Effect of first trimester body mass index and gestational weight gain on maternal and neonatal outcomes: a cross-sectional study

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ABSTRACT

Introduction: Malnutrition and poor weight gain as well as maternal obesity have significant influences on the pregnancy outcome. This study aims to show the effect of first-trimester body mass index and the corresponding gestational weight gain on the outcome of pregnancy.

Method: It was a cross-sectional study conducted from 2017 to 2018. The sample size of the study was 740 respondents, which is calculated based on $N=Z^2pq/d^2$ formulae, where Z=1.96 for 95% CI, p=11.5, q=100-p and d=2.3(20%) of permissible error of prevalence. Frequency, percentage, mean and standard deviation were calculated for descriptive analysis. Chi-square test was used to find out the association for categorical variables. Odds Ratio and Logistic regression were also calculated for categorical variables.

Result: Most of the women (57.3%) had normal Body Mass Index (BMI). Compared to women of adequate Gestational Weight Gain (GWG), the Odds Ratio of Hypertensive Disorder in Pregnancy (HDP), Gestational Diabetes Mellitus (GDM), induction of labor and instrumental/caesarean delivery for women of excessive GWG was 3.88(95%, CI 1.65-9.12, p<0.05), 0.63(95% CI 0.24-1.63), 1.87(95% CI 1.11- 3.15, p<0.05), and 1.93(95% CI 1.14-3.27, p<0.05) respectively. Compared to women of normal BMI, the Odds Ratio of HDP, GDM, induction of labor and instrumental /caesarean delivery for overweight/obese women were 2.32(95% CI 1.15-4.66, p<0.05), 1.94(95% CI 1.10-3.41, p<0.05), 1.15(95% CI 0.75-1.77), 1.48(95% CI 0.96-2.28), respectively. Regarding neonatal outcomes, the OR of macrosomia and APGAR score <7 at 1&5 minute in the overweight/obese-group were 1.61(95% CI 0.56-4.61), 1.24(95% CI 0.21-7.25), and 2.04(95% CI 0.07-55.3), respectively.

Conclusion: Both overweight/obesity and excessive GWG are the risk factors of Hypertensive Disorder in Pregnancy, induction of labor, instrumental/cesarean delivery, macrosomia, and APGAR<7 at1&5 minutes.

Keywords: Body mass index, first trimester, gestational weight, neonate

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INTRODUCTION

Though maternal nutritional status is important for health and quality of life in women and their growing fetus, fertile women are affected by obesity or excessive gestational weight gain (GWG) around the world.[1] Maternal pre-pregnancy nutritional status and pregnancy weight gain also affect the health and survival of the newborn.[2] There is a need to identify appropriate weight management interventions that are effective and safe in pregnancy.[3] High pre-pregnancy body mass index (BMI) or excessive GWG may be associated with increased risks of maternal and neonatal outcomes including gestational diabetes mellitus (GDM), hypertensive disorders in pregnancy (HDP), caesarean delivery, large for gestational age infant (LGA) and macrosomia. Conversely, underweight or inadequate GWG may contribute to the increased risks of low birth weight (LBW) and small for gestational age infant (SGA).[4]

In 1990, the Institute of Medicine in the United States recommended that weight gain during pregnancy be based on pre-pregnancy BMI. American College of Obstetricians and Gynecologists has adopted these recommendation, for BMI < 19.8 kg/m^2, a weight gain of 28–40 lb (12.5-18kg), for BMI 19.8–24.9 kg/m^2, a weight gain of 25–35 lb (11.5-16 kg), for BMI 25.0–29.9 kg/m^2, a weight gain of 15–25 lb (7-11.5 kg) and for BMI> 29.9 kg/m^2, a weight gain of at least 15 lb with no upper limit (5-9 kg).[5] Globally, in 2015, neonatal deaths accounted for 45% of total deaths, 5% more than in 2000. Low birth weight (LBW) defined as birth weight less than 2500 grams, and is an important determinant of infant morbidity and mortality.[6] A strong relationship between maternal pregnancy weight gain and birth weight has been demonstrated consistently, and low maternal weight gain is considered as a preventable risk factor for LBW.[2] Globally and in Asian region also, a number of studies show pre-pregnancy body mass index and gestational weight gain affects the neonatal birth weight. [6,7]

Low birth weight (LBW) is a major cause of neonatal deaths in developing countries including Nepal.[7] Its social determinants in Nepal have rarely been identified.[7] A number of studies showed pre gestational body mass index and gestational weight gain affects the neonatal birth weight and such study will be important in context of people of Nepal also.

This study is chosen to find out the association of maternal first trimester BMI &gestational weight gain on neonatal birth weight in people of Nepal. The aim of the study is to evaluate the effect of first trimester BMI and gestational weight gain on neonatal birth weight.

METHOD

An observational cross sectional study was conducted at BPKIHS, Dharan, a teaching and tertiary care hospital. The calculated minimal sample size was 739 (considering prevalence of LBW in Nepal 11.5% as NDHS 2011 report) which is calculated based on $N=Z^2pq/d^2$ formulae, where Z=1.96 for 95% CI, p=11.5, q=100-p and d=2.3 (20% of permissible error of prevalence). Total 740 pregnant women in their first trimester who came for safe confinement, meeting the study criteria admitted at BPKIHS (singleton pregnancy at 37-42 weeks of gestation admitted for safe confinement and having first trimester known weight) during study period was considered for the study. Convenient sampling method was applied. Pregnant woman with multiple gestations, polyhydramnios, chronic hypertension, Overt DM, fetus having congenital anomaly and those who are planned for elective cesarean Section were excluded from this study. Preterm and Post term cases were also excluded from this study. The study was carried out from December 2017 to November 2018. Structured pro-forma was used and the data were collected.

Ethical Approval was taken from Institutional Review Committee, BP Koirala Institute of Health Sciences "IRC-BPKIHS" (Reference Number: 269/074/075-IRC). Informed written consent was taken from 740 respondents to collect their response with standard set of proforma. Confidentiality of the patient information was assured by maintaining the privacy and not recording the personal information.

The socio-demographic variables included: Age of the patients which was categorized as <18, 18-35, >35 years. Education of the respondent was categorized as Primary Level, Secondary level and Higher Education level. Parity of mother was categorized as Primigravida and Multigravida. Mode of delivery was categorized as Vaginal, Instrumental and LSCS. Birth weight was categorized as Low Birth Wight (<2500 gm) and Normal Birth Weight (≥2500 gm) and Macrosomia (>3500 gm). APGAR Score at 1 and 5 minute was categorized as Less (<7) or Normal (≥7).

Though the BMI classification for Asian population is slightly different but in general BMI is categorizes as Underweight (BMI < 18.50 kg/m2),

normal weight (BMI 18.50–24.99 kg/m2), overweight (BMI 25.00–29.99 kg/m2), obese (BMI 30.00–39.99 kg/m2), and morbidly obese (BMI >40.00 kg/m2) as per WHO guidelines. GWG is categorized as excess, normal and inadequate.

The data were fed into Microsoft excel and analyzed using SPSS software, version 16. As data were normally distributed, Frequency, Percentage, Mean and Standard deviation were calculated for descriptive analysis. To find out the association, Chi- square test was used for categorical variables. P value less than 0.05 was considered statistically significant. We performed bivariable and multivariable logistic regression and the results are presented in odds ratios with 95%.

RESULT

A total of 740 women participated in our study with a mean age 25.3±4.8 years. Of those, 659 cases (89.1%) were between ages 19–35 years, 6.4% were over 35 years of age and 4.6% were less than 18 years as shown in Table 1. Most of the respondents (59.5%) had completed their higher education. The majority 482(65.1%) of subjects were primigravida. Most of the respondents (70.7%) underwent vaginal delivery followed by LSCS (25.8%) and instrumental (3.5%). Table 1 also shows that most of the cases (69.1%) did not need the induction of labor (IOL).

Table 2 shows 57.3% had normal BMI, among total, 11.1% gained excess weight and 61.2% gained inadequate weight and 27.7% gained adequate weight than IOM recommendations.

In our study, we found mean birth weight in underweight, normal BMI, overweight, obese and overall were respectively 3035.8 ± 453.6g, 3104.6± 449.2g, 3218.6 ± 503.7g, 3351.9 ± 412.8g and3111.4 ± 463.0g respectively. In Table 3 and table 4 shows, in different BMI groups, we found four adverse maternal outcomes (HDP, GDM, induction of labor and operative delivery) and two neonatal outcomes (macrosomia and APGAR<7 at 1 and 5 minute) were positively associated with overweight/obese category whereas no adverse maternal outcome. Similarly, two neonatal outcomes LBW and APGAR<7 at 1 and 5 min were associated in underweight group. Compared to women of normal BMI, the OR of HDP, GDM, induction of labor and instrumental /caesarean delivery for overweight /obese women were 2.32 (95% CI 1.15-4.66, p<0.05), 1.94(95% CI 1.10-3.41, p<0.05), 1.15 (95% CI 0.75-1.77),1.48 (95% CI 0.96-2.28), respectively but only HDP and GDM were significantly associated.

Table 5 and table 6 shows, after adjusting for potential confounders, we found that four maternal outcomes [HDP, induction of labor and operative deliveries] and one neonatal outcome [macrosomia] were positively associated with GWG. Compared to women of adequate GWG, the OR of HDP, GDM, induction of labor and instrumental/ caesarean delivery for inadequate GWG women was 1.58(95% CI 0.73-3.4), 1.50(95% CI 0.86-2.61), 1.69 (95% CI 1.16-2.46, p<0.05), 1.77 (95% CI 1.21-2.59, p<0.05), respectively and for women of excessive GWG was 3.88 (95% CI 1.65-9.12, p<0.05), 0.63(95% CI 0.24-1.63), 1.87 (95% CI 1.11- 3.15, p<0.05), and 1.93(95% CI 1.14-3.27, p<0.05) respectively (Table 7). But only induction of labor and instrumental/LSCS delivery in insufficient GWG group. Regarding neonatal outcomes, the OR of macrosomia and APGAR <7 at 1 & 5 min in overweight/obese group were 1.61 (95% CI 0.56-4.61), 1.24 [95% CI 0.21-7.25), and 2.04(95% CI 0.07-55.3), respectively but no outcome was significantly associated as shown, whereas in underweight group, only LBW and APGAR<7 were associated with OR 1.31,95% CI 0.71-2.42] and [OR 6.02,95% CI 0.34-104.07) respectively at 1 and 5 minutes.

Table 7 and 8 shows macrosomia is significantly associated with gestational weight gain among the inadequate weight gain and excess GWG. Whereas there is no association of neonatal adverse outcome according to different BMI group.

Table 1. Characteristics of pregnant wome

Characteristics	Categories	Freq. (%)		Characteristics	Categories	Freq. (%)
Age	<18 years	34 (4.6%)		Parity	Primigravida	482 (65.1%)
	18-35 years	659 (89.1%)			Multigravida	258 (34.9%)
	>35 years	47 (6.4%)		Mode of delivery	Vaginal	523 (70.7%)
Education	Primary	64 (8.6%)			Instrumental	26 (3.5%)
	Secondary	236 (31.9%)			LSCS	191 (25.8%)
	Higher	440 (59.5%)		Induction of labor	Needed	229 (30.9%)
					Not needed	511 (69.1%)

Table 2. Frequency among different categories of BMI and gestational weight gain (GWG) groups

Characteristics	Categories	Freq. (%)	Characteristics	Categories	Freq. (%)
BMI	Underweight	179 (24.2%)	(Gestational Weight Gain) GWG	Excess	82 (11.1%)
	Normal	424 (57.3%)		Normal	205 (27.7%)
	Overweight	124 (16.8%)		Inadequate	453 (61.2%)
	Obese	13 (1.8%)			

Table 3. Maternal adverse outcomes according to different BMI groups

Maternal Outcomes	Category	Normal (%)	Underweight (%)	p-value (Normal & Underweight)	Over weight/ Obese (%)	p-value (Normal & Overweight)
GDM	Present	38 (9.0)	10 (5.6)	0.16	22 (16.1)	**0.01***
	Not Present	386 (91,0)	169 (94.4)		115 (84.9)	
HDP	HDP Present	21 (5.0)	5 (2.8)	0.23	16 (11.7)	**0.00***
	HDP absent	403 (95.0)	174 (97.2)		121 (88.3)	
Instrumental/ LSCS	Instrumental/ LSCS done	121 (28.5)	42 (23.5)	0.20	54 (39.4)	**0.01***
	Instrumental/LSCS not done (Vaginal delivery)	303 (72.5)	137(76.5)		83 (60.6)	
PPH	Present	11 (2.6)	1 (0.6)	0.18	0 (0.0)	0.07**
	Not Present	413 (97.4)	178 (99.4)		137 (100)	
Induction oflabor	Induction Needed	131(30.9)	47 (26.3)	0.25	51 (37.2)	0.16
	Induction not Needed	293 (69.1)	132 (73.7)		86 (62.8)	

*Test applied is chi-square ; **Test applied is Fischer Exact test; **Bold** signifies statistically significant (p<0.05)

Table 4. Multivariable logistic regression analysis of the association between first trimester BMI and adverse outcomes.

GWG Category	Outcome	Outcome Category	Adjusted OR (95% CI)	p-value
Inadequate GWG	HDP		0.52 (0.19-1.43)	0.20
	GDM		0.60 (0.293-1.23)	0.16
	Labour induction		0.85 (0.56-1.28)	0.44
	Birth Weight	LBW	1.31 (0.71-2.42)	0.38
		Macrosomia	0.06 (0.32-3.48)	0.91
	Neonatal APGAR <7	At 1 minute	1.33 (0.23-7.48)	0.74
		At 5 minute	6.02 (0.34-104.07)	0.21
	Instrumental LSCS		0.79 (0.52-1.21)	0.296
Excess GWG	HDP		2.32 (1.15-4.66)	**0.01**
	GDM		1.94 (1.10-3.41)	**0.02**
	Labour induction		1.15 (0.75-1.77)	0.50
	Birth Weight	LBW	0.78 (0.35-1.70)	0.56
		Macrosomia	1.61 (0.56-4.61)	0.37
	Neonatal APGAR <7	At 1 minute	1.24 (0.21-7.25)	0.80
		At 5 minute	2.04 (0.07-55.3)	0.67
	Instrumental LSCS		1.48 (0.96-2.28)	0.07

Bold Signifies Statistically Significant (p<0.05)

Table 5. Maternal adverse outcomes according to gestational weight gain

Characteristics	Adequate GWG (N=205)	Inadequate GWG (N=453)	P value	Excess GWG (N=82)	P value
GDM	28 (13.7%)	36 (7.9%)	**0.02***	6 (7.3%)	0.13*
HDP	14 (6.8%)	17 (3.8%)	0.085*	11(13.4%)	0.07*
Instrumental/LSCS	79 (38.5%)	104 (23.0%)	**0.00***	7 (12.7%)	<0.01*
PPH	4 (2.0%)	5 (1.1%)	0.38*	3 (3.7%)	0.41*
Induction oflabor	82 (40.0%)	112 (24.7%)	**0.00***	35 (42.7%)	0.67*

*Test applied is chi-square; **Bold** signifies statistically significant (p<0.05)

Table 6. Logistic regression analyses showing maternal and neonatal outcomes between inadequate and excess GWG

GWG Category	Outcome	Outcome Category	Adjusted OR (95% CI)	p-value
Inadequate GWG	HDP		1.48 (0.73-3.4)	0.24
	GDM		1.50 (0.86-2.61)	0.14
	Labour induction		1.69 (1.16-2.46)	**<0.01**
	Birth Weight	LBW	0.61 (0.31-1.21)	0.16
		Macrosomia	4.28 (1.4-12.7)	**<0.01**
	Neonatal APGAR <7	At 1 minute	0.78 (0.14-4.24)	0.77
		At 5 minute	-	-
	Instrumental LSCS		1.77(1.21-2.59)	**<0.01**
Excess GWG	HDP		3.88 (1.65-9.12)	**<0.01**
	GDM		0.63 (0.24-1.63)	0.34
	Labour induction		1.87 (1.11-3.15)	**0.01***
	Birth Weight	LBW	0.43 (0.14-1.29)	0.13
		Macrosomia	3.64 (0.90-14.62)	**0.06**
	Neonatal APGAR <7	At 1 minute	0.96 (0.10-8.92)	0.97
		At 5 minute	3.20 (0.17-59.41)	0.43
	Instrumental LSCS		1.93 (1.14-3.27)	**0.01***

Bold signifies statistically significant (p<0.05)

Table 7. Neonatal adverse outcome by gestational weight gain

Characteristics	Category	Adequate GWG (%)	Inadequate GWG (%)	p-value	Excess GWG (%)	p-value
Birth weight	LBW	44 (9.7%)	12 (5.9%)	0.13*	4 (4.9%)	0.28*
	Macrosomia	5 (1.1%)	11 (5.4%)	**0.00***	4 (4.9%)	**0.04***
	Normal	404 (89.2%)	182 (88.8%)		74 (90.2%)	
Malpresentation	-	7 (1.5%)	3 (1.5%)	1.00*	2 (2.4%)	0.62*
APGAR<7	At 1 Minute	8 (1.8%)	2 (1.0%)	0.73*	3 (3.7%)	0.14*
	At 5 Minute	3 (0.7%)	0 (0.0%)	-	2 (2.4%)	-
Need of special neonatal care		10 (2.4%)	4 (2.2%)	0.92*	6 (4.4%)	0.21*

*Test applied is chi-square; **Bold** signifies statistically significant (p<0.05)

Table 8. Adverse neonatal outcomes according to different BMI groups

Characteristics	Category	Normal (%)	Underweight (%)	p-value	Overweight	p-Value
Birth Weight	LBW	33 (7.8 %)	18 (10.1 %)	0.36*	9 (6.6 %)	0.68*
	Macrosomia	10 (2.4 %)	4 (2.2 %)	1.00*	6 (4.4%)	0.22*
	Normal	381(89.9 %)	157 (87.7%)		122 (89.1%)	
Malpresentation		6 (1.4%)	3 (1.7 %)	1.00*	3 (2.2%)	0.81*
APGAR <7	At 1 minute	5 (1.2%)	5 (2.8%)	0.15*	3 (2.2%)	0.65*
	At 5 minute	1 (0.2%)	3 (1.7%)	0.81*	1 (0.7%)	0.42*
Need of special neonatal care		10 (2.4%)	4 (2.2%)	0.92*	6 (4.4%)	0.21*

*Test applied is chi-square, **Bold** signifies statistically significant (p<0.05)

DISCUSSION

Maternal first trimester BMI and gestational weight gain reflect nutritional status before and during pregnancy. First trimester BMI and GWG is an important predictor of adverse maternal and neonatal outcomes. To reduce the influence of lifestyle interventions on weight gain, we used not only the single effects but also the joint effects of first trimester BMI and GWG on adverse outcomes. The prevalence of overweight and obesity (16.8%, 1.8%, respectively) in our study was not only much lower than the figures of foreign countries using WHO cutoff (39% overweight and 13% obese in 2016) but also lower than the results reported in previous studies (in Northern China about 18.0%, 6.0% respectively, in Crane et al study (26.4%, 20% respectively) and in Zhang et al(12.0%, and 2.6%).[4,8,24,25] However the prevalence of underweight is much higher (24.2%) in our study compared to study by Zhang et al (16.2%).[4] Of further concern, only 11.1% of the study participants had excessive GWG, which is lower than in different studies (*in Tianjin, China (57.1%)*, in Zhang et al (47.3%).[4,25] Regarding insufficient weight gain 61.2% gained insufficient weight which is very high compared to Zhang et al (12.1%).[4] The high value of underweight and very low percentage of overweight and obese women and also high number of inadequate GWG might

be due to low socio-economic status and poor nutritional status in women of our country Nepal.

Previous studies have showed that overweight/obesity and excessive GWG were positively associated with HDP as shown in Zhang et al 2015 and Crane et al 2009.[4,8] Consistently, we also found in our study that overweight/obese women and excess GWG had the highest risk of HDP. However, the mechanism through which obesity and excessive GWG affect HDP is still unclear, it may be involved with excessive adiposity, endothelial dysfunction resulting from inflammation reaction (Zhang et al).[4]

In our study mean birth weight in underweight, normal BMI, overweight, obese and overall were respectively 3035.8 ± 453.6g, 3104.6± 449.2g, 3218.6 ± 503.7g, 3351.9 ± 412.8g and3111.4 ± 463.0g. Mean birth weight in inadequate GWG, adequate GWG and excess GWG were respectively 3020.3 ± 434.7g (min-1580g & max-4275g), 3236.9 ± 470.9g (min-2100g&max-4595g) and 3301.2 ± 469.3g (min-1805g&max-5000g). The mean birth weight was 3024 (SD = 654.5) grams. KC Kurnit, et al. in 2015 found on bivariate analysis, birth weight was significantly lower in those with inadequate GWG compared with those with adequate and excessive GWG.[9] Similar results were seen in our study also.

A total of 12.1% children had low birth weight (<2500 grams) at the time of birth in Nepal.[7] In our study overall 8.1% had low birth weight and LBW was present more (10.1%) in the underweight category of women compared to normal (7.8%) and overweight/obese (6.6%) women. Houde, et al., in 2015 found the odds of low birth weight were significantly higher for lower BMI groups and consistently increased rate of low birth weight was associated with poor weight gain groups.[22] Moreover, macrosomia was more frequently present (4.4%) in the overweight/obese women compared to the underweight women (2.2%) and normal BMI (2.4%) in our study. Similar results were seen in Zhang et al 2015, Tai-Ho Hung, et al Taiwan and macrosomia was not consistent in inadequate GWG.[4,14] Maternal obesity, gestational weight gain excess and diabetes should be considered as independent risk factors for newborn macrosomia.[26] Energy taken by mothers is mainly used for the growth of fetal muscle and fat since fetal organs have almost developed completely in the early trimester. So excessive energy intake would lead to the accumulation of fetal fat, and then increase the incidence of macrosomia. In contrast, inadequate GWG would raise the risk of LBW. Some studies reported that macrosomia has a higher risk of becoming overweight or obesity in the future, while LBW or SGA has a higher risk of developing noninfectious chronic disease according to the theory of Development Origins of Health and Disease.[23] Therefore, it is necessary to improve the infant health through keeping maternal first trimester BMI and GWG in normal range.

But in our study, macrosomia was seen significantly more both in excess as well as inadequate GWG groups 4.9% and 5.4% respectively compared to adequate GWG ($p<0.05$). Also APGAR <7 @1min was more seen in excess GWG group (3.7%) in compared to adequate and inadequate GWG groups.

We found the three maternal outcomes (HDP, Induction of labor and operative deliveries) and one neonatal outcome (macrosomia) were positively associated with excess GWG as shown in 'table no 12' and three maternal outcomes [HDP, induction of labor and operative delivery] and two neonatal outcomes (macrosomia and APGAR<7 at 1 and 5 minutes) were positively associated with overweight /obese category shown in table 13 whereas only one maternal outcome (GDM) and one neonatal outcome (APGAR<7 at 1 and 5 min) were associated with underweight group shown in table no 12 which was similar to other studies. But in Crane et al,2009 found the rates of gestational diabetes, Apgar score < 7 at five minutes were not different in women with more or less than recommended weight gain in the different BMI groups. Cigdem Yayla Abide, et al., in 2018 also found that insufficient GWG was associated with increased risk of having Infant with low birth weight (LBW) ($p<0.01$), 5 minute APGAR score <7 ($p<0.01$) and admission to the neonatal intensive care unit (NICU) ($p=0.04$). In women, excess weight gain was associated with increased rates of macrosomia ($p<0.01$) and cesarean delivery compared to women with insufficient and adequate weight gain ($p<0.05$).[9,13]

Only first trimester weight was considered instead of pre-pregnancy weight, so there were less GWG reported than usual.

CONCLUSION

Both overweight/obesity and excessive GWG are the risk factors of HDP, induction of labor, instrumental/caesarean delivery, macrosomia and APGAR<7 at 5minute. In addition, inadequate GWG and underweight are the risk factor of LBW and APGAR<7 at 1 minute.

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Availability of data and materials
The data supporting the findings of this article is available in IRC-BPKIHS and with authors.

Conflict of Interests
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Author Contributions
RBS conceived, conceptualized, and designed the study. Data analysis was done by KPY & RKS. MKS drafted manuscript for publication. PR, AT &AA revised the manuscript. All authors critically read the manuscript, and agreed to its submission and publication. Guarantor: RBS.

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