TITLE: The influence of dietary intake and decision-making during pregnancy on birth outcomes.

Running title: Diet, decisions and birth outcomes

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Ethics

This research was approved by the Gold Coast Hospital and Health Service Human Ethics (HREC 16/QGC/70) and Griffith University Human Ethics Committees (HREC 2016/423).

ABSTRACT

Aim

This study aimed to examine dietary intake and decision-making in a cohort of pregnant South-East Queensland women to determine compliance with dietary guidelines and the relationships between dietary intake, decision making and birth outcomes.

Methods

Pregnant women attending maternity services at participating hospitals reported food-frequency and motivations using the Maternal Outcomes and Nutrition Tool, a novel digital instrument. Birth outcomes were sourced from hospital records. A cross-sectional cohort design was used to examine the data.

Results

Analysis demonstrated suboptimal intake of core food groups; meat and alternatives (2.6 [2.0-3.4] serves/day) and grains (3.1 [2.1-4.1]) fell below recommendations; fruit (3.8 [2.5-5.3]) and discretionary foods (3.1 [2.1-4.4]) exceeded them. Hypertensive disorders demonstrated a negative linear relationship with vegetable intake ($p=0.017$). Cultural diversity was significantly associated with decreased birthweight ($p=0.022$) but increased intake of meat and alternatives (3.1 versus 2.6, $p<0.001$) compared to Caucasian women; median intake of meat and alternatives was lower in women who reported smoking in the examined time frame. Smokers were less likely to declare health motives for food selection than non-smokers; smoking and health were inversely associated with increasing maternal age. Food choice was primarily sensory-

driven.

Conclusions

This cohort demonstrated poor adherence to dietary guidelines. Culturally and linguistically diverse women and smokers exhibit dietary behaviours which may contribute to suboptimal birth outcomes; targeted nutrition counselling may improve outcomes in these women. These findings highlight the need for transdisciplinary maternity care, and provide a foundation for further research aimed at optimising nutrition-related birth outcomes in at-risk groups.

Key words

Pregnancy, cultural diversity, nutritional status, diet, decision-making, birth outcomes.

INTRODUCTION

Suboptimal maternal diet is associated with poor perinatal outcomes¹, outcomes common to populations from low and middle-income countries². However, a growing body of evidence highlights the associations between poor diet and suboptimal birth outcomes in high-income countries, including increased rates of caesarean section and macrosomia³. In Australia, states of over and undernutrition can influence perinatal outcomes, particularly in groups identified as exhibiting nutritional risk factors, including women who smoke⁴, are from cultural and linguistically diverse (CALD)⁵ or low socio-economic backgrounds (SES)⁶.

The Australian Dietary Guidelines for pregnant women indicate optimal dietary intake across five core food groups (meat and alternatives, vegetables and legumes,

fruit, dairy and alternatives and grains), and discretionary foods (including those high in fat and sugar - energy-dense nutrient-poor (EDNP) foods)⁷. Compliance with these guidelines during pregnancy is traditionally poor⁸, with a maternal knowledge gap regarding dietary recommendations highlighted as a significant contributing factor⁸.

Several factors influence awareness of nutrition requirements during pregnancy. A variety of health disciplines contribute to primary maternity care, including general practitioners, midwives and obstetricians, each of which has limited access to specialised nutrition education.⁹ Additionally, dietetic referrals during pregnancy are currently restricted to women with modifiable risk factors identified in Australia's clinical practice guidelines for pregnancy care,¹⁰ such as gestational diabetes and obesity. These factors have resulted in inconsistent nutritional advice¹¹ in the context of uncomplicated pregnancy³.

Adding to these challenges is a paucity of knowledge surrounding maternal food selection motivations. These dietary behaviours are currently under-studied, yet their understanding is vital for the development of public health strategies targeting improved perinatal outcomes¹². Therefore, addressing this research deficit is an essential step toward understanding how dietary motivations may influence the health of an infant at birth¹³.

This research aimed to collect and examine self-reported dietary intake and decision-making information from a cohort of pregnant South-East Queensland (SEQ) women in order to determine their adherence to dietary intake recommendations and the factors driving their dietary decision making. Further, the study explored interactions between dietary intake, motivations, socio-cultural determinants of health, and birth outcomes in this cohort.

METHODS

This cross-sectional cohort study was approved by the Gold Coast Hospital and Health Service Human Ethics (HREC 16/QGC/70) and Griffith University Human Ethics Committees (HREC 2016/423). Pregnant women aged 16-44 residing in South-East Queensland and attending antenatal clinics at the Logan, Beaudesert, Redlands, Gold Coast University (GCUH) and Royal Brisbane and Women's Hospitals (RBWH) between 23rd May 2016 and 30th September 2018 were the target population for this research. Women were provided with study information at routine visits by way of promotional material distributed and displayed by the clinics. All women attending hospital pathology centres at GCUH and RBWH for the Oral Glucose Tolerance Test at 26-28 weeks gestation on recruiting days were offered participation by the researcher. Women were not provided any dietary education prior to participation; information regarding daily intake was afforded after completion of data collection. Digital or written consent was required from all participants prior to participation.

Data were self-reported using the Maternal Outcomes and Nutrition Tool (MONT), a novel digital instrument whose design has previously been described elsewhere¹⁴. Adapted from the Norwegian Mother and Child (MoBa) Study¹⁵, Harvard¹⁶, the Block¹⁷, and diet history questionnaires¹⁸, the MONT Food Frequency Questionnaires (FFQ) facilitate collection of data regarding 259 individual foods; additionally, demographic, health and birth outcome information is collected by the full survey set.

Food frequency for each of the food groups (vegetables and legumes, fruit, grain, meat and alternatives, dairy and alternatives and discretionary) were recorded for the month prior to participation. Each FFQ response was allocated a numerical value

(supplementary file 1), facilitating calculation of the average equivalent serves consumed by the respondent per day. Calculated totals were compared to the Australian Dietary Guidelines for pregnant women⁷. Respondents also declared the motives driving their food selection using the MONT food choice questionnaire, adapted for research in pregnancy from Steptoe, Pollard and Wardle's Food Choice Questionnaire (FCQ)¹⁹. The food choice survey proposed the statement "I choose the foods I eat based on...", with participants able to select multiple responses from 21 available options (supplementary file 2). Responses were classified into eight motives (health, mood, convenience, sensory appeal, natural content, price, weight control and familiarity) according to the original FCQ¹⁹. Birth outcomes were derived from each hospital's mandatory perinatal data reporting system.

Descriptive statistics were used to detail the cohort; maternal age (≤ 24 , 25-29, 30-34, ≥ 35 years), parity (nulliparous/multiparous), ethnicity (defined as identifying with an ethnicity other than Caucasian and/or birth in a traditionally non-English speaking country, including Indigenous Australian - dichotomous), education (did not attend/finish high school, finished high school, TAFE trade or apprenticeship, university degree), annual family income ($< \$50k$, $\$50-70k$, $\$70-120k$, $> \$120k$), currently smoking (dichotomous), and pre-pregnancy BMI (lean, ≤ 24.99 kg/m²/overweight or obese, ≥ 25.00 kg/m²). Calculated food group frequencies and declared food choice factors were analysed in relation to individual demographic groups and the cohort as a whole. Demographic variables were reported with mean ($\pm$ SD); intake variables with median, [25th - 75th percentile]. Frequency of each health motive was also reported (n, % responses). Hypertensive disorders of pregnancy (HDP), gestational diabetes (GDM), preterm birth and birthweight constituted the examined outcomes. All variables were

assessed for correlation with Pearson correlation analysis (r , p value); significant associations were examined with chi-square analysis (χ^2 , df , p value). Significant relationships were subject to linear regression analysis (β , 95% CI, p value). Data were analysed using IBM SPSS version 25; significance was accepted at $p \leq 0.05$.

RESULTS

Four hundred and thirty-one women (28 ± 2 weeks gestation) participated in this research; 259 completed the full survey set (60%); descriptive groups have been detailed in table 1. The calculated median energy intake of the cohort was 12743 kJ/day (5925 – 33970 kJ/day), a figure within the calculated requirements of pregnant women (7200-14600 kJ/day)²⁰.

Suboptimal consumption of three of the five core food groups for pregnant women (19-50 years) was demonstrated; intake of meat and alternatives (2.6 [2.0-3.4] of 3.5 serves/day) and grains (3.1 [2.1-4.1] of 8.5 serves/day) were below recommendations; median fruit consumption was 90% above requirements (3.8 [2.5-5.3] vs 2 serves/day). Intake of vegetables and legumes (4.6 [3.6-5.9] of 5 serves/day) and dairy and alternatives (2.3 [1.5-3.0] of 2.5 serves/day) were the closest to meeting recommendations. Discretionary food intake (3.1 [2.1-4.4] serves/day) exceeded the limitations recommended by the Australian Dietary Guidelines (0-2.5 serves/day)⁷ (table 2).

Significant relationships were found between food groups and selection motives (table 2); further correlations were found with dietary behaviours, demographic characteristics and birth outcomes. Women identifying as culturally and linguistically diverse reported a higher daily intake of meat and alternatives (3.1 versus 2.6 median serves/day; $\beta=0.488$, 95%CI 0.232, 0.745, $p<0.001$) and placed a lower emphasis on

convenience ($\beta=-0.339$, 95%CI -0.558, -0.120, $p=0.003$) than those identifying as Caucasian. Current smokers consumed a lower median number of serves of meat (and alternatives) per day than their non-smoking counterparts (2.3 versus 2.8 serves; $\beta=-0.501$, 95%CI -0.968, -0.034, $p=0.036$), however declared a higher median number of serves of discretionary foods per day (4.6 versus 3.4 serves; $\beta=1.174$, 95%CI 0.255, 2.093, $p=0.012$); these women were also less likely to declare health as a motivation for food selection ($\beta=-0.993$, 95%CI -1.625, -0.361, $p=0.002$). ‘Health’ motive scores increased with age ($\beta=0.317$, 95%CI 0.139, 0.495, $p=0.001$) and education ($\beta=0.250$, 95%CI 0.106, 0.395, $p=0.001$). The consumption of the core food group grains also increased concurrently with age ($\beta=0.068$, 95%CI 0.026, 0.111, $p=0.002$).

Birth outcomes were available for 186 women (39%). Hypertensive disorders ($n=14$, 7.5%), preterm birth ($n=18$, 9.7%) and gestational diabetes ($n=21$, 11.3%) were not associated with any descriptive group or food selection motive ($p>0.05$), however the incidence of HDP increased with decreasing vegetable intake ($\beta=1.514$, 95%CI 0.270, 2.757, $p=0.017$). Low birthweight in the absence of multiple pregnancy or medical complexity was recorded for 29 infants (15.6%). Birthweight was significantly associated with cultural and linguistic diversity in this cohort ($p=0.022$); mean birthweight for CALD women was 8% lower than their non-diverse peers (3025 grams vs 3290 grams).

DISCUSSION

This research aimed to collect and examine self-reported dietary intake and decision-making data from a cohort of pregnant South-East Queensland women, exploring the overall interactions between diet, food selection motives, health

determinants and birth outcomes.

This cohort demonstrated poor adherence to dietary recommendations during pregnancy, a finding supported by similar Australian studies²¹⁻²³. Fruit and discretionary food intake exceeded recommendations in this cohort, however the daily serves of grain-based foods were less than half the recommended intake. While this deficit suggests a dietary guideline knowledge gap, it may also be indicative of a poor understanding of serving sizes for complex carbohydrates. The halving of the cereal serving size and concurrent increase of daily grain serves for pregnant women in the 2013 Australian Dietary Guidelines^{7, 8} may have contributed to these results. These findings are supported by two Australian cohorts^{21, 22}, suggesting that suboptimal dietary intake and nutrition literacy during pregnancy are nationwide rather than a regional public health issue.

The median daily serves of meat (and alternatives) was universally low, however CALD women exhibited a significantly higher intake of this food group than their non-diverse peers. Despite this, women of CALD backgrounds exhibited a lower mean birthweight than Caucasian women, a disparity that cannot be explained by the dietary intake of this group of women. However social influences - including the known socio-economic disadvantage and reluctance to engage with health services²⁴ demonstrated by CALD women in high-income countries - may have contributed to this finding. Additionally, these women declared a significantly lower emphasis on convenience in their dietary decision-making than non-CALD group, suggesting a trend toward home-cooked, traditional meals in the culturally diverse population. These behaviours may have cumulatively contributed to the lower mean birthweight demonstrated by this group.

Conversely, women who declared smoking in the previous month reported lower meat (and alternative) intake than their non-smoking counterparts. This is a novel finding in the context of pregnancy. Smokers also demonstrated excessive discretionary food intake and a negative association with ‘health’ motivations. These findings support previous research linking tobacco smoking and unhealthy diet (defined as high in refined grain and low in fruit and vegetables)²⁵, and continued smoking despite knowledge of associated health risks²⁶. Identification of continuing smokers during pregnancy may facilitate provision of dietary education and advice aimed at optimising outcomes through dietary management. These strategies may minimise the effects of continued smoking on the health of women and their infants improving both immediate and longitudinal health outcomes²⁷.

Despite their association with unhealthy dietary practices, smokers did not demonstrate any significant association with the birth outcomes in question. This reflects findings reported in a similar study population, who reported no relationship between smoking and the incidence of pre-eclampsia²⁸. However, a significant inverse linear relationship between maternal vegetable intake and the incidence of HDP has been reported in both local²⁸ and international research²⁹, an association also demonstrated by the women of this cohort. This suggests that adequate vegetable intake acts as a protective factor in the aetiology of hypertensive disorders, potentially due to the high proportion of micronutrients with antioxidant effects found in this food group³⁰ and their effect on the oxidative stress associated with hypertensive disorders of pregnancy³¹. Therefore, nutrition counselling for women with identified risk for HDP may reduce the incidence and severity of these pregnancy disorders.

Significant positive associations were evident between health factor scores,

maternal age and education. Analysis suggests that women of the cohort were more motivated to make healthy dietary choices with advancing age and increasing education, conclusions supported by contemporary research in a comparative population^{32, 33}. As such this data may indicate the presence of a nutrition literacy deficit in young women of this cohort, particularly those who have not undertaken a tertiary education³³. Appropriate dietetic intervention in these women has the potential to influence the development of life-long dietary behaviours for both themselves and their children³⁴.

This study has inherent strengths and limitations. Participants were recruited through public hospital antenatal clinics; busy, fragmented models with limited access to continuity of care. This recruitment environment resulted in an inability to compare the intake and outcomes of women engaging private maternity services. While women with high income and education levels are more likely to access private models of care³⁵, potential inequities have been negated by the heterogeneity of income brackets and the high percentage of university-educated women in the cohort. Furthermore, data were collected from a representative cohort of the South-East Queensland region^{36, 37}, and included data declared by women of cultural, linguistic, literacy and socio-economic diversity.

Over and under-reporting of intake is common with self-reported dietary recall³⁸. While reporting inconsistencies potentially exist within this research, outliers had no significant impact on the mean for any food group. As such, these effects have been considered minimal and all declarations retained in the analysis. Social desirability bias is also common in research of this nature³⁹; the anonymisation of respondents and the unassisted and unsupervised survey completion has minimised this

effect.

This study has highlighted the importance of considering individual risk factors, dietary intake and decision-making motivations when assessing the need for nutrition counselling and referral during pregnancy. Women with identified risk factors exhibit dietary behaviours which may benefit from individualised dietary assessment, planning and service provision. This novel examination of food-selection motives in relation to socio-cultural risk factors has determined that selected birth outcomes may be modifiable with behaviour-specific counselling in at-risk groups of this region. These findings form a foundation for further transdisciplinary research and service integration.

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Table 1: Demographic characteristics of participants (n=431)

Variable	n (%)
Mean gestation at recruitment (weeks,	28 (± 2 weeks)
Mean age (years, $\pm$ SD)	29.9 (± 5.87)
Mean pre-pregnancy BMI ($\pm$ SD)	25.15 (± 5.67)
Maternal age (years)	47 (10.9)
<24 <24 yrs	
25-29	69 (16.0)
30-34	71 (16.5)
≥ 35	50 (11.6)
Not declared	194 (45.0)
Annual household income (thousand)	115 (26.7)
<50 <50k	
50-70	75 (17.4)
70-120	124 (28.8)
>120	95 (22.0)
Not declared	22 (5.1)
Education < High	54 (12.5)
school	
Finished high school	94 (21.8)
TAFE trade or apprenticeship	96 (22.3)
University degree	165 (38.3)
Not declared	22 (5.1)
Ethnicity	291 (67.5)
Cultural or linguistic diversity (ex	101 (23.4)
Indigenous Australian	18 (4.1)
Not declared	21 (4.9)
Parity	171 (39.7)
Multiparous	241 (55.9)
Not declared	19 (4.4)
Smoker	21 (4.9)
Yes	
No	293 (68.0)
Not declared	117 (27.1)
Pre-pregnancy BMI (kg/m^2) Lean	193 (44.8)
(<25)	
Overweight/obese (≥ 25)	130 (30.2)

Not declared	108 (25.1)
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Supplementary file 2: Frequency of food choice factors

	MONT options	n (% total)
Factor 1 – Health	Gives me energy	92 (33.1)
	Nutritious	167 (60.1)
	It's good for me	158 (56.8)
	Fibre content	52 (18.7)
Factor 2 – Mood	Comfort food	115 (41.4)
Factor 3 – Convenience	Ease of preparation	148 (53.2)
	It's easily available	120 (43.2)
Factor 4 – Sensory appeal	Tastes good	246 (88.5)
	Looks good	124 (44.6)
	Smells good	141 (50.7)
	Texture	29 (10.4)
Factor 5 – Natural content	Preservative content	36 (12.9)
Factor 6 – Price	My budget	129 (46.4)
	Value for money	108 (38.8)
Factor 7 – Weight control	Calorie content	40 (14.4)
	Fat content	30 (10.8)
Factor 8 – Familiarity	Habit	109 (39.2)
	It's familiar	104 (37.4)
	Cultural/Ethnic beliefs	23 (8.3)
	My friends/family eat it	100 (36.0)
	Childhood memories	39 (14.0)