British Journal of Nutrition (2019), 121, 1413–1423 doi:10.1017/S0007114519000758

Nutrition in transition: historical cohort analysis summarising trends in under- and over-nutrition among pregnant women in a marginalised population along the Thailand–Myanmar border from 1986 to 2016

Ahmar H. Hashmi[1,2*†], Nicola Solomon[3†], Sue J. Lee[4,5], Aung Myat Min[1], Mary Ellen Gilder[1], Jacher Wiladphaingern[1], Nay Win Tun[1], Emma Plugge[5], Kremlin Wickramasinghe[6], Chaisiri Angkurawaranon[2], Prakaykaew Charunwatthana[4], François Nosten[1,5], Verena I. Carrara[1,7] and Rose McGready[1,5*]

[1]*Shoklo Malaria Research Unit, Mahidol-Oxford Tropical Medicine Research Unit, Faculty of Tropical Medicine, Mahidol University, Mae Sot 63110, Thailand*
[2]*Department of Family Medicine, Faculty of Medicine, Chiang Mai University, Chiang Mai 50200, Thailand*
[3]*Department of Obstetrics and Gynaecology, St. Mary's Hospital, Central Manchester NHS Foundation Trust, Oxford Road, Manchester M13 9WL, UK*
[4]*Mahidol-Oxford Tropical Medicine Research Unit, Faculty of Tropical Medicine, Mahidol University, Bangkok 10400, Thailand*
[5]*Nuffield Department of Medicine, Centre for Tropical Medicine and Global Health, University of Oxford, Oxford OX3 7FZ, UK*
[6]*Nuffield Department of Population Medicine, University of Oxford, Oxford OX3 7LF, UK*
[7]*Department of Medicine, Swiss Tropical and Public Health Institute, 4002 Basel, Switzerland*

(Submitted 1 August 2018 – Final revision received 9 March 2019 – Accepted 20 March 2019 – First published online 26 June 2019)

Abstract

The objective of the present study is to summarise trends in under- and over-nutrition in pregnant women on the Thailand–Myanmar border. Refugees contributed data from 1986 to 2016 and migrants from 1999 to 2016 for weight at first antenatal consultation. BMI and gestational weight gain (GWG) data were available during 2004–2016 when height was routinely measured. Risk factors for low and high BMI were analysed for $<18{\cdot}5$ kg/m^2 or ≥ 23 kg/m^2, respectively. A total of 48 062 pregnancies over 30 years were available for weight analysis and 14 646 pregnancies over 13 years (2004–2016) had BMI measured in first trimester (<14 weeks' gestational age). Mean weight at first antenatal consultation in any trimester increased over the 30-year period by 2·0 to 5·2 kg for all women. First trimester BMI has been increasing on average by 0·5 kg/m^2 for refugees and 0·6 kg/m^2 for migrants, every 5 years. The proportion of women with low BMI in the first trimester decreased from 16·7 to 12·7 % for refugees and 23·1 to 20·2 % for migrants, whereas high BMI increased markedly from 16·9 to 33·2 % for refugees and 12·3 to 28·4 % for migrants. Multivariate analysis demonstrated low BMI as positively associated with being Burman, Muslim, primigravid, having malaria during pregnancy and smoking, and negatively associated with refugee as opposed to migrant status. High BMI was positively associated with being Muslim and literate, and negatively associated with age, primigravida, malaria, anaemia and smoking. Mean GWG was 10·0 (SD 3·4), 9·5 (SD 3·6) and 8·3 (SD 4·3) kg, for low, normal and high WHO BMI categories for Asians, respectively.

Key words: Maternal nutrition: Myanmar: Social marginalisation: Under-nutrition: Over-nutrition

Low- and middle-income countries (LMIC) face a dual epidemic of under- and over-nutrition in women of reproductive age. This has a direct impact on the immediate outcome for the mother and newborn, and long-term effects on the child through to adulthood[1–3]. In the context of this nutrition transition, the new trends in over-nutrition have been linked to greater access to and consumption of energy-dense diets high in fats, tobacco use and increasingly

Abbreviations: ANC, antenatal care; AOR, adjusted OR; EGA, estimated gestational age; GWG, gestational weight gain; LMIC, low- and middle-income countries; SMRU, Shoklo Malaria Research Unit.

* **Corresponding authors:** Rose McGready, email rose@shoklo-unit.com; Ahmar H. Hashmi, email ahmar.hashmi715@gmail.com

† Shared first co-authors.

sedentary lifestyles[4–6]. Persistent problems with under-nutrition are now exacerbated by a rapid rise in overweight and obesity and concomitant rise in diet-related chronic disease[1,5,7].

These problems are particularly felt in Asian populations that are at increased risk of diet-related non-communicable disease (CVD, stroke, hypertension and diabetes) for similar measures of nutritional status compared with Western populations[7–9]. Globally, and increasingly within Asia, trends in BMI and gestational weight gain (GWG) are important determinants of disease related to nutrition in pregnancy: overweight and excessive GWG can lead to gestational hypertension, gestational diabetes and macrosomia complicating delivery, while being underweight in pregnancy is associated with pre-eclampsia, intra-uterine growth restriction and low infant birth weight[10–16]. Furthermore, we continue to learn how the nutritional status of the mother and its relation to the intra-uterine environment leads to intergenerational, long-term effects on non-communicable disease incidence in adulthood, perpetuating a cycle of risk[1,17].

The nutrition transition and epidemiological shift from infectious diseases such as malaria to a larger burden of diet-related non-communicable disease – a new development over the past 20 years – is well underway in Asia, including places such as Thailand[4,8,18–20]. A 2011 study showed that 40·0 % of reproductive age women are estimated to be overweight and 11·1 % obese in Thailand, with women in neighbouring Myanmar approaching 47·0 % overweight and 11·3 % obese – likely underestimates as the BMI categories used were not adjusted for Asian populations[5].

Although the nutrition transition is well underway in LMIC settings, there remains a paucity of data documenting trends in nutritional status of marginalised populations in these contexts, particularly for pregnant refugee and migrant women. Most of the published data on these populations come from refugee and migrant populations resettled in high-income countries[21,22]. With a growing global need to address the health of refugees, displaced persons and migrant communities in both LMIC and high-income countries, we examine changes in nutritional status among pregnant women from the Thailand–Myanmar border: in the setting of a protracted refugee situation and among a large and growing migrant worker population from Myanmar. The objective of this manuscript is to describe trends in over- and under-nutrition using weight (1986–2016) and BMI at first antenatal presentation (2004–2016) and GWG (2004–2016) in these marginalised populations.

Methods

A brief history of the Shoklo Malaria Research Unit and populations along the Thailand–Myanmar border

Refugee populations. Mass movement of persons from Myanmar began in 1984 as ‘persons fleeing fighting’ amassing in informal shelters along the border region were permitted entry into neighbouring Thailand through formalised ‘temporary shelters’[23]. The Border Consortium, tasked with providing basic services to refugees along the border, documented a peak in this population at 165 901 in 2006, housed in ten temporary shelters within Thailand[24]. The Shoklo Malaria Research Unit (SMRU) began work in the Shoklo refugee camp in 1986, which was closed in 1998 and amalgamated to Mae La refugee camp where it is currently the most populous of the remaining nine refugee camps. As of December 2016, the Border Consortium aided 37 518 persons living in Mae La[25]. More than 90 % of the refugee pregnant population in Mae La received antenatal care (ANC) services at the SMRU clinic and more than 75 % of women delivered at the SMRU birth centre[26–28].

Karen are the predominant ethnic groups[24,28], comprised primarily of Sgaw and Pwo Karen, and religious affiliations are predominantly Buddhist or Christian, but with a significant proportion of Muslims, who also generally self-report their ethnicity as ‘Muslim’. Literacy rates among the pregnant women in Mae La camp have remained stable around 50 %[29]. Refugees from Myanmar have historically had poor access to maternal health services; however, once in Thailand refugees have access to food assistance and medical services within refugee camps but are barred from work[30–32].

Migrant populations. Informal networks of low-skilled, migrant labour developed along the Thailand–Myanmar border in the context of persistent economic hardship within Myanmar coupled with lax labour law enforcement in neighbouring Thailand[23]. Migrants have limited access to health services within Thailand[23,31–33]. In the face of a growing migrant population with a significant burden of malaria, SMRU began ANC for migrants in Maw Ker Thai village in 1998, south of SMRU headquarters in Mae Sot, and subsequently in the north in Wang Pha village in 2004 (Fig. 1).

As of December 2009, the Thailand Ministry of Interior counted nearly 1·1 million registered migrant workers from Myanmar, of which 45 % were women. SMRU estimates that its clinics serve a catchment of approximately 200 000 migrants that has remained relatively stable since the late 1990s[34]. The predominant ethnic groups among migrants are Burman and Karen (Sgaw and Pwo). They are predominantly Buddhist. Approximately 45 % of migrant women presenting for ANC are literate[29].

Shoklo Malaria Research Unit antenatal care and labour and delivery services. Home birth with traditional birth attendants remained widely practised in the refugee camps when SMRU began its ANC and obstetric programme, with SMRU promoting facility-based deliveries with trained midwives beginning in 1994[35]. Ultrasound was introduced in 2001 using Dynamic Imaging, Fukuda Denshi UF 4100 (since 2002) and Toshiba Powervision 7000 machine (Toshiba, Tokyo, Japan since 2006), all with a 3·75-MHz convex probe, with all women routinely offered two scans. The booking visit scan (between 8 and 14 weeks’ gestation) calculates estimated gestational age (EGA) by crown–rump length measurement using the British ultrasound guidelines and with regular quality control in place[36,37]. Labour and delivery wards were established in Wang Pha in 2008 and Maw Ker Thai in 2010. SMRU’s entire operation has grown to include locally trained medical assistants, nurses, midwives, sonographers, laboratory technicians, home-visitors and a small number of expatriate doctors, about half of whom are from Myanmar[35].

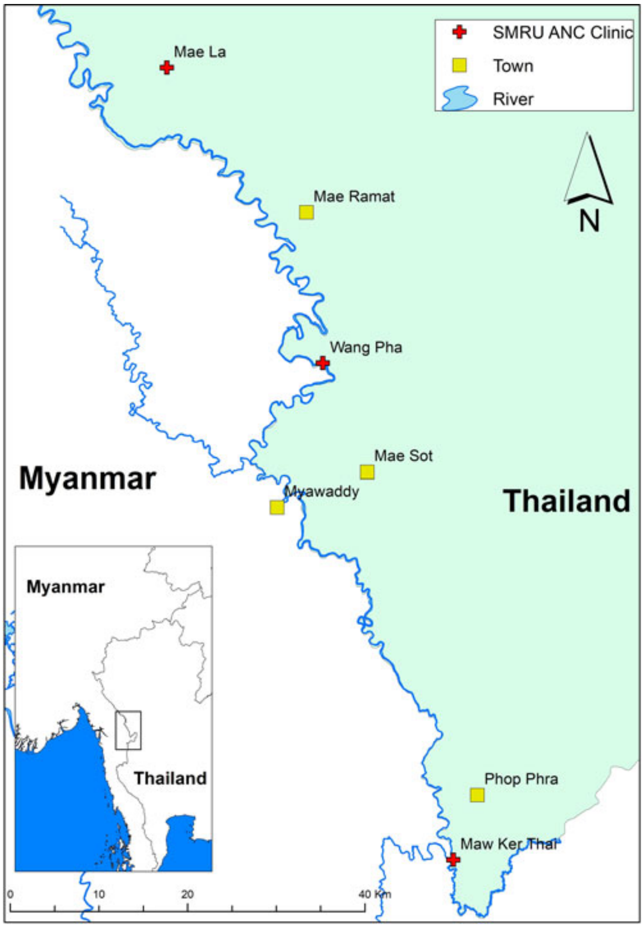

Fig. 1. Map of Thailand–Myanmar border showing locations of Shoklo Malaria Research Unit (SMRU) antenatal care (ANC) clinic sites. Includes active sites as of December 2016 (Mae La, Wang Pha, Maw Ker Thai). Credit to Myochit Min.

Study design

Anonymous digital clinical records were available from a historical cohort of 72 622 pregnant women presenting to SMRU ANC between January 1986 and December 2016. A series of analyses were performed to assess: weight at first ANC, BMI in the first trimester (<14 weeks' gestation) and GWG. We included women with appropriate EGA and delivery of live, term (37–41 completed weeks), congenitally normal, singleton newborns. All analyses excluded women with spontaneous abortions, lost to follow-up before pregnancy outcome was known and inaccurate EGA or weight measurements. BMI analysis included only those women with weight and height measurements at first ANC visit. GWG analysis included women with last weight measured between 34 and 41 completed weeks and Karen (Sgaw and Pwo Karen) and Burman ethnicity.

Variables available for analysis

Anthropometric variables. Trained midwives measured weight at first ANC consultation and at each follow-up visit by mechanical scale with 0·5 kg precision on Salter medical grade scales. Maternal weight at delivery was defined as the last weight taken between 34 + 0 and 41 + 6 weeks of gestation. Standing mechanical scales were available at the main clinic, but weight scales purchased locally in 2002 and 2003 were excluded from this analysis as they gave significantly higher weights (2–3 kg) compared with other years included in this analysis.

Height measurement at first ANC was introduced in 2004 using a portable, mechanical stadiometer with 0·5 cm precision, with newer digital, stationary stadiometers allowing for precision up to 1 mm since 2010, using the SECA brand. Both weight and height measurements were taken according to standard procedures[38].

BMI was calculated when both weight and height measurements were available, beginning in 2004. BMI for this analysis was categorised as defined by the WHO expert consultation on Asian populations: low (BMI <18·5 kg/m^2), normal (BMI 18·5–22·9 kg/m^2) and high (BMI ≥ 23 kg/m^2)[8]. Height and weight measurements from the first ANC visit for the first trimester were used to calculate BMI and categorise each woman. It has been shown that first trimester weight as a proxy for pre-pregnancy weight is accurate in up to 95 % of pregnant women[39].

GWG was summarised in this cohort and compared with the Institute of Medicine recommendations for pre-pregnancy BMI and GWG[40]. In addition, BMI and GWG in this cohort were also compared with a cohort of healthy pregnant Asian women in Vietnam using Asian WHO criteria, as this population was considered similar to the population analysed here[15].

Estimation of gestational age. Different techniques were used to calculate EGA over the course of this historical cohort. Fundal height was used until 1992, followed by the Dubowitz method of neonatal assessment. Beginning in 2001, ultrasound became the preferred method of calculating EGA, with Dubowitz used for those women without a reliable dating ultrasound (e.g. late ANC attenders)[28,37,41]. The variation in EGA between these methods in this population is minimal[42].

Demographic, malaria and haematocrit variables. Available demographic variables collected at first ANC were: length of residency at current address, refugee or migrant status, age, gravidity and parity. In 1999, self-report of smoking status (cigarettes or cheroots) was added as a dichotomous variable. Beginning in 2010, women self-reported literacy as 'able to read' and 'able to write'. Clinical data included malaria infection (any species) and anaemia (haematocrit less than 30 %) at first ANC visit.

Statistical analysis

Descriptive statistics were performed according to data type (continuous or categorical) and distribution (normal or skewed). Univariate analysis determined associations between demographic variables and nutritional status indicators. Proportions were calculated as the number of refugee or migrant women with low, normal or high BMI that year, over the total number of refugee or migrant women with a BMI measurement in the first trimester that year. Patterns over time (unit = 1 year) were assessed using a non-parametric test for trend for ordered groups (an extension of the Wilcoxon rank-sum test) or using a

British Journal of Nutrition

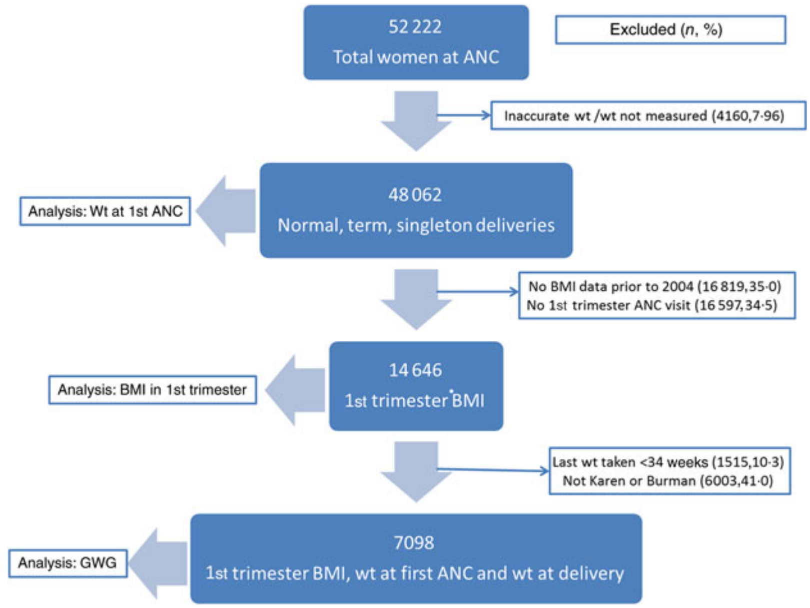

Fig. 2. Study flow. ANC, antenatal care; GWG, gestational weight gain; wt, weight.

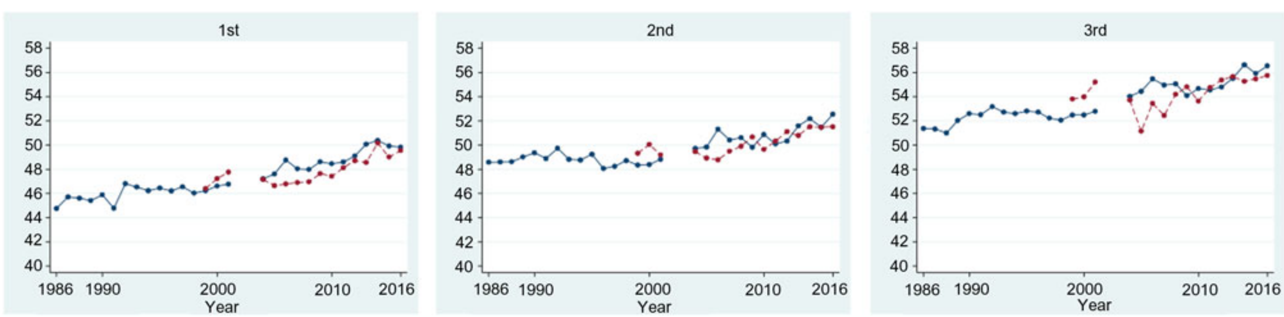

Fig. 3. Mean weight of refugee (blue, —) and migrant (red, - - -) women, by trimester of first antenatal care presentation. Note: 2002–2003 data excluded due to inaccuracy in weight assessment. For a colour figure, see the online version of the paper.

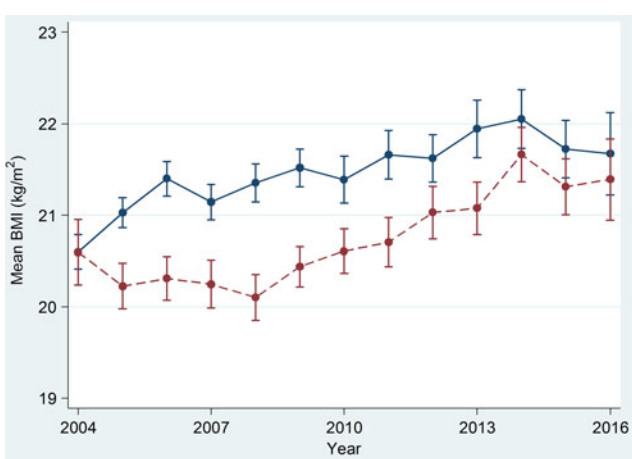

Fig. 4. Mean BMI in first trimester among pregnant refugees (blue, —) and migrants (red, - - -). For a colour figure, see the online version of the paper.

1-df test for trend. Average changes in weight or BMI per 5-year intervals were estimated using linear regression. Comparisons were made using the normal BMI group as the reference group against the low or high BMI group. To identify significant predictors of low or high BMI, factors significant on univariate analysis ($P < 0{\cdot}05$) were included in multivariate logistic regression models: age (<20 years), length of residence (months), ethnicity (Karen, Muslim, Burman or others), refugee or migrant status, parity (gravidity 1 and parity 0 *v.* all others), malaria infection at any time during pregnancy, anaemia (yes/no), smoking status (yes/no) and literacy (can read or not). Associations were quantified as adjusted OR (AOR) with 95 % CI. Data were analysed using STATA, version 14.2 (StataCorp).

Ethical standards

The present study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects/patients were approved by the Oxford Tropical Research Ethics Committee (OXTREC 28–09, amended 19 April 2012). Written informed consent was obtained from all subjects. This research also received ethical approval from the Tak Province Community Advisory Board, Thailand (reference: TCAB-9/2/2015).

British Journal of Nutrition

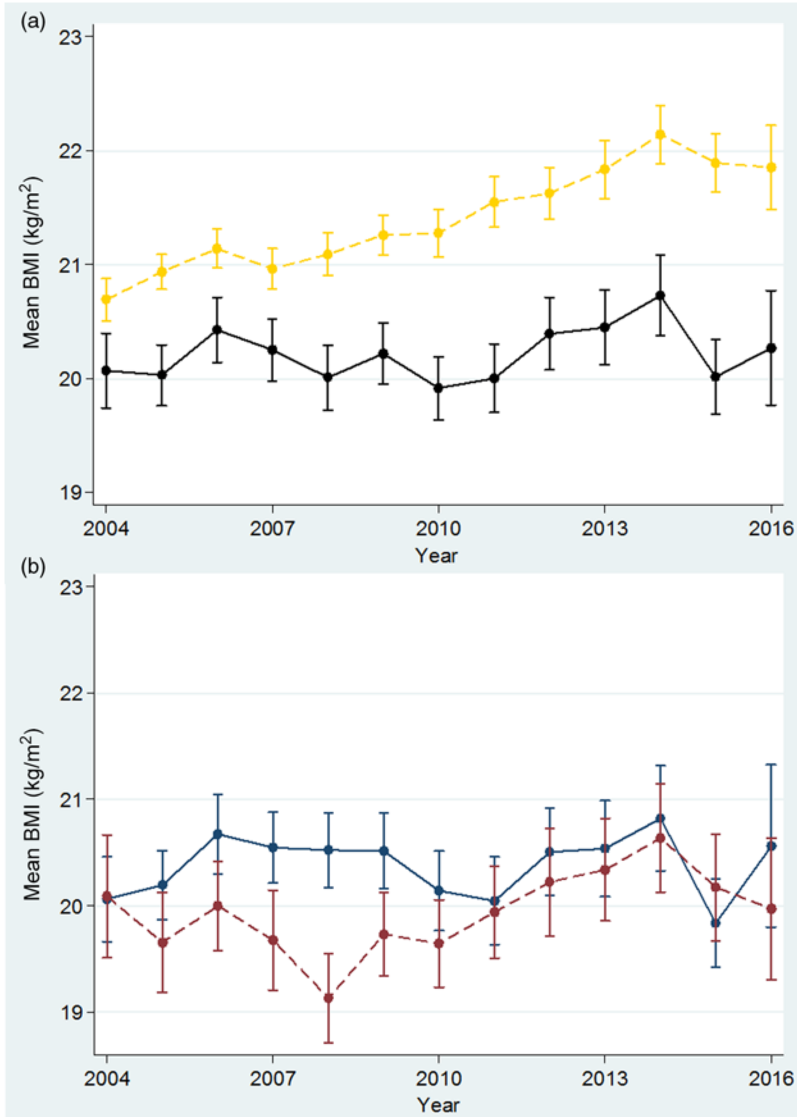

Fig. 5. Mean BMI in first trimester among adult (≥20 years) and teenage (<20 years) women. (a) Adults: yellow, - - -; teens: black, —. (b) Refugee teens: blue, —; migrant teens: red, - - -. For a colour figure, see the online version of the paper.

Results

A total of 52 222 pregnant women had known gestational age and delivered a singleton, term, live newborn. There were 4160 (8·0 %) women excluded: 3341 with inaccurate weight measurements from 2002 to 2003 and 819 for whom first trimester weight was not measured. Of the 48 062 women included in the analysis, 32 507 (67·6 %) were refugees and 15 555 (32·4 %) migrants (Fig. 2).

Weight at first antenatal care visit

Among women with first ANC weight available, the proportion of first ANC visits was highest in the first trimester (*n* 21 155, 44·0 %), followed by the second (*n* 19 307, 40·2 %) and third (*n* 7600, 15·8 %) trimesters. The difference in mean weight at first ANC visit increased over the 30-year study period (1986–2016) in refugees for first, second and third trimester by: 5·1 (SE 2·2), 4·0 (SE 1·2) and 5·2 (SE 1·8) kg; and over the 18-year period (1998–2016) in migrants by: 3·2 (SE 1·0), 2·2 (SE 1·0) and 2·0 (SE 1·3) kg (significant for trend $P < 0·001$, all six groups) (Fig. 3). Every 5 years, weight at first ANC visit increased by an average of 0·9 kg in refugees who presented in the first trimester (95 % CI 0·81, 0·99), by 0·5 kg (95 % CI 0·47, 0·62) and by 0·8 kg (95 % CI 0·65, 0·90) for those who first presented in the second and third trimesters. Trends were similar in migrants with an average increase every 5 years in women presenting in first, second or third trimesters of: 1·0 kg (95 % CI 0·79, 1·26), 0·90 kg (95 % CI 0·67, 1·12) and 0·90 kg (95 % CI 0·52, 1·28), respectively.

Mean BMI

For BMI data (*n* 31 243 women) from 2004 onwards, the proportion of first ANC visits was also highest in the first trimester (14 646, 46·9 %), followed by the second (11 537, 36·9 %) and

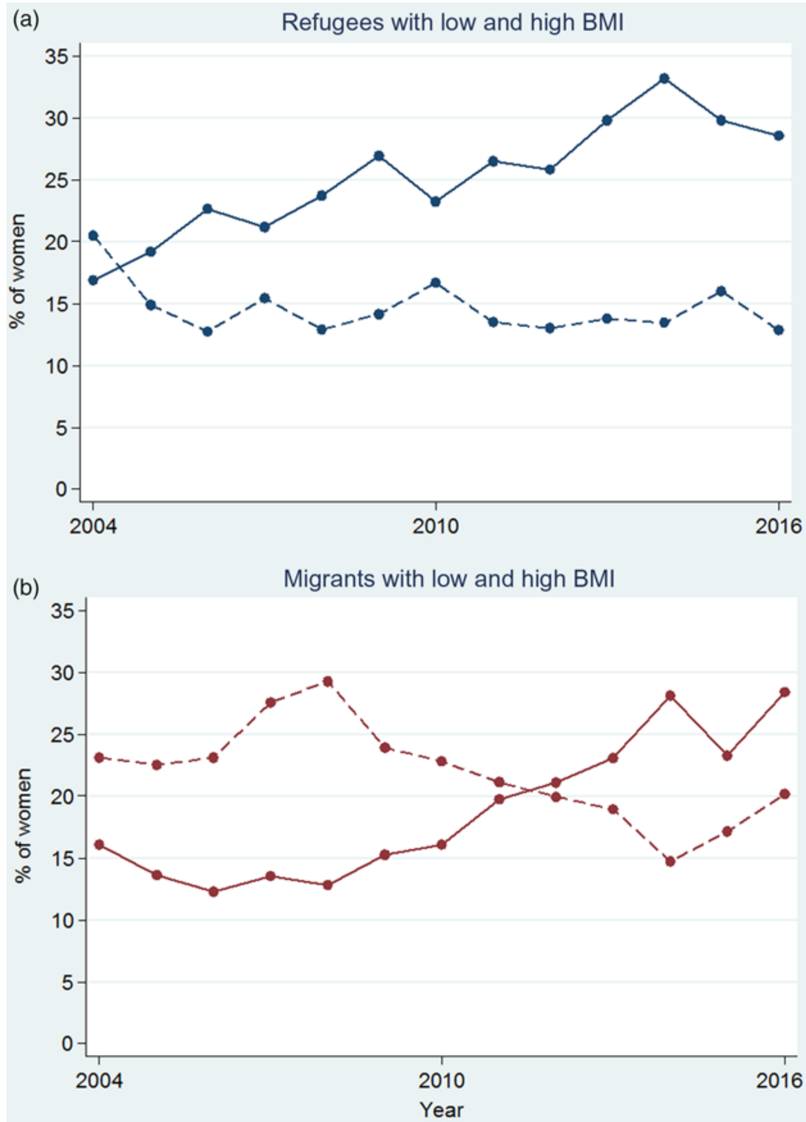

Fig. 6. Proportion of low (- - -) and high (—) BMI for refugee (a) and migrant (b) women presenting at first antenatal care visit in the first trimester. For a colour figure, see the online version of the paper.

third trimesters (5060, 16·2 %). BMI data were analysed for 9022 (61·6 %) refugees and 5624 (38·4 %) migrants who presented in the first trimester. Mean first trimester BMI (*n* 14 646) showed a similarly increasing trend over the years for both refugees and migrants ($P < 0{\cdot}001$, for both) (Fig. 4). First trimester BMI increased by an average of 0·5 kg/m^2 (95 % CI 0·38, 0·57) for refugees and 0·6 kg/m^2 (95 % CI 0·50, 0·72) for migrants every 5 years over the 13-year period.

From 2004 to 2016, the mean BMI increased significantly in adults (*n* 12 070, $P < 0{\cdot}001$) but not in teenagers (<20 years) (*n* 2576, $P = 0{\cdot}256$), whose BMI was lower than in adults and showed minimal variation from 2004 to 2016 (Fig. 5(a)). Amongst teenagers (1543 refugees and 1033 migrants), the mean BMI (Fig. 5(b)) fluctuated around 20 kg/m^2, demonstrating a significant increase for migrants ($P = 0{\cdot}006$) but not for refugees ($P = 0{\cdot}936$).

Comparisons of low, normal and high BMI

Overall, there were 17·5 % (2568), 60·6 % (8870) and 21·9 % (3208) of women in the Asian BMI categories of low, normal and high BMI, respectively. The proportion of women with low BMI decreased over time in both refugees and migrants (Fig. 6). Although there was an overall decreasing trend in the proportion of refugee women with low BMI ($P = 0{\cdot}020$), it appeared to be driven by a peak in low BMI in 2004 (Fig. 6(a)). From 2005 to 2016, the proportion of refugee women with low BMI varied from 16·7 % to 12·7 %, with no discernible increasing or decreasing trend ($P = 0{\cdot}945$). The proportion of migrant women with low BMI decreased from 23·1 % to 20·2 % ($P < 0{\cdot}001$, trend from 2004 to 2016). In both refugees and migrants, there was a 2-fold increase in the proportion of pregnant women with high BMI in the first trimester in 13 years: from

Table 1. Maternal characteristics and association with low and high BMI (normal BMI as referent) for a total of 14 646 pregnant women from 2004 to 2016 (Numbers of participants and percentages; medians and interquartile ranges (IQR))

	Normal			Low				High			
Characteristic	*N*	*n*	%	*N*	*n*	%	*P*	*N*	*n*	%	*P*
Age (years)	8870			2568			0·002	3208			<0·001
Median		25			24				28		
IQR		20, 30			20, 29				23, 33		
Age < 20 years	8870	1780	20·1	2568	554	21·2	0·198	3208	252	7·86	<0·001
Length of residence (months)	3861			1133			<0·001	1663			<0·002
Median		60			48				72		
IQR		24, 120			24, 120				36, 144		
Ethnicity	6416			1823			<0·001, 3 df	2541			<0·001, 3 df
Karen		4782	74·5		1184	65·0			1765	69·5	
Muslim		445	6·94		153	8·39			331	13·0	
Burman		940	14·7		406	22·3			354	13·9	
Other		249	3·88		80	4·39			91	3·58	
Status	8870			2568			<0·001	3208			<0·001
Refugee		5513	62·2		1332	51·9			2177	67·9	
Migrant		3357	37·9		1236	48·1			1031	32·1	
Primigravid	8870	2754	31·1	2568	862	33·6	0·017	3208	564	17·6	<0·001
Malaria	8869	322	3·63	2567	146	5·69	<0·001	3208	43	1·34	<0·001
Anaemia	8772	328	3·74	2544	119	4·68	0·040	3180	66	2·08	<0·001
Smoker	8835	1795	20·3	2561	611	23·9	<0·001	3194	421	13·2	<0·001
Literate	4291	2708	63·1	1227	773	63·0	0·915	1834	1236	67·4	0·003

Table 2. Multivariate logistic regression for maternal characteristics and association with low and high BMI (normal BMI as referent with 4989 and 5520 women included in low and high BMI models, respectively) for pregnant women from 2004 to 2016*
(Adjusted odds ratios and 95 % confidence intervals)

	Low BMI		High BMI	
Risk factors	Adjusted OR	95 % CI	Adjusted OR	95 % CI
Age < 20 years	1·09	0·91, 1·30	0·42	0·34, 0·52
Length of residency (per 12 months)	1·00	0·98, 1·01	1·02	1·01, 1·03
Ethnicity†				
Muslim	1·64	1·26, 2·13	1·94	1·58, 2·39
Burman	1·49	1·23, 1·81	0·99	0·82, 1·19
Others	1·18	0·85, 1·65	0·92	0·68, 1·26
Status‡	0·82	0·70, 0·97	1·03	0·89, 1·19
Primigravid	1·28	1·10, 1·49	0·47	0·40, 0·56
Malaria	1·55	1·01, 2·37	0·35	0·17, 0·74
Anaemia	1·25	0·78, 2·02	0·54	0·30, 0·97
Smoker	1·38	1·12, 1·71	0·60	0·48, 0·73
Literate	0·99	0·85, 1·15	1·19	1·05, 1·35

* All variables listed in the table were included in the models, with models stratified by year.
† Karen ethnicity used as referent, as this is the predominant ethnic group over the duration of the study period.
‡ Migrants used as referent.

a low of 16·9 % to a high of 33·2 % in refugees (Fig. 6(a)) and from a low of 12·3 % to a high of 28·4 % for migrants (Fig. 6(b)) ($P < 0·001$ for both trends from 2004 to 2016).

Using normal BMI as the referent group, maternal characteristics associated with low and high BMI were evaluated in univariate and multivariate analysis (Table 1). Variations in BMI and ethnicity were significant by univariate analysis (Table 1), and this was maintained in multivariate analysis (Table 2). Burman women (AOR 1·49, 95 % CI 1·23, 1·81), Muslim women (AOR 1·64, 95 % CI 1·26, 2·13), primigravid women (AOR 1·28, 95 % CI 1·10, 1·49), malaria infection during pregnancy (AOR 1·55, 95 % CI 1·01, 2·37) and smoking (AOR 1·38, 95 % CI 1·12, 1·71) demonstrated increased odds of low BMI when compared with the normal BMI group (Table 2). Refugee women were less likely to have low BMI (AOR 0·82, 95 % 0·70, 0·97). Muslim women (AOR 1·94, 95 % CI 1·58, 2·39), literate women (AOR 1·19, 95 % CI 1·05, 1·35) and those with longer residency (AOR 1·02, 95 % CI 1·01, 1·03) were at increased odds for high BMI. Teenage women (AOR 0·42, 95 % CI 0·34, 0·52), primigravid women (AOR 0·47, 95 % CI 0·40, 0·56), malaria infection during pregnancy (AOR 0·35, 95 % CI 0·17, 0·74), anaemia during pregnancy (AOR 0·54, 95 % CI 0·30, 0·97) and smoking (AOR 0·60, 95 % CI 0·48, 0·73) had decreased odds of high BMI when compared with the normal BMI group.

Gestational weight gain

Of the 14 646 women with BMI measured in the first trimester, 7098 were included in the GWG analysis. Mean GWG was 10·0 (SD 3·4, range −1·0 to 24·0), 9·5 (SD 3·6, range −6·0 to 24·1) and

Table 3. Comparison of gestational weight gain (GWG) and first trimester BMI with Institute of Medicine (USA) (IOM) recommendations and Asian BMI categories as reported from an Asian population (Vietnam)

GWG IQR (kg)			Mean GWG (kg)		
BMI category	IOM	SMRU	BMI category	Vietnam[15]	SMRU
BMI <18·5 kg/m^2 (underweight; WHO)*	12·7–18·1	8–12 *n* 1211	BMI <18·5 kg/m^2 (low; Asian)†	12·5 (SD 3·6) *n* 780	10·0 (SD 3·4) *n* 1211
BMI 18·5–24·9 kg/m^2 (normal; WHO)*	11·3–15·9	7–12 *n* 5211	BMI 18·5–22·9 kg/m^2 (normal; Asian)†	12·2 (SD 3·8) *n* 1955	9·5 (SD 3·6) *n* 4306
BMI 25–29·9 kg/m^2 (overweight; WHO)*	6·8–11·3	5–11 *n* 575	BMI ≥23 kg/m^2 (high; Asian)†	11·5 (SD 4·7) *n* 254	8·3 (SD 4·3) *n* 1581
BMI ≥30 kg/m^2 (obese; WHO)*	5·0–9·1	4–10 *n* 101			

IQR, interquartile range; SMRU, Shoklo Malaria Research Unit.
* WHO BMI categories consistent with IOM comparison[40].
† WHO BMI categories for Asian populations[8] and consistent with Ota *et al.*[15].

8·3 (SD 4·3, range −4·8 to 25·0) kg for low, normal and high BMI, respectively, with some women losing weight over the course of their pregnancy. GWG was compared with international recommendations from Institute of Medicine for appropriate GWG ranges determined by pre-pregnancy BMI[40]. Women with low or normal BMI in this cohort fell short of Institute of Medicine recommendations for GWG (Table 3). In addition, GWG in this cohort was compared with population means from a Vietnamese cohort of healthy pregnant women, which were analysed based on Asian BMI categories (Table 3). GWG for women in the present study was lower for each Asian BMI category than the Vietnamese cohort[15].

Discussion

The present study offers a unique perspective: it documents trends in nutritional status of marginalised populations of pregnant women in a protracted refugee situation and among migrants in a socially, politically and economically turbulent region in Southeast Asia. Taken from over 40 000 women and with data spanning 30 years in refugees and 19 years in migrants along the Thailand–Myanmar border, the present study adds to the literature due to its size and scope. It adds to the dearth of literature highlighted by a study of thirty-seven LMIC, by summarising important trends in nutritional status of pregnant women within a marginalised population in an LMIC context[43], against the backdrop of a nutrition and epidemiological transition.

The trends toward overweight in these marginalised communities of refugees and migrants along the Thailand–Myanmar border reflect global trends[1] and present significant challenges. In 2004, 16·6 % of refugee and migrant women had a high BMI (≥23 kg/m^2). By 2016, over one-fourth (28·5 %) had BMI ≥23 kg/m^2 and 6 % of the women included in the present study had BMI ≥27 kg/m^2, putting them at higher risk of pregnancy and delivery complications and poor perinatal outcomes as demonstrated elsewhere in Asia[11,13,15,44,45]. We observed this increase in overweight and obesity among both refugees and migrants, with an earlier and more pronounced trend among refugees. Here, we briefly outline a few considerations for these trends, including underlying biology, access to foods of varying nutritional quality, and the social, economic and political context along the border within which we observe these nutritional trends. The 'Developmental Origins of Adult Disease' may help explain this trend[46,47]. This hypothesis posits that under-nutrition in early life leads to increased risk of diet-related chronic disease later in life. As we cover a generation by study end, we may be witnessing this 'programming' effect among pregnant women with high BMI linked to malnutrition in early life. However, these trends would not be possible without being enhanced by environmental and behavioural factors[48,49]. The 'nutrition transition' documented in Thailand and in Asian populations elsewhere provides evidence of overweight and obesity and their association with increasingly sedentary lifestyles and diets high in animal and saturated fats, sweetened beverages and industrially and locally processed foods[4,5,6,19]. A recent study in this population links sweetened beverage consumption within the prior 24 h with high BMI in pregnancy[50], with more controlled studies needed to understand the effects of other processed foods on maternal nutrition and pregnancy outcomes in this population. With the nutrition transition well underway in Thailand and its effects more pronounced among the marginalised, the introduction of and easier access to unhealthy, processed foods is compounded by limited access to health information through media; language barriers; low literacy and health literacy among pregnant women; and a lack of awareness among health workers and the communities as to the ill effects of poor nutrition[50,51–53].

Trends and differences in nutritional status in refugees and migrants – namely in relation to risk factors for low and high BMI – can also be considered in the context of fluctuating political and civil stability along the border. Periods of stability are marked by more consistent access to health care services, education and greater food security, more clearly documented for refugees compared with migrants[29,32,54,55]. As far as the authors are aware, this is the largest cohort demonstrating a significant association with low BMI and malaria among pregnant women[56] and, therefore, the history of malaria control efforts along the border over the present study period bears mentioning. Between 2004 and 2008, the higher incidence of malaria among migrants and its association with the nutritional status of pregnant women occurred over a period marked by a fraught ceasefire process in Eastern Myanmar and continued political and civil instability leading to greater disruption of access to health services. Active malaria programmes could be established more easily in refugee camps, leading to greater malaria reduction and its concomitant reduction in risk of low BMI among refugees, while less effective programming allowed malaria to persist in the more mobile migrant communities over the same time period[57]. Occupational and behavioural risk factors and inadequate housing conditions common among seasonal migrants in the border region likely exacerbated these trends[31,32,58]. Although recognising that this is not a complete explanation for trends in nutrition among these marginalised groups, the authors view fluctuating political and civil stability as contributing to the observed trends.

Therefore, alongside the relative political and civil stability seen in the refugee camps beginning in 1998, we observe an increase in the proportion of refugee women with high BMI. Earlier studies on nutritional status in this refugee population implicate limited dietary diversity and poor food security as risks for low BMI[59–61]. However, with greater food security through provided rations, studies have demonstrated trends in improved maternal micronutrient status among refugees and improved birth outcomes[60,62]. Stuetz *et al.* demonstrated that ownership of livestock and gardens in addition to food rations was significantly associated with improved refugee maternal micronutrient status[62]. These findings reflect greater stability in living and livelihood in the refugee communities. In addition, restrictions on field work outside the camps and an accompanying decrease in physical activity lend risk for sedentary lifestyles associated with over-nutrition in this population. The relative risks for poor nutrition attributable to long-standing armed conflict, occupational and behavioural risk factors, unstable residency, food insecurity and limited health care access are far from clear. However, the suggestion that nutritional trends follow fluctuations in stability in this region over time may shed light on similar dynamics in areas of conflict elsewhere in developing contexts.

However, even as malaria, anaemia and smoking during pregnancy as risk factors for low BMI have decreased over time, the overall rates of low BMI still persist. Therefore, the present study adds to the literature on the double burden of malnutrition in LMIC settings. Although the present study did not find an association between teenage pregnancy and low BMI (likely due to the small sample size), we note that teen pregnancy hovers consistently around 20 % over the study period and has been demonstrated to be associated with low BMI and under-nutrition in a larger cohort in this same population[63]. Therefore, as a risk factor for low BMI, programming around maternal nutrition in communities along the Thailand–Myanmar border may do well to pay specific attention to teen pregnancy for the reduction in the burden of maternal underweight.

The present study is not without limitations. Given that this analysis takes place over a long period of time, the variables analysed have been assessed through different methods over the course of SMRU's work in the region, reflecting the most accurate methods of anthropometric data collection given logistical constraints and changes in appropriate assessments over time. For example, missing data from 2002 to 2003 are due to problems with weight scales that were corrected in 2004. Despite these challenges, the large sample size allows for a robust characterisation of changes in nutritional status among these refugee and migrant populations. The authors note that the present study may have limited generalisability as this is specific to Myanmar refugees and migrants, but hope that the basic indicators of weight and BMI presented here will prove useful for other crisis situations globally. In addition, these findings may help inform the care of pregnant women in high-income countries receiving refugees and migrants from LMIC by providing a plausible context for understanding nutritional status of refugee and migrant women and targeting care to ameliorate the effects of poor nutrition on pregnancy outcomes.

As the double burden of underweight and over-nutrition has been linked to complications in pregnancy and adverse birth outcomes in Asian populations, future analyses will assess optimal BMI and GWG in relation to pregnancy outcomes among refugee and migrant populations along the Thailand–Myanmar border.

Acknowledgements

We would like to thank the pregnant women who voluntary agreed to have their data collected over the past 30 years and the SMRU ANC and midwifery staff responsible for the care of these pregnant women over the years.

This study was funded as part of the Wellcome-Trust Major Overseas Programme in Southeast Asia (grant number: 106698/Z/14/Z). Supplementary funds were also provided by the John Fell Oxford University Press (OUP) Fund, UK (project code: B9D00030). The funders had no role in the collection, analysis and interpretation of the data, the writing of the article or in submission of the paper for publication. The views expressed in the paper are those of the authors and do not represent the positions of their respective institutions or that of the funding agencies.

A. H., N. S., R. M., V. I. C., F. N., A. M. M. and M. E. G.: conceived and designed the protocol; N. S., S. L. and J. W.: prepared databases and performed statistical analysis; A. H. and N. S.: first draft of the manuscript; E. P., K. W., C. A. and P. C.: provided feedback on the protocol and design, and supported funding applications. All the authors read, contributed to and approved the final manuscript.

The authors declare that there are no conflicts of interest.

References

1. Black RE, Victora CG, Walker SP, *et al.* (2013) Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* **382**, 427–451.
2. Grantham-McGregor S, Cheung Y, Cueto S, *et al.* (2007) Developmental potential in the first 5 years for children in developing countries. *Lancet* **369**, 60–70.
3. Victora C, Adair L, Fall C, *et al.* (2008) Maternal and child undernutrition: consequences for adult health and human capital. *Lancet* **371**, 340–357.
4. Asia Pacific Cohort Studies Collaboration (2007) The burden of overweight and obesity in the Asia-Pacific region. *Obes Rev* **8**, 191–196.

British Journal of Nutrition

5. Dans A, Ng N, Varghese C, *et al.* (2011) The rise of chronic non-communicable diseases in southeast Asia: time for action. *Lancet* **377**, 680–689.
6. Popkin BM (2006) Global nutrition dynamics: the world is shifting rapidly toward a diet linked with noncommunicable diseases. *Am J Clin Nutr* **84**, 289–298.
7. Stevens GA, Singh GM, Lu Y, *et al.* (2012) National, regional, and global trends in adult overweight and obesity prevalences. *Popul Health Metr* **10**, 22.
8. World Health Organization Expert Consultation (2004) Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* **363**, 157–163.
9. Woodward M, Huxley R, Ueshima H, *et al.* (2012) The Asia pacific cohort studies collaboration: a decade of achievements. *Glob Heart* **7**, 343–351.
10. Aune D, Saugstad OD, Henriksen T, *et al.* (2014) Maternal body mass index and the risk of fetal death, stillbirth, and infant death: a systematic review and meta-analysis. *JAMA* **311**, 1536–1546.
11. Ee TX, Allen JC, Jr., Malhotra R, *et al.* (2014) Determining optimal gestational weight gain in a multiethnic Asian population. *J Obstet Gynaecol Res* **40**, 1002–1008.
12. Kiel DW, Dodson EA, Artal R, *et al.* (2007) Gestational weight gain and pregnancy outcomes in obese women: how much is enough? *Obstet Gynecol* **110**, 752–758.
13. Liu Y, Dai W, Dai X, *et al.* (2012) Prepregnancy body mass index and gestational weight gain with the outcome of pregnancy: a 13-year study of 292,568 cases in China. *Arch Gynecol Obstet* **286**, 905–911.
14. Nohr EA, Vaeth M, Baker JL, *et al.* (2009) Pregnancy outcomes related to gestational weight gain in women defined by their body mass index, parity, height, and smoking status. *Am J Clin Nutr* **90**, 1288–1294.
15. Ota E, Haruna M, Suzuki M, *et al.* (2011) Maternal body mass index and gestational weight gain and their association with perinatal outcomes in Viet Nam. *Bull World Health Organ* **89**, 127–136.
16. Wells J (2017) The new “obstetrical dilemma”: stunting, obesity and the risk of obstructed labour. *Anat Rec (Hoboken)* **300**, 716–731.
17. Hanson M & Gluckman P (2011) Developmental origins of noncommunicable disease: population and public health implications. *Am J Clin Nutr* **94**, 1754S–8S.
18. Aekplakorn W (2014) *Thai National Health Examination Survey, NHES V*. Nontaburi: Health Systems Research Institute.
19. Kosulwat V (2002) The nutrition and health transition in Thailand. *Public Health Nutr* **5**, 183–189.
20. Saito M, Keereevijit A, San T, *et al.* (2018) Challenges to primary healthcare services in the management of non-communicable diseases in marginalised populations on the Thailand–Myanmar border: a pilot survey. *Trop Doct* **48**, 273–277.
21. Berkowitz SA, Fabreau GE, Raghavan S, *et al.* (2016) Risk of developing diabetes among refugees and immigrants: a longitudinal analysis. *J Community Health* **41**, 1274–1281.
22. Dawson-Hahn E, Pak-Gorstein S, Matheson J, *et al.* (2016) Growth trajectories of refugee and nonrefugee children in the United States. *Pediatrics* **138**, e20160953.
23. Huguet JW & Chamratrithirong A (2011) *Thailand Migration Report 2011*. Bangkok: International Organization for Migration.
24. The Burma Border Consortium (2007) *Programme Report: July to December 2006 Including Revised Funding Appeal for 2007*. Bangkok: The Burma Border Consortium.
25. The Border Consortium (2017) *2016 Annual Report*. Bangkok: The Border Consortium.
26. Fellmeth G, Plugge E, Paw MK, *et al.* (2015) Pregnant migrant and refugee women’s perceptions of mental illness on the Thai–Myanmar border: a qualitative study. *BMC Pregnancy Childbirth* **15**, 93.
27. Gilder ME, Zin TW, Wai NS, *et al.* (2014) Gestational diabetes mellitus prevalence in Maela refugee camp on the Thai–Myanmar border: a clinical report. *Glob Health Action* **7**, 23887.
28. Luxemburger C, McGready R, Kham A, *et al.* (2001) Effects of malaria during pregnancy on infant mortality in an area of low malaria transmission. *Am J Epidemiol* **154**, 459–465.
29. Carrara VI, Hogan C, Pree CD, *et al.* (2011) Improved pregnancy outcome in refugees and migrants despite low literacy on the Thai–Burmese border: results of three cross-sectional surveys. *BMC Pregnancy Childbirth* **11**, 45.
30. Boel M, Carrara V, Rijken M, *et al.* (2010) Complex interactions between soil-transmitted helminths and malaria in pregnant women on the Thai-Burmese border. *PLoS Negl Trop Dis* **4**, e887.
31. Mullany L, Lee C, Yone L, *et al.* (2008) Access to essential maternal health interventions and human rights violations among vulnerable communities in Eastern Burma. *PLoS Med* **5**, 1689–1690.
32. Parker DM, Carrara VI, Pukrittayakamee S, *et al.* (2015) Malaria ecology along the Thailand–Myanmar border. *Malar J* **14**, 388.
33. Amnesty International (2005) *Thailand: The Plight of Burmese Migrant Workers*. Bangkok: Amnesty International.
34. Carrara VI, Lwin KM, Phyo AP, *et al.* (2013) Malaria burden and artemisinin resistance in the mobile and migrant population on the Thai–Myanmar border, 1999–2011: an observational study. *PLoS Med* **10**, e1001398.
35. McGready R, Boel M, Rijken M, *et al.* (2012) Effect of early detection and treatment on malaria related maternal mortality on the north-western border of Thailand 1986–2010. *PLOS ONE* **7**, e40244.
36. Rijken MJ, De Livera AM, Lee SJ, *et al.* (2014) Quantifying low birth weight, preterm birth and small-for-gestational-age effects of malaria in pregnancy: a population cohort study. *PLOS ONE* **9**, e100247.
37. Rijken MJ, Lee SJ, Boel ME, *et al.* (2009) Obstetric ultrasound scanning by local health workers in a refugee camp on the Thai–Burmese border. *Ultrasound Obstet Gynecol* **34**, 395–403.
38. Centers for Disease Control and Prevention (2007) *National Health and Nutrition Examination Survey (NHANES): Anthropometry Procedures Manual*. Atlanta: CDC.
39. Krukowski RA, West DS, DiCarlo M, *et al.* (2016) Are early first trimester weights valid proxies for preconception weight? *BMC Pregnancy Childbirth* **16**, 357.
40. Institute of Medicine (2009) *Weight Gain During Pregnancy: Reexamining the Guidelines*. Washington, DC: Institute of Medicine.
41. Dubowitz L & Dubowitz V (1977) *Gestational Age of the Newborn: A Clinical Manual. ed*. Reading: Addison-Wesley.
42. Moore K, Simpson J, Thomas K, *et al.* (2015) Estimating gestational age in late presenters to antenatal care in a resource-limited setting on the Thai-Myanmar border. *PLOS ONE* **10**, e0131025.
43. Razak F, Corsi DJ & Subramanian SV (2013) Change in the body mass index distribution for women: analysis of surveys from 37 low- and middle-income countries. *PLoS Med* **10**, e1001367.
44. Koh H, Ee TX, Malhotra R, *et al.* (2013) Predictors and adverse outcomes of inadequate or excessive gestational weight gain in an Asian population. *J Obstet Gynaecol Res* **39**, 905–913.

British Journal of Nutrition

45. Koyanagi A, Zhang J, Dagvadorj A, *et al.* (2013) Macrosomia in 23 developing countries: an analysis of a multicountry, facility-based, cross-sectional survey. *Lancet* **381**, 476–483.
46. Gluckman PD, Hanson MA, Cooper C, *et al.* (2008) Effect of in utero and early-life conditions on adult health and disease. *N Engl J Med* **359**, 61–73.
47. Hales C & Barker D (2013) Type 2 (non-insulin-dependent) diabetes mellitus: the thrifty phenotype hypothesis. *Int J Epidemiol* **42**, 1215–1222.
48. Li Y, Ley S, Tobias D, *et al.* (2015) Birth weight and later life adherence to unhealthy lifestyles in predicting type 2 diabetes: prospective cohort study. *BMJ* **351**, h3672.
49. Wells J, Pomeroy E, Walimbe S, *et al.* (2016) The elevated susceptibility to diabetes in India: an evolutionary perspective. *Front Public Health* **4**, 145.
50. Hashmi A, Paw M, Nosten S, *et al.* (2018) “Because the baby asks for it”: a mixed methods study on local perceptions of nutrition during pregnancy among marginalized migrant women along the Myanmar–Thailand border. *Glob Health Action* **11**, 1473104.
51. Aung MN, Lorga T, Srikrajang J, *et al.* (2012) Assessing awareness and knowledge of hypertension in an at-risk population in the Karen ethnic rural community, Thasongyang, Thailand. *Int J Gen Med* **5**, 553–561.
52. Lorga T, Aung MN, Naunboonruang P, *et al.* (2012) Predicting prediabetes in a rural community: a survey among the Karen ethnic community, Thasongyang, Thailand. *Int J Gen Med* **5**, 219–225.
53. Lorga T, Srithong K, Manokulanan P, *et al.* (2012) Public knowledge of diabetes in Karen Ethnic rural residents: a community-based questionnaires study in the far north-west of Thailand. *Int J Gen Med* **5**, 799–804.
54. Parmar PK, Barina CC, Low S, *et al.* (2015) Health and human rights in eastern Myanmar after the political transition: a population-based assessment using multistaged household cluster sampling. *PLOS ONE* **10**, e0121212.
55. Srikanok S, Parker DM, Parker AL, *et al.* (2017) Empirical lessons regarding contraception in a protracted refugee setting: a descriptive study from Maela camp on the Thai–Myanmar border 1996–2015. *PLOS ONE* **12**, e0172007.
56. Cates JE, Unger HW, Briand V, *et al.* (2017) Malaria, malnutrition, and birthweight: a meta-analysis using individual participant data. *PLoS Med* **14**, e1002373.
57. Parker DM, Landier J, Thu AM, *et al.* (2017) Scale up of a Plasmodium falciparum elimination program and surveillance system in Kayin State, Myanmar. *Wellcome Open Res* **2**, 98.
58. Luxemburger C, Ricci F, Nosten F, *et al.* (1997) The epidemiology of severe malaria in an area of low transmission in Thailand. *Trans R Soc Trop Med Hyg* **91**, 256–262.
59. Banjong O, Menefee A, Sranacharoenpong K, *et al.* (2003) Dietary assessment of refugees living in camps: a case study of Mae La camp, Thailand. *Food Nutr Bull* **24**, 360–367.
60. Carrara VI, Stuetz W, Lee SJ, *et al.* (2017) Longer exposure to a new refugee food ration is associated with reduced prevalence of small for gestational age: results from 2 cross-sectional surveys on the Thailand-Myanmar border. *Am J Clin Nutr* **105**, 1382–1390.
61. Stuetz W, Carrara VI, McGready R, *et al.* (2012) Micronutrient status in lactating mothers before and after introduction of fortified flour: cross-sectional surveys in Maela refugee camp. *Eur J Nutr* **51**, 425–434.
62. Stuetz W, Carrara VI, Mc Gready R, *et al.* (2016) Impact of food rations and supplements on micronutrient status by Trimester of pregnancy: cross-sectional studies in the Maela Refugee Camp in Thailand. *Nutrients* **8**, 66.
63. Parker AL, Parker DM, Zan BN, *et al.* (2018) Trends and birth outcomes in adolescent refugees and migrants on the Thailand–Myanmar border, 1986–2016: an observational study. *Wellcome Open Res* **3**, 62.

British Journal of Nutrition