An investigation into utilising gestational body mass index as a screening tool for adverse birth outcomes and maternal morbidities in a group of pregnant women in Khayelitsha

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Abstract

Objective: The aim of this study was to investigate the ability of the gestational body mass index (BMI) method to screen for adverse birth outcomes and maternal morbidities.

Design: This was a substudy of a randomised controlled trial, the Philani Mentor Mothers' study.

Setting and subjects: The Philani Mentor Mothers' study took place in a peri-urban settlement, Khayelitsha, between 2009 and 2010. Pregnant women living in the area in 2009-2010 were recruited for the study.

Outcome measures: Maternal anthropometry (height and weight) and gestational weeks were obtained at baseline to calculate the gestational BMI, which is maternal BMI adjusted for gestational age. Participants were classified into four gestational BMI categories: underweight, normal, overweight and obese. Birth outcomes and maternal morbidities were obtained from clinic cards after the births.

Results: Pregnant women were recruited into the study (n = 1 058). Significant differences were found between the different gestational BMI categories and the following birth outcomes: maternal (p-value = 0.019) infant hospital stay (p-value = 0.03), infants staying for over 24 hours in hospital (p-value = 0.001), delivery mode (p-value = 0.001), birthweight (p-value = 0.006), birth length (p-value = 0.007), birth head circumference (p-value = 0.007) and pregnancy-induced hypertension (p-value = 0.001).

Conclusion: To the best of our knowledge, this is the first study that has used the gestational BMI method in a peri-urban South African pregnant population. Based on the findings that this method is able to identify unfavourable birth outcomes, it is recommended that it is implemented as a pilot study in selected rural, peri-urban and urban primary health clinics, and that its ease and effectiveness as a screening tool is evaluated. Appropriate medical and nutritional advice can then be given to pregnant women to improve both their own and their infants' birth-related outcomes and maternal morbidities.

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Introduction

Maternal and child health has been one of the top health priorities in South Africa since the African National Congress came into power in 1994 and the Millennium Development Goals were agreed and implemented by the United Nations in 2000 (using 1990 figures).[1] Despite some progress, maternal and child mortality rates are still unacceptably high in South Africa.[1] A mother's nutritional status is one of the most important determinants of maternal and birth outcomes.[2,3] There are several methods of measuring nutritional status during pregnancy, although a universal method has not been accepted.[4] This has led to different methods being used in different studies, and could explain some of the conflicting reported results.[4] The Institute of Medicine method is similar to the majority of these methods which require the pregravid weight and body mass index (BMI) of a pregnant woman, and for her to be weighed at regular antenatal clinic appointments.[5] Attendance at antenatal clinics has increased in South Africa by 25% since 1994, mainly because of the implementation of basic free health care for pregnant women and children below the age of six.[6] The mean number of antenatal visits in South Africa was 3.8 in 2003. The Western Cape had the highest continuous attendance of 4.9.[6,7] Nevertheless, the reality is that in a peri-urban township setting many women attend these clinics later on in their pregnancy (a mean of 5.5 months).[6] Therefore, pregravid weight and BMI are not always measured or known, thus impacting on the calculation method recommended by the IOM.

The Argentinian Ministry of Health developed a logarithmic equation to adjust maternal BMI for gestational age using an adaptation of the Epi Info® nutrition software programme.[8] Using this software,

the calculated gestational BMI can be grouped into categories.[8] Subsequently Cruz et al[9] utilised this equation, together with specific biochemical parameters.[9] They investigated the BMI of human immunodeficiency virus (HIV)- positive South American pregnant women and birth outcomes (n = 697).[9] The main findings were similar to those of studies which observed accumulative weight gain and birth outcomes, namely those in which underweight women gave birth to infants of lower weight, shorter length and with a smaller head circumference (HC), compared to infants born to mothers in the normal or overweight category.[9,10] This method does not depend on the timing of the antenatal visit as it adjusts for gestational age.[8,9] Therefore, it could be used as an alternative method with which to screen for adverse birth outcomes and maternal morbidity in a South African peri-urban setting.

There is no consensus as to which method is the most appropriate when screening for birth outcomes and maternal morbidity. Risk factors need to be identified and managed accordingly to prevent maternal and infant deaths.[6] The establishment and implementation of a reliable and uni-occasion screening method is required as public health policy. Appropriate medical and nutritional intervention can then be given to pregnant woman before, during and after birth to improve maternal and birth outcomes. The aim of this study was to investigate the ability of the gestational BMI method to identify adverse birth outcomes and maternal morbidities in a South African peri-urban setting.

Materials and methods

Participants

The current study used baseline data from participants (n = 1 058) in a community-based, cluster-randomised controlled trial, the Philani Mentor Mothers' study.[11] The study took place in Khayelitsha, Western Cape, between 2009 and 2010. Twenty-four matched neighbourhoods [matched according to housing density, type of housing (formal or informal), source of public services, length of residence and number of shebeens (informal unlicenced bars)] were identified in the peri-urban settlement. Twelve of these were randomly assigned to a mentor mother in the intervention (described elsewhere),[11] while the other 12 were assigned to standard-care control. Recruiters knocked on the door of every house in each neighbourhood and invited pregnant women in the household to participate in the Philani Mentor Mothers' study. If no one was present at the house, the recruiter would return until someone was at home to ensure that no pregnant women were missed. All participants were given a personal participant identity number (ID).

Participants were included in the Philani Mentor Mothers' study if the following inclusion criteria were met: they were over 18 years of age, pregnant, living in the study neighbourhood within Khayelitsha for the duration of the study, and were able to provide informed consent.

Ethics

Ethical approval was obtained for the Philani Mentor Mothers' study from the University of California (No G07-02-033) and Stellenbosch University (No8/08/218) ethics committees. Each participant signed an informed consent form and was given a participant ID to maintain participant confidentiality.

Procedure

Participants who were willing to participate in the Philani Mentor Mothers' study were collected from their homes, and taken to the data assessment centre in Khayelitsha, Cape Town. Once they had signed an informed consent form, trained research assistants carried out interviews using population-specific questionnaires (baseline questionnaires developed by the research team and translated into Xhosa, the predominant spoken language in Khayelitsha).[11] The questionnaires included child health status, health care and monitoring, HIV-related preventive acts, mental health and social support.[11] Information was recorded using mobile phone technology.[12] Once the interview was uploaded to a central database, it was automatically deleted from the mobile phone. The uploaded data were reviewed and managed for each entry against written folders. The quality of the data for each interview was checked by the Philani Mentor Mothers' study assessment data coordinator. A random selection of interviews was cross-checked by an external quality controller. Participants were then given a food voucher and taken home. They were also given a card with their participant ID and the assessment centre phone number. They were asked to contact the assessment centre once their babies were born. The assessment interviewers went to the participants' homes two days after the birth and carried out the birth questionnaire.

Anthropometric measurements

Data collectors attended a training workshop held by a registered dietitian with International Society of Kinanthropometry accreditation on obtaining anthropometric measurements. Maternal weight was measured to the nearest 0.1 kg using a calibrated precision health scale.[13] Maternal height was measured to the nearest 0.01 m using a calibrated stationary stadiometer. Duplicates of these measures were completed by three data collectors during the baseline questionnaire using standardised methods.[13]

The infant's birthweight, length and HC were obtained from the clinic card which was completed at the maternal obstetric unit. Duplicate measures of all three measurements were taken by the data collectors during the birth questionnaire. Birthweight was obtained by weighing mother and child and subtracting maternal weight. Length was measured using a standard length board, and HC was obtained using a non-distorting measuring tape.[13]

Gestational body mass index

Gestational BMI was calculated using the equation for adjusted BMI for gestational age, e.g. if pregravid BMI is ≥ 21 to < 25 kg/m^2, then the equation; [(weight - 5.5) ÷ (height^2)] = gestational BMI[8] at enrolment. The GBMI is categorised into underweight (≥ 10 to ≤ 19.8 kg/m^2), normal weight (≥ 19.8 to ≤ 26.1 kg/m^2), overweight (≥ 26.1 to ≤ 29 kg/m^2), and obese (≥ 29 to ≤ 50 kg/m^2).[8,9]

Birth outcomes and adverse events

The participants were asked the following birth outcomes in the birth questionnaire: delivery facility, delivery mode, length of maternal hospital stay, length of infant hospital stay, the development of gestational diabetes or pregnancy-induced hypertension. The following birth outcomes were obtained from the infant's clinic

card: gestational age, weight, length and HC. Gestational age was classified as preterm ≤ 37 weeks, term ≥ 37 to ≤ 42, and post-term 42 weeks or more.[14] Z-scores were calculated (for this particular cohort) for birthweight, length and HC. They were then categorised into z-score 1 [≤ - 2 standard deviation (SD)], z-score 2 (≥ - 2 SD, ≤ + 2 SD) and z-score 3 (≥ + 2 SD).[15] Weight was documented as low birthweight ≤ 2 500 g and macrosomia ≥ 4 500 g.[16] The Philani Mentor Mothers' study followed-up the participants until the end of 2011. Therefore, the following occurrences were included and were termed as adverse events in this study: miscarriages; stillbirths; neonatal, infant or maternal deaths; or termination of pregnancy.

Data analysis

Microsoft Excel® was used to capture the data and SPSS® (version 18) to analyse the data. Summary statistics described the variables. Medians and quartiles or means and SD were used to describe ordinal and continuous responses. A multivariate analysis of variance was used to determine if there was a statistical difference between the intervention and control groups. If groups were significantly different, the results were calculated separately. If there was no significant difference, results were calculated using the combined data. The association of gestational BMI at enrolment with categorical birth outcomes was evaluated using contingency tables and the likelihood ratio chi-square test. If cells had a count less than 5%, data were transformed using (x + 0.5).[17] Randomised block analysis of variance was then calculated using this transformed data. Student-Newman-Keuls post hoc tests were performed to analyse the significant difference between categories and outcome groups. P-value < 0.05 represented statistical significance.

Results

Characteristics of the participants

The baseline characteristics collected during the enrolment of 1 058 pregnant women participating in the Philani Mentor Mothers' study are shown in Table I. There was a refusal rate of 2% during recruitment. Participants had an average age (± SD) of 26 ± 5.4 years. Most participants (50.8%, n = 537) were in the third trimester. Xhosa (99.5%, n = 1 053) was the predominantly spoken language among participants.

Few of the participants (3.6%, n = 38) reported that they were smokers. Approximately 90% (89.4%, n = 946) of participants had IDs. IDs are essential for booking into the antenatal clinics. 78.6% (n = 832) had booked in. The majority of births took place in a hospital (67.0%, n = 709).

More than half (57.1%, n = 604) of the participants were either married or cohabiting, but 88.8% (n = 939) had completed high school. Unemployment was high at 80.3% (n = 850). Over half (54.5%, n = 580) had a monthly household income of less than 2 000 South African Rands (US$290). Nearly two thirds of the participants (69.6%, n = 736) lived in an informal dwelling, i.e. a wood and iron structure which did not meet basic building standards). During their current pregnancy, 20.3% (n = 215) and 91.9% (n = 973) had been tested for tuberculosis and HIV, respectively. Of those tested, 1.4% (n = 3) had tuberculosis and 26.2% (n = 255) were HIV-positive.

Anthropometry and gestational body mass index

Anthropometry and calculated gestational BMI scores are detailed in Table IIa. Participants had an average height of 1.59 m ± 0.06 and a gestational BMI of 27.19 ± 5.83. The highest number in the group (44.2%, n = 468) were in the normal gestational BMI category.

Adverse events

Adverse events were categorised according to gestational BMI categories (Table IIb). The most common adverse event were miscarriages (2.5%, n = 26), followed by infant deaths (2.3%, n = 23). Although these occurred predominantly in the normal gestational BMI group, no statistical difference was found between the four gestational BMI categories and adverse events as the frequency counts were too low to analyse.

Table I: Socio-economic and demographic characteristics of the participants

	n	Mean ± SD or %	95% CI
Socio-economic and demographic characteristics			
Age	1 058	26.3 ± 5.4	
Smokers	38	3.6.	2.6-4.9
Identity document available	946	89.4	87.4-91.1
Xhosa-speaking	1 053	99.5	98.9-99.8
Third trimester	537	50.8	47.7-53.8
Booked at antenatal clinic	832	78.6	76.1-81
Planned pregnancies	278	26.3	23.7-29
Babies born in hospital, MOU or day clinic	709	67	64.1-69.8
Babies born at home, in their native home (Eastern Cape) and other*	349	33	30.1-35.3
Marital status			
Single	454	42.9	40-45.9
Married or cohabiting	604	57.10	54.1-60
Education			
Primary	80	7.60	6.1-9.3
Secondary	939	88.8	86.7-90.5
Tertiary	39	3.6	2.7-5
Employment and monthly income			
Employed	208	19.7	17.4-22.2
Unemployed	850	80.3	77.8-82.6
> 2 000 South African Rand	478	45.5	42.2-48.2
< 2 000 South African Rand	580	54.5	51.8-57.8
Housing			
Formal structure	322	30.4	27.7-33.3
Informal structure	736	69.6	66.7-72.3
Tuberculosis or HIV status			
Tuberculosis-positive (of those who tested) (20.3%, n = 215)	3	1.4	0.5-4
HIV-positive (of those who tested) (91.9%, n = 973)	255	26.2	23.5-29.1

*: otherwise not specified by the mother during the birth questionnaire
CI: confidence interval, HIV: human immunodeficiency virus, MOU: midwife obstetric units, SD: standard deviation

Birth outcomes

Birth outcomes are presented in Table III. No significant difference was found between the intervention and control groups. Over three quarters (75.5%, n = 799) of the births were vaginal deliveries. Over half of the births were term (56.6%, n = 598). Most of the infants were in the normal z-score range for birthweight (90.5%, n = 958), birth length (82.1%, n = 869) and birth HC (80.2%, n = 849). There was a low percentage of low birthweight infants (3.4%, n = 36). Ninety (8.5%) infants were macrosomic. Only 2.8% (n = 30) of the women developed gestational diabetes mellitus, whereas more developed pregnancy-induced hyptertension (17.6%, n = 186).

A significant difference was found between the gestational BMI groups, where the highest prevalence of the following birth outcomes was found in the obese group: Caesarean sections (p-value = 0.001) and pregnancy-induced hypertension (p-value = 0.001). There was a significant difference between the four gestational BMI categories and maternal hospital stay (p-value = 0.02). The greatest proportion of women who stayed in hospital longer than one day were found in the overweight (47.8, n = 86) and obese (56%, n = 196) groups. There was a significant difference between the gestational BMI categories and the number of babies staying for more than 24 hours in hospital (p-value = 0.024). The majority of infants born to women in the obese gestational BMI category stayed in hospital for longer than 24 hours. A significant difference was found between the underweight and normal-weight gestational BMI groups, and underweight and obese gestational BMI groups, and infants staying in hospital for longer than 24 hours (p-value = 0.001). The majority of infants from mothers in the underweight, obese and normal gestational BMI categories stayed in hospital for ≤ 3 days, ≥ 3 days but ≤ 2 weeks, and ≥ 2 weeks, respectively.

The majority (95.6%, n = 1 012) of women in the Philani Mentor Mothers' study had clinic cards. Of these, 91.1%, 53% and 86.1% had their babies' birthweight, length and HC measured and documented, respectively. These measures were repeated when the birth questionnaire was undertaken. There was no significant difference between results. Therefore, z-scores were calculated for both time measures. A significant difference was found between birth (values not included in Table III) and current (2-7 days after birth) birthweight, length and HC. A significant difference was found between the z-score 1 and z-score 2, and z-score 2 and z-score 3, for birthweight (p-value = 0.006), length (p-value = 0.01) and HC (p-value = 0.01); and post-birth (2-7 days) (p-value = 0.006), length (p-value = 0.007) and HC (p-value = 0.007). A significant difference was also found between women who developed gestational diabetes mellitus and those who did not (p-value = 0.048). Although significant differences were found between groups, post hoc tests revealed that there was no significant difference between the gestational BMI categories.

Table IIa: Gestational body mass indices of participants

Anthropometry	n of total	Mean (± SD) or %	95% CI
Height	1 058	1.59 ± 0.06	
Gestational body mass index		27.19 ± 5.83	
Underweight	60	5.7	4.4-7.2
Normal	468	44.2	41.3-47.2
Overweight	180	17	14.9-19.4
Obese	350	33.1	30.3-35.9

CI: confidence level, SD: standard deviation

Discussion

Significant results were reported in this study which linked to the ability of the gestational BMI method to identify certain birth outcomes and maternal morbidities. No significant difference was found between the four gestational BMI categories and adverse events, such as stillbirths and miscarriages, as the frequency counts were too low to analyse.

South Africa's Caesarean section rate (16.1%, range 3.2-32.5%) was higher than the World Health Organization's recommended rate of 15% in 2008/2009.[18,19] The rate in the Western Cape (20.4%) was at the upper end of the South African range.[19] The Caesarean section rate is an important indicator of obstetric care in low-income countries.[20] Several factors influence this high rate, one of which is a high HIV prevalence, although HIV is not a clinical indicator for a Caesarean section.[20] Caesarean sections impact on the cost to the health system and the well-being of the mother and child.[19] Knowledge of the reasons behind these differences in the rates in South Africa is required.[19] In the present study, women in the obese gestational BMI category had significantly more Caesarean sections, as have women in other studies.[20-22] Only a quarter (24%) of the births in the peri-urban settings are performed by a doctor.[6] This highlights the need for a more accurate way in which to classify at-risk women, so that high-risk births can be carried out by a doctor and more postpartum care given.[6]

In this study, significantly more mothers and babies who stayed in hospital for over 24 hours in were found in the obese gestational BMI category. Public hospitals in middle- to low-income countries

Table IIb: Perinatal adverse events categorised according to maternal gestational body mass index

Gestational body mass index	Adverse events					
	Miscarriages % (n) 2.5 (26)	Stillbirths % (n) 1.9 (21)	Neonatal deaths % (n) 1.4 (15)	Termination of pregnancy % (n) 0.5 (5)	Infant deaths % (n) 2.2 (23)	Maternal deaths % (n) 0.4 (4)
Underweight	3.8 (1)	4.8 (1)	6.7 (1)	0 (0)	0 (0)	0 (0)
Normal	38.4 (10)	42.8 (9)	20.0 (3)	40 (2)	73.8 (17)	0 (0)
Overweight	26.9 (7)	14.3 (3)	26.7 (4)	20 (1)	13.1 (3)	75 (3)
Obese	30.9 (8)	38.1 (8)	46.6 (7)	40 (2)	13.1 (3)	25 (1)

Table III: Birth outcomes and maternal morbidities overall and according to gestational body mass index at enrolment

Maternal gestational body mass index (kg/m²) at enrolment							
Birth outcome	**Overall % (n of total) 100 (1 058 of 1 058)**	**Underweight (≥ 10.0 to ≤ 19.8) % (n of total) 5.7 (60 of 1 058)**	**Normal weight (≥ 19.8 to ≤ 26.1) % (n of total) 44.2 (468 of 1 058)**	**Overweight (≥ 26.1 to ≤ 29) % (n of total) 17.1 (180 of 1 058)**	**Obese (≥ 29 to ≤ 50) % (n of total) 33 (350 of 1 058)**	**Test statistic**	**p-value**
Delivery mode							
Vaginal delivery	75.5 (799)	83.3 (50)	81.4 (381)	72.7 (131)	67.7 (237)	$X^2 = 23.03$	< 0.001*
Caesarean section	24.5 (259)	16.7 (10)	18.6 (87)	27.3 (49)	32.3 (113)		
Maternal hospital stay							
≤ 1 day	21.7 (230)	16.7 (10)	23.3 (109)	23.9 (43)	19.4 (68)		
1 day	31.6 (334)	38.3 (23)	37.2 (174)	28.3 (51)	24.6 (86)	$X^2 = 15.06$	0.022*
≥1 day	46.7 (494)	45 (27)	39.5 (185)	47.8 (86)	56 (196)		
Baby staying for over 24 hours in the hospital							
No	42.7 (452)	41.6 (25)	48.5 (227)	42.8 (77)	35.1 (123)	$X^2 = 7.46$	0.024*
Yes	57.3 (606)	58.4 (35)	51.5 (241)	57.2 (103)	64.9 (227)		
Babies staying for over 24 hours in the hospital: duration	52.3 (606)	5.8 (35 of 606)	39.8 (241 of 606)	16.9 (103 of 606)	37.5 (227 of 606)		
≤ 3 days	47.7 (289)**	62.9 (22)	51.5 (124)	47.6 (49)	41.4 (94)		
≥ 3 days, ≤ 2 weeks	45.7 (277)**	34.3 (12)	41.1 (99)	45.6 (47)	52.4 (119)	$F_{5,11} = 18.63$***	0.001*
≥ 2 weeks	6.6 (40)**	2.8 (1)	7.4 (18)	6.8 (7)	6.2 (14)		
Gestational period							
Preterm	28.7 (304)	36.6 (22)	28.6 (134)	28.9 (52)	27.4 (96)		
Term	56.6 (598)	51.7 (31)	58.2 (272)	57.2 (103)	54.9 (192)	$X^2 = 5.43$	0.487
Post-term	14.7 (156)	11.7 (7)	13.2 (62)	13.9 (25)	17.7 (62)		
Mean current birthweight (2-7 days after birth) = 3.6 kg (± 0.74)							
Birthweight z-scores							
Below - 2 SD	7.1 (75)**	16.7 (10)	7.5 (35)	6.1 (11)	5.4 (19)		
≥ - 2 SD, ≤ + 2 SD	90.5 (958)**	81.7 (49)	89.9 (421)	92.7 (167)	91.7 (321)	$F_{5,11} = 10.40$	0.006*
Above + 2 SD	2.4 (22)**	1.6 (1)	2.6 (9)	1.2 (2)	2.9 (10)		
Mean length (2-7 days after birth) = 51.2 cm (± 3.12)							
Birth length z-scores							
Below - 2 SD	12.6 (134)**	23.3 (14)	12.8 (60)	11.7 (21)	11.1 (39)		
≥ - 2 SD, ≤ + 2 SD	82.1 (869)**	70 (42)	83.5 (391)	83.9 (151)	81.4 (285)	$F_{5,11} = 9.89$	0.007*
Above + 2 SD	5.3 (52)**	6.7 (4)	3.7 (14)	4.4 (8)	7.5 (26)		
Mean HC (2-7 days after birth) = 35.7 cm (± 2.01)							
Birth HC z-score							
Below -2 SD	7.3 (77)**	18.3 (11)	7.7 (36)	4.4 (8)	6.3 (22)		
≥-2 sd, ≤+2sd	80.2 (849)**	73.3 (44)	82.7 (387)	84.4 (152)	76 (266)	$F_{5,11} = 9.01$	0.007*
Above +2sd	12.5 (129)**	8.4 (5)	9.6 (42)	11.2 (20)	17.7 (62)		
Low birthweight ≤ 2 500 g							
No	96.6 (1 022)	96.7 (58)	96.8 (453)	93.3 (170)	97.4 (341)	$F_{4,7} = 7.08$	0.07
Yes	3.4 (36)	3.3 (2)	3.2 (15)	6.7 (10)	2.6 (9)		
Macrosomic ≥ 4 500 g							
No	91.5 (968)	90 (54)	91.5 (428)	93.3 (168)	90.9 (318)	$X^2 = 1.138$	0.768
Yes	8.5 (90)	10 (6)	8.5 (40)	6.7 (12)	9.1 (32)		
Gestational diabetes							
No	97.8 (1028)****	100 (60)	97.4 (456)	97.8 (176)	96 (336)	$F_{4,7} = 9.44$	0.048*
Yes	2.8 (30)****	0 (0)	2.6 (12)	2.2 (4)	4 (14)		
Pregnancy-induced hypertension							
No	82.4 (872)	83.3 (50)	87.2 (408)	81.1 (146)	76.6 (268)	$X^2 = 15.83$	0.001*
Yes	17.6 (186)	16.7 (10)	12.8 (60)	18.9 (34)	23.4 (82)		

F: Manova test statistic, HC: head circumference, SD: standard deviation, X^2 = chi-square test statistic

*: p-value < 0.05

**: Significant difference between groups < - 2 standard deviation and > - 2 standard deviation and < + 2 standard deviation and groups > - 2 standard deviation and < + 2 standard deviation and > = 2 standard deviation

***: Significant difference between underweight and normal gestational body mass index categories and underweight and obese gestational BMI categories

****: Significant difference between developing gestational diabetes mellitus and not developing gestational diabetes mellitus

consume the majority of the healthcare resources, compared to primary and preventative clinics.[23] Approximate costs of hospital stay per day without drugs and diagnostic testing vary between clinics and hospitals (primary clinic: US$60.89, secondary hospital: US$79.44 and a tertiary hospital: US$108.51).[24] Olukoga[23] reported that the unit cost per day in district South African hospitals was highest for maternal inpatients.[23] Women who were identified as being in the obese gestational BMI category should be allocated more antenatal clinic appointments. This would potentially decrease the risk of them (and their babies) staying longer in hospital postnatally, which would also have a positive impact on the economic cost of the health service.[25]

This study showed a significant difference between the z-score categories and birth and post-birth anthropometry. Significant differences were also found between gestational BMI categories. These findings agree with those of other considerably larger studies that have found gestational BMI to be positively associated with birthweight, length and HC.[23,24,26-28] One of these studies also found that women who were classified in the low gestational BMI group had a higher risk of delivering preterm, and an increase in neonatal mortality, whereas those in this study did not.[29] This could be because of the fact that only 5.7% of the women in our study were in the underweight gestational BMI category.

Studies indicate that women with a lower[30] and higher[26-28] pregravid BMI are more at risk of giving birth to a low birthweight baby. There was a relatively low percentage (3.4%) of low birthweight babies in the present study, compared to the rates (9.7-29.2%) in the most recent *Saving babies* report (2010-2011).[31] However, the z-score was calculated for this particular cohort. The mean birthweight of the cohort was 3.6 kg, which is higher than the average birthweight of infants of black African ethnic origin (3.1 kg).[32,33] Therefore, the SDs would be shifted to the right. Another factor to take into consideration is the fact that the *Saving babies* report is an audit for the whole of South Africa, which includes different population groups and different geographical locations. This lower rate could also be owing to the low percentage (5.7%, 60 of 1 058) of women in the underweight gestational BMI category. Women who had given birth prematurely were missed during recruitment and no data for women under 18 years of age were obtained. Babies from teenage pregnancies are at a higher risk of low birthweight.[34] There was also a low prevalence of smokers in the cohort (3.6%). Smoking may inhibit maternal weight gain and is a risk factor for low birthweight babies.

In this study, there was a relatively higher percentage (8.5%) of macrosomic babies compared to that in other South African studies (2.3-3.43%) which focused on the black African population.[35,36] There are various risk factors for macrosomia, the strongest being gestational diabetes mellitus, followed by high gestational BMI.[35-37] The later could be the reason for the higher macrosomic incidence in this substudy. However, no significant difference was found between the gestational BMI categories and macrosomia. Mothers who develop gestational diabetes mellitus have an increased risk of developing type 2 diabetes mellitus, and infants born to mothers who have gestational diabetes mellitus are at an increased risk of adverse birth outcomes, including macrosomia and childhood obesity.[38-40] A reason for the low prevalence of gestational diabetes mellitus could be the low mean age (26.3 ± 5.4 years) of the women in this study, which is comparable with that of the women in a study by Mamabola et al.[41] The highest proportion of women who developed gestational diabetes mellitus were categorised in the obesity group. This is in agreement with the findings of Mamabola et al,[41] who also reported that women who developed gestational diabetes mellitus were significantly heavier than those who did not.[41]

The prevalence of hypertension is increasing in South African women (25%) alongside the increase in obesity.[42] Approximately 16% of maternal deaths were due to complications of pregnancy-induced hypertension.[43] In the present study, more than twice as many women (17.6%) had pregnancy-induced hypertension, than those in another South African study.[43] This could possibly be explained by the fact that the other study used women from both urban and rural regions, whereas this study's participants' diet and weight were influenced by urbanisation.[43] Black South Africans are particularly at risk because of a genetic susceptibility to low-renin, low-aldosterone hypertension.[44] In agreement with others,[45-47] this study found that significantly more women in the obese gestational BMI category developed pregnancy-induced hypertension.[47-49] If the women have been placed in a high-risk category, more observation, monitoring and appropriate intervention should take place.[45] Pregnancy-induced hypertension is frequently exposed by pregnancy and the mother often develops hypertension later in life.

Weight (97%) and height (90.4%) were recorded in the majority of antenatal clinics in the Western Cape.[5] With appropriate training and calibrated equipment, the gestational BMI method is simple to determine using a calculator, and can be used to identify women at high risk during pregnancy and labour.

Limitations to the study

The participants were not informed of the distinction between pregnancy-inducted hypertension and pre-eclampsia. Therefore, the two different morbidities could not be separated in the analysis. Most of the women were recruited in their third trimester, so women who gave birth prematurely could have been missed. No participants under the age of 18 were included in the study. Teenage pregnancies are at higher risk of the following adverse birth outcomes: low birthweight, premature infants, and those with a smaller length and HC.[34] There was intervariable reliability as infant anthropometric measurements (birthweight, length and HC) were obtained from the clinic card and post-birthweight, length and HC and maternal weight and height were measured by trained data collectors. Most of the information was obtained from participants' memory recollection, so accuracy of recall was a potential limitation. No significant difference was found between the gestational period and the gestational BMI categories. The gestational period in the substudy was questionable as it was calculated based on the last menstrual cycle.

Conclusion

To the best of our knowledge, this is the first study that has used the gestational BMI method in a peri-urban South African pregnant

population. Based on findings, it is recommended that the gestational BMI one-off method is implemented as a pilot study in a selection of rural, peri-urban and urban primary health clinics, and that the simplicity and effectiveness thereof is evaluated as a screening tool. The gestational BMI method could be a useful and practical tool with which to identify high-risk pregnancies. With appropriate training, it is relatively easy to use. Appropriate medical and optimal nutrition advice could then be given to pregnant women antenatally and postnatally to improve birth-related outcomes and maternal morbidities. Gestational BMI could identify women who need to be referred for hospital delivery as their chances of having to undergo a Caesarean section would be higher.

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