dairy foods. It should be noted that there was a small sample size ($n=8$) of Aboriginal participants, so these findings are not likely to be generalisable to all pregnant Aboriginal women. The mean intake of discretionary foods was above recommendations for all participants (mean intake 3.7 serves of a recommended 0–2.5).

Results from the Gomeri gaaynggal and DBBB cohorts have demonstrated that the nutrient and food group intakes of Aboriginal women in the perinatal period are sub-optimal. This has indicated a need for intervention and health promotion for this nutritionally vulnerable population. The systematic review identified 20 programs that target improving nutrition for pregnant Indigenous women, only

five of which were set in Australia. There were some limitations in the quality of study design and reporting of studies included in this systematic review, and it was difficult to determine the true effect of studies where appropriate control groups were not used. Future intervention studies should include more comprehensive nutrition interventions, with evaluation protocols designed to identify the effects of the nutrition intervention on defined outcomes. Recommended guidelines for the reporting of nutrition epidemiological studies should be followed in order for results to be comparable to other reported results [215]. Details of intervention methods and measurement tools could be accessible via supplementary files or by establishment of a research repository. Randomised controlled trials may not be feasible, or acceptable, to all Aboriginal populations, and therefore future studies should also consider use of other appropriate comparison data.

8.5.4 Body composition and anthropometry of Aboriginal women and their infants: findings and implications

There are higher rates of low birth weight (LBW, <2500g) for Indigenous Australian infants than for non-Indigenous infants: in 2014, the rate of LBW was 11.8% for infants born to Indigenous mothers, and 6.2% for non-Indigenous mothers [3]. A rapid rate of weight gain in the first year of life for infants who are small for gestational age at birth is associated with an increased risk of some chronic disease, including cardiovascular disease [180]. In the Gomeroi gaaynggal cohort there was some indication of rapid growth for preterm boys from 12 months, and no apparent stunting or wasting observed in infants in this cohort. The sample size in the Gomeroi gaaynggal cohort was small, and so results should be interpreted with caution. In the systematic review of factors associated with successful nutrition intervention programs for pregnant Indigenous women (chapter 7), nine programs evaluated changes in infant birthweight. Programs that reported statistically significant results utilised the following nutrition activities: individual counselling or education (n=3); group education or counselling (in n=1 program); provision of food supplementation or food vouchers (n=2); delivery by senior Indigenous women (n=1); and use of traditional practices (n=1).

There was a high proportion of overweight and obesity for women at every postpartum time point in the Gomeroi gaaynggal study: at one and two years postpartum, the proportion of women with a BMI $\geq 25.0 \text{ kg/m}^2$ was 66.7% and 63.7%, respectively. Retention of postpartum weight is associated with central distribution of pregnancy weight, which is a risk factor for chronic disease development [19, 20]. Women entering pregnancy with an overweight BMI are at greater risk of retaining weight at 12 months postpartum, and excess weight gain between pregnancies is associated with pregnancy complications; including gestational diabetes, macrosomia, pre-eclampsia, and stillbirth [18]. Guidelines for weight gain during pregnancy recommend that weight management be addressed by health practitioners at pre-conception or between pregnancies but not during pregnancy, as the safety of weight loss during pregnancy has not been established [8]. This may be challenging, as there are known barriers to accessing health services for Aboriginal Australians, including their physical availability (particularly in remote areas), affordability, appropriateness and acceptability [57].

The systematic review identified four programs that aimed to influence gestational weight gain amongst Indigenous pregnant women [235, 238, 242, 253]. Only one of these studies had an aim to reduce postpartum weight [238], and none of the studies were set in Australia. The time and burden of caring for a new infant, prioritising caring for the infant over oneself, and lack of social support can make weight loss in the postpartum period challenging [265], and Aboriginal Australian women may need targeted programs to support the return to a healthy body weight. In the Gomeroi gaaynggal study, strategies to retain participants in the study included provision of home visits and transportation where required, and offering telephone calls for collection of some data. The systematic review likewise identified that home visits may help to limit some of the burden on postpartum women participating in research studies. The use of eHealth for nutrition counselling in the DBBB study (video feedback combined with telephone consultation) was met favourably by pregnant participants, and may be a valuable method for delivery of nutrition interventions for women in the perinatal period which limits the barriers of transportation and distance.

8.5.5 Use of image-based dietary records in pregnant Aboriginal and non-Aboriginal women: findings and implications

The results of the DBBB relative validity studies are important and timely, as they establish that using an image-based dietary assessment method is a valid method of dietary assessment of pregnant women compared with 24-R, and that the SNaQ is a valid tool for estimating intakes of core and non-core food groups and selected micronutrients of pregnant women. True indication of bias may be established via criterion validity (i.e. comparison with a known objective measure, such as comparison of energy intake with total energy expenditure established via the doubly-labelled water technique), however establishing criterion validity was not an aim of the DBBB study.

More days of recording are recommended for future studies employing this method of dietary assessment. Three days may be adequate for capturing energy intake (as used in the DBBB study), however more days may be required for capturing intake of macro and micronutrients [78]. In the DBBB study, women expressed that longer recording times for capturing intake may be feasible. Participants stated they would be willing to use the method over longer recording periods, with five participants willing to record up to one month.

An interesting finding of the DBBB study was that 64% of participants (n=16) would be willing to use the DietBytes method again for self-monitoring of their dietary intake. While this was not an aim of the DBBB study, this finding may have implications for future use of an image-based method for capturing dietary intake. A previous study in young women found that use of smartphone food records for self-monitoring of diet were preferred over traditional paper-based records, and did not affect the accuracy [221].

There is a plethora of generalised advice on pregnancy nutrition available, and from various sources (e.g. health professionals, friends, family, websites), which may be overwhelming for women during their pregnancy [209]. Despite the ready availability of nutrition information, knowledge gaps on what to eat during

pregnancy persist [204, 205]. Women may feel they are not receiving adequate or correct nutrition information; in the DBBB study, less than half (n=12, 46%) of participants had received information on prenatal nutrition supplements prior to enrolment, and only 42% (n=11) felt they had received enough information about eating for a healthy pregnancy. Where previously dietitians have provided personalised dietary advice to patients with medical conditions or to remedy nutrient deficiencies, personalised advice is now being given to healthy individuals to optimise nutrition [76]. The method of feedback used in DBBB allowed for the provision of individualised dietary counselling to healthy pregnant women. In the short video summary sent to participants' smartphones, the feedback provided was based on participants' individual diets, and this was supported by the telephone counselling where personalised advice was given to help participants optimise their dietary intake. The method was well-received by participants, the majority of whom (83%, n=18/22) preferred the combined feedback over the video summary or telephone call alone. In the systematic review, individual counselling or education was employed by six programs resulting in statistically significant outcomes for breastfeeding initiation and/or duration, and utilised by all programs that resulted in significant outcomes for birth weight. Individualised nutrition counselling and provision of personal, tailored dietary advice for pregnant women may therefore be an effective tool for nutrition intervention and should be evaluated in future research.

8.5.6 Roles of dietitians supporting Aboriginal communities: findings and implications

As explored in section 1.3.5, there are structural barriers that can make it challenging to achieve positive nutrition outcomes for Aboriginal women and their infants; including issues of food security, food access, gaps in knowledge on how to choose and prepare nutritious foods, and busy lifestyles. Building Aboriginal research capacity has been identified as crucial to the successful implementation of Indigenous intervention studies: establishing effective partnerships between researchers and Indigenous health services is essential, and ultimately Aboriginal people need to be engaged as equal partners at every stage of the research process.

[62, 124, 187]. Ten of the authors in the systematic review presented in chapter 7 emphasised the importance of community collaboration in the design of interventions aimed at improving nutrition-related outcomes in pregnant Indigenous women, to ensure that the study represents the interests of the community. Interventions should be community-directed and involve Indigenous people wherever possible in their design, conception and implementation. Ongoing community collaboration is also recommended; in the Gomeroi gaaynggal study an Aboriginal Steering Committee ensures continued community partnership in the study. It may not be necessary for dietitians to be directly involved in the delivery of programs; in the systematic review, only one nutrition intervention program included in the review was delivered by nutritionists [238], and this program did not result in statistically significant improvements in outcomes. However, as nutrition health professionals, dietitians are well-placed to advise on and support the design and delivery of nutrition promotion programs.

8.6 Implications of this body of research for practice

1. Students in undergraduate nutrition and dietetics degree programs should seek out and engage in real-life experiences working with Aboriginal communities. Degree programs can encourage these activities through practical placements and opportunities for volunteer experience, such as those offered by the collaboration between the University of Newcastle Department of Rural Health and the Gomeroi gaaynggal centre. This may not be feasible for all undergraduate students, and so it is recommended that nutrition and dietetics degree curriculums incorporate practical advice for building rapport and addressing nutrition issues in cultural awareness lectures. Employment of these strategies may assist students with developing the cultural competency skills that are essential for working in Aboriginal communities.
2. Health professionals should seek opportunities to collaborate with Aboriginal communities to support Aboriginal women to increase breastfeeding duration and encourage the timely introduction of solid foods and cow's milk to their infants.

3. An image-based method of dietary assessment, captured via smartphone, has demonstrated validity relative to 24-R, and acceptability by participants for the assessment of nutrient intakes of pregnant women. In addition, a brief tool for analysis of nutrient intakes has shown relative validity compared with nutrient analysis software. These may be useful tools for dietary assessment for dietitians in practice working with pregnant clients.

4. Provision of nutrition counselling via a brief video summary delivered to individuals' smartphones, in combination with a telephone call from a dietitian, shows promise as an acceptable method of nutrition counselling of pregnant Aboriginal and non-Aboriginal women. This method of nutrition counselling transcends distance and may be of great use to dietitians in clinical practice.

5. The results from the systematic review can be used to inform future nutrition health promotion programs for Aboriginal Australian women during pregnancy. Provision of nutrition counselling and/or education may contribute to improvements in nutrition-related outcomes. Inclusion of Aboriginal staff in the delivery of intervention programs is recommended. Finally, collaboration with Aboriginal communities in the development and design of programs is essential.

6. Areas of focus for nutrition health promotion programs include: improving dietary intakes of pregnant and postpartum Aboriginal women, improving rates of breastfeeding duration, improving timing of introduction to solid foods and cow's milk, encouraging healthy gestational weight gain and limiting postpartum weight retention.

8.7 Implications of this body of research for further research

1. Ongoing evaluation of the experiences of students working with Aboriginal communities is recommended, in order for universities to provide high quality nutrition education to nutrition and dietetics students.

2. The preliminary results reported on the dietary intakes, anthropometric measures, and body composition of Aboriginal women and their infants was in a

small sample of women. As the Gomeroi gaaynggal study is ongoing, further evaluation from this study is recommended and will be able to provide further evidence in a larger sample size to support these findings.

3. Three days of dietary assessment using the image-based dietary records may not have been optimal for assessment of some macro and micronutrients, and longer recording periods may be required. Participants in the DBBB study expressed willingness to report intake over longer recording periods, and therefore longer reporting periods should be considered in future research protocols using the DietBytes method.

4. The results of the DBBB study showed that 77% of participants made changes to their diets as a result of receiving the nutrition counselling, including changes to the kinds and amounts of foods they consumed, changes to cooking methods used and changes to how participants monitored their dietary intake. It was not a goal of the DBBB study to investigate changes to dietary intake, however future research could examine the use of the DietBytes method for nutrition counselling as an intervention to optimise pregnancy nutrition.

5. Future intervention studies are recommended for Aboriginal women during their pregnancies and the postpartum period to improve nutrition-related outcomes for mothers and their infants. Results from the systematic review suggest that there is a need for interventions that make use of appropriate comparison groups. Randomised controlled trials may not be practical or acceptable for use in Aboriginal communities, and using other communities as a control group may not be feasible given differences between communities. A pre-/post-test study design, use of a wait-listed control group, or use of historical controls may be more appropriate. More comprehensive nutrition interventions are required, and studies should be evaluated to determine intervention effects on defined nutrition-related outcomes. Study results should be reported so that the effects of the nutrition intervention on outcomes are clear. Details of interventions and measurement tools used should be reported or easily accessible for other researchers, via supplementary files or research repository. Appropriate evaluation of future

intervention studies is needed, to corroborate or refute the findings of the systematic review.

6. Nutrition-related areas for intervention studies to target include: improving dietary intakes of pregnant and postpartum Aboriginal women, improving rates of breastfeeding duration, improving timing of introduction to solid foods and cow's milk, encouraging healthy gestational weight gain and limiting postpartum weight retention.

8.8 Implications of this body of research for Aboriginal Communities

There are a number of areas where developments to the research presented in this thesis may benefit Aboriginal communities. In the quality assurance project described in chapter 2, the perspectives of Aboriginal women attending ArtsHealth sessions were not explored. However this would be an important area for future exploration, as it is not currently known if the Aboriginal participants perceive the same benefits of attending ArtsHealth as expressed by student and new-graduate dietitians; and whether or not they consider the space to be safe and appropriate for interacting with health professionals. Future research could also explore the perceptions of the Aboriginal participants on what strategies could be employed to further support women to optimise maternal and infant nutrition.

This research thesis was developed from a dietitian's perspective, and the perspectives of Aboriginal women and communities should be considered in future research and by health professionals in practice. Aboriginal women should be involved in the development and delivery of nutrition programs, and the importance of collaboration between Aboriginal communities and researchers in health research and promotion has been highlighted by both the Gomeroi gaaynggal research team and authors of studies included in the systematic review. This collaboration should occur at every stage of the research process, from conception and development of programs onwards.

8.9 Concluding remarks

This research thesis has made several important and positive findings in the field of Aboriginal nutrition for women and their infants. A high rate of breastfeeding initiation was found amongst a cohort of Aboriginal women in rural and remote settings of NSW, which is encouraging. A smartphone image-based dietary record method for dietary assessment has demonstrated relative validity for establishing food group and nutrient intakes of pregnant Aboriginal and non-Aboriginal women. Provision of nutrition counselling to pregnant women, guided by the image-based dietary records and delivered via both a smartphone app and telephone consultation with a dietitian, was deemed an acceptable method of receiving dietary feedback by pregnant Aboriginal and non-Aboriginal women.

Aboriginal women may benefit from additional support and encouragement to optimise the following nutrition-related areas: breastfeeding duration, the timely introduction of solid foods and cow's milk to their infants, encouraging postpartum weight management, and improving food group and nutrient intakes in the pregnancy and postpartum periods. Dietitians can provide support to optimise nutrition by working in collaboration with Aboriginal women and their communities, and encourage in-person experiences for building cultural competency skills of student and new-graduate dietitians.

Chapter 9 References

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Chapter 10 Appendices

10.1 Appendix: Brief description of the general inductive approach

In chapters 2, 5 and 6 of this thesis, qualitative data was analysed using a general inductive approach as described by David R Thomas in the following reference:

Thomas D. A general inductive approach for analysing qualitative evaluation data. American Journal of Evaluation 2006;27(2):237-46

A brief summary of this process is outlined below.

Inductive analysis involves in-depth reading of raw data to derive themes inherent in this data, through interpretations made by the researcher. The purpose of inductive analysis may be to condense raw data into a summary format, establish links between research aims and raw data, or to develop theories or models about experiences or processes. The process of inductive analysis of qualitative data involves the following procedures: 1) Data cleaning of raw data files, 2) Close reading of the text until the evaluator is familiar with content and has an understanding of the themes, 3) Creation of categories or themes identified and defined by the evaluator, 4) Overlapping coding and un-coded text (text may be coded into more than one category and some text may not be coded into any category), 5) Revision and refinement of categories, including identifying sub-topics, and quotations that convey key themes.

10.2 Appendix: Statement of contribution and collaboration for chapter 2

I attest that Research Higher Degree candidate Amy M Ashman contributed to the following paper:

Rae K, Bohringer E, Ashman A, Brown L, Collins C. Cultural experiences of student and new-graduate dietitians in the Gomeri gaaynggal ArtsHealth program: a quality assurance project. *Health Promotion Journal of Australia*. 2016;27(2):162-166.

AA contributed to data collection, data analysis, and manuscript preparation. KR contributed to the conception, design, and implementation of the study, data collection, and manuscript drafting and development. EB, LB, and CC contributed to manuscript development.

Ms Amy M Ashman Date: 09/02/2017

Associate Professor Kym Rae Date: 10/02/2017

Ms Emma Bohringer 10/2/17

Dr Leanne Brown Date: 13/02/2017

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10.4 Appendix: Statement of contribution and collaboration for chapter 3

I attest that Research Higher Degree candidate Amy M Ashman contributed to the following paper:

Ashman A. M., Collins C.E., Weatherall L., Brown L.J., Rollo M. E., Clausen D., Blackwell C.C., Pringle K.G., Attia J., Smith R., Lumbers E.R., Rae K.M. A cohort of Indigenous Australian women and their children through pregnancy and beyond: the *Gomerol gaaynggal* study. *Journal of Developmental Origins of Health and Disease*. 2016;7(4):357-368.

AA conducted data collection for the follow up study and drafted the manuscript. KR, RS, EL, CC, KP, DC and CB all made substantial contributions to the conception and design of the *Gomerol gaaynggal* study. KR is the *Gomerol gaaynggal* Program Director. LW recruits all participants within the pregnancy cohort, conducts data collection for the pregnancy study, made substantial contributions to the study design and assisted with editorial aspects of the paper. JA provides statistical expertise to the study. LB and MR contributed significantly to the editing of this paper. All authors contributed to manuscript development and approval of the final manuscript.

Ms Amy M Ashman Date: 09/02/2017

Professor Clare Collins Date: 10/02/2017

Ms Loretta Weatherall Date: 14/02/2017

Dr Leanne Brown Date: 13/02/2017

Dr Megan Rollo Date: 10/02/2017

Mr Don Clausen
Date: 10/02/2017

Conjoint Professor Caroline Blackwell

Dr Kirsty Pringle

Professor John Attia Date: 15/02/2017

Professor Eugenie Lumbers **Date:** 12/02/2017

Associate Professor Kym Rae **Date:** 10/02/2017

Digitally signed by Robert Callister
DN: cn=Robert Callister, o=University of
Newcastle, ou=Faculty of Health and
Medicine,
email=robert.callister@newcastle.edu.au,
c=au

Professor Robert Callister

Deputy Head of Faculty of Health and Medicine (Research and Research Training)

I attest that Research Higher Degree candidate Amy M Ashman contributed to the following paper:

Ashman A. M., Collins C.E., Weatherall L., Brown L.J., Rollo M. E., Clausen D., Blackwell C.C., Pringle K.G., Attia J., Smith R., Lumbers E.R., Røe K.M. A cohort of Indigenous Australian women and their children through pregnancy and beyond: the *Gomeri gaaynggal* study. *Journal of Developmental Origins of Health and Disease*. 2016;7(4):357-368.

AA conducted data collection for the follow up study and drafted the manuscript. KR, RS, EL, CC, KP, DC and CB all made substantial contributions to the conception and design of the *Gomeri gaaynggal* study. KR is the *Gomeri gaaynggal* Program Director. LW recruits all participants within the pregnancy cohort, conducts data collection for the pregnancy study, made substantial contributions to the study design and assisted with editorial aspects of the paper. JA provides statistical expertise to the study. LB and MR contributed significantly to the editing of this paper. All authors contributed to manuscript development and approval of the final manuscript.

Ms Amy M Ashman Date: 09/02/2017

Professor Clare Collins Date: 10/02/2017

Ms Loretta Weatherall Date: 14/02/2017

18th Feb 2019

Smith

I attest that Research Higher Degree candidate Amy M Ashman contributed to the following paper:

Ashman A. M., Collins C.E., Weatherall L., Brown L.J., Bollo M. E., Clausen D., Blackwell C.C., Pringle K.G., Abia J., Smith R., Lumbers E.R., Rae K.M. A cohort of Indigenous Australian women and their children through pregnancy and beyond: the *Gomeri gaaynggal* study. *Journal of Developmental Origins of Health and Disease*. 2016;7(4):357-368.

AA conducted data collection for the follow up study and drafted the manuscript. ER, RS, EL, CC, KP, DC and CB all made substantial contributions to the conception and design of the *Gomeri gaaynggal* study. ER is the *Gomeri gaaynggal* Program Director. LW recruits all participants within the pregnancy cohort, conducts data collection for the pregnancy study, made substantial contributions to the study design and assisted with editorial aspects of the paper. JA provides statistical expertise to the study. LB and MR contributed significantly to the editing of this paper. All authors contributed to manuscript development and approval of the final manuscript.

Ms Amy M Ashman Date: 09/02/2017

Professor Clare Collins Date: 10/02/2017

Ms Loretta Weatherall Date: 14/02/2017

Dr Leanne Brown Date: 13/02/2017

Dr Megan Rollo Date: 10/02/2017

Mr Don Clausen
Date: 10/02/2017

Conjoint Professor Caroline Blackwell

Dr Kirsty Pringle **Date:** 17/02/2017

Professor John Attia Date: 15/02/2017

Laureate Professor Roger Smith

I attest that Research Higher Degree candidate Amy M Ashman contributed to the following paper:

Ashman A. M., Collins C.E., Weatherall L., Brown L.J., Rollo M. E., Clausen D., Blackwell C.C., Pringle K.G., Attia J., Smith R., Lumbers E.R., Rae K.M. A cohort of Indigenous Australian women and their children through pregnancy and beyond: the *Gomerioi gaaynggal* study. *Journal of Developmental Origins of Health and Disease*. 2016;7(4):357-368.

AA conducted data collection for the follow up study and drafted the manuscript. KR, RS, EL, CC, KP, DC and CB all made substantial contributions to the conception and design of the Gomerioi gaaynggal study. KR is the Gomerioi gaaynggal Program Director. LW recruits all participants within the pregnancy cohort, conducts data collection for the pregnancy study, made substantial contributions to the study design and assisted with editorial aspects of the paper. JA provides statistical expertise to the study. LB and MR contributed significantly to the editing of this paper. All authors contributed to manuscript development and approval of the final manuscript.

Ms Amy M Ashman Date: 09/02/2017

Professor Clare Collins

Ms Loretta Weatherall

Dr Leanne Brown

Dr Megan Rollo

Mr Don Clausen

Conjoint Professor Caroline Blackwell

Date: 17/02/2017

Dr Kirsty Pringle

Professor John Attia

Laureate Professor Roger Smith Professor Eugenie Lumbers

10.5 Appendix: Permission to reproduce the published manuscript granted by publishers for chapter 3

Correspondence from the journal's publishers regarding permission to use the published article in the research thesis.

From: Amy Ashman [<mailto:AMY.ASHMAN@UON.EDU.AU>]
Sent: Sunday, February 12, 2017 6:40 PM
To: Journals Customer Services
Subject: Seeking permission to include published articles in PhD thesis

To whom it may concern,

I am writing to seek permission to include my published research articles in my PhD thesis by publication. These publications make up two chapters of my PhD thesis. Citations for both papers have been included in the thesis.

I have two articles published in the Journal of Developmental Origins of Health and Disease. The references for these are below:

Ashman A. M., Collins C.E., Weatherall L., Brown L.J., Rollo M. E., Clausen D., Blackwell C.C., Pringle K.G., Attia J., Smith R., Lumbers E.R., Rae K.M. A cohort of Indigenous Australian women and their children through pregnancy and beyond: the *Gomeri gaaynggal* study. *Journal of Developmental Origins of Health and Disease*. 2016;7(4):357-368. DOI: <http://dx.doi.org/10.1017/S204017441600009X>

Ashman A.M., Collins C.E., Weatherall L.J., Keogh L., Brown L.J., Rollo M.E., Smith R., Rae K.M. Dietary intakes and anthropometric measures of Indigenous Australian women and their infants in the Gomeri gaaynggal cohort. *Journal of Developmental Origins of Health and Disease*. 2016;7(5):481-497. DOI: <http://dx.doi.org/10.1017/S2040174416000325>

Please let me know if you require any further information from me.

Thank you very much,

Kind Regards,
Amy

Seeking permission to include published articles in PhD thesis /STR



Georgia Stratton <gstratton@cambridge.org>

Wed 29/03, 22:49

Amy Ashman ✉



Reply all | ▾



Action Items



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10.6 Appendix: Ethics approval for the Gomeroi gaaynggal study

Ethics approval from the Aboriginal Health & Medical Research Council:

Aboriginal Health & Medical Research Council of New South Wales



AH&MRC ETHICS COMMITTEE

21 August 2009

Ms Kym Rae
Project Co-ordinator
Post Doctoral Fellow in Rural and Reproductive Medicine
The University of Newcastle
University Department of Rural Health
Locked Mail Bag 9783
TAMWORTH NSW 2348.

Dear Ms. Rae,

Stress During Pregnancy and the Developmental Origins of Renal Disease (654/08)

The Aboriginal Health and Medical Research Council (AH&MRC) Ethics Committee has considered your application of 5 June 2008 for ethics approval for the above project. Your emails of 14 August 2008, 24 November 2008, 25 February 2009, 15 May 2009, and 3 July 2009 and 31 July 2009 providing further information are considered to form part of the application.

The Committee agreed to approve the application, subject to the conditions below.

Standard Conditions of Approval (where applicable to the project)

1. The approval is for the period from 1 August 2009 until 31 August 2010, with extension for an additional period subject to providing a report on the research by 31 August 2010.
2. All research participants are to be provided with a relevant Participant Information Statement and Consent Form in the format provided with your application.
3. Copies of all signed participant consent forms must be retained and made available to the Ethics Committee on request. A request will only be made if there is a dispute or complaint in relation to a participant.
4. Any changes to the staffing, methodology, timeframe, or any other aspect of the research relevant to continued ethical acceptability of the project must have the prior written approval of the Ethics Committee.
5. The research must comply with:
 - the *AH&MRC Guidelines for Research in Aboriginal Health – Key Principles*;
 - the *National Statement on Ethical Conduct in Research Involving Humans* (2007); and
 - the *NSW Aboriginal Health Information Guidelines*.

Funded by NSW Health Department

Lvl 3, 66 Wentworth Avenue Surry Hills NSW 2010 : PO Box 1665 Strawberry Hills NSW 2012
Ph: +61 (02) 9212 4777; Fax: +61 (02) 9212 7211 Email: ahmrc@ahmrc.org.au
ABN 66 085 654 397; ACN 085 654 397

6. A final draft report must be provided to the AH&MRC Ethics Committee to be reviewed for compliance with ethical and cultural criteria prior to:
 - any submission for publication; and/or
 - any dissemination of the report.
7. A copy of the final published version of any publication is to be provided to the AH&MRC Ethics Committee.

Special Conditions

8. For each community participating in the research, provision of a letter of support from the Chair or CEO of the local Aboriginal Community Controlled Health Service (ACCHS), or an appropriate alternative Aboriginal community organisation or group in that community, prior to commencing the research in the community.

Please acknowledge receipt of this letter and your acceptance of the above conditions within fourteen (14 days).

We would also appreciate your agreement that the AH&MRC may, on request, obtain access to the data obtained from the research in order to assist the future development of policy and programs in Aboriginal health.

We take this opportunity to wish you well in your research.

On behalf of the AH&MRC Ethics Committee,

Yours sincerely,

Val Keed
Chairperson
AH&MRC Ethics Committee

Ethics approval from Hunter New England Human Research Ethics Committee:

3 November 2008

Dr K Rae
University Dept of Rural Health
University of Newcastle
Locked Bag 9783
NEMSC
TAMWORTH NSW 2348

HUNTER NEW ENGLAND
NSW HEALTH

Dear Dr Rae,

RE: Stress During Pregnancy and Developmental Origins of Renal Disease in Aboriginal Australians (08/05/21/4.01)

HNEHREC Reference No: 08/05/21/4.01
NSW HREC Reference No: 08/HNE/129

Thank you for submitting the above protocol which was first considered by the Hunter New England Human Research Ethics Committee at its meeting held on 21 May 2008. This Human Research Ethics Committee is constituted and operates in accordance with the National Health and Medical Research Council's *National Statement on Ethical Conduct in Human Research (2007)* (National Statement) and the *CPMP/ICH Note for Guidance on Good Clinical Practice*. Further, this Committee has been accredited by the NSW Department of Health as a lead HREC under the model for single ethical and scientific review.

As part of the procedure for ethical approval of research involving humans in Hunter New England Health the above protocol has reviewed by the Rural Research Methods Support Group, an advisory group of the Hunter New England Human Research Ethics Committee.

I am pleased to advise that following receipt of the requested clarifications and revised information pamphlet and recruitment booklet by the Professional Officer, the Hunter New England Human Research Ethics Committee has granted ethical approval of the above project.

The following documentation has been reviewed and approved by the Hunter New England Human Research Ethics Committee:

- The information pamphlet;
- The recruitment booklet
- The Consent Form (version 1 dated 22 April 2008);
- The Survey of Cigarette Exposure (version 1 dated 21 November 2007); and
- The Stressful Life Events – National Aboriginal and Torres Strait Islander Health Survey (version 1 dated 22 April 2008)

For the protocol **Stress During Pregnancy and Developmental Origins of Renal Disease in Aboriginal Australians**

Approval from the Hunter New England Human Research Ethics Committee for the above protocol is given for a maximum of 5 years from the date of this letter, after which a renewal application will be required if the protocol has not been completed.

Hunter New England Human Research Ethics Committee
(Locked Bag No 1)
(New Lambton NSW 2305)
Telephone (02) 49214 950 Facsimile (02) 49214 618
Email: hnehrec@hnehealth.nsw.gov.au
Nicole.gerrand@hnehealth.nsw.gov.au
Lisa.worren@hnehealth.nsw.gov.au
http://www.hnehealth.nsw.gov.au/Human_Research_Ethics

The *National Statement on Ethical Conduct in Human Research (2007)*, which the Committee is obliged to adhere to, include the requirement that the committee monitors the research protocols it has approved. In order for the Committee to fulfil this function, it requires:

- a report of the progress of the above protocol be submitted at 12 monthly intervals. Your review date is **November 2009**. A proforma for the annual report will be sent two weeks prior to the due date.
- A final report be submitted at the completion of the above protocol, that is after data analysis has been completed and a final report compiled. A proforma for the final report will be sent two weeks prior to the due date.
- All variations or amendments to this protocol, including amendments to the Information Sheet and Consent Form, must be forwarded to and approved by the Hunter New England Human Research Ethics Committee prior to their implementation.
- The Principal Investigator will immediately report anything which might warrant review of ethical approval of the project in the specified format, including:
 - any serious or unexpected adverse events
 - Adverse events, however minor, must be recorded as observed by the Investigator or as volunteered by a participant in this protocol. Full details will be documented, whether or not the Investigator or his deputies considers the event to be related to the trial substance or procedure.
 - Serious adverse events that occur during the study or within six months of completion of the trial at your site should be reported to the Professional Officer of the Hunter New England Human Research Ethics Committee as soon as possible and at the latest within 72 hours.
 - Copies of serious adverse event reports from other sites should be sent to the Hunter New England Human Research Ethics Committee for review as soon as possible after being received.
 - Serious adverse events are defined as:
 - Causing death, life threatening or serious disability.
 - Cause or prolong hospitalisation.
 - Overdoses, cancers, congenital abnormalities whether judged to be caused by the investigational agent or new procedure or not.
 - unforeseen events that might affect continued ethical acceptability of the project.
- If for some reason the above protocol does not commence (for example it does not receive funding); is suspended or discontinued, please inform Dr Nicole Gerrand, the Professional Officer of the Hunter New England Human Research Ethics Committee as soon as possible.

The Hunter New England Human Research Ethics Committee also has delegated authority to approve the commencement of this research on behalf of the Hunter New England Area Health Service. This research may therefore commence.

Hunter New England Human Research Ethics Committee
(Locked Bag No 1)
(New Lambton NSW 2305)
Telephone (02) 49214 950 Facsimile (02) 49214 818
Email: hnehrec@hnehealth.nsw.gov.au
Nicole.gerrand@hnehealth.nsw.gov.au
Lisa.woseen@hnehealth.nsw.gov.au
http://www.hnehealth.nsw.gov.au/human_research_ethics

Should you have any queries about your project please contact Dr Nicole Gerrand as per her contact details at the bottom of the page. The Hunter New England Human Research Ethics Committee Terms of Reference, Standard Operating Procedures, membership and standard forms are available from the Hunter New England Area Health Service website:

Internet address:
http://www.hnehealth.nsw.gov.au/Human_Research_Ethics

Please quote 08/05/21/4.01 in all correspondence.

You are reminded that this letter constitutes ethical approval only. You must not commence this research project at a site until separate authorisation from the Chief Executive or delegate of that site has been obtained.

The Hunter New England Human Research Ethics Committee wishes you every success in your research.

Yours faithfully

For: Dr M Parsons
Chair
Hunter New England Human Research Ethics Committee

Hunter New England Human Research Ethics Committee
(Locked Bag No 1)
(New Lambton NSW 2305)
Telephone (02) 49214 950 Facsimile (02) 49214 918
Email: hnehrec@hnehealth.nsw.gov.au
Nicole.gerrand@hnehealth.nsw.gov.au
Lisa.wcseen@hnehealth.nsw.gov.au
http://www.hnehealth.nsw.gov.au/Human_Research_Ethics

13 April 2012



Health
Hunter New England
Local Health District

Dr Kym Rae
University Dept of Rural Health
Locked Bag 9783
NEMSC
Tamworth NSW 2348

Dear Dr Rae

Re: Stress During Pregnancy and Development Origins of Renal Disease in Aboriginal Australians (08/05/21/4.01)

HNEHREC Reference No: 08/05/21/4.01
NSW HREC Reference No: HREC/08/HNE/129
SSA Reference No: SSA/10/HNE/336 – Birra-Li Birthing Service
SSA/08/HNE/130 – HNELHD

Thank you for a notification of a variation to the authorisation of this project for the Hunter New England Local Health District. I am pleased to inform you that this variation to the authorisation has been accepted.

As part of the Governance review process for the variation to this protocol, the following documentation was reviewed for use at the **Hunter New England Local Health District** site:

- To extend the study to follow the development, for two years, of babies born to mothers already enrolled;
- For the addition of Professor Mark McLean as co-investigator;
- For the addition of Professor Sandra Eades as co-investigator;
- For the addition of Professor John Thomas Boulton as co-investigator;
- For the addition of Professor Clare Collins as co-investigator;
- For the addition of Professor Pathik Wadhwa as co-investigator;
- For the addition of A/Professor Ian Wright as co-investigator;
- For the addition of Dr Alex Brown as co-investigator;
- For the addition of Mr Shane Sykes as student researcher;
- For the Participant Information Sheet AMB 2 (Version 1 dated 28 March 2012); and
- For the Participant Consent Form AMB (Version 1 dated 28 March 2012)

The following conditions apply to this research project. These are additional to those conditions imposed by the Human Research Ethics Committee that granted ethical approval:

Hunter New England Research Ethics & Governance Unit

(Locked Bag No 1)

(New Lambton NSW 2305)

Telephone (02) 49214 950 Facsimile (02) 49214 818

Email: hnehrec@hnehealth.nsw.gov.au

http://www.hnehealth.nsw.gov.au/research_ethics_and_governance_unit

1. Proposed amendments to the research protocol or conduct of the research which may affect the ethical acceptability of the project, and which are submitted to the lead HREC for review, are copied to the Research Governance Officer; and
2. Proposed amendments to the research protocol or conduct of the research which may affect the ongoing site acceptability of the project are to be submitted to the Research Governance Officer.

Yours faithfully

Dr Nicole Gerrard
Research Governance Officer
Hunter New England Local Health District

Hunter New England Research Ethics & Governance Unit

(Locked Bag No 1)

(New Lambton NSW 2305)

Telephone (02) 49214 950 Facsimile (02) 49214 818

Email: hnehrec@hnehealth.nsw.gov.au

http://www.hnehealth.nsw.gov.au/research_ethics_and_governance_unit



13 April 2012

Dr Kym Rae
University Dept of Rural Health
Locked Bag 9783
NEMSC
Tamworth NSW 2348

Dear Dr Rae

Re: Stress During Pregnancy and Development Origins of Renal Disease in Aboriginal Australians (08/05/21/4.01)

HNEHREC Reference No: 08/05/21/4.01
NSW HREC Reference No: HREC/08/HNE/129
SSA Reference No: SSA/10/HNE/336 – Birra-Li Birthing Service
SSA/08/HNE/130 – HNELHD

Thank you for submitting a request for an amendment to the above project. This amendment was reviewed by the Hunter New England Human Research Ethics Committee. This Human Research Ethics Committee is constituted and operates in accordance with the National Health and Medical Research Council's *National Statement on Ethical Conduct in Human Research (2007)* (National Statement) and the *CPMP/ICH Note for Guidance on Good Clinical Practice*. Further, this Committee has been accredited by the NSW Department of Health as a lead HREC under the model for single ethical and scientific review.

I am pleased to advise that the Hunter New England Human Research Ethics Committee has granted ethical approval for the following amendment requests:

- To extend the study to follow the development, for two years, of babies born to mothers already enrolled;
- For the addition of Professor Mark McLean as co-investigator;
- For the addition of Professor Sandra Eades as co-investigator;
- For the addition of Professor John Thomas Boulton as co-investigator;
- For the addition of Professor Clare Collins as co-investigator;
- For the addition of Professor Pathik Wadhwa as co-investigator;
- For the addition of A/Professor Ian Wright as co-investigator;
- For the addition of Dr Alex Brown as co-investigator;
- For the addition of Mr Shane Sykes as student researcher;
- For the Participant Information Sheet AMB 2 (Version 1 dated 28 March 2012); and
- For the Participant Consent Form AMB (Version 1 dated 28 March 2012)

Hunter New England Human Research Ethics Committee
(Locked Bag No 1)
(New Lambton NSW 2305)
Telephone (02) 49214 950 Facsimile (02) 49214 818
Email hnehrec@hnehealth.nsw.gov.au
http://www.hnehealth.nsw.gov.au/research_ethics_and_governance_unit

For the protocol: **Stress During Pregnancy and Development Origins of Renal Disease in Aboriginal Australians**

Approval from the Hunter New England Human Research Ethics Committee for the above protocol is given for a maximum of **5** years from the date of the approval letter of your initial application, after which a renewal application will be required if the protocol has not been completed. The above protocol is approved until **November 2013**.

Approval has been granted for this study to take place at the following sites:

- **Hunter New England Local Health District**
- **Birra-Li Birthing Service**
- **Walgett Aboriginal Medical Service**
- **Walgett Hospital**
- **Dubbo Hospital**
-

The *National Statement on Ethical Conduct in Human Research (2007)* which the Committee is obliged to adhere to, include the requirement that the committee monitors the research protocols it has approved. In order for the Committee to fulfil this function, it requires:

- A report of the progress of the above protocol be submitted at 12 monthly intervals. Your review date is **November 2012**. A proforma for the annual report will be sent two weeks prior to the due date.
- A final report must be submitted at the completion of the above protocol, that is, after data analysis has been completed and a final report compiled. A proforma for the final report will be sent two weeks prior to the due date.
- All variations or amendments to this protocol, including amendments to the Information Sheet and Consent Form, must be forwarded to and approved by the Hunter New England Human Research Ethics Committee prior to their implementation.
- The Principal Investigator will immediately report anything which might warrant review of ethical approval of the project in the specified format, including:
 - any serious or unexpected adverse events
 - Adverse events, however minor, must be recorded as observed by the Investigator or as volunteered by a participant in this protocol. Full details will be documented, whether or not the Investigator or his deputies considers the event to be related to the trial substance or procedure.
 - Serious adverse events that occur during the study or within six months of completion of the trial at your site should be reported to the Professional Officer of the Hunter New England Human Research Ethics Committee as soon as possible and at the latest within 72 hours.
 - Copies of serious adverse event reports from other sites should be sent to the Hunter New England Human Research Ethics Committee for review as soon as possible after being received.
 - Serious adverse events are defined as:
 - Causing death, life threatening or serious disability.

Hunter New England Human Research Ethics Committee
(Locked Bag No 1)
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Telephone (02) 49214 950 Facsimile (02) 49214 818
Email: hnehec@hnehealth.nsw.gov.au
http://www.hnehealth.nsw.gov.au/research_ethics_and_governance_unit

-
- Cause or prolong hospitalisation.
 - Overdoses, cancers, congenital abnormalities whether judged to be caused by the investigational agent or new procedure or not.

- Unforeseen events that might affect continued ethical acceptability of the project.

- If for some reason the above protocol does not commence (for example it does not receive funding); is suspended or discontinued, please inform Dr Nicole Gerrand, the Manager, Research Ethics and Governance Unit as soon as possible.

The Hunter New England Human Research Ethics Committee also has delegated authority to approve the commencement of this research on behalf of the Hunter New England Local Health District. This research may therefore commence.

Should you have any queries about your project please contact Dr Nicole Gerrand as per the contact details at the bottom of the page. The Hunter New England Human Research Ethics Committee Terms of Reference, Standard Operating Procedures, membership and standard forms are available from the Hunter New England Local Health District website:
Internet address: http://www.hnehealth.nsw.gov.au/research_ethics_and_governance_unit

Please quote **(reference no)** in all correspondence

The Hunter New England Human Research Ethics Committee wishes you every success in your research.

Yours faithfully

For: Associate Professor M Parsons
Chair
Hunter New England Human Research Ethics Committee

Hunter New England Human Research Ethics Committee
(Locked Bag No 1)
(New Lambton NSW 2305)
Telephone (02) 49214 950 Facsimile (02) 49214 818
Email hrehrec@hnehealth.nsw.gov.au
http://www.hnehealth.nsw.gov.au/research_ethics_and_governance_unit

10.7 Appendix: Consent forms for the Gomeroi gaaynggal study

CONSENT FORM FOR THE RESEARCH PROJECT Stress During Pregnancy and Developmental Origins of Renal Disease in Aboriginal Australians

Version 3 dated 26.11.15

- ☐ I agree to be a part of the research project. I give my willing consent.
- ☐ I understand I can stop at anytime. I don't have to give a reason for why I want to stop.
- ☐ I can ask for my information and samples to be destroyed if I decide that I want to stop.
- ☐ I agree to providing 3 blood samples for research. Two of these samples will happen in my normal pregnancy care. One is an extra sample.
- ☐ I agree to providing 3 spit samples for research. These are all extra samples from my normal pregnancy care.
- ☐ I agree to providing urine samples for research. These samples may be extra from my normal pregnancy care.
- ☐ I understand that these samples will **only** be tested for hormones of stress, renal health, by-products of tobacco, and genetic markers of inflammation.
- ☐ I agree to the researchers to asking about stressful life events and how bad these can be, cigarette smoking and experiences of racism, at three different times in my pregnancy.
- ☐ I agree for researchers to access my medical records for details on previous pregnancies (number of previous pregnancies, miscarriages, premature births, stillbirths, low birthweight delivery).
- ☐ I agree to researchers finding out about this pregnancy (weight gain, blood pressure, gestational diabetes, ultrasound measurements, pregnancy test results, blood pressure, and any other health problems)
- ☐ I agree to the researchers having information on my baby's birth. This would be things like – birthweight, gender, length, head size, and information about the type of labour.
- ☐ I agree to the researchers asking me questions about what I eat. This would be through a survey in person with a dietitian, and an online survey. This can be over the phone if this is more convenient for me.
- ☐ I understand that this information will **remain private**. All of my information will be coded. Only the Chief Investigator will have access to the codes.
- ☐ I agree to have my coded information stored in a research database that may be used in future research.
- ☐ If I am under 18 years of age I understand that the research team is obliged to ensure my safety, welfare and wellbeing. If I share information with the research team that tells them I am at risk of harm, the researcher has a responsibility to report this according to NSW Department of Health –Child Protection Guidelines.
- ☐ I have been able to ask as many questions as I needed.

Participant Name: _____ (Please print)

Participant Signature: _____ Date: _____

Guardian Name if participant is < 16 years of age: _____ (Please print)

Guardian Signature if participant is < 16 years of age: _____ Date: _____

The ethical aspects of this study have been approved by the Hunter New England Human Research Ethics Committee (approval number: 08/05/21/4.01) and by the Aboriginal Health and Medical Research Council (approval number: 654/08). If you have any complaints or reservations about any aspect of your involvement in this research you may contact the Hunter New England Human research Ethics Committee, Hunter New England Health, Locked Bag 1, New Lambton, NSW, 2305, Tel (02) 4921 4950, email: HNELHD-HREC@hnehealth.nsw.gov.au or the Aboriginal Health and Medical Research Council, PO Box 1565 Strawberry Hills, NSW 2012, Tel (02) 9212 4777, email: ahmrc@ahmrc.org.au



CONSENT FORM FOR PARTICIPANTS
Gomeri gaaynggal Follow up Study
Stress during Pregnancy and the Development Origins of Renal Disease in Aboriginal Australians
Version 3 26.11.15

- I agree to be a part of the research project. I give my willing consent.
- I understand I can stop at any time. I don't have to give a reason for why I want to stop.
- I can ask for my information and samples to be destroyed if I decide that I want to stop.
- I agree to provide two blood samples from myself for the research project.
- I agree to provide two blood samples from my child. These samples will be used for research.
- I agree to provide two urine samples from myself for the research project.
- I agree to provide two urine samples from my child. These samples will be used for research.
- I agree to my baby having a retinal photograph.
- I agree to have my baby's growth measured on five occasions over a five year period after birth. This includes length, weight and the baby's skinfold thickness (amount of fat under the skin).
- I understand that these samples will only be tested for hormones of kidney health and diabetic health.
- I agree to being asked questions about my diet and the food that my child eats.
- I agree to have my weight, skinfold thickness and diabetic health checked on three occasions in the five years after my baby's birth.
- I agree to researchers finding out about my baby's pregnancy (weight gain, blood pressure, gestational diabetes ultrasound measurements, blood pressure, and any other health problems)
- I agree to the researchers having information on my baby's birth. This would be things like – birth weight, gender, length, head size, and information about the type of labour.
- I understand that this information will remain private. All of my information will be coded. Only the Chief Investigator will have access to the codes
- I agree to having my coded information stored in a research database that may be used in future research
- If I am under 18 years of age I understand that the research team is obliged to ensure my safety, welfare and wellbeing. If I share information with the research team that tells them I am at risk of harm. The researcher has a responsibility to report this according to NSW Department of Health- Child Protection Guidelines.
- I have been able to ask as many questions as I needed.

Participants name: _____

Participants signature: _____

Date: _____



10.8 Appendix: Statement of contribution and collaboration for chapter 4

I attest that Research Higher Degree candidate Amy M Ashman contributed to the following paper:

Ashman A.M., Collins C.E., Weatherall L.J., Keogh L., Brown L.J., Rollo M.E., Smith R., Rae K.M. Dietary intakes and anthropometric measures of Indigenous Australian women and their infants in the Gomeri gaaynggal cohort. *Journal of Developmental Origins of Health and Disease*. 2016;7(5):481-497.

AA conducted postpartum data collection, analysed the data and prepared the manuscript. KR, RS and CC are principal investigators on the Gomeri gaaynggal study. KR is the Gomeri gaaynggal Program Director. LW was responsible for the recruitment of participants during pregnancy and assisted with collection of postpartum data. AA, KR and LK managed the postpartum data. LB and MR contributed significantly to the editing of this paper. All authors contributed to development of this manuscript and have read and approved of the final manuscript.

Ms Amy M Ashman Date: 09/02/2017

Professor Clare Collins Date: 10/02/2017

Ms Loretta Weatherall Date: 14/02/2017

Mrs Lyniece Keogh Date: 10/02/2017

Dr Leanne Brown Date: 13/02/2017

Dr Megan Rollo Date: 10/02/2017

Date 18th Feb 2017

Laureate Professor Roger Smith

Associate Professor Kym Rae Date: 10/02/2017

Digitized by Google
2015-2016
University of
Birmingham
Faculty of Health and
Medicine
Email: robert.callister@bham.ac.uk
r.callister@bham.ac.uk
Date: 2017/02/17 15:08:11, 1778P

Professor Robert Callister

Deputy Head of Faculty of Health and Medicine (Research and Research Training)

10.9 Appendix: Permission to reproduce the published manuscript granted by publishers for chapter 4

Correspondence from the journal's publishers regarding permission to use the published article in the research thesis.

From: Amy Ashman [<mailto:AMY.ASHMAN@UON.EDU.AU>]
Sent: Sunday, February 12, 2017 6:40 PM
To: Journals Customer Services
Subject: Seeking permission to include published articles in PhD thesis

To whom it may concern,

I am writing to seek permission to include my published research articles in my PhD thesis by publication. These publications make up two chapters of my PhD thesis. Citations for both papers have been included in the thesis.

I have two articles published in the Journal of Developmental Origins of Health and Disease. The references for these are below:

Ashman A. M., Collins C.E., Weatherall L., Brown L.J., Rollo M. E., Clausen D., Blackwell C.C., Pringle K.G., Attia J., Smith R., Lumbers E.R., Rae K.M. A cohort of Indigenous Australian women and their children through pregnancy and beyond: the *Gomeri gaaynggal* study. *Journal of Developmental Origins of Health and Disease*. 2016;7(4):357-368. DOI: <http://dx.doi.org/10.1017/S204017441600009X>

Ashman A.M., Collins C.E., Weatherall L.J., Keogh L., Brown L.J., Rollo M.E., Smith R., Rae K.M. Dietary intakes and anthropometric measures of Indigenous Australian women and their infants in the Gomeri gaaynggal cohort. *Journal of Developmental Origins of Health and Disease*. 2016;7(5):481-497. DOI: <http://dx.doi.org/10.1017/S2040174416000325>

Please let me know if you require any further information from me.

Thank you very much,

Kind Regards,
Amy

Seeking permission to include published articles in PhD thesis /STR



Georgia Stratton <gstratton@cambridge.org>

Wed 29/03, 22:49

Amy Ashman ✉



Reply all | ▾



Action Items



Dear Ms Ashman,

Thank you for your request to reproduce the below material in your forthcoming PhD thesis, for non-commercial publication. We apologise for the delay in our reply.

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Yours sincerely,

Georgia Stratton,

Permissions Sales Administrator | Permissions Sales | Academic, ELT, Education

Cambridge University Press

University Printing House | Shaftesbury Road | Cambridge | CB2 8BS, UK



10.10 Appendix: Statement of contribution and collaboration for chapter 5

I attest that Research Higher Degree candidate Amy M Ashman contributed to the following paper:

Ashman A.M., Collins C.E., Brown L.J., Rae K.M., Rollo M.E. A Brief Tool to Assess Image-Based Dietary Records and Guide Nutrition Counselling Among Pregnant Women: An Evaluation. *JMIR Mhealth and Uhealth*. 2016;4(4):e123.

AA and MR were responsible for participant recruitment, data collection, dietary analysis, and provision of nutrition feedback to participants. MR was responsible for the conception of the study and design of the study protocol and materials. AA analysed results and prepared this manuscript and MR, CC, KR, and LB assisted with its development and revision. All authors significantly contributed to this research and have read and approved the final manuscript.

Ms Amy M Ashman Date: 09/02/2017

Professor Clare Collins Date: 09/02/2017

Dr Leanne Brown Date: 13/02/2017

Associate Professor Kym Rae Date: 10/02/2017

Dr Megan Rollo Date: 09/02/2017

 Digitally signed by Robert Callister
DN: cn=Robert Callister, o=University
of Newcastle, ou=Faculty of Health
and Medicine,
email=robert.callister@newcastle.edu.au, c=AU
Date: 2017.02.14 14:00:22 +11'00'

Professor Robert Callister

Deputy Head of Faculty of Health and Medicine (Research and Research Training)

10.11 Appendix: Permission to reproduce the published manuscript granted by publishers for chapter 5

Screenshot from the Journal of Medical Internet Research website, available at: <https://jmir.zendesk.com/hc/en-us/articles/115001313067-Can-you-give-me-permission-to-publish-my-article-as-part-of-my-thesis->

The screenshot shows a Zendesk article page. At the top, there's a navigation bar with 'JMIR Publications > Production and Post-Publication > General Post-Publication Questions' and a search bar. The article title is 'Can you give me permission to publish my article as part of my thesis?'. It is authored by the 'Editorial Director' and was updated '24 days ago'. A 'Follow' button is visible. The article text explains that JMIR articles are published under a Creative Commons Attribution license, allowing authors to publish their work in a thesis or book chapter as long as they cite the source and state it was published in a JMIR journal. A related article link is provided: 'Can you give me copyright or the permission to use a figure (or other material from a JMIR article)?'. At the bottom, there is a feedback section asking 'Was this article helpful?' with 'Yes' and 'No' buttons. A note indicates '1 out of 1 found this helpful'.

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Editorial Director
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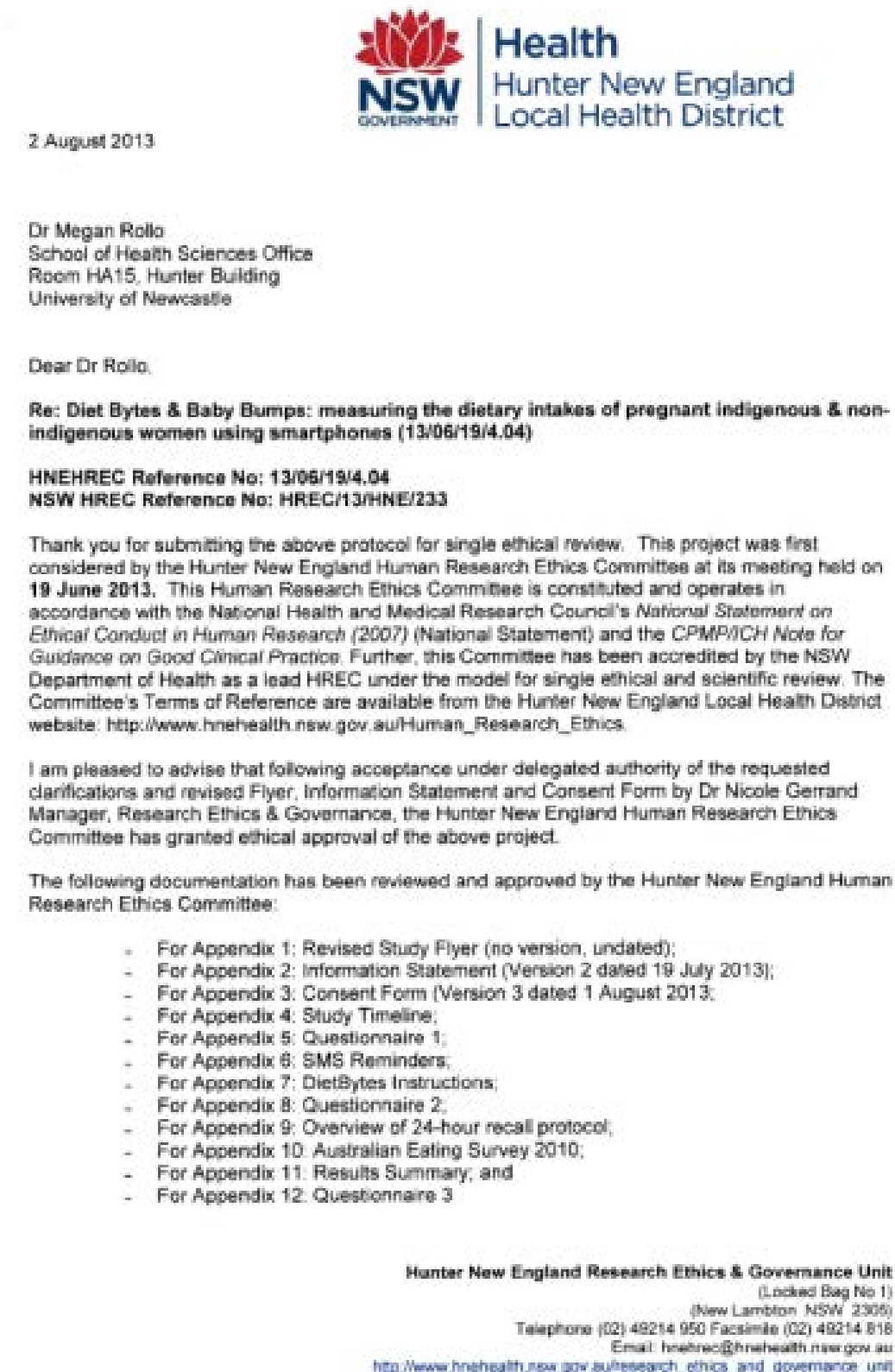
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10.12 Appendix: Ethics approval for the Diet Bytes and Baby Bumps study

Ethics approval from the Hunter New England Human Research Ethics Committee:



For the protocol: **Diet Bytes & Baby Bumps: measuring the dietary intakes of pregnant indigenous & non-indigenous women using smartphones**

Approval has been granted for this study to take place at the following site:

- **Gomerol Gaaynggal Centre, Tamworth**

Approval from the Hunter New England Human Research Ethics Committee for the above protocol is given for a maximum of **3** years from the date of this letter, after which a renewal application will be required if the protocol has not been completed.

The *National Statement on Ethical Conduct in Human Research (2007)*, which the Committee is obliged to adhere to, include the requirement that the committee monitors the research protocols it has approved. In order for the Committee to fulfil this function, it requires:

- A report of the progress of the above protocol be submitted at 12 monthly intervals. Your review date is **August 2014**. A proforma for the annual report will be sent two weeks prior to the due date.
- A final report must be submitted at the completion of the above protocol, that is, after data analysis has been completed and a final report compiled. A proforma for the final report will be sent two weeks prior to the due date.
- All variations or amendments to this protocol, including amendments to the Information Sheet and Consent Form, must be forwarded to and approved by the Hunter New England Human Research Ethics Committee prior to their implementation.
- The Principal investigator will immediately report anything which might warrant review of ethical approval of the project in the specified format, including:
 - any serious or unexpected adverse events
 - Adverse events, however minor, must be recorded as observed by the investigator or as volunteered by a participant in this protocol. Full details will be documented, whether or not the investigator or his deputies considers the event to be related to the trial substance or procedure. These do not need to be reported to the Hunter New England Human Research Ethics Committee
 - Serious adverse events that occur during the study or within six months of completion of the trial at your site should be reported to the Manager, Research Ethics & Governance, of the Hunter New England Human Research Ethics Committee as soon as possible and at the latest within 72 hours.
 - All other safety reporting should be in accordance with the NHMRC's Safety Monitoring Position Statement – May 2009 available at http://www.nhmrc.gov.au/health_ethics/hrecs/reference/_files/090609_nhmrc_position_statement.pdf
 - Serious adverse events are defined as;
 - Causing death, life threatening or serious disability.
 - Cause or prolong hospitalisation.
 - Overdoses, cancers, congenital abnormalities whether judged to be

Hunter New England Research Ethics & Governance Unit

(Locked Bag No 1)

(New Lambton NSW 2305)

Telephone (02) 49214 950 Facsimile (02) 49214 818

Email: hnehrec@hnehealth.nsw.gov.au

http://www.hnehealth.nsw.gov.au/research_ethics_and_governance_unit

caused by the investigational agent or new procedure or not

- Unforeseen events that might affect continued ethical acceptability of the project.

- If for some reason the above protocol does not commence (for example it does not receive funding); is suspended or discontinued, please inform Dr Nicole Gerrand, as soon as possible.

You are reminded that this letter constitutes ethical approval only. You must not commence this research project at a site until separate authorisation from the Chief Executive or delegate of that site has been obtained.

A copy of this letter must be forwarded to all site investigators for submission to the relevant Research Governance Officer.

Should you have any concerns or questions about your research, please contact Dr Gerrand as per the details at the bottom of the page. The Hunter New England Human Research Ethics Committee wishes you every success in your research.

Please quote **13/06/19/4.04** in all correspondence.

The Hunter New England Human Research Ethics Committee wishes you every success in your research.

Yours faithfully

For: Professor M Parsons
Chair
Hunter New England Human Research Ethics Committee

Hunter New England Research Ethics & Governance Unit

(Locked Bag No 1)

(New Lambton NSW 2305)

Telephone (02) 49214 950 Facsimile (02) 49214 818

Email: hnehrec@hnehealth.nsw.gov.au

http://www.hnehealth.nsw.gov.au/research_ethics_and_governance_unit

Ethics approval from the University of Newcastle Human Research Ethics Committee

HUMAN RESEARCH ETHICS COMMITTEE



Notification of Expedited Approval

To Chief Investigator or Project Supervisor:	Doctor Megan Rollo
Cc Co-investigators / Research Students:	Ms Loretta Weatherall Professor Clare Collins Doctor Kym Rae Doctor Geoffrey Skinner Professor Roger Smith Ms Amy Ashman
Re Protocol:	Diet Bytes & Baby Bumps: measuring the dietary intakes of pregnant Indigenous and non-Indigenous women using smartphones.
Date:	23-Aug-2013
Reference No:	H-2013-0185
Date of Initial Approval:	01-Aug-2013

Thank you for your Response to Conditional Approval (minor amendments) submission to the Human Research Ethics Committee (HREC) seeking approval in relation to the above protocol.

Your submission was considered under Expedited review by the Ethics Administrator.

I am pleased to advise that the decision on your submission is **Approved** effective 01-Aug-2013.

In approving this protocol, the Human Research Ethics Committee (HREC) is of the opinion that the project complies with the provisions contained in the National Statement on Ethical Conduct in Human Research, 2007, and the requirements within this University relating to human research.

Approval will remain valid subject to the submission, and satisfactory assessment, of annual progress reports. *If the approval of an External HREC has been "noted" the approval period is as determined by that HREC.*

The full Committee will be asked to ratify this decision at its next scheduled meeting. A formal *Certificate of Approval* will be available upon request. Your approval number is H-2013-0185.

If the research requires the use of an Information Statement, ensure this number is inserted at the relevant point in the Complaints paragraph prior to distribution to potential participants You may then proceed with the research.

(Approval was granted in consultation with the Hunter New England Human Research Ethics Committee.)

<https://rims.newcastle.edu.au/administration/ShowPDF.asp?UCCommID=E49438368EECE51BE040007F01001A08>[27/08/2013 10:37:10 AM]

Conditions of Approval

This approval has been granted subject to you complying with the requirements for *Monitoring of Progress, Reporting of Adverse Events, and Variations to the Approved Protocol* as detailed below.

PLEASE NOTE:

In the case where the HREC has "noted" the approval of an External HREC, progress reports and reports of adverse events are to be submitted to the External HREC only. In the case of Variations to the approved protocol, or a Renewal of approval, you will apply to the External HREC for approval in the first instance and then Register that approval with the University's HREC.

• *Monitoring of Progress*

Other than above, the University is obliged to monitor the progress of research projects involving human participants to ensure that they are conducted according to the protocol as approved by the HREC. A progress report is required on an annual basis. Continuation of your HREC approval for this project is conditional upon receipt, and satisfactory assessment, of annual progress reports. You will be advised when a report is due.

• *Reporting of Adverse Events*

1. It is the responsibility of the person first named on this Approval Advice to report adverse events.
2. Adverse events, however minor, must be recorded by the investigator as observed by the investigator or as volunteered by a participant in the research. Full details are to be documented, whether or not the investigator, or his/her deputies, consider the event to be related to the research substance or procedure.
3. Serious or unforeseen adverse events that occur during the research or within six (6) months of completion of the research, must be reported by the person first named on the Approval Advice to the (HREC) by way of the Adverse Event Report form (via RIMS at <https://rims.newcastle.edu.au/login.asp>) within 72 hours of the occurrence of the event or the investigator receiving advice of the event.
4. Serious adverse events are defined as:
 - Causing death, life threatening or serious disability.
 - Causing or prolonging hospitalisation.
 - Overdoses, cancers, congenital abnormalities, tissue damage, whether or not they are judged to be caused by the investigational agent or procedure.
 - Causing psycho-social and/or financial harm. This covers everything from perceived invasion of privacy, breach of confidentiality, or the diminution of social reputation, to the creation of psychological fears and trauma.
 - Any other event which might affect the continued ethical acceptability of the project.
5. Reports of adverse events must include:
 - Participant's study identification number;
 - date of birth;
 - date of entry into the study;
 - treatment arm (if applicable);
 - date of event;
 - details of event;
 - the investigator's opinion as to whether the event is related to the research procedures; and
 - action taken in response to the event.
6. Adverse events which do not fall within the definition of serious or unexpected, including those reported from other sites involved in the research, are to be reported in detail at the time of the annual progress report to the HREC.

• *Variations to approved protocol*

If you wish to change, or deviate from, the approved protocol, you will need to submit an *Application for Variation to Approved Human Research* (via RIMS at <https://rims.newcastle.edu.au/login.asp>). Variations may include, but are not limited to, changes or additions to investigators, study design, study population, number of participants, methods of

<https://rims.newcastle.edu.au/administration/ShowPDF.asp?UCCommID=E49438368EECE51BE040007F01001A08/27/08/2013 10:37:10 AM>

recruitment, or participant information/consent documentation. Variations must be approved by the (HREC) before they are implemented except when Registering an approval of a variation from an external HREC which has been designated the lead HREC, in which case you may proceed as soon as you receive an acknowledgement of your Registration.

Linkage of ethics approval to a new Grant

HREC approvals cannot be assigned to a new grant or award (ie those that were not identified on the application for ethics approval) without confirmation of the approval from the Human Research Ethics Officer on behalf of the HREC.

Best wishes for a successful project.

Professor Allyson Holbrook
Chair, Human Research Ethics Committee

For communications and enquiries:
Human Research Ethics Administration

Research Services
Research Integrity Unit
The Chancellery
The University of Newcastle
Callaghan NSW 2308
T +61 2 492 17894
F +61 2 492 17164
Human-Ethics@newcastle.edu.au

RIMS website - <https://RIMS.newcastle.edu.au/login.asp>

Linked University of Newcastle administered funding:

Funding body	Funding project title	First named investigator	Grant Ref
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[ps://rims.newcastle.edu.au/administration/ShowPDF.asp?UCommID=E49438368EECE51BE040007F01001A08](https://rims.newcastle.edu.au/administration/ShowPDF.asp?UCommID=E49438368EECE51BE040007F01001A08)[27/08/2013 10:37:10 AM]

Ethics approval from the Aboriginal Health and Medical Research Council:



AH&MRC ETHICS COMMITTEE

12th September 2013

Dr Megan Rollo
School of Health Sciences Office
Room HA15, Hunter Building
The University of Newcastle
Callaghan, NSW 2308

Dear Dr Rollo,

RE: 962/13 – Diet Bytes & Baby Bumps: measuring the dietary intakes of pregnant Indigenous and non- Indigenous women using smartphones

The Aboriginal Health and Medical Research Council (AH&MRC) Ethics Committee has considered your application received on 22nd July 2013 for ethics approval for the above project. Your email correspondence of 25th July 2013, 27th August 2013, 9th September 2013 and 10th September 2013 containing additional information is considered to form part of the application.

The Committee agreed to approve the application, subject to the Standard Conditions and Special Conditions of Approval below:

Standard Conditions of Approval (where applicable to the project)

1. The approval is for a period from 12th September 2013 until 12th September 2014 (12 months after), with extension subject to providing a report on the research by 12th September 2014.
2. All research participants are to be provided with a relevant Participant Information Statement and Consent Form in the format provided with your application.
3. Copies of all signed consent forms must be retained and made available to the Ethics Committee on request. A request will only be made if there is a dispute or complaint in relation to a participant.
4. Any changes to the staffing, methodology, timeframe, or any other aspect of the research relevant to continued ethical acceptability of the project must have the prior written approval of the Ethics Committee.
5. The AH&MRC Ethics Committee must be immediately notified in writing of any serious or unexpected adverse effects on participants.
6. The research must comply with:
 - the *AH&MRC Guidelines for Research in Aboriginal Health – Key Principles*

Supported by the NSW Ministry of Health

Location
Level 3, 66 Wentworth Avenue
Sydney Hills NSW 2010

Postal Address
PO Box 1565
Strawberry Hills NSW 2012

Contact
Phone: +61 (0) 282 4777
Fax: +61 (0) 282 770
e-Mail: ahmrc@ahmrc.org.au
web: www.ahmrc.org.au

ABN
ABN 55 085 634 397

-
- *National Statement on Ethical Conduct in Research Involving Humans* (April 2007)
 - the *NSW Aboriginal Health Information Guidelines*.
7. The final draft report from the research, and any publication or presentation prior to that report where new data or findings are presented, must be provided to the AH&MRC Ethics Committee to be reviewed for compliance with ethical and cultural criteria prior to:
 - any submission for publication; and/or
 - any dissemination of the report.
 8. A copy of the final published version of any publication is to be provided to the AH&MRC Ethics Committee.

Special Condition/s

9. Nil

Please acknowledge receipt of this letter and your acceptance of the above conditions within fourteen (14 days).

We would also appreciate your agreement that the AH&MRC may, on request, obtain access to the data obtained from the research in order to assist the future development of policy and programs in Aboriginal health.

On behalf of the AH&MRC Ethics Committee,

Yours sincerely,

Val Keed
Chairperson
AH&MRC Ethics Committee

10.13 Appendix: Recruitment materials for the Diet Bytes and Baby Bumps study

Recruitment flyer for the Diet Bytes and Baby Bumps study:

Diet Bytes & Baby Bumps Study



Are you pregnant? Would you like some advice on eating for a healthy baby?

Did you know...

Healthy food and a balanced diet during pregnancy helps your baby to grow strong for good health throughout their life.

By participating in the *Diet Bytes & Baby Bumps study*, you will receive tailored advice on your pregnancy food intake and eating patterns.

Who can participate in the study?

- Women who are less than or equal to 24 weeks pregnant (in the first or second trimester),
- Aged 18 years and above,
- Live in Newcastle or Tamworth or surrounding areas,
- Have no current medical conditions,
- Have a smartphone (e.g. iPhone, Android or Windows Phone).

To find out more information, please contact us:

Phone: 02 4921 5649 (in Newcastle)
OR 02 6762 1034 (in Tamworth)

Email: DBBBStudy@newcastle.edu.au



The Diet Bytes and Baby Bumps study is being conducted at the University of Newcastle, NSW, and the Gomerol gaaynggal Centre, Tamworth NSW. This research has been reviewed and approved by the Hunter New England, University of Newcastle and Aboriginal Health and Medical Research Council Human Research Ethics Committees (Reference numbers 13/05/19/4.04, H-2013-0185 and 962/13; respectively).

Social media post for recruitment for the Diet Bytes and Baby Bumps study:

Are you pregnant? Would you like some advice on healthy eating?

Are you in your first or second trimester?

Are you able to attend two face-to-face sessions in Newcastle or Tamworth?

Do you have a Smartphone that you are happy to use to collect photographs of your food and drinks?

Then you may be eligible to join the Diet Bytes and Baby Bumps research study! This is an exciting new study evaluating the use of smartphones to take photographs of your diet, and to deliver nutrition advice.

For more information contact:

T: 02 4921 5649 (Newcastle) or 02 6762 1034 (Tamworth)

E: DBBBStudy@newcastle.edu.au

This research has been reviewed and approved by the Hunter New England, University of Newcastle and Aboriginal Health and Medical Research Council Human Research Ethics Committees (Reference numbers 13/06/19/4.04, H-2013-0185 and 962/13; respectively).



Brochure providing information on the Diet Bytes and Baby Bumps study:



Did you know...

- Healthy food and a balanced diet during pregnancy helps your baby to grow strong.
- However, the effects don't just stop there. Eating well when you are pregnant sets your baby up for good health throughout their life.
- By participating in the **Diet Bytes & Baby Bumps study**, you will receive tailored advice on your pregnancy food intake and eating patterns.

Why are we doing this study?

- Information is limited on the diets of pregnant women living in Australia.
- We are interested in this information to determine if the foods women eat during pregnancy meet their nutrition needs.
- We are also trialling a new method which uses a smartphone to collect a photographic dietary record and deliver advice about your food intake.



Who can participate in the study?

- Women who are less than or equal to 24 weeks pregnant (in the first or second trimester).
- Aged 18 years and above,
- Live in Newcastle or Tamworth, or surrounding areas,
- Have no current medical conditions,
- Have a smartphone (e.g. iPhone, Android or Windows Phone) that can use the Evernote app.

What choice do I have?

- Participation is entirely your choice.
- Your decision will not change your current or future relationship with the University of Newcastle or the Gomerol Gaaynggal Centre in Tamworth.
- If you do decide to participate, you may withdraw from the study at any time and have the option of withdrawing all information that identifies you or that you have provided.



Are you interested in joining Diet Bytes & Baby Bumps?

To find out more information, please contact us:

Phone: 02 4921 5649 (in Newcastle) OR 02 6762 1034 (in Tamworth)

Email: DBBBStudy@newcastle.edu.au

University of Newcastle Research Team:

Dr Megan Rollo (Chief Investigator), Ms Amy Ashman (PhD Student), Dr Kym Rae, Ms Loretta Weatherall, Dr Leanne Brown, Dr Geoff Skinner, Professor Roger Smith and Professor Clare Collins.

This study is being conducted at The University of Newcastle, NSW, and the Gomerol Gaaynggal Centre, Tamworth NSW. This research has been reviewed and approved by the Hunter New England, University of Newcastle and Aboriginal Health and Medical Research Council Human Research Ethics Committees (Reference numbers 13/06/19/4.04, H-2013-0185 and 962/13; respectively).

PHOTO: PHOTOFEST/GETTY IMAGES



If I participate, what will I be asked to do?

- You will be asked to:
 - Use your smartphone to take photographs of all the food and drinks you have over 3 days (you will be given instructions).
 - Answer surveys about yourself, the food you eat and your experiences with using your phone in the study.
 - Attend the two sessions in weeks 1 and 2 in-person.
 - Other sessions (in weeks 3, 4, 6, 8 and 12 weeks) are completed online or over the phone (or, if you prefer, in-person).
- All measures used are standard methods and have no known risks.
- There should be no costs to you or use of your smartphone's data allowance when collecting your photographic dietary record.



THE UNIVERSITY OF
NEWCASTLE
AUSTRALIA

The Diet Bytes & Baby Bumps Study

Are you pregnant?

Would you like some advice on eating for a healthy baby?



What will I receive for participating?

- You will receive:
 - Feedback on your food intake and eating patterns sent to your smartphone via a video (see above).
 - Time with a dietitian to get tailored advice on healthy eating in pregnancy.
 - A \$30 Coles/Myers gift voucher.
 - A brief summary of the study results.

What will you do with the information collected about me?

- You will not be identified in any publication or reports.
- Any identifying information collected will be replaced with an ID code and stored securely.
- Study results will be reported at scientific conferences and in publications.

10.14 Appendix: Information statement for the Diet Bytes and Baby Bumps study



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**Information Statement for the Research Project:
Diet Bytes & Baby Bumps: measuring the dietary intakes of pregnant Indigenous and non-Indigenous women using smartphones.**

Document Version; 4 dated 29/04/14

You are invited to participate in the research project identified above which is being conducted by Dr Megan Rollo and Professor Clare Collins from the School of Health Sciences, Professor Roger Smith, Dr Kym Rae, Ms Loretta Weatherall and Ms Amy Ashman from the School of Medicine and Public Health and Dr Geoff Skinner from the School of Design, Communication and Information Technology at the University of Newcastle.

Why is the research being done?

Limited information exists on the dietary intakes of pregnant women living in Australia, particularly among Aboriginal and/or Torres Strait Islander women. The purpose of the research is to measure the dietary intakes of Indigenous and non-Indigenous pregnant women. In particular, this study will evaluate a new method which uses a smartphone to collect a photographic dietary record. The use of smartphones to deliver nutrition advice will also be assessed.

Who can participate in the research?

We are seeking both indigenous and non-indigenous pregnant women who :

- Are ≤ 24 weeks gestation (in their first or second trimester);
- Are aged 18 years and above;
- Who reside in the Newcastle or Tamworth areas or surrounding areas

In addition to the above this study is suitable for you if you:

- Have no current medical conditions;
- Have a smartphone (iPhone, Android, Windows Phone or Blackberry) that is capable of using the Evernote app;
- Willingness to use your smartphone to keep a photographic dietary record (you will be provided with instructions); and
- Willingness to attend a minimum of two sessions in-person (Tamworth or Newcastle) across a 12 week period, with an additional five sessions consisting of interviews/surveys completed either in-person, via phone and/or online.

What choice do you have?

Participation in this research is entirely your choice. Only those people who give their informed consent will be included in the project. Whether or not you decide to participate,

your decision will not disadvantage you or your current or future relationship with the Gomeri Gaaynggal Centre in Tamworth or the University of Newcastle. If you do decide to participate, you may withdraw from the project at any time without giving a reason and have the option of withdrawing all information that identifies you or that you have provided.

What would you be asked to do? How much time will it take?

The study will run over a 12 week period. During the study period your dietary intake (the food and drink that you consume) will be measured using three different methods: a 3-day smartphone photographic dietary record, three 24-hour recalls and a food frequency questionnaire. You will receive feedback on your diet sent via a short video to your smartphone and an opportunity to discuss your results with an Accredited Practising Dietitian. In addition you will be asked to complete three short surveys. You will be provided with a \$30 gift card to reimburse you for your time and costs associated with attending the in-person sessions.

The table below lists the specific activities that will be undertaken during the study, whether you will need to attend the session in-person or if the measures can be collected via the telephone or online, and approximately how long each session will take.

Session number, time point in the study and estimated session time	What you will be asked to do during this week/session
1. <u>Week 1</u> ► <u>Must</u> be attended in-person. ► <i>Estimated session time: 60 minutes.</i>	<ul style="list-style-type: none"> • Complete a survey to collect general background information on you (e.g. age, previous pregnancies, use smartphones, etc). • Keep a photographic dietary record over three non-consecutive days (two week days, one weekend day) over this week using the Evernote app on your smartphone. You will use this app to collect a photographic dietary record with a voice record description of the contents of the photograph. During this session, your phone will be set-up (install app and settings) and you will be provided with instructions on how to use the app on your smartphone to collect your photographic dietary record. • Your height and weight will be measured.
2. <u>Week 2</u> ► <u>Must</u> be attended in-person. ► <i>Estimated session time: 60 minutes.</i>	<ul style="list-style-type: none"> • Bring your smartphone to the session so that your photographic dietary record can be uploaded to our database. • Complete a survey to evaluate photographic dietary assessment method. • Complete one 24-hour recall. A member of the research team will ask you about the food and drinks that you consumed over the past 24 hour period.
3. <u>Week 3</u> ► <i>Can be completed either in-person or telephone</i> ► <i>Estimated session time: 30 minutes.</i>	<ul style="list-style-type: none"> • Complete one 24-hour recall. A member of the research team will ask you about the food and drinks that you consumed over the past 24 hour period (i.e. day before).
4. <u>Week 4</u> ► <i>Can be completed either in-person or telephone.</i> ► <i>Estimated session time: 30 minutes.</i>	<ul style="list-style-type: none"> • Complete one 24-hour recall. A member of the research team will ask you about the food and drinks that you consumed over the past 24 hour period.
5. <u>Week 6</u> ► <i>Can be completed either in-person or telephone.</i>	<ul style="list-style-type: none"> • You will be provided with a summary of the results from the assessment of your photographic dietary record. This information will be sent to your smartphone in the form of a short video (~1.5 MB in file size). An Accredited Practising Dietitian

<p>► Estimated session time: 30 minutes.</p>	will contact you to discuss your results.
<p>6. <u>Week 8</u></p> <p>► Can be completed either telephone or online.</p> <p>► Estimated session time: 15 minutes.</p>	<ul style="list-style-type: none"> • Complete a survey to evaluate the method of delivery of nutrition advice.
<p>7. <u>Week 12</u></p> <p>► Can be completed either in-person or telephone or online.</p> <p>► Estimated session time: 30-45 minutes.</p>	<ul style="list-style-type: none"> • Complete one food frequency questionnaire. You will be asked how often you consume a select number of food items over the past 6 months.

During the first session you will be asked to download the Evernote app on your smartphone (this is a free app and the UoN WiFi network will be used) and set-up an Evernote account. This app will be used to collect your 3-day photographic dietary record during week 1 and will be used to send a short video (~1.5MB) containing feedback on your diet that you will receive during week 6. We will disable automatic syncing of your Evernote account (including your photographic dietary record) over your phone network and ask you to bring your smartphone to the session in week 2 where your account will be synced and only your photographic dietary record uploaded to the study account. For week 1, we will also ask that you disable the function on your phone which allows it to automatically join recognised WiFi networks that you have set-up, such as those at home, work or university, otherwise your account will sync automatically upon joining. We are asking you to do this so that you are not charged for costs associated the data transfer of your photographic dietary record on a WiFi network and/or if your smartphone plan does not have a data allowance or if this allowance is exceeded.

What are the risks and benefits of participating?

All measures used in this study are standard methods and have no known risks. There should be no costs to you associated with the data transfer of your smartphone photographic dietary record during week 1 of the study if you maintain the settings on your phone outlined above. At your week 2 appointment following the upload of your photographic dietary record, the “sync only on a WiFi network” setting on the Evernote app will be disabled and you can re-establish the internet connections on your smartphone. Therefore, it is important to note that the transfer of the video feedback to your smartphone in week 6 may occur using your cellular or WiFi network. The file size of the video has been purposely kept small (~1.5 MB) to minimise any data transfer and potential data allowances.

We cannot promise you any benefit from participating in this research, however through the collection of dietary intake information, the assessment of your diet and the provision of nutrition advice from an Accredited Practising Dietitian it is likely that participation will result in an increased awareness of your diet and discussion of healthy eating strategies.

How will your privacy be protected?

Any information collected by the researchers which might identify you will be stored securely and only accessed by the researchers unless you consent otherwise, except as required by law. Data collected in non-electronic form will be stored in a locked filing cabinet in the chief investigator's office to ensure its security and the confidentiality of any identified data. Only members of the research team will have access to the raw data. Data collected in electronic form will be password protected and stored securely on a server. Identifying information will be removed and replaced with a numerical code for the analysis of the raw data.

You will be asked to register an account with Evernote in order to use the app for the purpose of this study (if you have previously registered a free account you will be asked to use your existing account). Your photographic dietary record will be collected using a third-

party app (Evernote) on your smartphone. A specific notebook (*DietBytes*) will be set-up on the participant's account and shared with the research team. The research team will have access to only your photographic dietary record files stored in your DietBytes notebook. This information is stored securely on a password protected cloud server. You will only be able to view your photographic dietary record in the DietBytes notebook.

All data will be retained for at least 5 years at the University of Newcastle.

How will the information collected be used?

The results of this study will be reported at national and international conferences and scientific publications. You will not be identified in any publication or reports arising from this study. You will receive a brief written summary of results from the research team at the conclusion of the study.

What do you need to do to participate?

Please read this Information Statement and be sure you understand its contents before you consent to participate. If there is anything you do not understand, or you have questions, contact the researcher.

If you would like to participate, please complete the attached Consent Form and return it in the reply paid envelope provided or via email. A member of the research team will then contact you.

Further information

If you would like further information please contact Dr Megan Rollo (megan.rollo@newcastle.edu.au OR 02 4921 5649).

Thank you for considering this invitation.

Dr Megan Rollo
School of Health Sciences, Faculty of Health
On behalf of research team

Complaints about this research

This research has been approved by the Human Research Ethics Committees of the University of Newcastle (Approval No. H-2013-0185), Hunter New England Health of the Hunter New England Local Health District (reference number 13/06/19/4.04) and the Aboriginal Health and Medical Research Council (AH&MRC) of New South Wales (reference number 962/13). Complaints about this research can be directed to any of these bodies as outlined below:

University of Newcastle Human Research Ethics Committee: Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office, The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone (02) 49216333, email Human-Ethics@newcastle.edu.au.

Hunter New England Human Research Ethics Committee:

Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to Dr Nicole Gerrand, Manager Research Ethics and Governance, Hunter New England Local Health District, Locked Bag 1, New Lambton NSW 2305, telephone (02) 49214950, email Hnehrec@hnehealth.nsw.gov.au.

Aboriginal Health and Medical Research Council (AH&MRC) of New South Wales: If at any stage you have complaints or concerns about this research, you should contact:
The Chairperson AH&MRC Ethics Committee, Aboriginal Health & Medical Research Council of NSW, PO Box 1565, STRAWBERRY HILLS NSW 2012, telephone 02-9212 4777, Email: ethics@ahmrc.org.au.

10.15 Appendix: Consent form for the Diet Bytes and Baby Bumps study

Dr Megan Rollo
School of Health Sciences
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Faculty of Health
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Ph: 02 49215649
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Email: megan.rollo@newcastle.edu.au



**Consent Form for the Research Project:
Diet Bytes & Baby Bumps: measuring the dietary intakes of pregnant Indigenous and non-Indigenous women using smartphones.**

Dr Megan Rollo, Professor Clare Collins, Professor Roger Smith, Dr Kym Rae, Ms Loretta Weatherall, Ms Amy Ashman and Dr Geoff Skinner

Document Version; 4 dated 4/04/14

1. I agree to participate in the above research project and give my consent freely.
2. I understand that the project will be conducted as described in the Information Statement, a copy of which I have retained.
3. I understand I can withdraw from the project at any time and do not have to give any reason for withdrawing.
4. I consent to:
 - Attending a minimum of two sessions in-person (Tamworth or Newcastle) across a 12 week period, with an additional five sessions consisting of interviews/surveys completed either in-person, via phone and/or online and undertaking the following activities over the 12 week period (as outlined in the participant information statement):
 - Having my height and weight measured;
 - Completing three dietary assessment methods: 3-day photographic dietary record using my smartphone, three 24-hour recalls and one food frequency questionnaire;
 - Receiving a summary of my diet via a short video (~1.5 MB file size) to my smartphone;
 - Completing three questionnaires.
5. I agree to enable the function within the Evernote app for my records to sync only when connected to a WiFi network. I also agree to disable the function on my smartphone which allows it to automatically join recognised WiFi networks that I have set-up, such as those at home, work or university for week 1 of the study until after my week 2 session appointment. I understand that if I do not do this my Evernote account containing photographic dietary record may sync automatically upon joining a WiFi network and I may be charged for costs associated the transfer this data if my plan does not have a data allowance or if the allowance is exceeded.
6. I understand that my personal information will remain confidential to the researchers.

7. I have had the opportunity to have questions answered to my satisfaction.

I have read the information statement and would like to participate in the study.

☐

Yes

☐

No

If you select yes this will be your informed consent to participate in the study and an appointment for you to attend a testing session will be organised. In addition, you will be required to sign your consent form at the start of the first session.

Please complete with your name, contact details and date and return to the research team DBBBStudy@newcastle.edu.au.

Print Name: _____

Contact Details (to arrange time and date for appointment for the first session):

Email address: _____

Phone number: _____

Signature: _____ **Date:** _____

10.16 Appendix: Statement of contribution and collaboration for chapter 6

I attest that Research Higher Degree candidate Amy M Ashman contributed to the following paper:

Ashman A.M., Collins C.E., Brown L.J., Rae K.M., Rollo M.E. Validation of a smartphone image-based dietary assessment method for pregnant women. *Nutrients*. 2017;9(73).

AA and MR were responsible for participant recruitment, data collection, dietary analysis, and provision of nutrition feedback to participants. MR was responsible for the conception of the study and design of the study protocol and materials. AA analysed results and prepared this manuscript and MR, CC, KR, and LB assisted with its development and revision. All authors significantly contributed to this research and have read and approved the final manuscript.

Ms Amy M Ashman Date: 09/02/2017

Professor Clare Collins Date: 09/02/2017

Dr Leanne Brown Date: 13/02/2017

Associate Professor Kym Rae Date: 10/02/2017

Dr Megan Rollo Date: 09/02/2017

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Professor Robert Callister

Deputy Head of Faculty of Health and Medicine (Research and Research Training)

10.17 Appendix: Permission to reproduce the published manuscript granted by publishers for chapter 6

Correspondence from the journal 'Nutrients' regarding permission to use the published article in the research thesis.



Support <support@mdpi.com>

Yesterday, 23:53

Amy Ashman

Inbox

You replied on 14/02/2017 00:40.

Dear Ms Ashman,

Thank you for your enquiry. Seeing that the article you are referring to was published under an Open Access license (CC BY 4.0), you are free to re-use its content without any further permission, always on condition that your original article is cited properly.

Kind regards,
Luca Rasetti
-MDPI Support

Am 13.02.2017 um 01:24 schrieb Amy Ashman:

> To whom it may concern,
>
> I am writing to seek permission to include my published research article in
> my PhD thesis by publication. This publications makes up one chapter of my
> PhD thesis. The citation for the the paper has been included in the thesis.
>
> The references for this article is below:
>
> Ashman A.M., Collins C.E., Brown L.J., Rae K.M., Rollo M.E. Validation of a
> smartphone image-based dietary assessment method for pregnant women.
> Nutrients. 2017;9(73). doi:10.3390/nu9010073.
>
> Please let me know if you require any further information from me.
>
> Thank you very much,
>
> Kind Regards,
> Amy
>
> AMY ASHMAN
> APD, BNutr&Diet (Hons I)
> PhD Candidate
> School of Health Sciences
> University Of Newcastle
> M 0488 399 533
> amy.ashman@uon.edu.au

--
Luca Rasetti
MDPI

10.18 Appendix: Statement of contribution and collaboration for chapter 7

I attest that Research Higher Degree candidate Amy M Ashman contributed to the following paper:

Ashman A.M., Brown L.J., Collins C.E., Rollo M.E., Rae K.M. Factors associated with effective nutrition interventions for pregnant Indigenous women: A systematic review. Under review with the *Journal of the Academy of Nutrition and Dietetics*.

AA, LB, CC, MR and KR were responsible for the study design and protocol for the systematic review. AA was responsible for developing the search strategy, performing the literature review search, retrieving articles, screening of studies for inclusion, performing quality appraisal of included studies, and data extraction. All other authors shared these tasks in their roles as second reviewers. AA prepared the manuscript and all authors contributed to manuscript development.

Ms Amy M Ashman Date: 17/02/2017

Dr Leanne Brown Date: 17/02/2017

Professor Clare Collins Date: 17/02/2017

Dr Megan Rollo Date: 17/02/2017

Associate Professor Kym Rae Date: 17/02/2017

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Professor Robert Callister

Deputy Head of Faculty of Health and Medicine (Research and Research Training)

10.19 Appendix: Permission to reproduce the published manuscript granted by publishers for chapter 7

Correspondence from the Journal of the Academy of Nutrition and Dietetics regarding permission to use the published article in the research thesis.



Amy Ashman

Fri 07/07, 13:51

Ahrens, Lois A <lois-ahrens@uiowa.edu>; jswitt@eatright.org <JSwitt@eatright.org> ↵



Reply all | ▾

Dear Ms Ahrens and Mr Switt,

Thank you for letting me know the publication date for my accepted manuscript.

I am writing to seek permission to include this research article in my PhD thesis by publication. This publication makes up one chapter of my PhD thesis. The citation for the paper will be included in the thesis.

Would you please be able to confirm that I can include this publication in my thesis?

Thank you,

Kind Regards,
Amy

AMY ASHMAN

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Ahrens, Lois A <lois-ahrens@uiowa.edu>

Fri 07/07, 22:00



Dear Amy,

Thank you for your inquiry. Including the research article in your PhD thesis will be fine.

Kind regards,

Lois Ahrens RDN, LD

Associate Editor

Journal of the Academy of Nutrition and Dietetics

www.jandonline.org

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E: lois-ahrens@uiowa.edu

10.20 Appendix: Medline search strategy for the systematic review investigating factors associated with effective nutrition interventions for pregnant Indigenous women

Example search strategy using Medline

1. Health Services, Indigenous/ or aborigin*.mp. or exp Oceanic Ancestry Group/ or Indians, South American/; 2. exp Oceanic Ancestry Group/ or torres strait islander*.mp.; 3. indigenous.mp.; 4. exp Indians, North American/ or native american*.mp.; 5. exp Indians, North American/ or native canadian*.mp.; 6. exp Indians, North American/ or first nation*.mp.; 7. maori*.mp.; 8. sami*.mp.; 9. lapp*.mp.; 10. pregnan*.mp.; 11. exp Pregnancy/; 12. exp Diet/ or diet*.mp.; 13. Nutrition Surveys/ or Nutrition Policy/ or nutrition.mp. or Nutrition Assessment/ or Nutrition Therapy/; 14. exp Breast Feeding/ or breastfe*d*.mp. or Infant Food/; 15. exp Lactation/ or lactat*.mp.; 16. Bottle Feeding/ or exp Infant Food/ or infant feed*.mp.; 17. infant wean*.mp.; 18. infant nutrition.mp.; 19. exp Feeding Behavior/ or eating behavio*r*.mp.; 20. exp Food Habits/ or food habit*.mp.; 21. exp Food Habits/ or exp Eating/ or food intake*.mp.; 22. healthy eating.mp. or Health Education/; 23. nutrition education.mp. or Nutritional Sciences/; 24. exp Inuits/ or Inuit*.mp.; 25. Eskimo*.mp.; 26. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 24 or 25; 27. 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23; 28. 10 or 11; 29. 26 and 27 and 28

Key: * truncation, utilizes root words to find variations of terms; .mp multi-purpose search searches several fields at once; exp explodes the term entered onto the command line.

10.21 Appendix: Quality assessment of intervention studies aimed at improving nutrition-related outcomes for pregnant Indigenous women residing in OECD countries, assessed using the Academy of Nutrition and Dietetics Quality Criteria Checklist for Primary Research

Study (First author, date)	Criteria 1 <i>Research question clearly stated</i>	Criteria 2 <i>Selection of subjects free from bias</i>	Criteria 3 <i>Study groups comparable</i>	Criteria 4 <i>Withdrawals described</i>	Criteria 5 <i>Blinding used</i>	Criteria 6 <i>Interventions described in detail</i>	Criteria 7 <i>Outcomes clearly defined</i>	Criteria 8 <i>Appropriate statistical methods</i>	Criteria 9 <i>Bias and limitations considered</i>	Criteria 10 <i>Bias unlikely</i>	Verdict
Barlow, 2013.	1	1	1	1	1	1	1	1	1	1	+
Barlow, 2015.	1	1	1	1	1	1	1	1	1	1	+
Bertilone, 2015.	1	1	1	U	0	1	1	1	1	1	+
Coughlin, 2013.	1	0	0	1	0	U	1	1	1	1	∅
D'Espaignet, 2003.	1	U	U	U	0	1	1	1	1	1	∅
Glor, 1987.	1	1	0	1	0	1	1	1	U	U	∅

Gray-Donald, 2000.	1	1	1	1	0	1	1	1	1	1	+
Hermann, 2001.	1	U	U	U	0	1	1	1	1	U	∅
Hoffhines, 2014.	1	U	U	U	U	1	1	U	1	1	∅
Karanja, 2010.	1	U	1	1	0	1	1	1	1	U	∅
Lawrence, 2004.	1	1	1	1	U	1	1	1	1	1	+
Long, 1995.	1	1	1	U	0	1	1	1	1	1	+
Mackerras, 2001.	1	1	U	U	0	U	1	1	1	1	∅
Martens, 2002.	1	1	1	NA	0	1	1	1	1	1	+
May, 1989.	1	U	U	U	0	1	1	1	1	1	∅
May, 2008.	1	1	1	1	0	1	1	1	1	1	+
McCalman, 2014	1	U	0	0	0	1	1	1	1	1	∅

Mehl-Madrone, 2000.	1	1	1	1	U	1	1	1	1	1	+
Muhajarine, 2012.	1	U	1	U	0	1	1	1	1	1	∅
Murphy, 2012.	1	U	U	0	0	0	1	U	1	1	∅
Panaretto, 2005.	1	1	1	U	0	1	1	1	1	1	+
Panaretto, 2007.	1	1	1	U	0	1	1	1	1	1	+
Smith, 2000.	1	1	U	U	0	1	1	1	1	1	∅
Walkup, 2009.	1	1	1	1	0	1	1	1	1	1	+
Wilhelm, 2012.	1	U	U	U	0	1	1	1	1	1	∅
Wright, 1997.	1	U	U	0	0	1	1	1	1	1	∅
Wright, 1998.	1	1	1	1	0	1	1	1	1	1	+

OECD Organisation for Economic Co-operation and Development, Criteria: 1) Was the research question clearly stated? 2) Was the selection of study subjects/patients free from bias? 3) Were study groups comparable? 4) Was the method of handling withdrawals described? 5) Was blinding used to prevent introduction of bias? 6) Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were intervening factors described? 7) Were outcomes clearly

defined and the measurements valid and reliable? 8) Was the statistical analysis appropriate for the study design and type of outcome indicators? 9) Were conclusions supported by results with biases and limitations taken into consideration? 10) Is bias due to study's funding or sponsorship unlikely? #1 = Yes; 0 = No; U = Unclear, N/A = Not Applicable.

MINUS/NEGATIVE (-) If most (six or more) of the answers to the above validity questions are "No", the report should be designated with a minus (-) symbol on the Evidence Worksheet.

NEUTRAL (Ø) If the answers to validity criteria questions 2, 3, 6, and 7 do not indicate that the study is exceptionally strong, the report should be designated with a neutral (Ø) symbol on the Evidence Worksheet.

PLUS/POSITIVE (+) If most of the answers to the above validity questions are "Yes" (including criteria 2, 3, 6, 7 and at least one additional "Yes"), the report should be designated with a plus symbol (+) on the Evidence Worksheet.