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Research Article

Maternal Obesity: Prevalence, Outcomes and Evaluation of Body Mass Index Cut-Off Values in a Multi-Ethnic Asian Obstetric Population

Si Ying Pang*, Eng Loy Tan, Lay-Kok Tan

Abstract

Introduction: Maternal pre-pregnancy obesity is a known risk factor for pregnancy complications. Our study looks at the prevalence, ethnic distribution of maternal obesity, associations with maternal complications and the relevance of different BMI cut-offs in predicting complications.

Design and Methods: A retrospective review of women followed up at Singapore General Hospital (SGH) over an eight-year period (2005-2012). World Health Organisation (WHO) international and Asian cut-offs for body mass index (BMI) was used. Multiple logistic regressions were applied to assess the association of maternal BMI with medical complications.

Results and Discussion: We identified 8843 mothers with singleton pregnancies. The prevalence of obesity was 12.2%. This varies greatly between different ethnicities – from 4.6% among Chinese women, 17.2% among Indian women, to 21.5% among Malay women.

Obesity is found to be strongly associated with existing diabetes mellitus (OR 7.81 [4.17-14.7]), essential hypertension (OR 13.9 [7.52-25.6]), gestational diabetes mellitus (OR 2.53 [1.99-3.22]) and hypertensive diseases of pregnancy.

The risk of developing maternal and obstetric complications is high at a lower BMI. Hence, the lower Asian BMI cut-offs may be useful in identifying women at risk in our population. The varying incidence of different complications between ethnicities also warrants different cut-offs for each ethnicity.

Conclusion: There is a high prevalence of obesity in our community with significant ethnic variations. It is important to identify obese mothers to be at an increased risk of having complications. A lower BMI cut-off may be recommended to better identify Asian women at risk.

Introduction

The incidence of obesity has been on the rise in Singapore in the recent years. In the 2010 nation-wide Singapore National Health Survey (NHS), the prevalence of obesity in women aged 18-65 years currently stands at 9.5% [1]. Differences in the prevalence of obesity in the different ethnic groups were also noted. The prevalence of obesity was 24.0% in Malays, 16.9% in Indians and 7.9% in Chinese. It is well established that there are differences in the risk of developing cardiovascular complications in non-pregnant individuals between Caucasian and Asian populations [2], with a suggestion for lower BMI cut-offs in an Asian population to better predict the risk. It is not widely studied whether lower cut-offs are applicable to the Asian obstetric population.

Maternal obesity is associated with presence of existing maternal illnesses such as diabetes mellitus and adverse obstetric and neonatal outcomes. It also leads to increased healthcare costs [3]. Associated illnesses such as gestational diabetes mellitus are also risk factors for cardiovascular diseases in the future [4].

We aim to explore the prevalence of maternal obesity, ethnic distribution, its associations with maternal complications, and the relevance of the different BMI cut-offs in the definition of obesity. We hope to gain a better understanding about our obstetric population, identify at-risk groups and provide appropriate information about the associated adverse outcomes.

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Methods

Data source

All information pertaining to the study was obtained from the labour ward database of Singapore General Hospital (SGH), a tertiary teaching hospital in Singapore. Antenatal and peripartum information was documented by doctors or nursing staff in a medical record folder before being manually entered into the labour ward database. Data entry was carried out by midwives or nursing staff in the labour ward.

BMI categories

BMI at first antenatal appointment is computed for the purpose of the study. There are two types of BMI classifications of interest here: firstly, the WHO BMI cut-offs, and secondly, BMI risk categories implemented by the Health Promotion Board (HPB), in accordance to the recommendations made by WHO Western Pacific Region (WPR), International Association for the Study of Obesity (IASO) and International Obesity Task Force (IOTF) in 2004 [5].

For the WHO BMI cut-offs, the different weight categories are defined as such: under- weight, BMI < 18.5; normal, 18.5 ≤ BMI < 25; overweight, 25 ≤ BMI < 30, and obese, BMI ≥ 30.

Recommendations for BMI cut-offs for Singaporeans are 23.0 and 27.5 kg/m^2 respectively for "moderate risk" and "high risk" for cardiovascular diseases and diabetes mellitus, as proposed by the HPB in 2005 [6].

Women were hence grouped into 4 BMI groups according to WHO international BMI cut-offs (obese, overweight, normal weight, underweight), and also according to the recommended Singaporean BMI risk categories (underweight, low risk, moderate risk, high risk). The group with normal BMI was used as the reference group in computation of odds ratios.

Inclusion criteria

All women with singleton pregnancies were included in the study. Entries with incomplete information on height and weight were excluded.

Outcomes

Outcomes include: prevalence of obesity in our obstetric population, ethnicity distribution, prevalence of obesity in each ethnic group, the presence of existing maternal medical conditions and development of maternal medical complications during pregnancy.

Maternal complications include: gestational diabetes mellitus, existing hypertension, pregnancy-induced hypertension, eclampsia, pre-eclampsia and urinary tract infection. Hypertensive disease of pregnancy included the following: pregnancy-induced hypertension, eclampsia and pre-eclampsia.

Statistical analysis

Statistical analysis was conducted using IBM SPSS Statistics (version 20.0). Adjusted odds ratios were calculated after applying multiple logistic regression analysis. Maternal complications were controlled for confounding factors. Maternal age in completed years, ethnicity and parity were identified to be possible confounders in the analysis.

Continuous variables are presented as mean ± standard deviation and qualitative variables are presented as absolute frequency. The risks of maternal complications are presented as adjusted odds ratio with 95% confidence interval after adjusting for possible confounding variables. Significance was accepted at the 5% level on two-tailed tests for all measures.

Ethics committee approval

The study is approved by the Centralised Institutional Review Board (CIRB), an independent ethics committee responsible for approving, monitoring and reviewing research in Singapore.

Results

Prevalence of obesity

The results of our study are discussed with respect to the WHO international BMI cut-offs and comparisons are made with the Asian BMI Risk Categories when appropriate.

A total of 8843 mothers were identified over eight years (2005-2012). The prevalence of obesity was 12.2% according to WHO international BMI cut-offs. The majority (56.3%) of women had a normal BMI, 9.3% were underweight and 22.2% were overweight. When the Asian BMI Risk Categories was used, the prevalence of obesity was increased to 21.0% [Diagrams 1,2].

Study population demographics

In our study, Chinese women made up 45.4% of the obstetric population, Malays 37.3%, Indians 9.8%. The prevalence of obesity ranged from 21.5% among Malay women, 17.2% among Indian women to 4.6% among Chinese women. Malays made up 37.3% of the obstetric population but comprised 65.4% of the obese group.

Mothers with higher BMI were more likely to be older and multiparous. The median gestational age at first appointment for both the overweight and obese mothers was also later. However, the median gestational age for all groups at first appointment still falls within the first trimester at 12 weeks.

When the Asian BMI risk categories were applied, the trends were similar.

Information on the demographics and characteristics population is shown in Tables 1-3.

Existing maternal medical conditions

Obese mothers were more likely to have pre-pregnancy diabetes (OR 7.56, 95% CI 3.04-14.2) and hypertension (OR = 14.0, 95% CI 7.59-26.0). Underweight mothers were more likely to have existing cardiac disease (OR 1.76, 95% CI 1.11-2.80) [Figures1,2].

Maternal complications

The maternal complications are described in Tables 4-7. Obese women were more likely to develop gestational diabetes mellitus (OR 2.87, 95% CI 2.27-3.63), hypertensive diseases in pregnancy

Diagram 1: Distribution by WHO international BMI cut offs

Diagram 2: Distribution by WHO Asian BMI risk categories

Characteristic	
Age (years)	30.4 ± 5.2
Ethnicity	
Chinese	4012 (45.4)
% obese	184 (4.6)
Malay	3296 (37.3)
% obese	708 (21.5)
Indian	864 (9.8)
% obese	147 (17.2)
Others	632 (7.1)
Not documented	39 (0.4)
Parity	1 (0-14)
0	3869 (43.8)
1	2950 (33.4)
2	1310 (14.8)
3	485 (5.5)
>3	229 (2.6)
Gestational age at first appointment (weeks)	11 (3-41)
Booked before 20 weeks	7283 (83.9)
Pre-existing diabetes	77 (0.9)
Pre-existing hypertension	96 (1.1)
BMI (kg/m2) by WHO international definition	
Underweight (<18.5)	821 (9.3)
Normal (>=18.5, <25)	4976 (56.3)
Overweight (>= 25, <30)	1963 (22.2)
Obese (>=30)	1083 (12.2)
BMI (kg/m2) by Asian BMI Risk Categories	
Underweight (<18.5)	821 (9.3)
Normal/ Low risk (>=18.5, <23)	3555 (40.2)
Overweight/ Moderate risk (>= 23, <27.5)	2614 (29.6)
Obese/ High risk (>=27.5)	1853 (21.0)

Values are n, (%)

Table 1: Patient Demographics.

(OR 5.77, 95% CI 4.31-7.73) and pre eclampsia (OR 7.11, 95% CI 4.79-10.5).

BMI and caesarean section

Excluding women who had previous Caesarean deliveries who opted for an elective repeat Caesarean section, the overall rate of Caesarean delivery was 27.2% in our population. When adjusted for age and parity, pre-existing medical conditions and conditions such as pre-eclampsia and gestational diabetes mellitus, obesity was associated with a 2-fold increased risk of requiring Caesarean section. Obese women were 2.23 times more likely in needing a crash or emergency Caesarean section [Table 8].

Characteristic				
	Underweight n=821 *BMI <18.5 kg/m2*	**Normal n=4976** *18.5 =< BMI < 25*	**Overweight n=1963** *25=< BMI < 30*	**Obese n=1083** BMI >= 30
Age (y)	29.0 ± 4.9	30.3 ± 5.1	30.9 ±5.3	31.0 ± 5.3
	p <0.05		*p <0.05*	*p <0.05*
Ethnicity				
Chinese	534 (65.0)	2654 (53.4)	636 (32.4)	184 (17.0)
Malay	178 (21.7)	1500 (30.1)	910 (46.4)	708 (65.4)
Indian	55 (6.7)	401 (8.1)	259 (13.2)	149 (13.8)
Others	50 (6.1)	399 (8.0)	145 (7.4)	38 (3.5)
Not documented	4 (0.5)	18 (0.4)	13 (0.7)	4 (0.4)
Parity	1 (0-6)	2 (0-10)	2 (0-15)	2 (0-10)
	p <0.05		*p <0.05*	*p <0.05*
Gestational age at first appointment (weeks)	10 (3-36)	11 (3-37)	12 (3-38)	12 (4-37)
	p <0.05		*p <0.05*	*p <0.05*
Booked before 20 weeks	757 (92.2)	4275 (85.9)	1469 (74.8)	782 (72.2)
Pre-existing diabetes	1 (0.1)	20 (0.4)	25 (1.3)	31 (2.9)
Pre-existing hypertension	0 (0)	19 (0.4)	26 (1.8)	41 (3.8)

Values are n, (%)

Table 2: Comparing patient characteristics between BMI groups, using the WHO international definition for BMI groups.

Existing maternal medical conditions	n (%) OR (95% CI)			
	Normal n=4976	**Underweight n=821**	**Overweight n=1963**	**Obese n=1083**
Anemia	1.00	1.33 (0.98-1.81)	**0.79 (0.63-1.00)**	0.80 (0.60-1.06)
Cardiac disease	1.00	**1.76 (1.11-2.80)**	0.72 (0.45-1.13)	0.53 (0.27-1.06)
Existing Diabetes Mellitus	1.00	0.36 (0.05-2.69)	**3.19 (1.73-5.90)**	**7.56 (4.04-14.2)**
Essential hypertension	1.00	Not significant	**5.13 (2.84-9.25)**	**14.0 (7.59-26.0)**
Renal disease	1.00	1.43 (0.58-3.50)	0.94 (0.43-2.05)	1.62 (0.69-3.77)
SLE & other autoimmune disease	1.00	0.69 (0.27-1.75)	0.76 (0.40-1.47)	0.58 (0.32-1.90)
Hyperthyroidism	1.00	1.43 (0.75-2.70)	0.83 (0.46-1.44)	0.83 (0.38-1.82)
Hypothyroidism	1.00	1.00 (0.51-1.96)	1.23 (0.78-1.97)	1.30 (0.71-2.38)
Asthma	1.00	1.12 (0.75-1.68)	**1.35 (1.04-1.75)**	**2.59 (1.99-3.38)**

Table 3: Comparing patient characteristics between BMI groups, using Asian BMI risk categories.

Obstetric and foetal complications

Obesity was also associated with increased risk of shoulder dystocia (OR 2.76, 95% CI 1.30-5.86) with normal vaginal delivery.

Maternal obesity was associated with prematurity (OR 1.22, 95% CI 1.04-1.44), post-term delivery (OR 5.82, 95% CI 1.28-26.4) and Apgar score of less than 7 at 1 minute (OR 1.95, 95% CI 1.37-2.80). Being underweight was not found to be associated with increased incidence of prematurity.

Maternal obesity is associated with birth weights of >4000g (OR 2.44, 95% CI 1.68-3.56) and foetal macrosomia (defined as birth weight >4500g, OR 8.98, 95% CI 3.11-30.0) [Table 9] [Figures 3-5].

Ethnic differences in maternal disease and obstetric outcomes

There is a higher rate of pre-existing diabetes mellitus in Malays and pre-existing hypertension in the Chinese population. There is also a higher incidence of gestational diabetes mellitus in Indians, as well as pre-eclampsia in Chinese [Figures 6-9].

Discussion

Prevalence of obesity in the study population

The prevalence of obesity in our population is 12.2%. This is higher compared to a prevalence of 2.3% in Hong Kong [7], 6.8% in northern China [8] and 8.5% in South Korea [9], but lower than that of study populations United States (20.0%) [10] and United Kingdom (24.0%) [11] [Figure10].

Our obstetric study population is multi-ethnic, with large differences in obesity prevalence between different ethnic groups, as seen in Table 1. The incidence of obesity in Chinese mothers was 4.6% as compared to 21.5% in the Malay mothers. In a paper studying the relationship between gestational diabetes and macrosomia and race, it is found that the difference in prevalence of gestational diabetes mellitus was attributed to the difference in prevalence of obesity between ethnicities [12]. It was hence necessary for us to take ethnicity into account when adjusting for confounders and presenting our study data.

BMI as an independent risk factor for complications

BMI is an independent risk factor for predicting existing

maternal medical problems and developing maternal as well as obstetric complications. After adjusting for age, ethnicity, parity and other relevant confounders by multiple logistic regression analysis, obese women were still at significantly higher risk of developing complications such as GDM and pre-eclampsia.

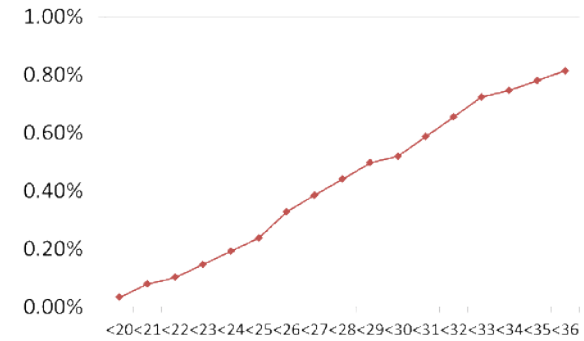

Figure 1: Leucocyte recruitment to the vessel wall.

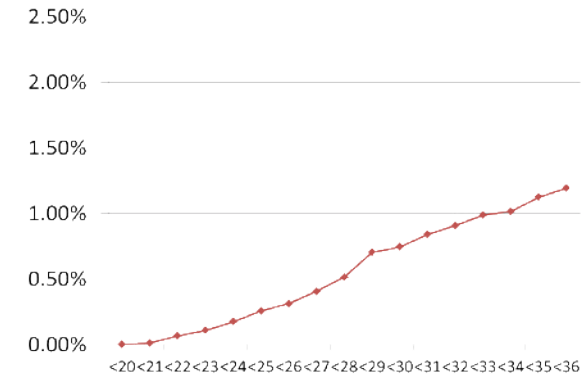

Figure 2: Incidence of existing hypertension with increasing BMI

While being overweight or obese proved to be a significant risk factor in shoulder dystocia, post-term delivery and low Apgar scores, the absolute number of such cases happening is small and may not be clinically significant in the short term. Likewise, the small numbers of cases with third degree tears may result in its statistical insignificance.

Age and parity were also independent factors in predicting the above outcomes. Mothers with higher BMI were also noted to be older. Such patients are at a higher risk of maternal complications and hence should be closely monitored. We propose that mothers who are overweight or obese be managed in intermediate to high-risk clinics by experienced obstetricians. They should be worked up for existing medical conditions such as existing diabetes mellitus and hypertension, and closely monitored for complications.

Accuracy in using BMI to predict complications and outcomes – Analysis with the area under receiver operator characteristic curve (AUROC)

The accuracy of BMI as a predictor for adverse maternal and foetal outcome can be calculated using the AUROC. An AUROC of >0.60 suggests that BMI is an acceptable predictor of the specific outcome it is measured against.

BMI appears to be an accurate predictor of the following complications: presence of gestational diabetes mellitus (0.653), pregnancy-induced hypertension (0.665), pre-eclampsia (0.724), post-term delivery (0.683), birth weights >4kg (0.652) and foetal macrosomia (0.773) [Table 10].

However, BMI does not appear to be a good predictor of

Existing maternal medical conditions	n (%) OR (95% CI)			
	Normal n=4976	Underweight n=821	Overweight n=1963	Obese n=1083
Anemia	1.00	1.33 (0.98-1.81)	**0.79 (0.63-1.00)**	0.80 (0.60-1.06)
Cardiac disease	1.00	**1.76 (1.11-2.80)**	0.72 (0.45-1.13)	0.53 (0.27-1.06)
Existing Diabetes Mellitus	1.00	0.36 (0.05-2.69)	**3.19 (1.73-5.90)**	**7.56 (4.04-14.2)**
Essential hypertension	1.00	Not significant	**5.13 (2.84-9.25)**	**14.0 (7.59-26.0)**
Renal disease	1.00	1.43 (0.58-3.50)	0.94 (0.43-2.05)	1.62 (0.69-3.77)
SLE & other autoimmune disease	1.00	0.69 (0.27-1.75)	0.76 (0.40-1.47)	0.58 (0.32-1.90)
Hyperthyroidism	1.00	1.43 (0.75-2.70)	0.83 (0.46-1.44)	0.83 (0.38-1.82)
Hypothyroidism	1.00	1.00 (0.51-1.96)	1.23 (0.78-1.97)	1.30 (0.71-2.38)
Asthma	1.00	1.12 (0.75-1.68)	**1.35 (1.04-1.75)**	**2.59 (1.99-3.38)**

Table 4: Adjusted odds ratio for existing maternal medical conditions with normal BMI as the reference group

Maternal complication	n (%) OR (95% CI)			
	Normal n=4976	Underweight n=821	Overweight n=1963	Obese n=1083
Gestational Diabetes Mellitus	1.00	0.78 (0.52-1.15) p = 0.20	**1.94 (1.59-2.37)**	**2.87(2.27-3.63)**
Pregnancy induced hypertension	1.00	0.82 (0.37-1.80)	**2.43 (1.64-3.60)**	**4.37 (2.86-6.68)**
Eclampsia	1.00	5.62 (0.34-93.1)	3.17(0.19-53.7)	N.S.
Pre-eclampsia	1.00	0.61 (0.24-1.53)	**3.45 (2.38-5.00)**	**7.11 (4.79-10.5)**
Hypertensive disease in pregnancy (PIH, Eclampsia, Pre-eclampsia)	1.00	0.75 (0.42-1.35)	**2.90 (2.21-3.81)**	**5.77 (4.31-7.73)**

Table 5: Adjusted odds ratio for maternal complications with normal BMI as the reference group.

Maternal medical condition	n (%) OR (95% CI)			
	Normal n=3555	Underweight n=821	Overweight n=2614	Obese n=1853
Anaemia	1.00	1.21 (0.87-1.66) p = 0.23	**0.71 (0.56-0.90)**	**0.71 (0.55-0.91)**
Cardiac disease	1.00	**1.70 (1.05-2.75)**	0.72 (0.47-1.10)	0.73 (0.44-1.20)
Existing Diabetes Mellitus	1.00	0.44 (0.06-3.41)	**2.80 (1.36-5.77)**	**6.47 (3.18-13.1)**
Essential hypertension	1.00	NS	**5.33 (2.30-12.4)**	**20.2 (8.91-45.5)**
Renal disease	1.00	1.49 (0.59-3.77)	1.03 (0.50-2.14)	1.45 (0.66-3.17)
SLE & other autoimmune disease	1.00	0.68 (0.27-1.76)	0.87 (0.49-1.55)	0.79 (0.38-1.64)
Hyperthyroidism	1.00	1.31 (0.68-2.50)	0.79 (0.47-1.32)	0.55 (0.27-1.11)
Hypothyroidism	1.00	0.98 (0.49-1.95)	1.12 (0.73-1.74)	1.04 (0.61-1.77)
Asthma	1.00	1.27 (0.83-1.94)	1.54 (1.17-2.01)	2.25 (1.71-2.96)

Table 6: Adjusted odds ratio for existing maternal medical conditions with normal BMI as the reference group, using Asian BMI risk categories.

Maternal complication	n (%) OR (95% CI)			
	Normal n=3555	Underweight n=821	Mod risk n=2614	High risk n=1853
Gestational Diabetes Mellitus	1.00	0.92 (0.61-1.38)	**1.82 (1.46-2.27)**	**3.22 (2.56-4.05)**
Pregnancy induced hypertension	1.00	0.88 (0.39-1.99)	**1.78 (1.15-2.76)**	**3.90 (2.53-6.00)**
Eclampsia	1.00	4.24 (0.26-69.3)	1.57 (0.09-26.4)	NS
Pre Eclampsia	1.00	0.86 (0.33-2.24)	**3.35 (2.12-5.29)**	**7.97 (5.07-12.5)**
Hypertensive disease in pregnancy (PIH, Eclampsia, Pre-eclampsia)	1.00	0.90 (0.50-1.65)	**2.35 (1.72-3.21)**	**5.53 (4.06-7.53)**

Figures are n, (%). Statistics are presented as OR, odds ratio (95% confidence interval), p value of 0.05 is considered as significant (shown in bold), Race not documented, n = 39, Reference group for ethnicity = Chinese, After adjusting for age, BMI, parity

Table 7: Adjusted odds ratio for maternal complications with normal BMI as the reference group, using Asian BMI risk categories.

	Normal *n=4605*	Underweight *n=772*	Overweight *n=1698*	Obese n=988
Rate of Caesarean section	1.00	**0.78 (0.62-0.97)**	**1.29 (1.11-1.50)**	**2.15 (1.78-2.58)**
Crash & EM Caesar rate	1.00	**0.68 (0.53-0.88)**	**1.31 (1.11-1.55)**	**2.23 (1.83-2.71)**

Statistics are presented as OR, odds ratio (95% confidence interval), p value of 0.05 is considered as significant (shown in bold)

Table 8: Adjusted odds ratio for obstetric complications according to WHO international BMI cut offs.

Characteristic				
	Normal n=4976	Underweight n=821	Overweight n=1963	Obese n=1083
Prematurity	1.00	1.13 (0.94-1.36)	1.01 (0.89-1.15)	**1.22 (1.04-1.44)**
Post term	1.00	N.S.	3.20 (0.70-14.5)	**5.82(1.28-26.4)**
apgar <7 at 1 minute	1.00	0.94 (0.57-1.55)	**1.41(1.03-1.94)**	**1.95 (1.37-2.80)**
apgar <7 at 5 minute	1.00	0.93 (0.28-3.17)	**2.19 (01.09-4.40)**	1.90 (0.75-1.80)
Birth weight <2500g	1.00	**1.62 (1.22-2.17)**	**0.72 (0.56-0.93)**	**0.54 (0.38-0.93)**
Birth weight >4000g	1.00	**0.23 (0.07-0.74)**	1.27 (0.89-1.83)	**2.44 (1.68-3.56)**
Macrosomia (>4500g)	1.00	N.S.	1.34 (0.33-5.44)	**8.98 (3.11-30.0)**

Statistics are presented as OR, odds ratio (95% confidence interval), p value of 0.05 is considered as significant (shown in bold)

Table 9: Adjusted odds ratio for obstetric complications according to WHO international BMI cut offs.

prematurity (0.532) and needing Caesarean delivery (0.549). There is no conclusive evidence for any BMI cut off as sensitivity increases and specificity decreases with decreasing BMI and the reverse occurs with increasing BMI.

Obesity, Ethnicity and complications

By stratifying our results by ethnicity, the different ethnicity groups are at varying risk of having pre-existing illness as well as pregnancy-related complications.

With increasing BMI, the incidence of pre-eclampsia in Chinese mothers increases more as compared to the risk in other races. They are 2.39 times more likely to get pre-eclampsia as compared to Indian mothers, who are at the lowest risk among the three ethnic groups. Likewise, obese Indian mothers are more likely to get gestational diabetes as compared to other ethnicities. They are 3.21 times more likely to get gestational diabetes as compared to Chinese mothers (Figures 8 & 9). The high prevalence of obesity as well as a high incidence of gestational diabetes mellitus has led to the implementation of universal screening for this condition in our centre. However, the prevalence of obesity and their subsequent complications vary greatly between the different ethnicities. Different BMI cut-offs for different ethnicities should be implemented. This will help to further individualise the care of pregnant mothers and optimise the use of healthcare resources - a one-size-fit-all approach may not be not clinically or cost effective in all situations.

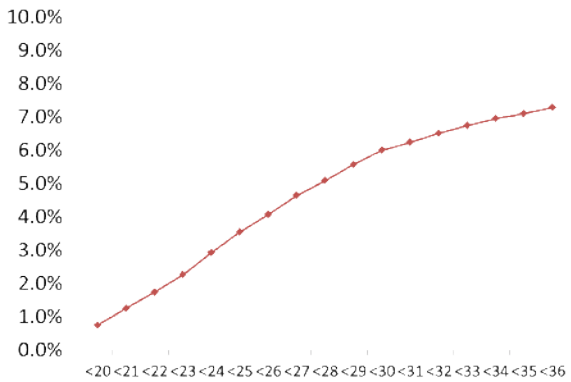

Figure 3: Incidence of gestational diabetes mellitus with increasing BMI.

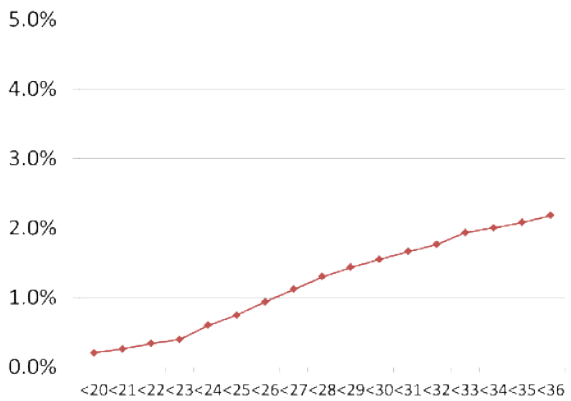

Figure 4: Incidence of pre-eclampsia with increasing BMI.

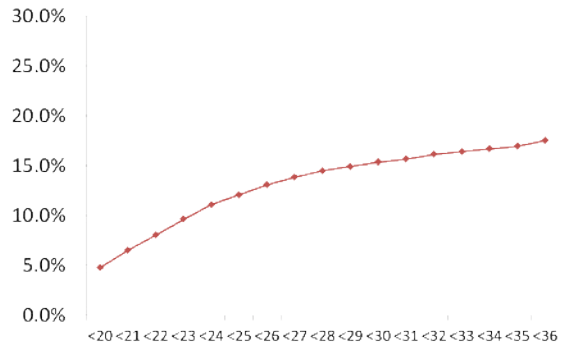

Figure 5: Incidence of women requiring C-section with increasing BMI.

WHO International BMI cut-offs versus Asian BMI cut-offs

The WHO proposed lower BMI cut offs for Asian populations in terms of predicting cardiovascular risk. At the same BMI, Asians tend to have a higher fat percentage and are hence at a higher risk of cardiovascular complications [13]. A study on cardiovascular mortality risk by Wen CP et al suggested using a lower BMI cut off for obesity as significant mortality risk occurred at a BMI of 25.0 kg/m^2 in Asians instead of 30 kg/m^2 in Caucasians [14].

In terms of maternal complications, there is a linear increase in cumulative percentage in terms of gestational diabetes, pre-eclampsia and pregnancy induced hypertension. This is in keeping with the study done by Bryant M et al, in which results suggest that the relationship between BMI and complications are largely linear and lowering the BMI threshold would only lead to a significant increase in high-risk clinic referrals, which may not be cost-effective [15]. This is unlike results in studies involving cardiovascular mortality, in which relative mortality risk increases once an individual's BMI is more than 25.0 kg/m^2 if he is of Asian ethnicity [16].

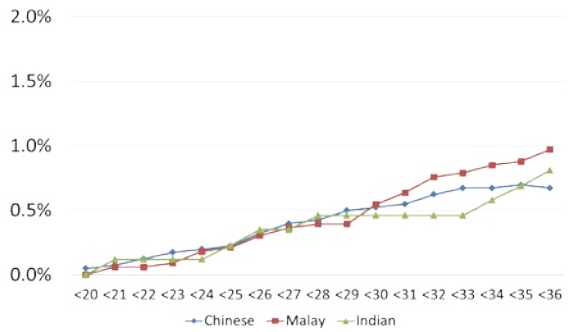

Figure 6: Incidence of existing diabetes mellitus by ethnicity, with increasing BMI.

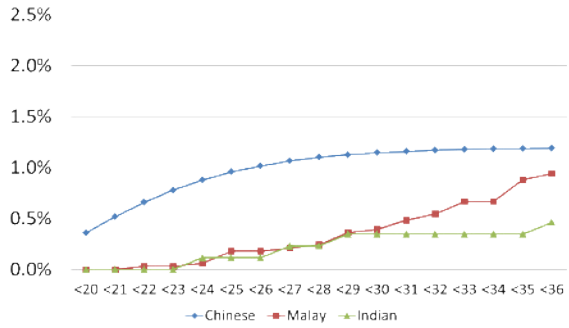

Figure 7: Incidence of existing hypertension by ethnicity, with increasing BMI.

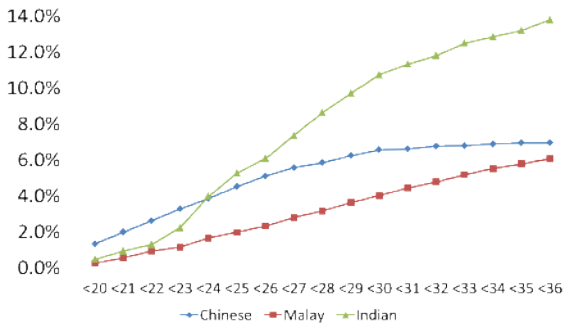

Figure 8: Incidence of gestational diabetes mellitus by ethnicity, with increasing BMI.

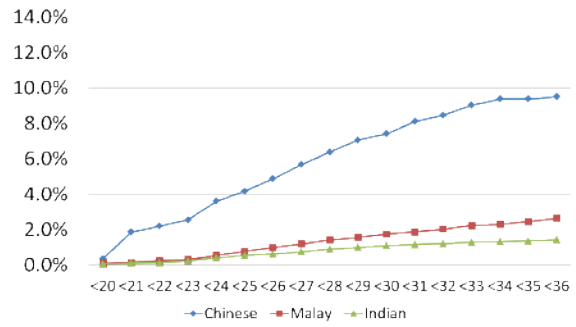

Figure 9: Incidence of pre-eclampsia by ethnicity, with increasing BMI.

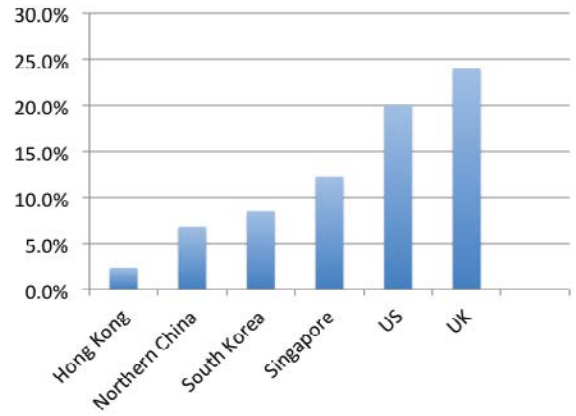

Figure 10: Comparing prevalence of obesity between countries.

Outcome	AUROC value
Foetal macrosomia	0.773
Pre-eclampsia	0.724
Post term delivery	0.683
Pregnancy induced hypertension	0.665
Gestational diabetes mellitus	0.653
Birth weight >4kg	0.652
Caesarean section	
Prematurity	0.532

Table 10: AUROC values for BMI as a predictor of adverse complications.

Other ways to justify a lower BMI threshold for referral would be to compare the cumulative incidence of complications at the same BMI between Asian and Caucasian populations, or to compare the risk of complications at each BMI level. If there is a higher cumulative incidence of complications occurring at a lower BMI in the Asian population, a lower BMI cut off may be justified. We propose using specific BMI cut-offs at which the cumulative incidence of a complication crosses a certain percentage instead of solely looking at BMI weight categories, which may not be evidence based [17]. For example, at a BMI of 25, the cumulative incidence of gestational diabetes mellitus in our study population is more than 50%. These percentages should be determined by the institution in a way that resources can be utilised in a cost-effective manner to provide the best health care for pregnant mothers.

Alternatively, if the incidence of complications at any BMI level is higher in the Asian population as compared to the Caucasian population, one may consider lowering the BMI cut offs.

Limitations of the discussion

Some limitations of the study include the relatively small number of the study and lack of availability of pre-pregnancy height and weight. Factors such as diet, lifestyle and physical activity were also not taken into account. Maternal gestational weight gain, which is a significant factor in predicting outcomes, was also not accounted for due to the nature of the data collection.

Some of the outcomes measured, such as shoulder dystocia, are rare, which may result in a wide confidence interval. Outcomes such as stillbirth and pregnancy loss were also not accounted for as the study involved retrospective data from the labour ward.

Conclusion

There is a high prevalence of obesity in our community with ethnic variations. BMI predicts complications like gestational diabetes mellitus, pre-eclampsia, pregnancy induced hypertension and birth weight of more than 4kg in a linear fashion. BMI cut-offs can be individualised to different ethnic communities, but further studies involving allocation of resources and cost-effectiveness are needed.

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