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Nutritional practices and growth of preterm infants in two neonatal units in the UK and Malaysia: a prospective exploratory study

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ABSTRACT

Objective To explore differences in nutritional practices and growth outcomes among preterm infants in neonatal units in Malaysia and the UK.

Design Prospective exploratory study of infants born at <34 weeks gestational age (GA).

Setting Two neonatal units, one in Malaysia and one in the UK (May 2019 to March 2020).

Methods Data collected from birth until discharge and compared between units.

Results From 100 infants included, median GA (IQR) was 31 (30–33) and mean±SD birth weight was 1549±444 g. There were more small-for-gestational age infants in Malaysian unit: 12/50 (24%) vs UK: 3/50 (6%), p=0.012 and more morbidities. More Malaysian infants received breast milk (Malaysia: 49 (98%) vs UK: 38 (76%), p=0.001), fortified breast milk (Malaysia: 43 (86%) vs UK: 13 (26%), p<0.001) and exclusive breast milk at discharge (Malaysia: 26 (52%) vs UK: 16 (32%), p=0.043). There was higher parenteral nutrition use among Malaysian infants (40/50 (80%)) vs UK (19/50 (38%)) (p<0.001) with higher protein intake (mean±SD Malaysia: 3.0±0.5 vs UK: 2.7±0.6 g/kg/d, p=0.004) in weeks 1–4 and smaller cumulative protein deficits (mean±SD Malaysia: 11.4±6.1 vs UK: 15.4±8.0 g/kg, p=0.006). There were no significant differences in short-term growth between units and more than half of the infants in both units had ≥1.28 changes in weight-for-age Z-score at discharge (p=0.841).

Conclusions An exploratory comparison of practices showed differences in patient characteristics and nutritional practices which impacted growth. Future studies with larger sample sizes and detailed analysis of maternal characteristics and infants' outcomes are needed for improving care of preterm infants in all settings.

What is known about the subject?

- There is high rate of postnatal growth failure among preterm infants in neonatal units worldwide.
- Postnatal growth failure in neonatal units in high-income countries is well studied, but in upper-middle-income countries, nutritional practices and growth outcomes are less explored despite rapid advancement in neonatal care.
- Varied nutritional practices such as parenteral nutrition and protein intakes are independent predictors of the growth outcomes of preterm infants at discharge.

What this study adds?

- In this exploratory study, we found that infants in the Malaysian unit were more likely to be small for gestational age and have comorbidities.
- Mother's own milk is more frequently used in the Malaysian unit and more infants received supplementation with breast milk fortifiers.
- More infants in the Malaysian unit received parenteral nutrition, although this may be a response to the greater nutritional needs of small-for-gestational age infants.

INTRODUCTION

Growth is one of the most important outcomes in determining the well-being of a preterm infant,[1] and provision of optimal nutrition is a modifiable independent factor that could facilitate growth.[2] Factors such as clinical traditions and resource limitations in hospitals may influence the adoption of effective feeding practices.[3] Internationally, nutritional recommendations[4 5] have been created and growth studies were evaluated among preterm populations in the UK,[6] USA[7] and other high-income settings.[8] However, there is a paucity of studies in this area among low-income, middle-income and upper-middle-income countries, despite the growing availability of neonatal intensive care in these settings. Malaysia, as an upper-middle income country, has one of the lowest Neonatal Mortality Rates (NMR) in ASEAN countries at 5 per 1000 live births in 2019, in line with its advancement in neonatal care services, which is comparable to the UK's NMR of 3 per 1000 live births.[9] A study on nutritional practices and growth outcomes from a neonatal unit in

Malaysia was last performed in 2011, showing that more than 80% of very low birthweight infants had a >1 SD decline in weight-for-age Z-score (WAZ) by 36 weeks corrected gestational age (GA).[10] This study was over a decade ago and not much research has explored the impact of improvements in neonatal care or considered whether it is feasible to compare nutritional practices in upper-middle-income settings with a higher-income country setting. This exploratory study aimed to describe nutritional practices and postnatal growth outcomes in a neonatal unit in Malaysia, as an upper-middle-income country, as compared with one in the UK.

METHODS

The study was carried out in the neonatal units of the Royal Derby Hospital (RDH), UK and the Hospital Canselor Tuanku Muhriz (HCTM), Malaysia, from May 2019 to March 2020. The UK unit is a local neonatal unit (level II)[11] routinely caring for infants born at >25 weeks GA. More immature infants and those requiring surgical care are transferred to appropriate centres. The Malaysian unit is a tertiary neonatal unit (level IIIb),[12] which also provides surgical support on-site (except for cardiac surgery). In RDH, the neonatal unit has 24 neonatal cots and caters for 6000–7000 birth per year, while in HCTM, its neonatal unit has 26 cots and also caters for approximately 6000 birth per year. With an exception for not providing inhouse surgical support in the UK unit, both units provide similar types of care which comprises of care for the stable to intensive care infants. Both hospitals follow similar discharge criteria including weight of at least 1800 g, not needing any additional medical support and fully milk fed.

Infants <34 weeks' GA who were admitted to either unit were recruited consecutively and followed to discharge until the sample size of 50 was reached at each site. Infants were included if admitted within 24 hours of birth, not transferred out for any part of their care and had length of stay of ≥14 days. Infants with major congenital anomalies, genetic abnormalities or missing records for ≥3 days were excluded. As this was an exploratory study, the sample size was determined based on the usual monthly admissions and length of stay at the respective units. Therefore, collection of data from 50 infants from each unit (total of 100) was deemed to be feasible within the time and resources available for the study.

Anonymised data were extracted from paper or electronic medical records (accessed from BadgerNet (Client V.2.9.1.0) in the UK, and the Caring Hospital Enterprise System in Malaysia).

Baseline and feeding data

Infant and maternal characteristics including sex, GA at birth, maternal age and parity as well as infants' clinical characteristics were collected prospectively. In the Malaysian unit, GA was determined by using early first trimester ultrasound or by estimation based on last menstrual period for those who presented in later pregnancy. In the UK unit, GA was determined by early first trimester ultrasound. These records were retrieved from both paper and electronic medical records. For feeding data, daily nutritional intakes including parenteral nutrition (PN) and enteral nutrition (EN) were recorded. Volume of breast milk intakes was recorded only from bottle feeding (expressed breast milk) as units do not routinely record before and after feeding weight for direct breast feeding. The nutritional content of EN and PN (protein, lipid and carbohydrate content) was calculated based on the manufacturers' literature while the composition of breast milk was based on current evidence.[13] Nutrient deficits were calculated as the difference between actual intake and the minimum intake recommended by The European Society for Paediatric Gastroenterology Hepatology and Nutrition (ESPGHAN) (2010) guidelines.[4]

Similar feeding protocols are used in both units. Generally, minimal enteral feeding (5–15 mL/kg/day) is started within the first 24 hours. The units have guidelines on advancing feeds, promoting the use of mother's milk and the use of breast milk fortification and micronutrient supplementation.

Growth measures

The Fenton growth chart[14] was used as a reference for all growth assessments in both units in determining Z-scores. We used the same charts for both groups to enable a comparison of postnatal growth trajectories. The Fenton chart was chosen for this study for its advantage of using more recent and larger sample of preterm infants' data from many countries which link to the WHO growth data. It is routinely used in the Malaysian unit. In this study, only weight and head circumference (HC) measurements were assessed, as length is not routinely measured in the UK unit.

The marker for growth used in this study is the change in WAZ from birth to discharge which was determined by subtracting the WAZ at birth from the WAZ at discharge. This was used due to the better sensitivity of weight than HC measurements in determining short term growth and Z-score as the best system for the presentation and evaluation of anthropometric data[15] especially in indicating change over time. Postnatal growth failure was defined as a decrease in WAZ between birth and discharge of ≥1.28 as used in previous studies.[16 17] Small-for-GA (SGA) was defined as birth weight <10th centile for birth weight.[18]

Statistical analysis

All statistical analyses were performed using STATA V.16.0 (StataCorp). Descriptive statistics were used to summarise the demographic and clinical characteristics of infants and their mothers. Infants' EN, PN and combined intakes in weeks 1–4 and weeks 5–8 and the cumulative deficits accrued in this period were analysed. Growth outcomes and other variables collected at discharge were also compared. The characteristics of infants and mothers, feeding practices as well as growth outcomes in the UK and Malaysia cohorts were compared using the Student's t-test or Mann-Whitney U test for continuous variables and by χ^2 or Fisher's exact tests for categorical variables, as appropriate. Mean or median difference and 95% CIs were calculated for nutritional intakes and growth outcomes value comparison between sites.

No parental consent was sought as this was a prospective exploratory study using routinely recorded clinical data and this approach received no objection from the Ethics Committee in both study sites.

Patient and public involvement

Patients or the public were not involved in the design, conduct, reporting or distribution plans of our study.

RESULTS

In this study, infants in Malaysia and the UK units were of similar GA, but Malaysian infants were lighter and had a lower WAZ and length-for-age Z-scores at birth although the HC Z-scores were not different (table 1). There were more SGA infants in Malaysia (12/50; 24%) compared with the UK unit (3/50; 6%) (p=0.039). In Malaysia unit, there were fewer multiple births, more morbidities, mothers were older and had had more previous births (table 1).

Enteral feeding

Milk feeding was started on median day of life (DOL) of 2 (p=0.833) in both units. Full milk feeds (defined as 150 mL/kg/day EN with no PN) was reached on median (IQR) DOL 9 (7–12) in Malaysia and DOL 8 (7–10) in the UK, p=0.400 (table 2).

Table 1 Infant and maternal characteristics of infants born at <34 weeks' gestational age and cared for in a neonatal unit in Malaysia and one in the UK

Variables	Infants in the malaysian unit, n=50	Infants in the UK unit, n=50	P value
Female, n (%)	21 (42)	22 (44)	0.84
Gestational age at birth (weeks) median (IQR)	32 (29 to 32)	31 (30 to 33)	0.736
Birth weight (g) mean (SD)	1448 (458)	1649 (409)	0.022
Birth weight-for-age z-score mean (SD)	–0.53 (0.93)	–0.10 (0.70)	0.009
Small for gestational age, n (%)	12 (24)	3 (6)	0.012
HC at birth (cm), mean (SD)	28 (2.68)	28.9 (2.35)	0.106
HC-for-age z-score at birth, median (IQR)	–0.26 (–0.98 to 0.59)	0.06 (–0.57 to 0.59)	0.310
Length at birth (cm) mean (SD)	38.4 (3.65)	41.9 (4.08)	<0.001
Length at birth-for-age z-score mean (SD)	–0.92 (1.05)	0.21 (1.23)	<0.001
Singleton birth, n (%)	45 (90)	34 (68)	0.007
Mother's age (years) mean (SD)	32 (5)	29 (5)	0.009
Parity, median (IQR)	3 (1–4)	0 (0–1)	<0.001
Caesarean section, n (%)	37 (74)	32 (64)	0.280
Apgar score at 5 min, median (IQR)	9 (8–10)	9 (9–9)	0.844
Antenatal steroid use, n (%)	47 (94)	42 (84)	0.194
Received positive pressure ventilation, n (%)	21 (42)	27 (54)	0.230
Late onset sepsis (confirmed)*, n (%)	13 (26)	4 (8)	<0.001
Necrotising enterocolitis (suspected)*, n (%)	6 (12)	3 (6)	0.243
Intraventricular haemorrhage*, n (%)	36 (72)	2 (4)	<0.001
Retinopathy of prematurity*, n (%)	4 (8)	1 (2)	0.181
Periventricular leukomalacia*, n (%)	7 (14)	0	0.006
Chronic lung disease*, n (%)	10 (20)	3 (6)	0.036
Patent ductus arteriosus*, n (%)	16 (32)	6 (12)	0.014

P values for comparisons between the two groups were determined by the Student's t-test or Mann-Whitney U test for continuous variables and by χ^2 or Fisher's exact tests for categorical variables, as appropriate.
*Diagnoses were noted from clinical records: late onset sepsis (culture proven sepsis after 72 hours of birth); necrotising enterocolitis (based on clinical or radiological features that needed at least 5 days of withheld feeding and antibiotics); retinopathy of prematurity (any stage diagnosed on screening examination); periventricular leukomalacia (any lesion reported on cranial ultrasound); chronic lung disease (infants requiring respiratory support including any supplemental oxygen at 36 weeks' corrected gestational age) and patent ductus arteriosus (diagnosed on echocardiography).
HC, head circumference.

Table 2 Feeding practices and nutritional intakes in infants born at <34 weeks' gestational age and cared for in a neonatal unit in Malaysia and one in the UK

Variables, n (%)	Malaysian group, n=50	UK group, n=50	P value
Received any breast milk	49 (98)	38 (76)	0.001
Any breast milk at discharge	46 (92)	25 (50)	<0.001
Exclusively breast milk feeding at discharge	26 (52)	16 (32)	0.043
Received infant formula milk	40 (80)	47 (94)	0.037
Energy proportion (%) from breast milk during admission*	66.5 (40–83)	15.5 (2–82)	0.010
Energy proportion (%) from formula milk during admission†	19.2 (2.2–52.3)	78.8 (12.7–93.9)	<0.001
Day of life at first enteral milk feed*	2 (1–3)	2 (1–2)	0.833
Day of life reaching 120 mL/kg/day feed*	4 (4–5)	5 (4–5)	0.044
Day of life reaching full enteral feed at 150 mL/kg/day*	9 (7–12)	8 (7–10)	0.400
Rate of feeding advancement to full feed*	13 (6–16)	16 (9–20)	0.390
Received breast milk fortifier	43 (86)	13 (26)	<0.001
Day of life at first breast milk fortifier received†	11 (8–16)	15 (10–20)	0.039
Received parenteral nutrition	40 (80)	19 (38)	<0.001
Day of life at first parenteral nutrition*	2 (1–2)	2 (1–2)	0.414
Duration of parenteral nutrition*	9 (6–14)	6 (5–8)	0.031
Energy intake, kcal/kg/day‡			
Weeks 1–4	103 (13)	100 (11)	0.238
Weeks 5–8	110 (18)	115 (15)	0.363
Cumulative energy deficits/excess†, kcal/kg‡			
Weeks 1–4	–191.6 (129.8)	–254.5 (152.0)	0.028
Weeks 5–8	93.2 (237.4)	–93.8 (539.3)	0.105
Protein intake, g/kg/day‡			
Weeks 1–4	3.0 (0.5)	2.7 (0.6)	0.004
Weeks 5–8	3.4 (0.7	3.0 (0.8)	0.088
Cumulative protein deficits/excess†, g/kg‡			
Weeks 1–4	–11.4 (6.1)	–15.4 (8.0)	0.006
Weeks 5–8	–8.7 (11.8)	–24.5 (25.6)	0.005
Protein energy ratio, g/100 kcal/day‡			
Weeks 1–4	2.82 (0.28)	2.61 (0.48)	0.008
Weeks 5–8	3.03 (0.31)	2.57 (0.38)	<0.001
Fat intake, g/kg/day‡			
Weeks 1–4	4.8 (0.7)	4.8 (0.6)	0.627
Weeks 5–8	5.3 (1.0)	5.8 (0.7)	0.058
Carbohydrate intake, g/kg/day‡			
Weeks 1–4	11.4 (1.9)	10.7 (1.4)	0.020
Weeks 5–8	11.9 (2.0)	12.2 (1.7)	0.607
Fluid intake, mL/kg/day‡			
Weeks 1–4	137.1 (12.9)	138.8 (10.9)	0.491
Weeks 5–8	141.4 (22.4)	153.9 (13.9)	0.024

P values for comparisons between the two groups were determined by the Student's t-test or Mann-Whitney U test for continuous variables and by χ^2 or Fisher's exact tests for categorical variables.
*Median (IQR).
†Negative value indicates deficits.
‡Mean (SD).

More infants in Malaysia received any mother's own milk (MOM) during admission (Malaysia: 98% vs UK: 76%, p=0.001) and more infants in the UK received formula milk (Malaysia: 80% vs UK: 94%, p=0.037). Among infants who were fed their MOM, 86% infants had breast milk fortifier (BMF) added on median (IQR) DOL 11[8–16] in Malaysia when they were receiving a median (IQR) milk volume of 154 (149-164) ml/kg/day while

26% infants had BMF added on median (IQR) DOL 15[10–20] at median (IQR) milk volume of 157 (132-167) ml/kg/day, p=0.655 in the UK. At discharge, 52% infants were exclusively breast milk-fed in Malaysia compared with 32% in the UK (p=0.043) (table 2).

Parenteral feeding

Forty (80%) infants received PN in Malaysia compared with 19 (38%) in the UK. PN was started on a median DOL 2 in both units (p=0.414) but was given for an average of 3 days longer in Malaysia than in the UK (median (IQR) days of PN in Malaysia: 9 (6–14) vs UK: 6 (5–8), p=0.031 (table 2).

Nutritional intakes

There was no significant difference in energy intakes in weeks 1–4 between the two units (p=0.238). However, Malaysian infants received more protein (Malaysia: 3.0±0.5 g/kg/day vs UK: 2.7±0.6 g/kg/day, p=0.004) and had smaller cumulative energy and protein deficits over this period, than the UK infants (Malaysia (energy): 191.6±129.8 vs UK: 254.5±152.0 kcal/kg, p=0.028 and Malaysia (protein): 11.4±6.1 vs UK: 15.4±8.0 g/kg, p=0.006). Protein energy ratio was also higher in the Malaysia unit (Malaysia: 3.03±0.31 g/100kcal/day vs UK: 2.61±0.48 g/100kcal/day, p<0.001) (table 2).

For those infants who remained in the hospital in weeks 5–8 of life (Malaysia: n=28, UK: n=23), better energy intakes were shown in both units although energy deficits in the UK cohort persisted. No significant difference in protein intakes was found between units but cumulative protein deficits in Malaysian infants improved while the magnitude of the deficit worsened in UK infants (Malaysia: 8.7±11.8 g/kg vs UK: 24.5±25.6 g/kg, p=0.005). This was despite a significantly lower total fluid intake at weeks 5–8 in the Malaysia unit (median, 141.4 mL/kg/day vs UK unit, 153.9 mL/kg/day) (table 2).

Postnatal growth

There were no significant differences in growth outcomes at discharge between infants from the two units (table 3). WAZ declined by ≥1.28 in 52% and 54% of infants in Malaysia and the UK, respectively. The mean±SD change in WAZ between birth and discharge was similar between the two cohorts (Malaysia: −1.31±0.57; UK: −1.33±0.58; p=0.975) (table 3). For weekly WAZ (figure 1), there was a decreasing trend in mean WAZ from postnatal weeks 1–8 in both the UK and Malaysian unit. Infants in the UK unit had consistently higher mean weekly WAZ than infants in Malaysian unit.

DISCUSSION

In this study, we observed more Malaysian infants received breast milk as compared with UK infants. This is consistent with each countries' national reports[19 20] that record a higher rate of breast feeding among Malaysian infants. The higher rate of breast milk feeding among

Table 3 Postnatal growth measurements in infants born at <34 weeks' gestational age and cared for in a neonatal unit in Malaysia and one in the UK

Variables	Malaysia, n=50	UK, n=50	MD (95% CI)	P value
Days to regain birth weight*	12 (11–14)	13 (10–16)	−1 (−3.17 to 1.17)	0.247
Maximum weight loss from birth weight (%)*	4.4 (1.9–7.5)	5.7 (2.5–9.4)	−1.25 (−3.63 to 1.14)	0.275
Weight (g) at discharge*	2060 (1890–2390)	2165 (2050–2380)	−105 (−252.02 to 42.02)	0.221
Weight Z-score at discharge*	−1.65 (−2.3 to −1.0)	−1.3 (−1.8 to −0.80)	−0.35 (−0.77 to 0.08)	0.088
Changes in weight Z-score from birth to discharge†	−1.31 (0.57)	−1.33 (0.58)	0.01 (−0.22 to 0.23)	0.975
Infants with weight Z- score decrease ≥1.28 from birth to discharge, n (%)	26 (52)	27 (54)	–	0.841
Head circumference at discharge, (cm)†	31.5 (1.61)	31.4 (1.39)	0.34 (−0.29 to 0.98)	0.287
Head circumference Z-score at discharge*	−1.33 (−1.69 to −0.59)	−0.91 (−1.61 to −0.4)	−0.42 (−0.87 to 0.04)	0.383
Gestational age at discharge*	36.5 (35–38)	36 (35–37)	0.50 (−0.53 to 1.52)	0.060
Length of stay (days)*	36 (22–55)	28.5 (20–52)	7.5 (−3.87 to 18.87)	0.157

P values and mean difference (MD) for comparisons between the two groups were determined by the Student's t-test or Mann-Whitney U test for continuous variables and by χ^2 or Fisher's exact tests for categorical variables, as appropriate.
*Median (IQR).
†Mean (SD).

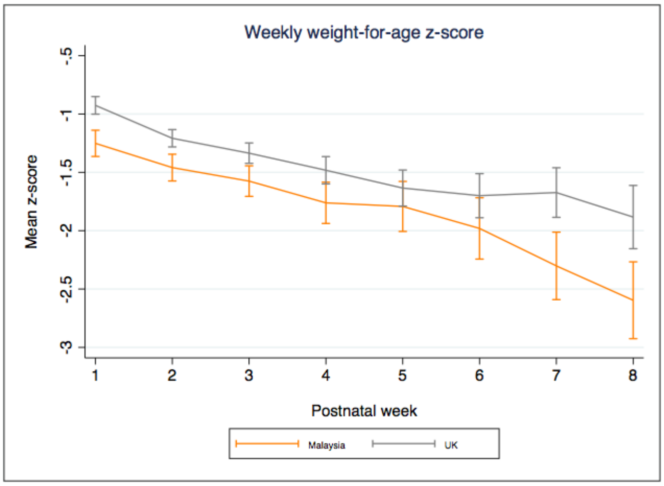

Figure 1 Mean weekly weight-for-age z-score (error bars represent the SE).

Malaysian infants is possibly related to older maternal age and higher parity among mothers, as shown in many studies.[21 22] Experienced mothers may have an easier start to breast feeding and their previous experiences could help with continuation of breast feeding in the unit. Cultural differences in attitudes to breast feeding between the UK and Malaysia, where breast feeding is the norm and the prevalence is increasing[23] may also underlie some of the differences between breastfeeding rates in the two units. The Malaysian unit has an established accreditation as Baby Friendly Hospital,[24] which is favourably related to the high rate of initiation and continuation of breast feeding.[25 26] The UK unit has achieved stage 1 of BFI accreditation and is building towards a stage 2.[27]

Supplementation of breast milk with BMF or protein supplements was more frequent in the Malaysian unit while BMF was used more selectively in the UK unit. The standard protocol recommends the addition of BMF at 75–100 mL/kg/day milk feeds in Malaysian unit while in the UK unit, protocol suggests the addition of BMF when feeding reaches 150–180 mL/kg/day but only at clinician's discretion when there are significant concerns about growth. The majority of infants who were fed breast milk in the Malaysian unit received some fortification, while the majority of infants who received breast milk in the UK unit received some supplemental formula feeding instead. Interestingly, in the Malaysian unit, infants on mixed feeds, that is, who had breast and formula milk, continued fortification if predominantly breast milk fed while most mixed fed infants in the UK unit did not receive BMF.

More Malaysian infants received PN which could be related to more SGA infants and higher rates of co-morbidities in this unit. Although they were given some enteral feeds, they were also started on PN possibly due to anticipation of feed intolerance and slower advancement of milk feeds. PN was used in this scenario possibly, with a view to boost nutrition while milk feeds were established. Additionally, PN support was provided for a longer duration. Infants in the UK unit were larger and less unwell and hence more likely to establish enteral feeding quicker and hence PN use was restricted. However, this study showed no difference between units with reference to the postnatal age when full feeds were established. The more frequent and longer use of PN and BMF resulted in significantly higher protein intake among the Malaysian infants when compared with those in the UK unit.

Despite the high use of formula milk which has more protein than that estimated for breast milk, average protein intakes in the UK unit did not meet the recommended intake of 3.5 g/kg/day. Previous studies showed that protein intakes aimed at >3.5 to 3.8 g/kg/day could decrease cumulative deficits and achieve better growth.[28 29] Fortifying breast milk can increase protein intake although this would also involve cow's milk protein exposure and interfere with exclusive human milk feeding. Additionally, any change to feeding strategies for the individual infant would also, understandably, be a response to infants' clinical conditions which might not be detected in this study.

Despite notable differences in intake, there were no significant differences in the short-term growth at discharge between the units. Throughout admission, the UK infants were observed to have consistently higher weekly weight Z-score than Malaysian infants, although both groups had a decline in growth trajectories. The differences in infant characteristics, possibly birth weight and comorbidities, may explain this. Baseline anthropometric assessment showed that there was a significantly higher proportion of SGA infants in the Malaysian unit. This is possibly due to the centre acting as a referral hospital for high-risk obstetric cases involving mothers with pre-eclampsia, diabetes and fetal growth restriction. In addition, the Fenton growth chart that was used in this study may not represent the Asian population as much as it was constructed based on mostly a Caucasian population,[14] which could also lead to higher SGA infants classified in the Malaysian unit. Studies showed that there were significant deviations in the assessments of growth depending on the growth charts used.[30 31] Infants in the Malaysian unit were also challenged with a higher incidence of comorbidities such as chronic lung disease and patent ductus arteriosus that likely necessitated the restriction of total fluid intake which could affect growth. However, any interpretation for 'optimal growth' outcome should explore factors other than weight only, including longer-term growth, neurodevelopmental and metabolic outcomes in later life. Studies show that preterm infants fed mainly breast milk have better long-term outcome despite slower weight gain in early life.[32 33]

The strengths of this study are that it is the first attempt to explore comparison of nutritional practices between two centres in different settings. Prospective collection of details of daily actual nutritional intake and weekly growth allowed a comprehensive analysis of nutritional practices. However, as this is an exploratory study, the sample size was small and not powered for differences in outcomes. A larger sample size is needed for evaluating the reasons for the differences observed in this study affecting growth failure. Estimation of nutritional intakes in breastfed infants cannot be accurate as intakes were analysed by using the best available estimates[13] and may not reflect the true nutritional composition of the milk received. Maternal details including her nutritional status, clinical conditions and antenatal care should also be considered as these are vital determinants of fetal nutrition and infants' outcomes including SGA status.[34]

Despite these limitations, studies comparing nutritional intakes and growth outcomes are feasible to do in these two countries. Malaysia is an upper-middle-income country with similar government-funded healthcare system and NMR as the UK. The nutritional protocols used in these two units were based on the similar international guideline but were applied differently perhaps due to differences in patient characteristics and cultural differences making such comparisons an interesting area of study. Studies with an adequately powered sample, collection of more data on maternal characteristics and infants' longer-term outcomes and the use of a more representative growth chart would provide evidence to ensure that preterm infants receive adequate nutrition, hopefully, in all care settings globally.

CONCLUSION

In our exploratory analyses, there were variations in nutritional practices between the two units included in this study. Current nutritional practices often do not meet recommended intakes, especially for protein in preterm infants. We found that with international collaboration, future comparison studies involving units in varied income settings are feasible and may provide evidence to support equity in care of preterm infants.

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Contributors HAH, SO, LS, HB and F-CC conceptualised and designed the study and reviewed and revised the manuscript. HAH performed the data collection in the UK unit, completed the data analysis in both units and drafted the initial manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Patient consent for publication Not required.

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REFERENCES

1 Young A, Andrews ET, Ashton JJ, *et al*. Generating longitudinal growth charts from preterm infants fed to current recommendations. *Arch Dis Child Fetal Neonatal Ed* 2020;105:646–51.
2 Stoltz Sjöström E, Öhlund I, Ahlsson F, *et al*. Nutrient intakes independently affect growth in extremely preterm infants: results from a population-based study. *Acta Paediatr* 2013;102:1067–74.
3 de Waard M, Li Y, Zhu Y. Time to full enteral feeding for very low-birth-weight infants varies markedly among hospitals worldwide but may not be associated with incidence of necrotizing enterocolitis: the NEOMUNE-NeoNutriNet cohort study. *J Parenter Enter Nutr* 2018.
4 Agostoni C, Buonocore G, Carnielli VP, *et al*. Enteral nutrient supply for preterm infants: commentary from the European Society of paediatric gastroenterology, hepatology and nutrition committee on nutrition. *J Pediatr Gastroenterol Nutr* 2010;50:85–91.
5 Koletzko B, Poindexter B, Uauy R. *Nutrition of the preterm infant: scientific basis and practical guidelines*. Basel: Karger, 2014.
6 Andrews ET, Ashton JJ, Pearson F. Early postnatal growth failure in preterm infants is not inevitable. *Arch Dis Child Fetal Neonatal Ed* 2018:10–12.
7 Horbar JD, Ehrenkranz RA, Badger GJ, *et al*. Weight growth velocity and postnatal growth failure in infants 501 to 1500 Grams: 2000-2013. *Pediatrics* 2015;136:e84–92.
8 Cormack BE, Jiang Y, Harding JE, *et al*. Relationships between neonatal nutrition and growth to 36 weeks' corrected age in ELBW babies–secondary cohort analysis from the provide trial. *Nutrients* 2020;12:760.
9 UNICEF. UNICEF data warehouse [online], 2019. Available: https://data.unicef.org/resources/data_explorer/unicef_f/?ag=UNICEF&df=GLOBAL_DATAFLOW&ver=1.0&dq=GBR.CME_MRM0.&startPeriod=1970&endPeriod=2021
10 Lee LY, Lee J, Niduvaje K, *et al*. Nutritional therapies in the neonatal intensive care unit and post-natal growth outcomes of preterm very low birthweight Asian infants. *J Paediatr Child Health* 2020;56:400–7.
11 British Association of Perinatal Medicine (BAPM). *Service standards for hospitals providing neonatal care [online]*. 3rd edn, 2010. http://www.bapm.org/publications/documents/guidelines/BAPM_Standards_Final_Au g2010.pdf
12 Ministry of Health Malaysia. *The operational policy for paediatric services. He medical services development section*, 2012.
13 Gidrewicz DA, Fenton TR. A systematic review and meta-analysis of the nutrient content of preterm and term breast milk. *BMC Pediatr* 2014;14:216.
14 Fenton TR, Kim JH. A systematic review and meta-analysis to revise the Fenton growth chart for preterm infants. *BMC Pediatr* 2013;13:59.
15 Geneva: World Health Organization. *Physical status: the use and interpretation of anthropometry. Report of a WHO expert committee. WHO technical report series No. 854*, 1995.
16 Lin Z, Green RS, Chen S, *et al*. Quantification of EUGR as a measure of the quality of nutritional care of premature infants. *PLoS One* 2015;10:e0132584.
17 Lee SM, Kim N, Namgung R, *et al*. Prediction of postnatal growth failure among very low birth weight infants. *Sci Rep* 2018;8:1–8.
18 Darmaun D, Lapillonne A, Simeoni U, *et al*. Parenteral nutrition for preterm infants: issues and strategy. *Arch Pediatr* 2018;25:286–94.
19 Institute for Public Health. *The National Health and Morbidity Survey (NHMS) 2016 [online]*. Kuala Lampur: Institute for Public Health, National Institutes of Health, Ministry of Health Malaysia, 2016. http://iku.moh.gov.my/images/IKU/Document/REPORT/2016/NHMS2016ReportVolumeII-MaternalChildHealthFindingsv2.pdf
20 NHS Maternity Statistics, England 2017-18. Maternity and breastfeeding [online]. Available: https://www.england.nhs.uk/statistics/statistical-work-areas/maternity-and-breastfeeding/

21 Casey PH, Whiteside-Mansell L, Barrett K, *et al*. Impact of prenatal and/or postnatal growth problems in low birth weight preterm infants on school-age outcomes: an 8-year longitudinal evaluation. *Pediatrics* 2006;118:1078–86.
22 Bonnet C, Blondel B, Piedvache A, *et al*. Low breastfeeding continuation to 6 months for very preterm infants: A E uropean multiregional cohort study. *Matern Child Nutr* 2019;15 https://onlinelibrary.wiley.com/doi/abs/
23 Fatimah S, Siti Saadiah HN, Tahir A, *et al*. Breastfeeding in Malaysia: results of the third National health and morbidity survey (NHMS III) 2006. *Malays J Nutr* 2010;16:195–206.
24 Ministry of Health Malaysia. National breastfeeding policy 2005 [online], 2005. Available: http://nutrition.moh.gov.my/wp-content/uploads/penerbitan/poster/polisi%20penyusuan%20ibu.jpg
25 Spaeth A, Zemp E, Merten S, *et al*. Baby-friendly hospital designation has a sustained impact on continued breastfeeding. *Matern Child Nutr* 2018;14:e12497.
26 Broadfoot M, Britten J, Tappin DM, *et al*. The baby friendly hospital initiative and breast feeding rates in Scotland. *Arch Dis Child Fetal Neonatal Ed* 2005;90:F114–6.
27 UNICEF UK. Accreditation [online], 2019. Available: https://www.unicef.org.uk/babyfriendly/accreditation/
28 Senterre T, Rigo J. Reduction in postnatal cumulative nutritional deficit and improvement of growth in extremely preterm infants. *Acta Paediatr* 2012;101:e64–70.
29 Embleton NE, Pang N, Cooke RJ. Postnatal malnutrition and growth retardation: an inevitable consequence of current recommendations in preterm infants? *Pediatrics* 2001;107:270–3.
30 Kim Y-J, Shin SH, Cho H, *et al*. Extrauterine growth restriction in extremely preterm infants based on the Intergrowth-21st project preterm postnatal follow-up study growth charts and the Fenton growth charts. *Eur J Pediatr* 2021;180:817–24.
31 Neubauer V, Fuchs T, Griesmaier E, *et al*. Comparing growth charts demonstrated significant deviations between the interpretation of postnatal growth patterns in very preterm infants. *Acta Paediatr* 2016;105:268–73.
32 Rozé J-C, Darmaun D, Boquien C-Y, *et al*. The apparent breastfeeding paradox in very preterm infants: relationship between breast feeding, early weight gain and neurodevelopment based on results from two cohorts, EPIPAGE and LIFT. *BMJ Open* 2012;2:e000834.
33 Vohr BR, Poindexter BB, Dusick AM, *et al*. Persistent beneficial effects of breast milk ingested in the neonatal intensive care unit on outcomes of extremely low birth weight infants at 30 months of age. *Pediatrics* 2007;120:e953–9.
34 McCowan L, Roberts C, Dekker G, *et al*. Risk factors for small-for-gestational-age infants by customised birthweight centiles: data from an international prospective cohort study: risk factors for SGA infants by customised centiles. *BJOG Int J Obstet Gynaecol* 2010;117:1599–607.