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.
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 [6].

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/m² 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) [Figures 1,2].

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
Characteristic | Value
--- | ---
Age (years) | 30.4 ± 5.2
Ethnicity | Chinese 4012 (45.4)
| Malay 3296 (37.3)
| Indian 864 (9.8)
| Others 632 (7.1)
Not documented | 39 (0.4)
Parity | 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].
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 conditions

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Underweight n=821 BMI &lt;18.5 kg/m²</th>
<th>Normal n=4976 BMI 18.5 &lt;= BMI &lt; 25</th>
<th>Overweight n=1963 BMI 25&lt;= BMI &lt; 30</th>
<th>Obese n=1083 BMI &gt;= 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>29.0 ± 4.9</td>
<td>30.3 ± 5.1</td>
<td>30.9 ±5.3</td>
<td>31.0 ± 5.3</td>
</tr>
<tr>
<td></td>
<td>p &lt;0.05</td>
<td>p &lt;0.05</td>
<td>p &lt;0.05</td>
<td>p &lt;0.05</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Chinese 534 (65.0)</td>
<td>Malaya 178 (21.7)</td>
<td>Indian 55 (6.7)</td>
<td>Others 50 (6.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not documented 4 (0.5)</td>
<td></td>
<td>18 (0.4)</td>
<td>13 (0.7)</td>
</tr>
<tr>
<td>Parity</td>
<td>1 (0-6)</td>
<td>2 (0-10)</td>
<td>2 (0-15)</td>
<td>2 (0-10)</td>
</tr>
<tr>
<td></td>
<td>p &lt;0.05</td>
<td>p &lt;0.05</td>
<td>p &lt;0.05</td>
<td>p &lt;0.05</td>
</tr>
<tr>
<td>Gestational age at first appointment (weeks)</td>
<td>10 (3-36)</td>
<td>11 (3-37)</td>
<td>12 (3-38)</td>
<td>12 (4-37)</td>
</tr>
<tr>
<td></td>
<td>p &lt;0.05</td>
<td>p &lt;0.05</td>
<td>p &lt;0.05</td>
<td>p &lt;0.05</td>
</tr>
<tr>
<td>Booked before 20 weeks</td>
<td>757 (92.2)</td>
<td>4275 (85.9)</td>
<td>1469 (74.8)</td>
<td>782 (72.2)</td>
</tr>
<tr>
<td>Pre-existing diabetes</td>
<td>1 (0.1)</td>
<td>20 (0.4)</td>
<td>25 (1.3)</td>
<td>31 (2.9)</td>
</tr>
<tr>
<td>Pre-existing hypertension</td>
<td>0 (0)</td>
<td>19 (0.4)</td>
<td>26 (1.8)</td>
<td>41 (3.8)</td>
</tr>
</tbody>
</table>

Values are n, (%)

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

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

<table>
<thead>
<tr>
<th>Existing maternal medical conditions</th>
<th>n (%) OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal n=4976</td>
<td>Underweight n=821</td>
</tr>
<tr>
<td>Anemia</td>
<td>1.00</td>
</tr>
<tr>
<td>Cardiac disease</td>
<td>1.00</td>
</tr>
<tr>
<td>Existing Diabetes Mellitus</td>
<td>1.00</td>
</tr>
<tr>
<td>Essential hypertension</td>
<td>1.00</td>
</tr>
<tr>
<td>Renal disease</td>
<td>1.00</td>
</tr>
<tr>
<td>SLE &amp; other autoimmune disease</td>
<td>1.00</td>
</tr>
<tr>
<td>Hyperthyroidism</td>
<td>1.00</td>
</tr>
<tr>
<td>Hypothyroidism</td>
<td>1.00</td>
</tr>
<tr>
<td>Asthma</td>
<td>1.00</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Maternal complication</th>
<th>n (%) OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal n=4976</td>
<td>Underweight n=821</td>
</tr>
<tr>
<td>Gestational Diabetes Mellitus</td>
<td>1.00</td>
</tr>
<tr>
<td>Pregnancy induced hypertension</td>
<td>1.00</td>
</tr>
<tr>
<td>Eclampsia</td>
<td>1.00</td>
</tr>
<tr>
<td>Pre-eclampsia</td>
<td>1.00</td>
</tr>
<tr>
<td>Hypertensive disease in pregnancy (PIH, Eclampsia, Pre-eclampsia)</td>
<td>1.00</td>
</tr>
</tbody>
</table>

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)
--- | ---
--- | --- | --- | ---
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)

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

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Normal n=4976</th>
<th>Underweight n=821</th>
<th>Overweight n=2614</th>
<th>Obese n=1853</th>
</tr>
</thead>
</table>
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) |

gpper <7 at 1 minute | 1.00 | 0.94 (0.57-1.55) | 1.41 (1.03-1.94) | 1.95 (1.37-2.80) |

gpper <7 at 5 minute | 1.00 | 0.93 (0.28-3.17) | 2.19 (0.09-4.40) | 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 (1.63-3.56) |
Macroosmia (>4500g) | 1.00 | N.S. | 1.34 (0.33-5.44) | 8.98 (3.11-30.0) |

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

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/m² in Asians instead of 30 kg/m² 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/m² if he is of Asian ethnicity [16].
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.

References


