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The Nutritional Online sUrvey for pRegnancy Induced Sickness & Hyperemesis (NOURISH) study: results from the first trimester

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Abstract

Background: Hyperemesis gravidarum (HG) is severe pregnancy sickness, often leading to dehydration, weight loss and electrolyte disturbances. Little is known about nutritional intake and its consequences in those affected. The aim of this study was to explore the first trimester nutritional intake and clinical characteristics in those with severe sickness.

Method: Recruitment was via the social media accounts of national pregnancy charities. The eligibility criteria were as follows: between 6 and 11 weeks pregnant, age ≥18 years and residing in the UK. Participants completed a self-report online questionnaire including the Pregnancy Unique Quantification of Emesis 24 (PUQE24) score and a 3-day online diet diary. Groups were compared by PUQE24 categories. Nutritional intakes were compared to dietary reference values.

Results: One hundred sixty-six participants took part in the study: 36 categorised with mild, 109 with moderate and 21 with severe symptoms at a median gestation of 8.1 (interquartile range [IQR] 3) weeks. Those in the severe category had significantly higher weight loss (3.0 kg, IQR 3.5) than the mild category (0.0 kg, IQR 0.9). In those who completed the diet diary ($n = 70$), intakes of energy, carbohydrate, protein, fat, fibre, calcium, iron, zinc, thiamine, riboflavin, folate and vitamin C were all significantly lower in the severe category ($p < 0.05$). The severe group consumed only 39.5% and 41.6% of energy and protein needs, respectively, and were more likely to stop taking micronutrient supplements ($p < 0.05$).

Conclusion: Nutritional and supplement intake in those with severe pregnancy sickness was poor; however, intake across all participants was suboptimal. Future research should investigate how to improve nutritional intake across all categories of pregnancy sickness.

KEYWORDS

hyperemesis gravidarum, maternal dietary intake, pregnancy malnutrition, pregnancy nausea and vomiting

Key points

- Hyperemesis gravidarum causes severe pregnancy sickness, affecting ~1%–2% of pregnancies.
- This study indicates that nutritional and supplement intake in those with severe pregnancy sickness was poor; however, intake across all participants was suboptimal.
- Future research should investigate how to improve nutritional intake across all categories of pregnancy sickness.

INTRODUCTION

Hyperemesis gravidarum (HG) is a condition at the extreme end of the pregnancy sickness spectrum. Unlike typical nausea and vomiting in pregnancy, which affects ~70% of pregnant women,[1] HG is a more severe condition estimated to affect 1.5% of pregnancies in the UK,[2] with a high recurrence rate in subsequent pregnancies.[3] Historically, a lack of clear definition that differentiates at what point nausea and vomiting of pregnancy becomes HG has made diagnosis, clinical management and research challenging.[4–6] However, in 2021, an international consensus definition was published, defining HG as follows: nausea and vomiting, with at least one of them being severe; starting before 16 weeks gestation, causing an inability to eat and/or drink normally and strongly limiting daily living activities.[7] The cause of HG is not fully understood, although recent research has implicated the placenta and appetite hormone gene GDF15,[8] suggesting a predominantly genetic aetiology.[9]

HG can persist throughout pregnancy, causing malnutrition, dehydration, electrolyte disturbances and extreme weight loss.[10] There is no single biomarker that can diagnose HG or predict disease severity[11]; however, symptom severity of nausea and vomiting can be classified objectively and validly using the Pregnancy Unique Quantification of Emesis (PUQE) tool,[12,13] although it does not consider aspects such as nutritional intake or medication. Treatment typically consists of medical intervention with antiemetic medication,[14] although evidence of effectiveness is equivocal.[15,16] Hospital admission is often required[2,17] for correction of dehydration and electrolyte disturbances with intravenous (IV) fluids. However, there is a lack of clear nutritional guidelines for the condition.[18]

HG can affect physical, psychological and emotional health, with long-lasting consequences for mother and child.[19] Approximately 25% of women with HG lose 15% or more of their preconception weight.[10] Those with the most pronounced weight loss are more likely to have prolonged symptoms, including gallbladder, liver dysfunction and renal failure.[20] A study which analysed >8 million pregnancies in England over 15 years found that those with HG had a higher risk of preterm birth and gave birth to babies who were smaller for their gestational age,[21] with a systematic review reporting similar findings.[22] An increased risk of autism spectrum disorder has also been identified, which could be due to the effect of maternal malnutrition on the developing brain at a critical time points[23]; however, studies have not specifically focused on nutritional status or intake.

Although malnutrition is a key feature of HG, there is a distinct lack of research in relation to dietary intake and/or nutritional interventions.[4,6] The extent of dehydration and malnutrition, when specifically they are most likely to occur, and how they impact pregnancy outcomes is unclear. Indeed a scoping review[24] identified only four previous research studies which assessed nutritional intake in HG. Two studies of the four studies did not report energy intake; however, of the two that did, both reported that women with HG consumed <50% of their calorie needs,[25,26] which did not take into account additional caloric value of food lost through vomiting. Intakes of several macro- and micronutrients were significantly below the control group and national recommendations.

In recent years, there has been growing momentum for the need to prioritise nutrition research in the management of HG. A James Lind Alliance Priority Setting Partnership exercise, carried out in consultation with clinicians, researchers and patients between 2017 and 2019, highlighted the importance of furthering our understanding of nutritional aspects of HG.[27] Additionally, an international consensus document[28] emphasised the importance of consistent outcome reporting in HG, specifying that food and fluid intake, weight, maternal well-being and perinatal outcomes are to be included in future studies. A systematic evidence map has determined that only a few studies seek to understand nutritional requirements or ways to improve dietary intake.[29] With this in mind, a UK-based prospective cohort study was set up, The Nutritional Online sUrvey for pRegnancy Induced Sickness & Hyperemesis (NOURISH), to assess the nutritional intake and well-being of women experiencing HG and their pregnancy outcomes. In this study, we presented the first trimester data from this cohort, specifically focused on describing participant characteristics and their nutritional intakes.

METHODS

Study design

The NOURISH study is a UK- based online prospective survey study.

Recruitment

Participants were recruited via social media accounts of national pregnancy charities over a 5-month period in 2021.As this was an exploratory study, there was no predefined sample size decided via a power calculation. We took a pragmatic approach and sought to recruit as many participants as possible within the timeframe funding was available for. The eligibility criteria were as follows: being between 6 and 11 weeks pregnant, being ≥18 years old and residing in the UK. Both individuals experiencing pregnancy sickness and those not experiencing it were encouraged to take part in the study. Participants who consented to take part were emailed a link to an online questionnaire and a mobile phone dietary assessment application.

Questionnaire

Participants completed a self-report online questionnaire via Jisc online surveys. The questionnaire was developed and piloted in conjunction with a patient and public involvement group and modified accordingly. It included the following sections (see Supporting Information: S1):

- Demographic questions: including age, ethnicity and occupational status.
- Clinical questions: pregnancy history including hospital admissions and anti-sickness medications.
- Questions about usual diet and dietary supplements, weight and height.
- PUQE24[12]: a validated scale which quantifies the amount of nausea, vomiting and retching over the preceding 24 h.
- HyperEmesis Level Prediction Score (HELP)[30]: a scale which collects information on urination frequency, symptoms, medication and weight.

Dietary assessment

Dietary information was collected and analysed via the Libro (Nutritics: https://en-gb.nutritics.com/p/home) mobile phone application. Participants were asked to prospectively record all food and drinks consumed for 3 consecutive days. Clear instructions and a video tutorial were provided about how to do this. The application contains images and data on over 750,000 foods and allows participants to visualise and input accurate portion sizes, while generating nutritional analysis data for researchers.

Participants were asked to complete the questionnaire and dietary assessment synchronously to minimise any time lag between different data points. Where it was not possible for participants to complete the diet assessment independently due to severe symptoms, partners and family members provided assistance.

Data analysis

Data were exported from Jisc online surveys and Nutritics Libro to Microsoft Excel for data cleaning and then SPSS v24 [31] for analysis. Any queries regarding food coding were resolved by discussion with the study dietitian.

Mean macro- and micronutrient intake values per day were generated for each participant and collated into grouped diet data for comparison to dietary reference values (DRVs). Energy intake was compared to age-specific estimated average requirement (EAR) for women.[32] Macro- and micronutrient intakes were compared to reference nutrient intakes (RNIs), the amount required to ensure the needs of 97.5% of the population studied being met.[33] Micronutrient nutritional adequacy was assessed by determining the proportion of individuals with intakes below the lower reference nutrient intake (LRNI),[33] the amount sufficient for the people who have low needs in a group. EAR, DRV, RNI and LRNI are all UK-specific metrics and assess nutritional intakes at population, rather than at individual level. Values for women aged between 18 and 50 years were used, with adjustment for the first trimester of pregnancy where relevant. Dietary intake data presented are derived from food and drinks only. Data about nutritional supplements are presented separately as complete information was unavailable on dose and brand of supplement.

Participants were categorised into mild (≤6), moderate (7–12) or severe (≥13) symptom categories using PUQE24[12] score guidance. Participants without any symptoms would score 3 on the PUQE24 questionnaire and were categorised in the mild category.

Data were checked for normality and analysed using descriptive statistics and frequencies. Continuous variables were compared using *t*-tests or Mann–Whitney tests; categorical variables were compared using chi-square or Fisher Exact tests. Differences between PUQE24 categories were assessed using Kruskal–Wallis or one-way ANOVA tests, with post hoc Bonferroni tests where indicated, dividing the 0.05 alpha level by the number of tests used. Statistical significance was taken as $p < 0.05$.

Patient and public involvement

A patient representative group from the UK Pregnancy Sickness Support charity was involved with and commented on drafts of the study procedures, questionnaire and recruitment materials.

Ethical approval was obtained from the University of Plymouth Faculty of Health Research Ethics and Integrity Committee (Reference 2476).

RESULTS

In total, there were 166 participants; 36 categorised as having mild, 109 as moderate and 21 as severe symptoms using the PUQE24 score. Demographic characteristics of participants per symptom category and overall are shown in Table 1. The majority of the participants were of White British ethnicity (88.4%, $n = 145$), between the ages of 25 and 34 years (63.3%, $n = 105.5$) and multiparous (84.2%, $n = 140$). Those in the mild category were more likely to be primiparous and older than those in the moderate and severe categories, but less likely to have a history of severe pregnancy sickness ($p < 0.05$ for all). There was no difference in ethnicity, educational level, occupational

TABLE 1 Participant demographics.

Variable	Sub category	Mild ($n = 36$)	Moderate ($n = 109$)	Severe ($n = 21$)	All ($N = 166$)	Chi-square/ Fisher Exact
Age (years)	18–24	0.0 (0)	0.9 (1)	14.3 (3)	2.4 (4)	0.045
	25–34	61.1 (22)	64.2 (70)	61.9 (13)	63.3 (105)	
	35–44	38.9 (14)	34.9 (38)	23.8 (5)	34.3 (57)	
Ethnicity	White British	91.7 (33)	86.1 (93)	95.0 (19)	88.4 (145)	0.924
	White Other	2.8 (1)	7.3 (8)	5.0 (1)	6.1 (10)	
	Asian	2.8 (1)	2.8 (3)	0.0 (0)	2.4 (4)	
	Black	0.0 (0)	0.9 (1)	0.0 (0)	0.6 (1)	
	Mixed race	2.8 (1)	0.9 (1)	0.0 (0)	1.2 (2)	
	Other	0.0 (0)	1.9 (2)	0.0 (0)	1.2 (2)	
Educational level	GCSE	0.0 (0)	1.9 (2)	0.0 (0)	1.2 (2)	0.462
	NVQ level 4-5/HND/HNC/diploma/ BTEC or equivalent	0.0 (0)	4.6 (5)	0.0 (0)	3.0 (5)	
	A-levels or equivalent	14.3 (5)	10.2 (11)	28.6 (6)	13.4 (22)	
	Degree	40.0 (14)	40.7 (44)	42.9 (9)	40.9 (67)	
	Postgraduate degree	45.7 (16)	42.6 (46)	28.6 (6)	41.5 (68)	
Occupational status	Working full-time	58.3 (21)	53.3 (57)	38.1 (8)	52.4 (86)	0.640
	Working part-time (<28 h/week)	27.8 (10)	29.9 (32)	42.9 (9)	31.1 (51)	
	Full-time college/university student	5.6 (2)	1.9 (2)	9.5 (2)	3.7 (6)	
	Looking after family/home	5.6 (2)	9.2 (10)	9.5 (2)	8.5 (14)	
	Unemployed	0.0 (0)	1.9 (2)	0.0 (0)	1.2 (2)	
	Not working due to sickness/disability	52.8 (1)	3.7 (4)	0.0 (0)	3.0 (5)	
Primiparous	Yes	36.1 (13)	11.0 (12)	5.0 (1)	15.8 (26)	0.001
Severe sickness in previous pregnancy	Yes	30.0 (6)	48.4 (45)	75 (15)	49.6 (66)	0.017
Family history of HG	Yes	16.7 (6)	29.4 (32)	28.6 (6)	26.5 (44)	0.153
Miscarriage	Yes	27.5 (10)	3.7 (4)	0.0 (0)	8.4 (14)	0.000
Usual diet	No restrictions	72.5 (26)	76.1 (83)	90.5 (19)	77.1 (128)	0.574
	Vegetarian	22.2 (8)	11.9 (13)	9.5 (2)	13.8 (23)	
	Vegan	2.8 (1)	5.5 (6)	0.0 (0)	4.2 (7)	
	Other	2.8 (1)	6.4 (7)	0.0 (0)	4.8 (8)	
Dietary conditions	Yes	8.3 (3)	19.3 (21)	0.0 (0)	14.4 (24)	0.026

Abbreviation: GCSE, general certificate of secondary education.

status or family history of HG between symptom severity categories. The majority of participants usually ate an unrestricted diet (77.1%, $n = 128$), with a minority usually consuming vegetarian, vegan or other diets. The 'other diets' included gluten-free, nut-free or low-lactose, which aligned with a small number of participants specifying dietary conditions, namely coeliac disease, irritable bowel disease and food allergies. The overall median gestation at recruitment was 8.1 (interquartile range [IQR] 3) weeks.

Unfortunately, 14 participants experienced miscarriages after completing this phase of the study, 10 of whom were in the mild category and 4 in the moderate category ($p < 0.05$).

Medication, hospitalisation, hydration and weight

Information on medication, hospitalisation and weight is show in Table 2. Usual (pre-pregnancy) median body mass index (BMI) was 24.8 kg/m^2 (IQR 6.8), which did not differ by sickness category. There were significant differences in rates of prescription of anti-sickness medication, hospital admission and receipt of intravenous (IV) fluids between severity categories. Almost all (90.5%, $n = 19$) of those in the severe category were prescribed anti-sickness medication, and 42.9% ($n = 9$) had been admitted to hospital and had IV fluids. Of note, a small proportion of those in the mild category had been admitted to hospital and given IV fluids (5.6%, $n = 2$), and just under a fifth (19.4%, $n = 7$) were prescribed anti-sickness medication. Upon further scrutiny, two of those who were admitted to hospital in the mild category had HG in a previous pregnancy, as did six out of seven of those who were prescribed medication.

There was no difference in usual (pre-pregnancy) weight or BMI between severity categories. In terms of weight change, there was a median change from pre-pregnancy weight to current weight of −1.17 kg (IQR 3.48). Those in the mild category (0.0 kg, IQR 0.9) lost significantly less weight than those in the moderate (2.1 kg, IQR 4.0) and severe categories (3.0 kg, IQR 3.5); however, there was no significant difference between the moderate and severe categories. In terms of percentage weight loss, the same pattern applied. Those in the mild category (0.00%, IQR 1.4) experienced significantly less percentage weight loss than those in the moderate (−2.77%, IQR 5.0) and severe categories (−4.33%, IQR 4.7); however, there was no significant difference between the moderate and severe categories. The maximum weight loss was 19.1%, experienced by one participant in the severe category. No participants had experienced tube feeding.

Respondents were asked about their urination frequency as part of the HELP scale,[34] as a proxy indictor of hydration. There were statistically significant differences between groups as follows: 52.7% ($n = 19$) of those in the mild category responded 'same as usual', compared to 11% ($n = 12$) of those in the moderate category and 0% in the severe category. Conversely, 33.3% ($n = 7$) of those in the severe category reported urinating less than once every 8 h, compared to 21.1% ($n = 23$) and 2.7% ($n = 1$) in the moderate and mild categories, respectively, (Fisher Exact test, $p < 0.05$).

Dietary intake

Forty-two per cent ($n = 70$) of participants completed the dietary assessment. This did not differ by severity category, with 44.4% ($n = 16$), 40.3% ($n = 44$) and 47.6% ($n = 10$) of those in the mild, moderate and severe categories completing it, respectively. There was no difference in any demographic variable (age, ethnicity, education level, occupational status, parity, previous history of pregnancy sickness or usual diet) between participants who did and didn't complete the dietary application, nor was there a difference in pre-pregnancy weight or weight change (data not shown).

Reported dietary intake data are shown in Table 3. Overall intakes of energy, carbohydrate, protein, fat,

TABLE 2 Clinical aspects and weight status of participants.

	Response	Mild ($n = 36$)	Moderate ($n = 109$)	Severe ($n = 21$)	All ($N = 166$)	Fisher Exact
Prescribed medication for pregnancy sickness	Yes	19.4 (7)	77.1 (84)	90.5 (19)	66.3 (110)	0.000
Admitted to hospital	Yes	5.6 (2)	22.9 (25)	42.9 (9)	21.7 (36)	0.007
Intravenous fluids	Yes	5.6 (2)	22.0 (24)	38.1 (8)	20.5 (34)	0.003
Tube feeding	Yes	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	
						Kruskal–Wallis
Current gestation (weeks)	Median (IQR)	7.5 (2.9)	9.0 (3.0)	8.0 (2.2)	8.1 (3)	0.335
Pre-pregnancy weight (kg)	Median (IQR)	64.7 (20.3)	69.0 (17.8)	67.0 (35.8)	67.54 (18.8)	0.428
Current weight (kg)	Median (IQR)	66.9 (18.7)	68.0 (15.7)	63.5 (35.8)	66.9 (17.8)	0.746
Weight change (kg)	Median (IQR)	0.00 (0.9)	−2.1 (4.0)	−3.0 (3.5)	−1.17 (3.48)	0.000
Percentage weight loss (%)	Median (IQR)	0.00 (1.4)	2.77 (5.0)	−4.33 (4.7)	−1.89 (4.8)	0.000
Pre-pregnancy BMI (kg/m^2)	Median (IQR)	23.9 (6.6)	24.9 (6.0)	24.6 (8.2)	24.8 (6.8)	0.686
Current BMI (kg/m^2)	Median (IQR)	24.2 (6.4)	24.5 (6.2)	21.9 (8.5)	24.2 (6.7)	0.637
BMI change (kg/m^2)	Median (IQR)	0.0 (0.3)	−0.73 (1.46)	−1.1 (1.33)	−0.45 (1.23)	0.000

Abbreviations: BMI, body mass index; IQR, interquartile range.

TABLE 3 Dietary intake of participants (from food only).

Variable	EAR/RNI for the first trimester pregnancy/day		Mild ($n = 16$)	Moderate ($n = 44$)	Severe ($n = 10$)	All ($n = 70$)	ANOVA/ Kruskal–Wallis
Energy (kcal)	2103–2175	Mean (SD)	1616.4 (500.7)	1253.8 (566.6)	858.4 (338.7)	1280.2 (567.6)	0.003
Carbohydrate (g)		Mean (SD)	200.4 (48.7)	166.6 (69.8)	116.6 (47.1)	167.2 (66.9)	0.006
Protein (g)	0.75 g/kg + 6 g	Mean (SD)	58.6 (20.9)	42.0 (22.8)	30.6 (20.9)	44.2 (23.6)	0.007
Fat (g)		Mean (SD)	63.3 (28.2)	47.1 (27.7)	29.9 (20.1)	48.3 (28.4)	0.011
Fibre (g)	30	Median (IQR)	19.7 (11.9)	10.35 (9.2)	7.2 (8.0)	11.65 (13.4)	0.002
Calcium (mg)	700	Median (IQR)	705.5 (394.5)	341.0 (396.0)	265.0 (325.3)	393.0 (484.3)	0.012
Iron (mg)	14.8	Median (IQR)	5.85 (6.77)	4.0 (4.8)	1.4 (2.98)	4.25 (4.60)	0.000
Zinc (mg)	7.0	Median (IQR)	3.75 (1.95)	2.3 (3.1)	2.0 (3.3)	3.0 (3.15)	0.045
Iodine (μg)	140	Median (IQR)	43.5 (47.8)	40.0 (56.7)	21.1 (62.5)	40.0 (55.0)	0.657
Vitamin A (μg)	700	Median (IQR)	275.0 (239.0)	157.0 (351.5)	125.5 (255.1)	198.0 (308.3)	0.099
Vitamin D (μg)	10	Median (IQR)	0.9 (2.3)	0.6 (1.7)	0.4 (0.9)	0.66 (1.7)	0.534
Thiamine (mg)	0.8	Median (IQR)	0.75 (0.89)	0.60 (0.46)	0.39 (0.35)	0.58 (0.43)	0.000
Riboflavin (mg)	1.4	Median (IQR)	0.91 (0.68)	0.65 (0.58)	0.40 (0.63)	0.71 (0.65)	0.044
Folate (μg)	400	Median (IQR)	157.5 (149.0)	77.0 (101.2)	45.6 (99.7)	86.0 (114.1)	0.001
Vitamin B12 (μg)	1.5	Median (IQR)	2.0 (1.5)	1.5 (1.6)	1.3 (2.5)	1.60 (1.7)	0.172
Vitamin C (mg)	40	Median (IQR)	74.5 (69.0)	21.7 (57.9)	9.3 (20.5)	23.2 (62.1)	0.002
% Energy from CHO	50% of energy	Mean (SD)	52.1 (9.65)	54.2 (8.5)	56.2 (14.5)	53.6 (13.5)	0.561
% Energy from fat	<35% of energy	Mean (SD)	33.6 (8.7)	13.0 (3.9)	30.1 (9.6)	32.9 (9.1)	0.600
% Energy from protein		Mean (SD)	14.3 (1.9)	32.4 (8.5)	13.7 (7.2)	13.3 (5.1)	0.592

Note: Energy requirement differs per age: 19–34 year olds: 2175 kcal/day; 35–44 year olds: 2103 kcal/day.

Abbreviations: CHO, carbohydrates; EAR, estimated average requirement; IQR, interquartile range; RNI, reference nutrient intake; SD, standard deviation.

fibre, calcium, iron, zinc, thiamine, riboflavin, folate and vitamin C were all significantly lower in the severe symptom category ($p < 0.05$ for all). The only nutrients that did not differ across categories were iodine, vitamins A, B12 and D.

Examining sickness severity categories, the moderate category had significantly lower intakes than the mild category for energy, fibre, iron, thiamine, folate and vitamin C. The severe category differed significantly from the moderate category by having a lower intake of iron. The severe category had significantly lower intakes of energy, protein, fat, carbohydrate, fibre, calcium, iron, thiamine, folate and vitamin C than the mild category (post hoc results not shown in detail).

Dietary intakes compared to recommended intakes for pregnant women in the first trimester are shown in Figure 1. Please note this does not include intake from any dietary supplements, which are discussed later.

Overall nutritional intakes were suboptimal, even for the group with mild symptoms, who only met their requirements for protein, calcium, vitamin B12 and vitamin C, but no other nutrients. The severe group consumed only 39.5% of their energy needs, 41.6% of their protein needs and <40% of their requirement for most micronutrients.

The proportion of participants not meeting the LRNI for specific micronutrients are shown in Table 4. It can be seen that even in the mild category, 18.8% did not meet the LRNI for iron from food, whereas 56.3% and 68.7% did not meet the LRNI for zinc and iodine, respectively. In the severe category, >50% did not meet the LRNI for the same micronutrients.

Nutritional supplements

Participants were asked which nutritional supplements they currently took and which they had stopped taking due to sickness. This information is presented in Table 5. Overall, the majority of participants (68.6%, $n = 114$) were taking some form

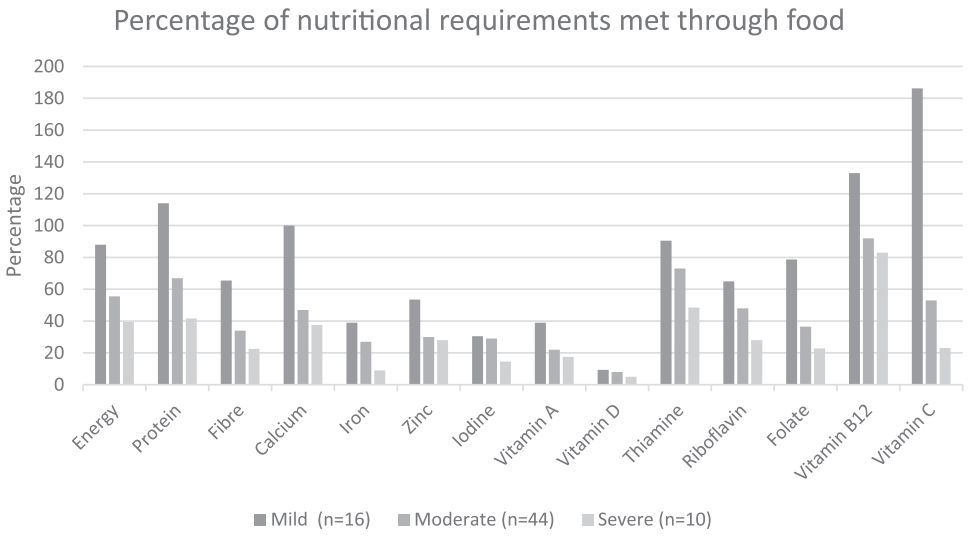

FIGURE 1 Participant dietary intakes compared to recommended intakes.

TABLE 4 Proportion of participants not meeting LRNIs[a] for micronutrients.

Variable	LRNI	Mild ($n = 16$)	Moderate ($n = 44$)	Severe ($n = 10$)	All ($n = 70$)	Fisher Exact
Vitamin A (μg)	250	43.8 (7)	56.8 (25)	60.0 (6)	54.2 (38)	0.521
Thiamine (mg)	0.23	0.0 (0)	13.8 (5)	30.0 (3)	11.4 (8)	0.048
Riboflavin (mg)	0.8	33.3 (5)	63.6 (28)	60.0 (6)	55.7 (39)	0.120
Folate (μg)	100	25.0 (4)	78.2 (30)	60.0 (6)	62.8 (40)	0.010
Vitamin B12	1.0	12.5 (2)	35.4 (16)	40.0 (4)	31.4 (22)	0.137
Vitamin C (mg)	10	6.3 (1)	29.5 (13)	50.0 (5)	27.1 (19)	0.025
Calcium (mg)	400	18.8 (3)	56.8 (25)	60.0(6)	48.5 (34)	0.016
Iron (mg)	4.7	18.8 (3)	59.1 (26)	90.0 (9)	54.2 (38)	0.000
Zinc (mg)	4.0	56.3 (9)	68.3 (30)	70.0 (7)	65.7 (46)	0.522
Iodine (μg)	70	68.7 (11)	77.3 (34)	70.0 (7)	74.2 (52)	0.769

Note: there is no LRNI for vitamin D.

[a]LRNI: lower reference nutrient intakes, the amount sufficient for the few people in a group who have low needs (lowest 2.5% of the population).[33]

of nutritional supplement, the most common being folic acid (52.4%, $n = 87$) or a combined pregnancy multivitamin/mineral (45.2%, $n = 75$), followed by vitamin D (36.1%, $n = 60$), omega 3 (10.2%, $n = 17$) and iron (7.8%, $n = 13$). A greater proportion of participants in the mild category were taking an omega 3 supplement (25.0%, $n = 9$) compared to the moderate (7.3%, $n = 8$) and severe categories 0.0% ($n = 0$) ($p < 0.05$). There were no other significant differences between intake of supplement and sickness severity categories.

However, when looking at supplements that were stopped due to sickness symptoms, significant differences were noted between categories, with a greater proportion of those in the severe category who stopped taking pregnancy multivitamins and iron ($p < 0.05$ for both).

DISCUSSION

NOURISH is a prospective cohort study, set up with the aim of assessing the nutritional intake and well-being of women experiencing HG and their pregnancy outcomes. This was in the context of the James Lind Alliance publication highlighting the lack of nutrition research on this topic,[27] despite HG being a condition that affects >1% of pregnancies in the UK (>8000/year in England),[2] often requiring hospital admission as a result of poor oral intake and dehydration. In this study, we have presented the first trimester data from this cohort of 166 pregnancies, specifically focused on describing participant characteristics and assessing their nutritional intakes. Using the PUQE24[12] score to categorise severity of nausea and vomiting symptoms, we divided

TABLE 5 Intake of nutritional supplements and cessation of supplementation due to sickness symptoms.

	Mild ($n = 36$)	Moderate ($n = 109$)	Severe ($n = 21$)	All ($N = 166$)	Fisher Exact
Currently take any dietary supplements, % (n)	77.7 (28)	69.7 (76)	47.6 (10)	68.6 (114)	0.063
Currently take a general multivitamin/mineral, % (n)	8.3 (3)	3.7 (4)	0.0 (0)	4.2 (7)	0.352
Stopped taking general multivitamin/mineral due to sickness, % (n)	2.8 (1)	6.4 (7)	19.0 (4)	7.2 (12)	0.078
Currently take a pregnancy multivitamin/mineral, % (n)	55.6 (20)	43.1 (47)	38.1 (8)	45.2 (75)	0.347
Stopped taking pregnancy multivitamin/mineral due to sickness, % (n)	2.8 (1)	24.8 (27)	47.6 (10)	22.9 (38)	0.000
Currently take vitamin D, % (n)	44.4 (16)	34.9 (38)	28.6 (6)	36.1 (60)	0.443
Stopped taking vitamin D due to sickness, % (n)	5.6 (2)	12.8 (14)	9.5 (2)	10.8 (18)	0.314
Currently take folic acid, % (n)	18 (50)	56.0 (61)	38.1 (8)	52.4 (87)	0.069
Stopped taking folic acid due to sickness, % (n)	5.6 (2)	15.6 (17)	28.6 (6)	15.1 (25)	0.066
Currently take iron, % (n)	11.1 (4)	6.4 (7)	9.5 (2)	7.8 (13)	0.611
Stopped taking iron due to sickness, % (n)	0.0 (0)	3.7 (4)	14.3 (3)	4.2 (7)	0.047
Currently taking omega 3, % (n)	25.0 (9)	7.3 (8)	0.0 (0)	10.2 (17)	0.005
Stopped taking omega 3 due to sickness, % (n)	2.8 (1)	3.7 (4)	0.0 (0)	3.0 (5)	1.000

participants into three categories (mild, moderate and severe) and compared clinical characteristics, weight change and intake of macro- and micronutrients and nutritional supplements. Overall, we demonstrated that those in the severe category lost significantly more weight (3.0 kg, IQR 3.5 or 4.33%, IQR 4.7%) than those in the mild category (0.0 kg, IQR 0.9 or 0.0%, IQR 1.4%) and were more likely to stop taking pregnancy multivitamins and iron supplements due to sickness ($p < 0.05$). In those who completed the dietary assessment ($n = 70$), intakes of energy, carbohydrate, protein, fat, fibre, calcium, iron, zinc, thiamine, riboflavin, folate and vitamin C were significantly lower in the severe category ($p < 0.05$), with the severe group consuming only 39.5% and 41.6% of their energy and protein needs, respectively, compared to DRVs.

Although only 42% of participants completed the dietary assessment, there was no difference in demographic and clinical characteristics between those who did and did not complete it, suggesting the results are representative of the overall sample. The number of completed dietary assessments ($n = 70$) is similar to other studies.[25,26,35] Although malnutrition and poor dietary intake/inability to consume a normal amount of food and fluids is considered a key feature of HG,[7] it is rarely quantified in detail,[24] which makes it difficult to determine which nutrients are of most concern, the extent of malnutrition caused by HG, when intake is most affected and how this influences pregnancy outcomes. In two published studies that have assessed macro- and micronutrient intake, both van Stuijvenberg[25] and Birkeland[26] reported that many women with HG had energy intakes <50% of the recommended amounts and were significantly different from control participants. Specifically, they reported median energy intakes of 443[25] and 990 kcal/day[26], compared to recommendations of 2500 and 2285 kcal, respectively. This is similar to our finding that those in the 'severe' PUQE category consumed 858.4 kcal/day. Both van Stuijvenberg[25] and Birkeland[26] also reported that increasing severity of symptoms was inversely related to nutritional intake and that the vast majority of intakes of micronutrients were below national recommendations, which concurs with our findings. It is worth highlighting that DRVs are population rather than personal reference values, designed for assessing group requirements, rather than individuals.[33] Although we did not assess individual energy requirements or activity levels, it is likely that those with severe sickness may be conserving energy due to being bedbound.[36] Therefore, it is conceivable that weight loss would be greater, given the reported low energy intakes.

Direct comparisons are difficult as both studies[25,26] were hospital-based, with different inclusion criteria, whereas the NOURISH study recruited participants via social media, although some 42.9% of those in the severe group had been admitted to hospital. For example, the inclusion criteria for the Birkeland et al.[26] study for the HG group were women hospitalised due to severe nausea and vomiting in pregnancy with at least

two out of three criteria: dehydration, weight loss or electrolyte imbalance or ketonuria. Yet within this group 1/38 was categorised as having mild symptoms, 15/38 as moderate and 22 as severe using the PUQE24 scale.[12] This agrees with our findings that even those in the moderate symptom severity group can have very poor nutritional intakes and, therefore, the impact of their symptoms should not be underestimated. The PUQE24 scale assesses three aspects: nausea, vomiting and retching, with the sum of each aspect used to give a total score.[12] Categorisation in the severe category of the PUQE scale is often used as a surrogate marker of HG; however, this categorisation does not consider those who may score very highly on two of the three aspects, but not the third, and are subsequently categorised as having 'moderate' symptoms. The new Windsor definition of HG[7] takes into account 'an inability to eat or drink normally' as a key characteristic of HG. This will hopefully improve diagnosis and ultimately inform better and quicker nutritional and medical treatment. However, no single diagnostic tool to accompany the new definition has yet been validated.

Of note, a small proportion of those in the mild category had been admitted to hospital and given IV fluids (5.6%, $n = 2$) and just under a fifth (19.4%, $n = 7$) were prescribed anti-sickness medication. Upon further scrutiny, both of those in the mild category who were admitted to hospital had HG in a previous pregnancy, as did six out of seven of those who were prescribed medication. The recurrence of HG has previously been shown to be the strongest independent risk factor for hospital admission,[2] and it is positive to note that those with recurrence have had pre-emptive medical treatment, which has resulted in symptoms now being mild. Some evidence suggests early or pre-emptive treatment in HG may reduce severity and duration of symptoms,[37] which would likely lead to less impact on nutritional intake, but further evidence is required.

HG has been described as a form of prolonged starvation,[25,38] with several researchers comparing the malnutrition experienced by women with HG to the malnutrition experienced by pregnant women during famines.[39,40] In terms of weight, there was a median change from pre-pregnancy weight to current weight of −1.17 kg (IQR 3.48), which equated to a decrease of 1.89% (IQR 4.8%). Those in the mild category (0.0 kg, IQR 0.9 or 0.0%, IQR 1.4%) lost significantly less weight than those in the moderate (2.1 kg, IQR 4.0, or −2.71%, IQR 5.0%) and severe categories (3.0 kg, IQR 3.5 or −4.33%, IQR 4.7%), but there was no significant difference between the moderate and severe categories. It is unclear which time point in pregnancy is the most critical in terms of weight restoration; however, recently published research has identified that not regaining pre-pregnancy weight specifically by week 13–18 is an independent risk factor for delivering a baby that is small for gestational age.[41] This emphasises the importance of seeking medical and nutritional treatment early in pregnancy. Previous research by our group has identified a need for further training for all clinicians and earlier recognition of malnutrition, alongside investment in the role of dietitians to improve the nutritional care of those with HG.[18]

It was of concern to note that even though the intake of those with severe symptoms was poor, in comparison to DRVs for pregnancy, the intake of those with absent/mild symptoms was also noticeably suboptimal. In the mild category group, iodine was the micronutrient with the highest proportion of participants not meeting the LRNI from food sources (68.7%), followed by zinc (56.3%), vitamin A (43.8%) and folate (25.0%). This pattern has also been noted in other pregnancy studies. A systematic review of nutritional intakes in pregnancies in developed countries concluded that that pregnant women are at risk of suboptimal micronutrient intakes, and specifically folate, iron, and vitamin D intakes were consistently below nutrient recommendations in each geographical region.[42] Sauder et al.[43] analysed data from 15 observational pregnancy cohort studies and found that even with dietary supplement use, >20% of participants were at risk of inadequate intake of ≥1 micronutrients, especially in some population subgroups.

Focusing on UK dietary intakes, a systematic review reported that women of childbearing age and pregnant women in the UK are generally iodine insufficient.[44] Of note, the UK RNI of 140 μg/day for the general adult population[45] is lower than the European Food Safety Authority (EFSA) recommended 200 μg/day[46] Supplemental iodine is not recommended for women in the UK during pregnancy. Therefore, regular and plentiful food sources (predominantly from milk, dairy products and fish) are needed, given that salt is not iodised in the UK.[47] This is relevant to HG, as research has linked HG to adverse child neurological outcomes,[23,48] which has been hypothesised to be due to nutritional factors. However, it is not known whether this is due to basic malnutrition caused by a basic lack of energy (calorie intake) or if it is more specifically linked to particular micronutrients of concern, known to be linked to child cognitive and neurodevelopment (e.g., iodine, iron[49–52]). Better characterisation of nutritional intake throughout pregnancy, linked to long-term follow-up of offspring, would allow this to be further explored and reduce reliance on retrospective studies, which may be subject to bias.

The findings regarding nutritional supplements are important to consider. In the UK, 400-μg supplemental folic acid is recommended before and during pregnancy to reduce the risk of neural tube defects,[53] whereas supplemental 10-μg vitamin D is recommended for all adults (including during pregnancy).[54] These may be taken as separate supplements or are commonly combined in a pregnancy-specific multivitamin/mineral, which often contains other minerals such as iron and

zinc. Overall, the majority of participants (68.6%, $n = 114$) were taking some form of nutritional supplement, the most common being folic acid (52.4%, $n = 87$) or a combined pregnancy multivitamin/mineral (45.2%, $n = 75$), followed by vitamin D (36.1%, $n = 60$). Of those in the severe category, 38.1% were taking a pregnancy multivitamin/mineral; however, 47.6% had stopped taking it due to sickness symptoms. They were also more likely to stop taking supplemental iron; however, it is not clear what dose the iron supplement was and whether it was prescribed for iron deficiency anaemia. This is similar to the finding in one of the original validation studies for the PUQE questionnaire[13] and is not surprising as iron supplementation is anecdotally noted to cause nausea and may be poorly tolerated during pregnancy.[55] However, it is worth highlighting again, as iron deficiency anaemia is estimated to affect 30.4% of pregnancies in the UK[56] and is significantly associated with adverse maternal and neonatal outcomes.[57] While in the general pregnant population this is concerning, in those with HG when intake from food is lacking, the inability to tolerate particular supplements is critical as it will further compromise nutritional status. This is an important point for healthcare professionals to note and to question whether supplements are actually being taken or whether they have been ceased. It is already known that uptake of folic acid supplementation in the UK is insufficient[58]; therefore finding alternative strategies or formulations to improve micronutrient intake is important in those vulnerable to inadequate nutrition.

LIMITATIONS

There are a number of limitations to consider when interpreting the results of this study. As with all dietary assessment studies, accurate and valid reporting is difficult to ascertain. Verification of actual consumption did not occur and due to the fact that HG is a condition characterised by minimal oral intake, it is not possible to say for certain whether nutritional intake was under- or misreported or is actually representative of true intakes, or whether vomiting of consumed food occurred. However, the use of a mobile phone-based dietary application enabled portion sizes to be accurately visualised, allowing for reduced participant burden and improved tracking of eating occasions.[59] Due to the nature of the data collection methods, a short time lag may exist between reporting of sickness symptoms and dietary intake, as the PUQE24 scale is retrospective, whereas the diet diary phone application is prospectively recorded. However, PUQE24 is a validated score, and it was anticipated that a 3-day food diary would elicit more detailed information than a 24-h recall. Questionnaire data was self-reported and not verified against clinical records. The generalisability of the data may be limited as the population group was skewed towards those from a higher educational level; however, this is typical of research in pregnancy.

Strengths of the study are the relatively high sample size, involvement of a patient group to develop the study materials and use of validated questionnaires.

CONCLUSION

Overall, we demonstrated that those in the severe pregnancy sickness category lost significantly more weight, consumed less than 40% of their energy needs, had deficient intakes of several micronutrients and were more likely to stop taking pregnancy multivitamin and iron supplements. However, nutritional intake in all severity subgroups was suboptimal. Future research should investigate associations between nutrition and perinatal outcomes in HG, and more generally, how to improve nutritional intake across all categories of pregnancy sickness.

AUTHOR CONTRIBUTIONS

K.M. was responsible for study design, data analysis, interpretation and drafting of the manuscript. C.D. and J.S. contributed to study design, writing and reviewing the final version of the manuscript submitted for publication.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICAL APPROVAL

Ethical approval was obtained from the University of Plymouth Faculty of Health Research Ethics and Integrity Committee (Reference 2476).

TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported. The reporting of this work is compliant with STROBE guidelines. The lead author affirms that no

important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

PEER REVIEW

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/jhn.13224.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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