Disparities Exist between the Dietary Intake of Indigenous Australian Women during Pregnancy and the Australian Dietary Guidelines: the *Gomeroi gaaynggal* Study

Abstract:

Background: Little is known about the adequacy of nutrient intakes and the overall diet quality of Indigenous Australian pregnant women. The aim of this cross-sectional study was to assess nutrient sufficiency and diet quality, measured using the Australian Recommended Food Score (ARFS), in pregnant women from the Gomeroi gaaynggal cohort (n=58).

Methods: Maternal dietary intake during pregnancy was assessed using the Australian Eating Survey (AES) Food Frequency Questionnaire (FFQ), which was self-administered in the 3rd trimester. Diet quality was determined using the ARFS. Food group servings and nutrient intakes were compared to the Australian Guide to Health Eating (AGHE) and Australian Nutrient Reference Values (NRVs). The current analysis examined the adequacy of usual intakes from food sources only, excluding supplements.

Results: None of the women met all AGHE daily food group serving recommendations. The highest alignment rates were for dairy (33%), meat/alternatives (31%) and vegetables (29.3%). Almost 93% of participants exceeded the recommended intake of energy-dense, nutrient-poor foods and % energy from saturated fat was high (15%). Of the five key nutrients for optimal reproductive health (folate, iron, calcium, zinc and fibre), the nutrients with the highest percentage of pregnant women achieving the NRVs were zinc (77.6%) and folate (68.9%) while iron was the lowest. Only one person achieved all NRVs (folate, iron, calcium, zinc and fibre) important in pregnancy. The median ARFS was 28 points (max 73).

Conclusions: Although the small cohort limits the generalisability of the findings, it provides some support to indicate that the diets of these Indigenous pregnant women are inadequate. Therefore, strategies to optimise nutrient intakes of Indigenous pregnant women are needed urgently.

Keywords: Maternal nutrition, pregnancy diet, Indigenous, diet quality

Background

The 'Developmental Origins of Health and Disease' (DoHAD) hypothesis has led to recognition of optimal maternal nutrition during preconception and pregnancy as being of upmost importance for the mother and developing fetus [1,2]. Current evidence indicates that pregnancy nutrition influences pregnancy outcomes and also has long-term consequences for offspring health in both childhood and adulthood [3,4]. *In utero* metabolic insults from the maternal environment (e.g. poor nutrition, obesity or diabetes) have been implicated in increasing offspring susceptibility to chronic disease including cardiovascular disease (CVD), end-stage renal disease (ESRD), obesity and type 2 diabetes later in life [5]. Poor maternal nutrition during pregnancy has been associated with preterm birth, intrauterine growth restriction and low birth weight (<2,500 grams) [6,7]. Nutrient deficiencies, particularly iron and folate, have been linked to congenital anomalies and birth defects [8].

Evidence suggests that having dietary patterns that align with national dietary recommendations lowers the risk of adverse pregnancy outcomes, including unhealthy gestational weight gain [9], gestational diabetes mellitus (GDM) [10], iron-deficiency anaemia [11], preeclampsia [12,13], small-for-gestational-age (SGA) [14] and fetal death [12,15]. It is therefore concerning that poor adherence to dietary guidelines during pregnancy has been consistently reported in countries such as Australia [16-18], New Zealand [19], the UK [20,21], the USA [22], Canada [23,24] and China [25]. Blumfield *et al.* systematically reviewed macronutrient and micronutrient intakes during pregnancy in developed countries [26,27] and found that folate, iron, calcium and vitamin D intakes were consistently below the national nutrient recommendations in USA, Canada, UK, Europe, Australia, New Zealand, and Japan [26]. Additionally, Blumfield *et al.* found that macronutrient intakes of pregnant women from developed countries were not in accordance with country-specific recommendations [27]. Carbohydrate, polyunsaturated fatty acids (PUFA) and fibre intakes were lower than recommended while total fat and saturated fat intakes exceeded recommendations [27].

In Australia, there are two cohort studies investigating the dietary pattern of pregnant women. In 1996, the Australian Longitudinal study on Women's Health (ALSWH) recruited 40,000 women in three age cohorts of 'young' (18-23 years), 'mid-aged' (45-50 years) and 'older' (70-75 years) women [28]. This is the first cohort study to obtain comprehensive dietary intake data in a nationally representative sample of Australian women, across the various age ranges [28]. In an analysis of the dietary intake of 7486 women, Hure *et al*. found that dietary fibre, folate and vitamin E intake were consistently below Nutrient Reference Values (NRVs) in this cohort, which included pregnant women (n=606) [28]. Similar results were found in 179 pregnant women from the Women and Their Children's Health (WATCH) Study, a prospective longitudinal cohort based in Newcastle, Australia

[29]. To the best of our knowledge, no Australian Indigenous cohort studies have investigated nutritional adequacy of maternal dietary intakes during pregnancy.

Diet quality refers to the concept of nutritional adequacy due to food variety within core, nutrient-dense food groups [30]. Diet quality scores assess how closely eating patterns align with national dietary guidelines and summarise intake into a single numeric variable [30]. Higher scores are assigned to each sub-scale if there are frequent, diverse or optimal intakes of food, nutrients or both [30]. Diet quality scores have been used to assess diet adequacy in pregnant women [23,31]. The Australian Recommended Food Score (ARFS) has been used to evaluate overall diet quality and demonstrates comparative validity in Australian women [28] and adults [30]. The ARFS has been used to previously measure overall diet quality within the ALSWH cohort of young Australian women aged 25 to 30 years, including pregnant women (n=606) [28]. However, Indigenous Australian women were not included in these analyses [28].

The Indigenous peoples of Australia are one of the most socially disadvantaged populations in the country. They continue to experience poorer health and have a lower life expectancy than non-Indigenous people due to generations of social and economic disadvantage and food insecurity [32]. Indigenous communities face many structural barriers to healthy eating, including limited access to fresh, nutritious food due to geographical and economic constraints, and poor knowledge in regard to purchasing and cooking nutritious meals [33]. Findings from a recent systematic review [34] of the available data on the dietary intake of the Aboriginal and Torres Strait Islander (Indigenous) peoples in Australia are consistent with the recent 2012-2013 National Aboriginal and Torres Strait Islander Health Survey (NATSIHS) [33], which identified that this population group in general consume low intakes of the five core food groups and high intakes of total sugars and energy-dense, nutrient poor food and beverages.

There are several programs around Australia which aim to promote improvement in the health of Indigenous women and their babies. Two such examples in the Northern Territory are the Aboriginal Birth Cohort Study (ABC) and the Strong Women, Strong Babies. Strong Culture Program. However, to date, to the best of our knowledge, no previously published studies have examined the dietary intake of Indigenous Australian women during pregnancy and have reported on their adherence to the current Australian dietary guidelines. Furthermore, no studies have reported on the diet quality of pregnant Aboriginal and Torres Strait Islander (Indigenous) Australian women. This is pertinent given the association between poor diet quality and the increase odds of developing gestational hypertension [35], gestational diabetes [36], delivering a child of low birth weight [35] or preterm birth

[37]. Maternal poor nutrition during pregnancy is recognised as a significant modifiable determinant in the development of chronic disease in offspring in later life [38]. Therefore, research in this area is an important priority in addressing the health and well-being of future generations of Indigenous Australians. Therefore, the objectives of the current study were: (i) to investigate whether the usual dietary intakes of pregnant Indigenous Australian women from the *Gomeroi gaaynggal* cohort align with national food group recommendations; (ii) to describe the nutritional adequacy of dietary intake of nutrients important for pregnancy; (iii) to describe overall diet quality.

Methods

Study Design

The Gomeroi gaaynggal study is a prospective longitudinal cohort of Indigenous Australian mother-child dyads followed from pregnancy, through the postnatal period and up until the children are five years of age. Further details of the Gomeroi gaaynggal study have been published elsewhere [39]. Recruitment began in 2010 and is still ongoing at the time of publication. Pregnant Indigenous women are recruited by Indigenous research assistants at the antenatal services who explain the study and obtain written consent. 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. This research study occurs in conjunction with the Gomeroi gaaynggal ArtsHealth program, which aims to engage Indigenous mothers in health promotion activities conducted by health professionals, including dietitians, in a culturally appropriate environment. Ethical approval for the study was obtained from the following committees: Hunter New England Human Research Ethics Committee (HNEHREC No. 08/05/21/4.01); the New South Wales Human Research Ethics Committee (NSW HREC HREC/08/HNE/129); and the Aboriginal Health and Medical Research Council Human Research Ethics Committee (AHMRC HREC 654/08).

Maternal Characteristics

Information on pre-pregnancy weight and height, smoking, maternal education, and employment were collected via questionnaires during the first visit. Maternal education was categorized as high (tertiary education) or low (high school/high-school certificate or less than high school). Maternal body mass index (BMI) was calculated from measured height (ht) and self-reported pre-pregnancy weight (wt) at first visit during pregnancy [wt(kg)/ht(m^2)]. BMI was categorized as underweight (BMI <18.5 kg/m^2), normal weight (BMI 18.5-24.9 kg/m^2), overweight (BMI 25.0-29.9 kg/m^2) or obese (BMI ≥30.0 kg/m^2) [40]. Height was measured to the nearest 0.1 cm and weight to the nearest 0.1 kg. For participants who could not recall their pre-pregnancy weight, their pre-pregnancy BMI was calculated using weight measured at less than 12 weeks gestation.

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140 ***Nutrition Assessment: Australian Eating Survey Food Frequency Questionnaire (AES FFQ)***

141 During the third trimester, maternal dietary intake was assessed using the Australian Eating Survey
142 Food Frequency Questionnaire (AES FFQ) [41]. The AES FFQ is a self-administered 120-item semi-
143 quantitative FFQ that asks respondents to report usual dietary intake over the previous 6 months [41].
144 This survey includes 15 supplementary questions on age, use of vitamin supplements, food
145 behaviours and sedentary behaviours. The response for each question is a frequency with options
146 ranging from "never" to "≥7 times per day". Standard portion sizes were determined for each food
147 item using data derived from the most current National Nutrition Survey [42]. An example of a
148 'natural' serving size for standard items would be a slice of bread. It contains a comprehensive food
149 list to enable estimation and ranking of usual macronutrient and micronutrient intakes [41]. Nutrient
150 intakes from the FFQ were computed from the AUSNUT 2011–13 database (all foods). This survey
151 has been shown to provide a valid and reliable estimate of usual dietary intake of Australian adults
152 (median age: males 44.9 years, females 41.3 years) over the previous six months [41]. Further details
153 of the AES FFQ have been published elsewhere [41].

154

155 ***Australian Recommended Food Score (ARFS)***

156 Diet quality scores were calculated using the Australian Recommended Food Score (ARFS) [30],
157 which utilises a sub-set of 70 AES FFQ questions where regular consumption of the item aligns with
158 recommendations in the 2013 Australian Dietary Guidelines and is described in detail elsewhere [30].
159 The ARFS has a total possible score between the range of zero and 73. This includes eight food group
160 subscales: vegetables (0–21), fruit (0–12), meat (0–7), meat alternatives (0–6), grain (0–13), dairy
161 (0–11), water (0–1) and condiments (0–2). Briefly, points are awarded for food consumed according
162 to frequency of consumption, with healthy foods receiving bonus points (e.g. 2 points for ≥5 nights
163 per week meals with vegetables, 2 points if usual bread choice is multigrain or wholemeal, 2 points
164 if usual type of milk is reduced fat milk or skim milk or soy milk). A maximum number of points are
165 awarded to food group subscales, which include foods with high saturated fat content. The meat
166 protein group is limited to a maximum of seven points, and the dairy group is limited to a maximum
167 of 11 points. Discretionary foods do not contribute to the calculation of the diet quality score. The
168 ARFS score was calculated by adding the points for each item. A higher score indicates greater
169 alignment with the Australian National Dietary Guidelines [43].

170

171 ***Australian Guide to Healthy Eating***

Australia's national food selection guide, the Australian Guide to Healthy Eating (AGHE) [44], was updated in 2013 and gives a suggested number of daily serves of key food groups to aim for age and sex based nutrient intake recommendations. It visually represents the proportion of the five core food groups recommended for daily consumption to optimise nutrient intakes, in proportions that are consistent with the Dietary Guidelines for Australians [43]. The core food groups include breads/cereals (grains), lean meat and vegetarian alternatives (including eggs, nuts and legumes), vegetables (including legumes), fruit and dairy [44]. Non-core or discretionary foods are energy-dense, nutrient-poor or 'junk' foods that are not a necessary part of a healthy diet and are recommended to be consumed in limited amounts and less frequently than core foods [44]. Recommended servings for each food group have been developed for different population subgroups, including pregnant women, based on meeting nutrient targets [45]. Table 1 highlights the AGHE recommended daily servings for pregnant women.

Nutrient Reference Values

The 2006 National Health and Medical Research Council of Australia Nutrient Reference Values (NRVs) recommend specific daily nutrient intake targets to optimise health and/or avoid nutritional deficiency for different life stages, including pregnancy [46]. The estimated average requirement (EAR) and adequate intake (AI) are the most appropriate NRVs for comparison with population group intakes and the focus of this paper [46]. The EAR is the daily nutrient level estimated to meet the requirements of half the healthy individuals in a particular life stage and gender group. When an EAR is unable to be determined, an AI is used instead, which represents the average daily nutrient intake level that is assumed to be adequate, based on observed or experimentally determined nutrient intake estimates by a group of apparently healthy people [46]. Recommendations for the extra energy required during the second and third trimesters of pregnancy have been developed, with an additional 1.4MJ/day and 1.9MJ/day suggested, respectively [46]. Subjects were excluded from these analyses if their calculated energy intake was <4.5 or >20.0 MJ/day [47]. Energy values outside this range were considered biologically improbable and indicative of a large degree of misreporting [47]. Niacin intakes and requirements are expressed as niacin equivalents where 1 mg niacin equivalent is equal to 1mg niacin or 60 mg tryptophan [46]. As the bioavailability of folate in food and that of the folic acid used to fortify foods or as a supplements differs, 50-60% and 85% respectively, the term dietary folate equivalents has been used to accommodate the varying bioavailabilities [46]. Retinol equivalents comprise of retinol + (Beta-carotene/6) + (alpha-carotene/12) + (cryptoxanthin/12) [46].

Statistical Analysis

The main outcome measures included food group intake in grams (g), daily servings and proportion meeting AGHE recommendations. Emphasis was placed on the intake and the proportion of participants meeting the EAR for folate, iron, calcium, zinc and AI for fibre due to their role in enhancing reproductive health and well-being of the mother and her growing fetus. Daily food group servings were calculated using the AGHE portion sizes described in the AGHE. The total number of daily food group servings were then compared with the minimum number of AGHE servings recommended for pregnant women aged 19 to 50 years. Data were tested for normality, with normally distributed data reported as mean (95% CI) and non-normal data reported as median [IQR]. All data manipulation and statistical analyses were performed using Intercooled Stata 14 (Stata, College Station, Texas, USA).

Results

Table 2 summarises the baseline characteristics of women included in the analysis. Of the 67 women, multiple births (n=1) and implausible total daily energy intakes (n=8) were excluded for a final analytic sample size of 58. The mean gestation at the time of the survey was 35.6 ± 2.1 weeks (mean ± SD). The mean age of pregnant women was 25.6 ± 6.7 years (mean ± SD), and 10.3% (n=6/58) of participants were ≤18 years of age. The majority of the women had a high school education or less (77.4%). Almost two-thirds (60.8%) reported being overweight/obese before pregnancy (mean ± SD: 33.25 ± 6.39 kg/m^2). Smoking during pregnancy was reported by 24.1% of study participants, below the national smoking rate of 39% for Aboriginal and Torres Strait Islander (Indigenous) mothers [48].

Table 1 lists the portion sizes for each FFQ category used to calculate each food group serving size. Table 3 summarises mean daily food group intakes in grams, the daily food group servings and the percentage of women achieving the recommended number of AGHE daily food group servings. This highlights that none of the women achieved the AGHE recommendation for all food groups. Highest alignment rates [proportion, median (IQR) servings/day] were for dairy [32.8%, 1.5(1.0-2.9)], meat/alternatives [31%, 2.7(1.8-3.6)] and vegetable [29.3%, 3.4(2.1-5.1)] groups. The recommended number of daily servings of bread/cereals and fruits were achieved by only 3.5% (n=2/58) and 27.6% (n=16/58) of the cohort respectively. The median [IQR] number of daily servings of energy-dense, nutrient-poor foods was 6.1 [4.1-8.3] servings/day, compared to the recommended maximum of 2.5 servings/day. Overall, 34.5% (n=20/58) met one, 31.0% (n=18/58) met two, 6.9% (n=4/58) met three and 3.5% (n=2/58) met four daily food group serving recommendations.

Table 4 summarises the participants' dietary intakes of selected nutrients, including energy, macronutrients, selected micronutrients and comparisons with NRVs. Intakes of nutrients were above

241 the estimated pregnancy EAR or AI for protein, calcium, zinc, thiamin, riboflavin, niacin, vitamin C,
242 potassium, magnesium, phosphorus. Of the five nutrients considered most important for optimal
243 reproductive health (folate, iron, calcium, zinc and fibre), the nutrients with the highest number of
244 women meeting the recommendations were zinc (77.6%; n=45/58) and folate (68.9%; n=40/58).
245 Almost half of the women achieved the calcium recommendation, followed by fibre, while iron had
246 the lowest adherence rate as only one woman had a usual intake above the EAR. Only one
247 participant's intake met all pregnancy NRVs (folate, iron, calcium, zinc, fibre). The median vitamin
248 A (retinol equivalents) intake was twice the EAR although no participant had an intake above the
249 upper limit of 3000 µg/day. The median sodium intake was twice the upper end level of estimated
250 AI. The median percentage of energy from saturated fat was 15%, higher than the recommended
251 maximum of 10% [46].
252
253 Total ARFS and sub-scale diet quality scores are summarised in Table 5. The vegetable subscale was
254 the most highly scored group relative to the total number of points available in each component.
255 Within the protein food subscale, the vegetarian foods subscale (including nut/bean/soya/egg) scored
256 the lowest, with a median of one point scored out of the maximum six points. Meat and grain
257 subscales were also low relative to the other food groups.
258
259 **Discussion**
260 There is a growing body of evidence indicating that maternal dietary intake during pregnancy is a
261 powerful determinant of offspring health and lifetime susceptibility to chronic disease such as
262 diabetes, obesity and cancer [3,4]. Furthermore, poor food patterns and diet quality during pregnancy
263 can exacerbate adverse maternal health outcomes by contributing to excessive gestational weight gain
264 [49] and post-partum weight retention [50]. Identifying the aspects of maternal diet and nutrient intakes
265 during pregnancy that differ to national recommendations may assist with development of targeted
266 nutrition interventions and inform public health policies seeking to optimise maternal nutrition. While
267 Ashman *et al.* have previously investigated the dietary intakes of Indigenous Australian women and
268 their infants [51], the current study evaluates the dietary pattern of Indigenous Australian women
269 during pregnancy from the Gomeroi gaaynggal cohort, relative to national recommendations. Overall,
270 the current analysis has identified that pregnant Indigenous women do not meet the target AGHE
271 daily food group servings recommended for pregnancy, nor key micronutrient intake targets
272 important for perinatal and long-term child health. Key findings indicate suboptimal diet quality, high
273 intakes of saturated fat and sodium, and sub-optimal intakes of iron, folate, fibre and core food groups.
274 These findings suggest that targeted interventions and support are needed to assist pregnant women
275 in optimising dietary intakes.

In the Gomeroi gaaynggal cohort, no pregnant women achieved the recommended number of daily servings for all five food groups. This is consistent with the findings from another nationally representative study [16] that compared the diets of Australian pregnant women (n=857) to the current national dietary guidelines, and with previously published data from ALSWH cohort (n=606) by Blumfield *et al.* [17] that was conducted prior to the publication of the revised national dietary guidelines in 2013. Parallel results were reported in a cohort of pregnant women in NZ [19] and Canada [52] where only 3-4% met the recommendations for all food groups. A cohort study of Irish pregnant women (n=1124) found 76% achieved the food group intake recommendations for fruits and vegetables, but less than half met the recommendations for the remaining major food groups [53]. Optimising dietary patterns internationally should be a major priority to assist women in improving nutrition in pregnancy.

A number of studies conducted in Australia [17,18,54,55], USA [56] and UK [57] have reported high intakes of sodium and saturated fat and inadequate intakes of fibre in pregnant women. This is attributed to the excessive intakes of energy-dense, nutrient-poor foods and inadequate fruit and vegetable intakes. Findings from the current cohort of pregnant Indigenous women indicate that their percentage energy from saturated fat and sodium intake exceed recommendations. Intakes of energy-dense, nutrient-poor foods were high, with the majority (93.1%; n=54/58) exceeding the target of 2.5 servings/day. Furthermore, few pregnant women met the recommended daily fruit and vegetable intake. Fruit and vegetables play an important role in the provision of nutrients for pregnancy, particularly folate and fibre, but also in reducing chronic disease risk [58]. This has important implications for long-term risk of heart disease and diabetes in this population.

From the current study, there are discrepancies between nutrient intakes reported by pregnant Indigenous Australian women in the Gomeroi gaaynggal cohort and those recommended in the national guidelines, especially for iron, calcium and folate. Only one woman in this cohort achieved the NRVs for all key nutrients (folate, iron, calcium, zinc, fibre), similar to results found in the ALSWH cohort [17]. Similar results, based on dietary intake alone, were found in a sample of pregnant Africa-American women (n=93) where 89% and 66% of subjects had usual intakes below the EAR for iron and folate respectively [59]. Siega Riz *et al.*, in a sample of pregnant black (n=971) and white (n=1,131) women, found that 70% of women had inadequate dietary intakes of iron and 40% had inadequate dietary intakes of folate [60]. Intakes of these key nutrients have also been reported as suboptimal in pregnant women in cohorts from the United Kingdom [21,61] and USA [23,62]. Evidence

suggests the importance of specific micronutrients, especially folate and iron, during pregnancy in achieving for fetal growth and *in utero* programming of long-term health [63].

Adequate intakes of folic acid during pregnancy lowers the risk of neural tube defects (NTD) in the offspring, while adequate iron intake prevent maternal iron-deficiency anaemia [63]. With the introduction of mandatory folate fortification in wheat flour in Australia in September 2009, improved folate status in Aboriginal people aged 16-44 years and reduced NTD in Aboriginal infants in Western Australia have been observed [64]. Nationally, the rate of NTDs decreased by 74% for Aboriginal and Torres Strait Islander (Indigenous) women [65]. However, even with fortification in place, only 69% of pregnant Indigenous women in the current study met the recommended folate intake. Iron deficiency is the most prevalent micronutrient deficiency among children and women of childbearing age, compounded by the increased requirements for growth and reproduction [66]. This suggests that further emphasis on the health promotion messages about the importance of obtaining adequate folate and iron during pregnancy are warranted in this community, through food and/or supplementation.

The diet quality and variety of this cohort of pregnant Indigenous women appears to be suboptimal, as evident from the discrepancies between the recommended and reported nutrient intakes, especially for folate, iron and fibre. Hure *et al.* [28] and Gresham *et al.* [35] found similar results in a large sample of pregnant Australian women participating in the ALSWH. A few studies have examined the association between diet quality during pregnancy and pregnancy and birth outcomes [35,67-70]. Both Rodriguez-Bernal *et al.* [70] and Gresham *et al.* [35] observed a significant increase in newborn birth weight among women with better diet quality during the first trimester compared with infants born to women with lowest diet quality scores. Women with the highest ARFS had the lowest risk of developing gestational hypertension [35]. This is cause for concern for the current cohort of pregnant Indigenous women in this study and suggests that improving diet quality is key to preventing adverse pregnancy and birth outcomes.

Strengths and limitations

Strengths of the current study include the methods used to assess micronutrient adequacy using EARs as opposed to the Recommended Dietary Intake (RDI) which overestimates inadequacy. FFQs are reliable, valid and useful instruments to obtain and assess usual dietary intake over time (e.g. months), including during pregnancy [71] and have less participant burden than methods such as a few days of weighed records [72]. Self-reported dietary data, including those from FFQs, have been utilised in the development of dietary guidelines and public health policies [71]. However, several points should be

considered when interpreting the results of the current study. Notably, the sample size was relatively small, and the population only comprised of women from one rural town in New South Wales, so the conclusions may not be generalisable to all Indigenous pregnant women. However, the sample was fairly similar to the wider population of Indigenous mothers with respect to mean maternal age and education attainment. As reported previously, measurement error is inevitable when collecting self-reported dietary data [73]. Women were asked to report their dietary intakes over the previous 6 months but may over-represent recently consumed foods [74]. Limitations in participant recall may lead to under- or overestimation of food intakes, however this analysis addressed this by excluding those with implausible total energy intakes. In the current study, we assessed diet at 35.6 ± 2.1 (mean ± SD) weeks of gestation, with previous research indicating that there is little change in usual dietary patterns throughout pregnancy [75-78]. Another limitation was that six Indigenous women were ≤18 years of age, however, comparisons were made with NRVs recommendations for 19-50 years age range, of which calcium, phosphorus and iron were lower. This suggests the current analysis is the best-case scenario for this cohort of young Indigenous pregnant women.

It is important to note that the current study examined the adequacy of usual intakes from dietary sources only, not including supplements. Even though almost 52% of pregnant women had been taking vitamin supplements over the past 6 months, we were unable to determine the specific nutrient profile of the supplements consumed and hence unable to assess their contribution to micronutrient intakes. The aim of the current paper was to focus on nutrients obtained from food only and the current analysis provides a useful benchmark for the sub-optimal nutritional adequacy and dietary intakes of pregnant Indigenous Australian women in this cohort. This data will enhance our knowledge of where to target nutrition interventions in consultation with the community in order to address the current gaps.

Implications for practice and research

The findings from the current study suggest a need for greater support to optimise dietary intakes with an emphasis on promoting optimal maternal nutrition during pregnancy among Indigenous Australian women. Results from a recent systematic review indicated that over 20 nutrition intervention programs internationally have sought to improve nutrition-related outcomes for pregnant Indigenous women, of which only five were set in Australia (Northern Territory, New South Wales, Queensland, and Western Australia) [79]. However, many of them had broad nutrition promotion messages rather than targeting key food and nutrient components. Hence, there is a need for more culturally relevant dietary interventions which focus on optimising diet quality in pregnant Indigenous Australian women. Successful prenatal nutrition interventions with positive nutrition-

related outcomes need to be tailored to the specific sociodemographic determinants of prenatal dietary patterns and are urgently needed [79]. The inclusion of community and Indigenous workers and collaboration with dietitians are essential components for success. Additionally, adapting a strengths-based approach to nutrition research and intervention has proven to be successful in international nutrition projects conducted in Indigenous communities [80,81].

Conclusion

The current study indicates that the dietary intakes of pregnant Indigenous Australian women from the Gomeroi gaaynggal cohort do not meet current national recommendations for pregnancy. In view of these findings, there is an urgent need to develop and implement culturally relevant programmes and public health policies aimed at improving the nutritional status of pregnant Indigenous women. More support is needed to raise awareness of the dietary guidelines and to assist pregnant Indigenous women in optimising dietary patterns and nutrient intakes. In order to have successful outcomes, these programs and policies should adopt a strengths-based approach when implementing in Indigenous Australian communities, partnering and drawing on the strengths of Indigenous families and communities.

Transparency declaration

A leader author affirms that this manuscript is an honest, accurate and transparent account of the study being reported, that no important aspects of the study have been omitted. The reporting of this work is compliant with STROBE guidelines.

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Table 1. The Australian Guide to Healthy Eating daily food group recommendations for pregnant women[1]

	Energy (kJ)	Breads & Cereals	Fruit	Vegetables	Dairy	Meat & Alternatives	Extras
Standard serving size[2]	n/a	1 slice bread ½ medium roll or flat bread ½ cup cooked rice, pasta, noodles, barley ½ cup cooked porridge 2/3 cup wheat cereal flakes ¼ cup muesli	1 medium apple 2 small pieces of fresh fruit (apricots, kiwi fruit, plums) ½ cup fruit juice 1 cup canned fruit	½ cup cooked vegetables 1 cup of salad vegetables ½ cup cooked legumes ½ medium potato or other starchy vegetables 1 medium tomato	1 cup (250ml) of milk 2 slices (40g) of cheese ¾ cup (200g) of yoghurt	65g cooked lean meats such as beef, lamb, pork 80g cooked lean poultry 100g cooked fish fillet 2 large eggs 1 cup cooked legumes/ beans 30g nuts, seeds, peanut	1/2 small bar (25 g) chocolate 2 scoops (75g) regular ice cream 30g salty crackers (a small individual serve packet) 2-3 sweet biscuits 1 slice (40 g) plain cake or small cake-type muffin 1 can (375 mL) soft drink
18 Years or under	8100-10900	8	2	5	3.5	3.5	0-2.5
19-50 years	8100-10900	8.5	2	5	2.5	3.5	0-2.5

[1]Food group data is reported as the recommended range for number of serves per day defined by the Australian Guide to Healthy Eating food group recommendations for pregnant women.

[2] Serve size

(a) Breads & Cereals: bread 40 g, cereal 30 g, cooked porridge 120 g, muesli 30 g, cooked rice/pasta/noodles (including lasagne) 75-120 g, dry biscuits 40 g

(b) Fruit: fruit whole (including canned fruit) 150 g, fruit juice 125 ml

(c) Vegetables: vegetable whole (including potatoes cooked without fat) 75 g

(d) Dairy: milk 250 ml, cheese 40 g, yoghurt 200 g, flavoured milk 250 ml

(e) Meat & Alternatives: beef/veal/chicken/lamb/pork 65 g, fish (steamed/grilled/baked/canned) 100 g, ham 100 g, baked beans/tofu/soy beans/soy bean curd/other beans (including chickpeas, lentils etc) 150g, nuts 30 g, eggs 120 g

(f) Extras: sweet biscuit 35 g, cakes/sweet pies/tarts/other sweet pastries 40 g, meat pies/pasties/quiche/other savoury pies 60 g, pizza 60 g, hamburger 60 g, chocolate 25 g, peanut butter 25 g, potato crisps/corn chips/Twisties® 30 g, jam/marmalade/honey/syrups 45 g, Vegemite®/Marmite®/Promite® 100 g, ice-cream 50 g, bacon 50 g, corned beef/luncheon meats/salami 110 g, sausages/frankfurters 55 g, fried fish 65 g, fat spread 20 g, sugar 40 g, fries 60 g, light beer 600 ml, heavy beer 400 ml, wine (including sparkling wines) 200 ml, spirits/liqueurs 60 ml, fortified wines/port/sherry 60 ml.

Table 2. Sociodemographic characteristics of Indigenous pregnant women in the *Gomeroi gaaynggal* cohort (n=58)

Variables	Mean ± SD or n (%)
Age, y, mean	25.6 ± 6.7
Pre-pregnancy BMI status (n=51)	
Underweight (<18.5 kg/m^2)	4 (7.8)
Normal weight (18.5-24.99 kg/m^2)	16 (31.4)
Overweight (25-29.99 kg/m^2)	12 (23.5)
Obese (≥ 30 kg/m^2)	19 (37.3)
Education Level (n=53)	
High school or lower	41 (77.4)
Beyond high school	12 (22.64)
Smoking status during pregnancy (n=58)	
Current smoker	14 (24.1)
Non-smoker	44 (75.9)
Employment status (n=52)	
Employed	15 (28.8)
Not employed	37 (71.2)

SD: Standard deviation **BMI:** Body Mass Index

Table 3. Median daily food group consumption and percentage of pregnant Indigenous women in the *Gomeroi gaaynggal* cohort (n=58) achieving daily food group recommendations for pregnant women

Food Group Intakes	**Median**	**IQR**
Breads/cereals (g/d)	117.7	82.8-177.0
Fruit (g/d)	199.4	76.6-313.9
Vegetables (g/d)	253.5	159.4-384.3
Dairy (g/d)	268.2	194.3-572.1
Meat/alternatives (g/d)	182.9	128.3-264.8
Extras (g/d)	1063.7	741.8-1544.5
Food Group Servings	**Median**	**IQR**
Breads/cereals (servings/d)	2.3	1.3-3.1
Fruit (servings/d)	1.4	0.5-2.2
Vegetables (servings/d)	3.4	2.1-5.1
Dairy (servings/d)	1.5	1.0-2.9
Meat/alternatives (servings/d)	2.7	1.8-3.6
Extras (servings/d)	6.1	4.1-8.3
Meeting Recommendations [1]	**n**	**%**
Breads/cereals	2	3.5
Fruit	16	27.6
Vegetables	17	29.3
Dairy	19	32.8
Meat/alternatives	18	31.0
Extras	4	6.9
Other	**Median**	**IQR**
Core foods [2] (kJ)	5434	4512-7004
Core foods (% Energy) [2,3]	59	51-66
Non-core foods [4] (kJ)	3694.5	2527-5040
Non-core foods (% Energy) [3,4]	41	34-49

IQR: Interquartile range. [1] Defined by the Australian Guide to Healthy Eating food group recommendations for pregnant women. [2] Core food includes breads and cereals, fruit, vegetables, dairy and alternatives, meat and alternatives. [3] Calculated as a percentage of total daily energy intake. [4] Non-core foods include soft drinks, sweets and energy-dense nutrient-poor foods.

Table 4. Daily dietary intakes of selected nutrients in pregnant Indigenous women from the *Gomeroi gaaynggal* cohort (n=58)

Meeting	EAR	Median	IQR	Meeting EAR or AI n (%)
Energy (kJ/day)				
With dietary fibre	-	8705	7196-11385	-
Without dietary fibre	-	8522	7016-11193	-
Protein (g)	47(≤18 y) 49	93.6	73.0-123.6	56 (96.6)
Fibre (g)	25* (≤18 y) 28*	24.5	18.2-30.1	22 (37.9)
Thiamin (mg)	1.2	1.7	1.3-2.1	45 (77.6)
Riboflavin (mg)	1.2	2.3	1.8-3.0	57 (98.3)
Niacin equivalents [1] (mg)	14	40.0	32.5-51.6	58 (100)
Vitamin C (mg)	38 (≤18 y) 40	200.8	132.3-290.2	57 (98.3)
Dietary folate equivalents [2] (µg)	520	593.8	498.2-744.8	40 (68.9)
Retinol equivalents [3] (µg)	530 (≤18 y) 550	1038.1	693.3-1418.2	49 (84.5)
Potassium (mg)	2800 *	3571.6	2802.5-4367.9	44 (75.9)
Magnesium (mg)	290 [+]	373.9	311.9-421.1	46 (79.3)
Calcium (mg)	1050 (≤18 y) 840	866.7	628.7-1141.1	31 (53.5)
Phosphorus (mg)	1055 (≤18 y) 580	1480.9	1185.9-1883.9	57 (98.3)
Iron (mg)	23 (≤18 y) 22	10.8	8.2-13.0	1 (1.72)
Zinc (mg)	8.5 (≤18 y) 9.0	12.3	9.2-15.6	45 (77.6)
Exceeding	**Upper Limit**	**Median**	**IQR**	**Exceeding Upper Limit n (%)**
Sodium (mg)	460-920*	1995.9	1567.2-2458.5	57 (98.3)[4]
%E Saturated fat	10%[5]	15	13-17	56 (96.6)

EAR: Estimated Average Requirement. **AI:** Adequate Intake**. IQR:** Interquartile range. Star (*) denotes adequate intake. [+]Magnesium recommendations are for pregnant women aged 19-30 years. The recommendation for pregnant women aged 31-50 years is EAR: 300mg/day.

[1] Niacin intakes and requirements are expressed as niacin equivalents: 1 mg niacin equivalent = 1mg niacin/60 mg tryptophan. Niacin + Niacin derived from tryptophan.
[2] 1 µg dietary folate equivalent = 1 µg food folate = 0.5 µg folic acid on an empty stomach = 0.6 µg folic acid with meals or as fortified foods.
[3] Retinol + (Beta-carotene/6) + (alpha-carotene/12) + (cryptoxanthin/12).
[4] Comparison made relative to the upper end level of sodium AI.
[5] For chronic disease risk reduction for general population.

Table 5. Australian Recommended Food Score (ARFS) for diet quality of pregnant Indigenous women in the *Gomeroi gaaynggal* cohort (n=58)

ARFS (max possible score)	Median	IQR
Total (73)	28	21-36
Vegetables (21)	12	7-16
Fruit (12)	4	3-6
Meat (7)	2	1-3
Meat alt. (6)	1	0-2
Grains (13)	4	2-4
Dairy (11)	4	3-5
Water (1)	1	0-1
Condiments (2) [1]	1	1-2

[1] Condiments include vegemite and tomato sauce for their nutritional properties.