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The double burden of maternal overweight and short stature and the likelihood of cesarean deliveries in South Asia: An analysis of national datasets from Bangladesh, India, Maldives, Nepal, and Pakistan

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Abstract

Background: The aim was to investigate: (a) whether there is an association between the maternal double burden of overweight and short stature and the risk of cesarean delivery and (b) whether socioeconomic status (SES) acts as a moderator in the association between the maternal double burden of overweight and short stature and the risk of cesarean birth (CB).

Materials and methods: The data for this study were obtained from the nationally representative Demographic and Health Survey databases of five South Asian countries. The analyses were based on responses from married women between 15 and 49 years of age. The maternal double burden of overweight and short stature (coexistence of overweight and short stature) was the exposure of interest.

Results: Maternal double burden of overweight and short stature was significantly associated with 179% higher likelihood of undergoing CB in Soth Asia (SA), with 125%, 167%, 155%, 304%, and 200% higher likelihood of undergoing CB in Bangladesh, India, Maldives, Nepal, and Pakistan, respectively. Findings also demonstrated that mothers belonging to low SES groups with a double overweight and short stature burden were not uniquely disadvantaged.

Conclusions: A significant marker in SA of higher risk of CB is the maternal double burden of overweight and short stature. The negative effect of the maternal double burden of overweight and short stature extends across all economic backgrounds in relation to the risk of CB. It is not limited to poor mothers who suffer from the double burden of overweight and short stature.

KEYWORDS
cesarean, maternal double burden of overweight and short stature, obesity, overweight, short stature, South Asia

1 | INTRODUCTION

Cesarean birth (CB) can save the lives of mothers and babies when certain justifiable medical conditions arise.[1] Unnecessary CB, however, is associated with short- and long-term health risks for mothers and their children.[2-4] The World Health Organization (WHO) has considered the ideal rate for CB to be between 10-15%.[5] However, in most countries, the CB rate has exceeded the recommended range.[6] CB rates are also gradually growing in South Asia (SA)[7] and surpass 15% of all deliveries in most countries in this region, such as Bangladesh (17%),[8] Bhutan (18.7%),[9] India (17.1%),[10] Maldives (33.1%),[11] Pakistan (15.8%),[12] and Sri Lanka (33.6%),[13] respectively. Due to potential maternal and perinatal risks, access inequality, and the associated costs, the global rise in CB has become a major public health issue.

Rising CB around the world has driven public health practitioners to address the determinants of this increase. Until now, the major determinants of the rise in CB were assumed to be related to multiple factors ranging from certain obstetric risks such as dystocia, fetal distress, breech births, post-term pregnancy, multiple pregnancy, and hypertensive disorder[14,15]; sociodemographic factors such as higher maternal age, higher birth order, urban residence, higher socioeconomic status (SES)[16,17]; psychological factors such as fear related to prolonged labor and vaginal delivery pain[18]; and factors related to physicians' decisions and patient demand.[19]

There is also increasing evidence that maternal somatic phenotype, such as maternal short stature[20,21] and maternal overweight/obesity[22,23] have been independently associated with an increased risk of CB. However, research to date has tended to target only one of these traits at a time, and no studies have assessed the relationship between the combination of these exposures and the risk of CB. This combined manifestation of the maternal double burden of overweight/obesity and short stature may affect the risk of cesarean delivery more profoundly than they do independently. Relevant mechanisms for these hypothesized relationships are greater gestational weight gain, cephalopelvic disproportion, and greater risk of macrosomia in offspring that predisposes overweight/obese or short stature mothers to suffer from labor dystocia and dysfunctional labor which may lead to CB.[24,25] Evidence has shown that, an increasing proportion of women in low-resource settings are characterized by both nutritional states, having been stunted in early life and subsequently becoming overweight or developing obesity in later life.[26,27] A more nuanced understanding of the separate and combined influences of this somatic phenotype and its association with the risk of CB is required to develop effective prevention programming for this region.

Furthermore, exposure to the maternal double burden of being overweight/obese and of short stature and the associated risk of CB needs to be studied in greater detail according to different socioeconomic strata in South Asian low-resource countries, where, in the last 10 years or so, rapid industrialization and urbanization have increased socioeconomic inequality. Evidence suggests that there exists a significant gradient in the maternal double burden of overweight/obesity and short stature across socioeconomic groups in this region, where a higher prevalence of maternal short stature and greater association between maternal short stature and overweight/obesity were observed in those belonging to lower socioeconomic groups.[28] Women belonging to higher socioeconomic status (SES) in this region have more access to and the ability to undergo CB delivery[29] and a greater prevalence of overweight/obesity.[30] Therefore, from a population health perspective, SES serves as a strong determinant of maternal phenotype *and* mode of delivery. Thus, the purpose of this research was to examine whether SES, which has an independent association with exposure to the maternal phenotype and/or the risk of CB, acts as a moderator in the association between the maternal double burden of overweight and short stature and the risk of CB in five nationally representative samples from Bangladesh, India, Maldives, Nepal, and Pakistan.

2 | MATERIALS AND METHODS

2.1 | Data sources

Data for this study were obtained from the Demographic and Health Surveys (DHS)[31-35] from five countries in the SA region, namely, Bangladesh (BDHS 2014), India (NFHS 2015-16), Maldives (MDHS 2016-17), Nepal (NDHS 2016), and Pakistan (PDHS 2017-18). Data from three other countries in this region—Afghanistan, Bhutan, and Sri Lanka—were not used because the data from the DHS survey were not available. DHS is a series of a nationally representative surveys of households designed to collect information on population health, nutrition, and behaviors related to fertility.[36] For each country selected, the study dataset contains only the latest round of DHS data collected.

To collect the data, DHS used a probability based-multistage cluster sampling technique.[31-35] First, on the basis of non overlapping geographical units (typically census enumeration areas) covering the whole country, sampling frames were created. These geographic areas have been defined as the primary sample units (PSUs) from which samples have been collected with a probability proportional to the size of the population. Next, through field visits within the selected PSU, a list of all households was generated and a fixed proportion of households was chosen through systematic sampling. All women between the ages of 15 and 49 who had ever been married were invited to be in the selection pool for interviews. The target number of women per PSU in this age group was typically 20 to 25 in urban areas and 30 to 40 in rural areas. Table 1 provides a list of selected countries and the corresponding survey years.

The DHS questionnaires were drawn up in English and then translated into each country's national language. Information regarding the reliability and validity of DHS anthropometry and CB data have been reported elsewhere.[31-35] CB-related information was collected from women aged 15 to 49 living with children under the age of five in India, Maldives, Nepal, and Pakistan as NFHS 2015-16, MDHS 2016-17, NDHS 2016, and PDHS 2017-18 surveys were adopted after the 5-10 years of the most recent NFHS 2005-06, MDHS 2009, NDHS 2011, and PDHS 2012-13. However, BDHS 2014 was introduced after three years of the most recent BDHS 2011, so CB data was collected from women living with their children under the age of three in Bangladesh.

2.2 | Measures

The outcome variable was CB. It was assessed by asking mothers whether or not their live-born babies were delivered via CB during the 5 years prior to the survey (three years prior to the survey in the case of Bangladesh). A binary variable was created, dichotomized as delivery via CB (1) or not (0). DHS surveys, however, do not include evidence to distinguish between medically indicated (eg, fetal distress/non reassuring fetal status, abnormal lie, macrosomia, multiple gestations, prolonged and obstructed labor, prior experience of CB, etc)[37] and non medically indicated cesarean deliveries (eg, request of the mothers).

The maternal double burden of overweight and short stature was defined, in this research, if women were both short and overweight/obese. The DHS survey measured the height and weight of all married women between the ages of 15 and 49 years. Trained investigators weighed each participant using a solar-powered scale with a precision of ±100 g. They measured each woman using a millimeter-calibrated and technically accurate adjustable board to 1 mm.[31-35] In order to measure the overweight/obesity status of a participant, body mass index (BMI) was used. As indicated by the WHO for populations from the Indian subcontinent, a BMI of 25 kg/m^2 or higher was used to classify overweight and 30 kg/m^2 or above as obesity.[38] In this study, overweight and obesity were grouped and labeled as overweight. Short stature was defined as a height of 147 cm or less in women.[39]

To assess the maternal double burden of overweight and short stature, we set the following categories: (a) non overweight and non-short-statured mothers (NONS), (b) non-overweight and short-statured mothers (NOS), (c) overweight and non-short-statured mothers (ONS), and (d) overweight and short-statured mothers (OS).

This research also included the following sociodemographic and health-related variables, theoretically and empirically linked to CB[7,14-24] and maternal anthropometry[40,41]: respondent's education, age, decision-making autonomy, employment status, place of residence, parity, pregnancy intention, offspring sex, and size of children at birth. It has long been known that women's

TABLE 1 Data cleaning and sample sizes

Data cleaning	Bangladesh[a]	India[b]	Maldives[c]	Nepal[d]	Pakistan[e]
Women with children aged <60 months	-	259,627	3106	5038	12,708
Women with children aged <36 months	5460	-	-	-	-
Missing data for CB	−967	-	−30	–	−13
Missing/flagged anthropometric data	−37	−3401	−246	−2489	−8031
BMI < 15 & BMI > 50	−37	−2572	−21	−12	−9
Currently pregnant	−179	−21,739	−95	−164	−613
Multiple births	−28	−3963	−50	−31	−98
Missing covariates	−56	−5281	−169	−28	−56
Final sample	4156	222,671	2495	2314	3884

[a]Bangladesh Demographic and Health Survey 2014.
[b]National Family Health Survey, 2015-16.
[c]Maldives Demographic and Health Survey 2016-17.
[d]Nepal Demographic and Health Survey 2016.
[e]Pakistan Demographic and Health Survey 2017-18.

autonomy in decision-making is a significant factor in the use of healthcare.[42,43] Therefore, we hypothesized that the greater the decision-making power a woman has, the greater the ability to ask or request the doctor for her opinion on CB. Jobs, education, property ownership, freedom from domestic violence, and freedom to travel without limitations[44] can affect decision-making power and influence the likelihood of a cesarean delivery. In the DHS, the decision-making autonomy of women was measured by asking women about their decision-making abilities in the household: "Who typically makes the final decision on the purchase of major household products, family/relative visits, and women's own health care?" There were three possible answers to each of these questions: the woman made the sole decision, the woman made the decision jointly with her husband/partner, or the sole decision was made by the husband/partner. The index of autonomy represents the number of decisions made by a woman alone or jointly with her husband; it was generated by summarizing the total number of decisions made by a woman alone or jointly with her husband in all three scenarios. A low score on the autonomy index indicates a lower level of autonomy in decision-making, while a high score on the autonomy index indicates a higher level of autonomy in decision-making. Since the majority of births in the surveyed countries occurred at home without reliable birth weight measurement, the DHS asked about the size of the baby at birth as the birth weight proxy: When (NAME) was born, was he/she very large, larger than average, average, smaller than average, or very small?A categorical variable was then created: (a) large ("larger than average" and "very large"), (b) average, and (c) small; ("smaller than average" and "very small").

As a SES measure, this study utilized the wealth index. The wealth index of this survey was calculated from household asset data, including ownership of durable goods, dwelling features, and construction materials. For each asset, principal component analysis was used to assign a weight (factor score). Then, each household was attributed a score for each asset. The sample was then split into population terciles and ranked from one (low) to three (high). To define the household SES, a binary variable was created: (a) low and (b) middle-to-high ("middle" and "high").

2.3 | Analytical methods

In order to provide general information about the sample characteristics, descriptive analyses were conducted first. To examine the association between the maternal double burden of overweight and short stature and CB delivery for each country, adjusted logistic regression models were performed. We simultaneously inserted all the covariates into the adjusted regression models. Multi collinearity was tested in the analysis of logistic regression by examining the variance inflation factor, which was <2.0, suggesting an absence of multi collinearity.

To assess the strength of the association, we calculated the odds ratios (ORs) and used 95% confidence intervals (CIs) to test their significance. For all tests, significance was set at $P < 0.05$. Logistic regression analyses were also performed to analyze the adjusted association between the maternal double burden of overweight and short stature and CB after stratification by the SES level of households to see if women from low SES households who are impacted by the maternal double burden of overweight and short stature were at increased risk of cesarean delivery.

The proportion of CB that was attributable to OS was estimated from the prevalence of OS and the odds ratios that were obtained in the multivariate model using the expression $(P \times [AOR - 1]/1 + P \times [AOR–1]) \times 100$, where P = prevalence of OS and adjusted odds ratio [AOR] =associated outcome effect size.[45] STATA version 14.0 (StataCorp LP, College Station, TX) was used to consider sample weighting.

3 | RESULTS

Table 2 shows descriptive statistics for the participants. Some of the significant differences between countries have been illustrated by key descriptive statistics. A large proportion of mothers in the SA region had no education, and the proportion with no education in the Maldives was much lower, while in Pakistan it was much higher. More than two-thirds of mothers lived in rural areas, and more than four-fifths of women lacked decision-making autonomy, while the highest proportion of Indian women did not have decision-making autonomy in comparison to other countries.

The percentage of maternal overweight (BMI ≥ 25 kg/m^2) in SA ranged from 16.3% to 73% and was substantially higher in the Maldives. In Pakistan, the prevalence of small stature (<148 cm) was the lowest (11.9%), but considerably higher in all other countries. The prevalence of the maternal double burden of overweight and short stature (both short and overweight) was 5.9% in the SA region and notably higher in Maldives (57.7%). The proportion of cesarean births ranged from 8.9% to 39.9% in SA and was substantially higher in the Maldives.

Figure 1 shows the overweight, short stature, and OS (maternal overweight and short stature jointly) prevalence

TABLE 2 Sociodemographic, CB, and anthropometry characteristics of the study participants (Demographic and Health Surveys, Bangladesh, India, Maldives, Nepal, and Pakistan)

Characteristics	Bangladesh (n = 4156) % (95% CI)	India (n = 222,671) % (95% CI)	Maldives (n = 2495) % (95% CI)	Nepal (n = 2314) % (95% CI)	Pakistan (n = 3884) % (95% CI)	South Asia (n = 235,520) % (95% CI)
Age, y						
15-24	54.4 (52.3-56.4)	34.3 (34.0-34.6)	13.2 (11.2-15.6)	41.2 (38.0-44.5)	22.3 (19.5-25.3)	34.4 (34.1-34.7)
25-34	39.7 (37.8-41.5)	57.0 (56.7-57.3)	64.0 (60.5-67.3)	49.5 (46.6-52.4)	58.9 (55.8-61.9)	56.7 (56.4-57.0)
35-49	6.0 (5.2-6.9)	8.7 (8.5-8.9)	22.8 (20.3-25.5)	9.3 (7.9-10.9)	18.9 (16.5-21.5)	8.9 (8.8-9.1)
Education						
No education	13.9 (12.0-16.0)	29.0 (28.8-29.3)	1.8 (0.8-1.7)	33.5 (30.2-37.0)	49.7 (44.7-64.6)	28.8 (28.5-29.1)
Primary	27.1 (25.2-29.0)	13.9 (13.7-14.2)	18.1 (15.8-20.6)	19.7 (17.3-22.4)	14.4 (12.2-16.9)	14.3 (14.1-14.5)
Secondary	48.7 (46.0-51.3)	46.2 (45.9-46.5)	59.0 (55.3-62.7)	32.5 (29.4-35.7)	22.4 (18.9-26.3)	44.9 (45.6-46.2)
Higher	10.4 (9.1-11.8)	10.8 (10.6-11.0)	21.7 (18.2-25.7)	14.3 (12.3-16.6)	13.6 (11.1-16.6)	11.0 (10.8-11.2)
Decision-making autonomy, no. of aspects[a]						
0	25.8 (23.8-28.0)	86.4 (86.2-86.6)	2.4 (0.9-6.2)	36.5 (33.1-40.0)	43.3 (39.8-46.8)	83.2 (83.1-83.5)
1	15.0 (13.4-16.7)	1.7 (1.6-1.7)	3.3 (2.3-4.7)	17.9 (15.6-20.4)	15.1 (12.7-17.8)	2.3 (2.2-2.4)
2	14.0 (12.5-15.7)	2.0 (1.9-2.1)	10.7 (8.9-12.8)	15.0 (12.9-17.4)	10.5 (8.8-12.4)	2.6 (2.5-2.7)
3	45.2 (41.9-48.6)	9.9 (9.7-10.1)	83.6 (8.0-86.7)	30.7 (27.9-33.6)	31/2 (27.7-35.0)	11.8 (11.7-12.0)
Respondent employed						
No	76.7 (74.4-78.8)	97.1 (96.9-97.2)	64.0 (60.7-67.3)	48.7 (44.8-52.5)	86.4 (83.4-88.4)	95.8 (95.6-95.9)
Yes	23.3 (21.3-25.6)	2.9 (2.8-3.0)	36.0 (32.8-39.3)	51.3 (47.5-55.2)	13.6 (11.1-16.4)	4.2 (4.1-4.4)
Parity						
1	39.8 (37.8-41.8)	23.9 (23.7-24.2)	31.3 (28.6-34.1)	28.8 (26.5-31.3)	12.3 (10.8-13.9)	24.2 (23.9-24.5)
2	30.2 (28.5-32.0)	38.6 (38.3-38.9)	34.1 (30.9-37.4)	34.7 (32.0-37.6)	22.8 (20.2-25.6)	38.1 (37.8-38.4)
3+	30.1 (27.9-32.3)	37.5 (37.2-37.8)	34.7 (31.6-37.8)	36.5 (33.2-40.0)	65.0 (62.1-67.8)	37.7 (37.4-38.0)
Area of residence						
Rural	73.5 (70.6-76.1)	71.5 (71.2-71.8)	65.7 (62.1-69.1)	46.8 (41.4-52.3)	67.0 (62.9-70.8)	71.2 (70.9-71.5)
Urban	26.5 (23.9-29.4)	28.5 (28.1-28.8)	34.3 (30.9-37.9)	53.2 (47.7-58.7)	33.0 (29.2-37.0)	28.8 (28.5-29.1)
SES						
Low	39.9 (36.7-43.2)	46.2 (45.9-46.5)	41.7 (38.4-45.0)	42.5 (38.4-46.7)	42.5 (37.4-47.8)	46.0 (45.7-46.3)
Middle-to-high	60.1 (56.8-63.3)	53.8 (53.5-54.1)	58.3 (55.0-61.6)	57.5 (53.3-61.6)	57.5 (52.2-62.6)	54.0 (53.7-54.3)
Pregnancy intented[b]						
No	26.0 (23.5-28.6)	8.4 (8.2-8.6)	23.4 (20.7-26.3)	18.7 (16.8-20.8)	13.5 (11.7-15.4)	9.0 (8.9-9.2)
Yes	74.0 (71.4-76.5)	91.6 (91.4-91.8)	76.6 (73.7-79.3)	81.3 (79.2-83.2)	86.5 (84.6-88.3)	91.0 (90.8-91.1)
Size of children at birth						
Large	13.3 (12.1-14.5)	11.8 (11.6-12.0)	12.0 (10.3-13.8)	16.0 (14.1-18.1)	7.5 (6.2-9.1)	11.8 (11.6-12.0)
Average	67.1 (65.2-68.9)	68.6 (68.3-68.9)	84.1 (82.0-86.0)	67.3 (64.7-70.0)	74.6 (71.9-77.2)	68.8 (68.5-69.0)
Small	19.7 (18.2-21.3)	19.6 (19.4-19.9)	3.9 (3.0-5.2)	16.7 (15.1-18.5)	17.9 (15.7-20.3)	19.4 (19.2-19.7)
Offspring sex						
Male	53.0 (51.1-54.8)	52.9 (52.5-53.2)	49.6 (46.4-52.8)	52.5 (50.1-54.9)	50.7 (48.7-52.7)	52.8 (52.5-53.1)
Female	47.0 (45.2-48.9)	47.1 (46.8-47.4)	50.4 (47.2-53.6)	47.5 (45.1-50.0)	49.3 (47.3-51.3)	47.2 (46.9-47.5)
Maternal BMI[c]						
Thin	23.7 (22.0-25.4)	24.8 (24.5-25.9)	3.8 (2.8-5.0)	19.2 (16.7-21.9)	11.8 (9.5-14.6)	24.3 (24.1-24.6)
Normal	47.3 (45.4-49.1)	48.9 (48.6-49.2)	23.2 (20.6-26.0)	64.6 (61.7-67.3)	31.1 (27.8-34.7)	48.5 (48.2-48.8)
Overweight	29.1 (27.1-31.1)	26.3 (26.1-26,6)	73.0 (70.0-75.9)	16.3 (14.3-18.5)	57.0 (52.6-61.4)	27.2 (26.9-27.5)

(Continues)

TABLE 2 (Continued)

Characteristics	Bangladesh (n = 4156) % (95% CI)	India (n = 222,671) % (95% CI)	Maldives (n = 2495) % (95% CI)	Nepal (n = 2314) % (95% CI)	Pakistan (n = 3884) % (95% CI)	South Asia (n = 235,520) % (95% CI)
Maternal height						
<148 cm	27.9 (26.2-29.6)	25.7 (25.4-25.9)	19.4 (17.1-22.0)	26.0 (23.7-28.6)	11.9 (10.0-14.1)	25.5 (25.2-25.7)
≥148 cm	72.1 (70.4-73.8)	74.3 (74.1-74.6)	80.6 (78.0-82.9)	74.0 (71.5-76.3)	88.1 (85.9-90.0)	74.5 (74.3-74.9)
Maternal phenotype						
NONS	54.4 (52.5-56.4)	53.7 (53.4 = 54.0)	22.8 (20.1-25.9)	61.5 (58.8-64.0)	37.8 (34.0-41.7)	53.3 (53.0-53.6)
NOS	16.5 (15.0-18.1)	19.9 (19.7-20.2)	4.1 (3.2-5.4)	22.2 (19.9-24.7)	5.2 (3.8-7.0)	19.5 (19.3-19.8)
ONS	21.6 (20.0-23.4)	20.6 (20.4-20.9)	15.3 (13.0-18.0)	12.5 (10.7-14.6)	50.3 (46.1-54.5)	21.3 (21.1-21.6)
OS	7.4 (6.5-8.5)	5.7 (5.6-5.9)	57.7 (54.5-60.9)	3.8 (2.9-4.9)	6.7 (5.3-8.5)	5.9 (5.7-6.0)
CB						
No	75.1 (73.9-77.2)	82.4 (82.2-82.7)	60.1 (57.5-62.7)	91.1 (89.4-92.5)	77.3 (73.8-80.4)	82.1 (81.9-82.4)
Yes	24.9 (22.8-27.1)	17.6 (17.3-17.8)	39.9 (37.3-42.5)	8.9 (7.5-10.6)	22.7 (19.6-26.2)	17.9 (17.7-18.2)

CI, confidence interval.

[a]Aspects of family decisions where a woman participated alone or jointly in the decision making on respondent's health care, on large household purchases, and on visits to family or relatives.

[b]Intended: live birth wanted at time of conception or unintended: live birth wanted after conception or not wanted at all.

[c]Body mass index is defined as weight in kg divided by the square of height in m and were categorized as thin (BMI < 18.5), normal (BMI = 18.5-24.9), or overweight/obese (BMI ≥ 25).

by SES, respectively. In the countries studied, the prevalence of maternal overweight and OS among the middle-to-high SES group is higher, whereas the prevalence of short stature among the low SES segment was higher.

Table 3 provides the multivariate logistic regression model, testing associations of maternal phenotype with the odds of delivering by CB. After adjusting all relevant covariates, OS was significantly associated with a 179% higher likelihood of undergoing CB delivery in SA, with 125%, 167%, 155%, 304%, and 200% higher risk of experiencing CB delivery in Bangladesh, India, Maldives, Nepal, and Pakistan, respectively. Moreover, in all five countries and for SA as a whole, the odds of CB were higher among mothers who were overweight and non-short-statured (ONS). A significant association was also observed between non-overweight mothers with short stature and the risk of CB delivery in SA (AOR = 1.32; 95% CI = 1.25-1.40).

Table 4 shows an association between maternal phenotype and cesarean delivery by SES. In Bangladesh, India, Maldives, Nepal, and the SA region as a whole, OS was significantly associated with increased risk of CB delivery both for low and middle-to-high SES group.

Based on population-attributable risk estimates, reducing the maternal double burden of overweight and short stature could reduce the likelihood of CB distribution by 8.4%, 8.7%, 47.2%, 5.9%, 11.8%, and 9.7% in Bangladesh, India, Maldives, Nepal, Pakistan, and the SA region as a whole.

4 | DISCUSSION

This is the first study to analyze data from five countries on the relationship between the maternal double burden of overweight and short stature and CB delivery in Bangladesh, India, Maldives, Nepal, and Pakistan. There are four significant findings: First, the coexistence of overweight and short stature was observed ~1 in 17 women (5.9%) in the SA region, with the proportion varying from 3.8% to 57.7% among counters within this region. Second, about 18% of women in the SA region gave birth via cesarean, with rates varying between countries from 8.9% to 39.9%. Third, in Bangladesh, India, Maldives, Pakistan, and for the SA region as a whole, maternal short stature and overweight increased the risk of CB most strongly when jointly present within individual women. Fourth, a significant association was observed between the maternal double burden of overweight and short stature and CB risk both for the low and middle-to-high SES groups in Bangladesh, India, Maldives, Nepal, and the SA region as a whole. A significant association between the maternal double burden of overweight and short stature and CB risk was, however, observed in Pakistan only for the middle-to-high SES categories.

The high prevalence of coexistence of maternal overweight and short stature indicate that OS is alarmingly prevalent in these impoverished SA nations. Our findings show that CB rates in all countries surpass the rates recommended by the WHO, except for in Nepal.[5] The high prevalence of CB over the WHO-recommended rate is of

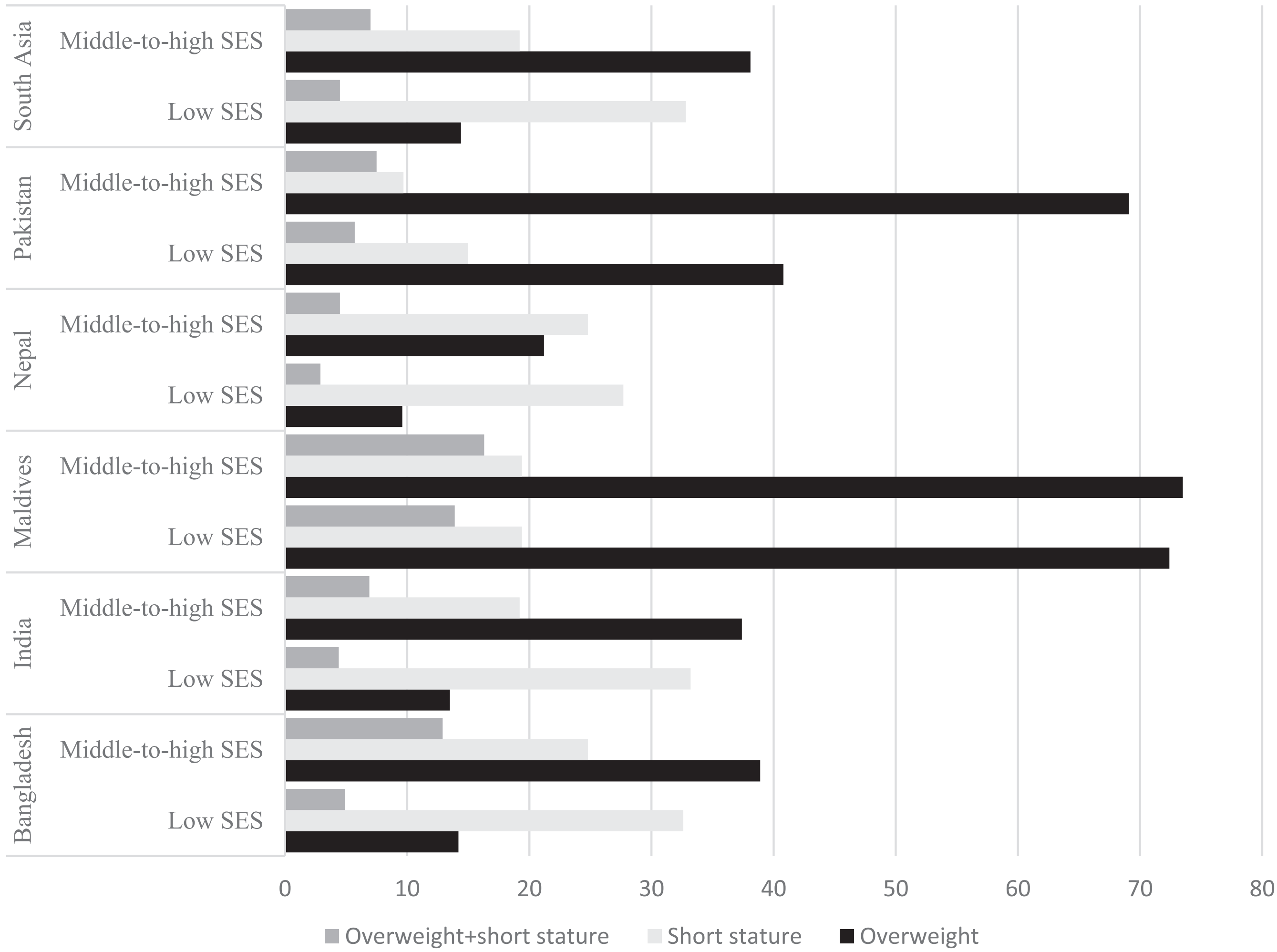

FIGURE 1 Maternal somatic phenotype and SES: Demographic and Health Surveys, Bangladesh, India, Maldives, Nepal, and Pakistan

concern to countries in South Asia. Therefore, critical review of these statistics and ensuring that overuse of CB is reduced is important for health ministries, healthcare practitioners, and civil society in SA countries. Guidelines issued by any medical society, including the American College of Obstetricians and Gynecologists (ACOG),[46] the Royal College of Obstetricians and Gynecologists (RCOG),[47] or the International Federation of Gynecology and Obstetrics (FIGO),[48] should be followed in order to minimize excessive CB. According to FIGO guidelines,[48] obesity alone is not an indication for the induction of labor in the absence of other obstetric or medical indications, and a normal birth should be encouraged, with caesarean delivery recommended as the only medically reasonable alternative if, and only if, there is certainty of an evidence-base for the clinical judgment that caesarean delivery is clinically superior to vaginal delivery. Women with obesity should have an informed discussion antenatally regarding possible intrapartum difficulties linked with a high BMI, and management measures should be considered, according to the guidelines.

Findings also show that in the Maldives, there is a dangerously high CB rate (47.2%). This may be explained by the fact that the prevalence of OS in the Maldives is far higher compared to other countries studied. In addition, in the Maldives, about 99% of deliveries occur in hospitals [49] where there are sufficient numbers of obstetricians, as well as a higher capacity for CB than in Afghanistan, Bangladesh, India, and Nepal where a large proportion of deliveries take place at home.

In Pakistan, the proportion of OS to NONS is much lower in the low SES group than in the middle to high SES group, which may help explain the insignificant association between the maternal double burden of overweight and short stature and the risk of CB for the low SES groups. In order to support this hypothesis, an additional analysis was conducted in our study, and the percentage difference in the proportion of OS compared to NONS in the low SES group is lower compared to the middle-to-high SES group in Pakistan than in Bangladesh, India, Nepal, and the Maldives. Moreover, the proportion of mothers belonging to the younger age

TABLE 3 Adjusted odd ratios for associations between maternal double burden of maternal overweight and short stature and other covariates with CB (Demographic and Health Surveys, Bangladesh, India, Maldives, Nepal, and Pakistan)

	CB (AOR, 95% CI)					
		India	Maldives	Nepal	Pakistan	South Asia
Characteristics	**Bangladesh (n = 4156)**	**(n = 222,671)**	**(n = 2495)**	**(n = 2314)**	**(n = 3884)**	**(n = 235,520)**
Age, y						
15-24	1	1	1	1	1	1
25-34	1.88 (1.40-2.51)[a]	1.39 (1.35-1.43)[a]	1.57 (1.12-2.19)[b]	1.43 (0.89-2.30)	1.66 (1.09-2.52)[c]	1.28 (1.22-1.34)[a]
35-49	2.94 (1.78-4.88)[a]	2.03 (1.93-2.14)[a]	1.78 (1.02-3.12)[c]	3.51 (1.37-9.04)[b]	1.02 (0.62-1.69)	1.82 (1.69-1.97)[a]
Education						
No education	1	1	1	1	1	1
Primary	1.82 (1.10-3.00)[c]	1.29 (1.22-1.36)[a]	1.40 (0.58-3.40)	1.60 (0.82-3.12)	1.58 (0.99-3.54)	1.57 (1.45-1.69)[a]
Secondary	3.48 (1.96-6.16)[a]	1.75 (1.59-1.83)[a]	1.13 (0.47-2.74)	1.95 (1.06-3.58)[c]	2.41 (1.43-4.08)[b]	1.94 (1.83-2.05)[a]
Higher	6.40 (3.38-12.09)[a]	2.33 (2.21-2.45)[a]	1.44 (0.55-3.74)	2.46 (1.33-4.56)[b]	2.97 (1.75-5.04)[a]	2.54 (2.36-2.73)$_a$
Decision-making autonomy, no. of aspects[1]						
0	1	1	1	1	1	1
1	1.02 (0.76-1.35)	1.11 (1.01-1.23)[c]	2.89 (0.98-8.52)	1.61 (0.95-2.73)	0.90 (0.48-1.70)	1.09 (0.98-1.22)
2	1.34 (0.99-1.82)	1.06 (0.97-1.17)	2.02 (0.86-4.73)	1.02 (0.58-1.78)	0.91 (0.49-1.67)	1.19 (1.07-1.32)[b]
3	1.08 (0.86-1.36)	1.10 (1.06-1.15)[a]	1.86 (0.87-3.98)	1.45 (0.87-2.42)	1.44 (0.93-2.22)	1.20 (1.14-1.27)[a]
Respondent employed						
No	1	1	1	1	1	1
Yes	0.74 (0.57-0.95)[c]	0.99 (0.90-1.06)	0.82 (0.63-1.06)	0.66 (0.42-1.03)	0.84 (0.51-1.39)	0.88 (0.80-0.97)[b]
Parity						
1	1	1	1	1	1	1
2	0.52 (0.40-0.68)[a]	0.63 (0.61-0.65)[a]	0.84 (0.65-1.08)	0.44 (0.28-0.70)[b]	0.83 (0.56-1.25)	0.67 (0.64-0.70)[a]
3+	0.26 (0.18-0.38)[a]	0.24 (0.22-0.24)[a]	0.58 (0.40-0.83)b	0.09 (0.04-0.21)[a]	0.49 (0.31-0.77)[b]	0.25 (0.24-0.27)[a]
Area of residence						
Rural	1	1	1	1	1	1
Urban	1.69 (1.34-2.12)[a]	1.30 (1.26-1.34)[a]	0.65 (0.46-0.92)[c]	0.92 (0.60-1.43)	1.04 (0.74-1.47)	1.22 (1.17-1.28)[a]
Socioeconomic status						
Low	1	1	1	1	1	1
Middle-to-high	2.219 (1.56-3.07)[a]	2.22 (2.14-2.30)[a]	1.14 (0.92-1.42)	2.75 (1.60-4.75)[a]	2.44 (1.40-4.24)b	2.20 (2.10-2.30)[a]
Pregnancy intented[2]						

TABLE 3 (Continued)

Characteristics	CB (AOR, 95% CI) Bangladesh (n = 4156)	India (n = 222,671)	Maldives (n = 2495)	Nepal (n = 2314)	Pakistan (n = 3884)	South Asia (n = 235,520)
No	1	1	1	1	1	1
Yes	0.76 (0.44-1.34)	1.08 (1.02-1.13)[b]	1.10 (0.83-1.45)	2.13 (0.51-8.93)	1.18 (0.61-2.26)	1.06 (0.9801.14)
Size of children at birth						
Large	1	1	1	1	1	1
Average	0.68 (0.52-0.90)b	0.94 (0.90-0.98)b	0.86 (0.62-1.20)	0.94 (0.52-1.70)	0.63 (0.38-1.05)	0.96 (0.91-1.01)
Small	0.74 (0.50-1.11)	1.26 (1.20-1.32)[a]	3.89 (1.82-8.32)[b]	1.01 (0.52-1.99)	0.82 (0.48-1.40)	1.28 (1.20-1.37)a
Offspring sex						
Female	1	1	1	1	1	1
Male	1.07 (0.91-1.27)	1.03 (0.99-1.05)	0.91 (0.75-1.09)	1.18 (0.81-1.72)	1.06 (0.80-1.40)	1.03 (0.99-1.05)
Maternal phenotype						
NONS	1	1	1	1	1	1
NOS	1.04 (0.76-1.42)	1.34 (1.29-1.40)[a]	1.04 (0.56-1.93)	1.69 (0.98-2.93)	2.63 (1.17-5.89)[c]	1.32 (1.25-1.40)[a]
ONS	2.01 (1.35-2.98)[b]	2.13 (2.07-2.20)[a]	1.68 (1.20-2.34)[b]	4.04 (2.44-6.69)[c]	2.36 (1.58-3.54)[b]	2.21 (2.11-2.31)[a]
OS	2.25 (1.83-2.78)[a]	2.67 (2.54-2.81)[a]	2.55 (1.67-3.87)[a]	2.64 (1.24-5.60)[a]	3.00 (1.57-5.74)[a]	2.79 (2.60-3.01)[a]

AOR, adjusted odds ratio; CI, confidence interval.

[1]Aspects of family decisions where a woman participated alone or jointly in the decision making on respondent's health care, on large household purchases, and on visits to family or relatives.

[2]Intended: live birth wanted at time of conception or unintended: live birth wanted after conception or not wanted at all. Here a, b and c indicate $P < 0.001$, $P < 0.01$ and $P < 0.05$.

TABLE 4 Adjusted odd ratios for associations between maternal double burden of overweight and short stature and CB by SES (Demographic and Health Surveys, Bangladesh, India, Maldives, Nepal, and Pakistan)

Characteristics	CB (AOR, 95% CI)[1] Bangladesh (n = 4156) Low SES (n = 1632)	Bangladesh Middle-to high SES (n = 2524)	India (n = 222,671) Low SES (n = 108,706)	India Middle-to high SES (n = 113,965)	Maldives (n = 2495) Low SES (n = 1404)	Maldives Middle-to high SES (n = 1091)
Maternal phenotype						
NONS	1	1	1	1	1	1
NOS	1.23 (0.73-2.07)	0.95 (0.67-134)	1.40 (1.32-1.49) [a]	1.31 (1.24-1.38) [a]	0.67 (0.35 = 1.27)	1.81 0.58-5.66)
ONS	1.00 (0.50-1.98)	1.93 (1.27-2.93)[b]	2.23 (2.06-2.41)[a]	2.10 (2.03-2.17)[a]	1.54 (1.11 = 2.14) [c]	2.80 (1.45-5.41) [b]
OS	2.54 (1.26-5.12)[b]	2.50 (1.95-3.20)[a]	2.67 (2.42-2.96)[a]	2.65 (2.50-2.80)[a]	2.29 (1.49-3.53)[a]	1.83 (1.7-3.10) [c]

AOR, adjusted odds ratio; CI, confidence interval.

[1]Models were adjusted by age, education, decision-making autonomy, residence, respondent's employment status, parity, size of children at birth, pregnancy intention, and offspring sex. Here a, b, and c indicate $P < 0.001$, $P < 0.01$, and $P < 0.05$.

group (15-24 years) with no education in the low SES group was higher compared to the middle-to-high SES group in Pakistan than in other studied countries. For an insignificant association, these confounders might play a role.

This study revealed that the maternal double burden of overweight and short stature was significantly associated with the risk of CB in the SA region. Therefore, our findings of the association between the maternal double burden of overweight and short stature and the risk of CB indicate that the emerging double burden of malnutrition is likely to have a substantial adverse effect on childbirth, impacting both mothers' and offsprings' risks of morbidity and mortality. Importantly, because these analyses have been adjusted for potential confounders, these effects persist after consideration of demographic characteristics, multiple SES domains, household, and child characteristics, which are strong confounders of maternal somatic phenotype[40,41] and cesarean delivery.[40,41]

Another critical new finding is that the maternal double burden of overweight and short stature appears to have more profound effects on the measured outcome. A dose-response relationship between the maternal phenotype and the risk of CB was observed in all the countries studied, except Nepal. In short women, and even more so in overweight women, the risk of CB was elevated; ultimately, the risk in women who were overweight was further increased if they were also short. When they occur together, overweight and short stature produce a higher risk for CB than when they occur separately.

Our findings also showed that mothers who belonged to low SES groups and who were suffering from the maternal double burden of overweight and short stature were not uniquely disadvantaged. Consequently, the maternal double burden of overweight and short stature per se increases the risk of CB, but lower SES does not increase the risk of CB among women suffering from OS specifically. The importance of this result must, therefore, be emphasized. Exposure to a double malnutrition burden adversely raises the likelihood of CB delivery regardless of whether the individual is of low economic status or not. The negative effect of the maternal double burden of overweight and short stature extends across all economic backgrounds for the risk of CB; it is not limited to mothers belonging to low SES groups with a double overweight and short stature burden.

Our findings are consistent with those of previous studies suggesting that women with higher education, women from urban areas, and older women were more likely to have cesarean deliveries,[7,16,17] and that higher parity women,[50] women belonging to the middle-to-high SES group,[51] and women with small babies at birth[52] had a higher probability of CB delivery in the SA region.

Similar to previous reports,[53,54] our findings showed that women with greater autonomy in decision making had a higher likelihood of CB. There are two potential explanations for the connection between women having greater decision-making autonomy and having a higher chance of having a CB.[55] Firstly, women with greater autonomy may be better able to access obstetric care, make health choices, and consider the value of interventions if necessary. Women with no or restricted autonomy, on the other hand, may have limited information and/or misconceptions about CB, which may deter usage even when CB is needed.[56] Secondly, it is possible that women with greater autonomy might be more likely to request cesarean

Nepal (n = 2314)		Pakistan (n = 3884)		South Asia (n = 235,520)	
Low SES (n = 1085)	Middle-to high SES (n = 1229)	Low SES (n = 1784)	Middle-to high SES (n = 2100)	Low SES (n = 114,611)	Middle-to high SES (n = 120,908)
					-
1	1	1	1	1	1
0.34 (0.10-1.10)	1.98 (1.22-3.26)[b]	3.80 (1.92-6.43)[c]	1.28 (0.49-3.31)	1.36 (1.26-1.47)[a]	1.32 (1.21-1.43)[a]
4.75 (1.32-17.02)[c]	2.01 (0.95-4.26)	1.37 (1.14-2.72)	2.79 (1.73-4.49)[a]	2.56 (2.33-2.81)[a]	2.14 (2.04-2.25)[a]
11.44 (2.88-45.4)[b]	2.85 (1.81-4.52)[a]	1.48 (0.94-4.58)	3.75 (1.71-8.25)[b]	3.00 (2.62-3.42)[a]	2.72 (2.49-2.96)[a]

delivery due to a perceived lower risk or fear of laboring. Health projects aimed at reducing unnecessary caesarean births should continue to emphasize women's autonomy. Future studies should concentrate on whether women with higher autonomy are more likely to request CB.

Furthermore, after stratifying the data by decision-making autonomy level, we performed additional multivariate logistic regression analyses to determine whether mothers with no decision-making autonomy and the maternal double burden of overweight and short stature were uniquely disadvantaged toward cesarean delivery in the SA region as a whole. OS was found to be significantly associated with an increased risk of CB if there was no or low autonomy. The significance of this result must be highlighted; exposure to a double malnutrition burden raises the likelihood of CB delivery, regardless of whether the individual has no or some autonomy.

There are numerous strengths to the present analysis. First, the data analyzed consisted of the most recent nationally representative sample of married women aged 15 to 49 years, covering both rural and urban areas, including a large number of subjects (Bangladesh: n = 4156; India: n = 222,671; Maldives: n = 2495; Nepal: n = 2314; Pakistan: n = 3884); hence, the results represent the national populations of Bangladesh, India, Maldives, Nepal, and Pakistan, respectively. Second, the DHS uses extensive interviewer training, standardized measuring tools and techniques, and the same core questionnaire, as well as pre-testing tools to ensure standardization and comparability across various sites and times. Finally, the study was provided with good statistical power by a high participation rate (92%-99%) with a low level of missing data (0.4%-5%).

We note a few important caveats regarding the findings presented here. First, our outcome variable was based on self-reporting, which is vulnerable to social desirability and biases in remembering. However, to prevent these prejudices, analyses were limited to women who gave birth within the 5 years (except for Bangladesh where women had given birth within the 3 years) before the survey. Second, analyses were cross-sectional, and causality cannot be assumed; for example, if maternal weight was measured within 3-5 years of giving birth, it is possible that their weight at the time of data collection did not reflect the actual weight at the time of birth. This could bias our results. Nonetheless, prospective investigations are needed to better evaluate the effects of maternal overweigh/obesity on CB rates.

Third, system-level variables such as good governance[57] are important to improving people's living standards, such as clean water, sanitation, healthy foods, and quality health care services. This is more useful in adjusting results, but this type of information is not included in the DHS surveys in the countries studied. Future research should take these factors into account, as they have a significant impact on the realities of people with low resources. Fourth, in order to determine overweight/obesity status among mothers, we used BMI. However, there may have been some mistakes in the use of standard WHO definitions for overweight and obesity, as they do not consider the ethnically relevant guidelines for BMI cut off values for overweight and obesity.[58] In addition, we have used standard cutoff values that define short stature even though these are based on European modelling.

In addition, maternal reports of relative infant size were included at the time of birth, but this measure has doubtful reliability and validity.[59] We used the anthropometric method (BMI) to measure the status of women overweight. Although several studies[60,61] have reported BMI as precise and accurate estimates, laboratory evaluation measurements are also necessary for more precise estimation. Due to the scarcity of relevant information in the DHS survey, we could not identify the specific type of health facility where a woman gave birth—for example, whether the birth occurred in a teaching hospital, district hospital, Upazila health complex, or NGO/private clinic. Furthermore, the DHS survey offered no details as to whether a woman belonging to the wealthy SES group requested cesarean delivery. These limitations have certainly influenced our results.

Finally, since the pre-existing DHS data constrained our selection of variables, we could not include additional potentially important variables such as specific types of pregnancy complications[15] that resulted in cesarean delivery or details of medical or non-medical reasons[37] for performing cesarean births. As such, the data do not provide sufficient detail to link the rise in the CB rate to malpractice involving unnecessary surgical procedures. However, since the demonstrated associations between the maternal double burden of overweight and short stature and the likelihood of CB were so strong, adding these variables to the model is unlikely to have resulted in an insignificant association between predicting the possibility of CB and the maternal double burden of malnourishment.

Despite these limitations, this study reveals valuable information that could reduce the risk of CB among women in the SA region. These findings may also be significant in other resource-limited settings with excessive CB rates.

4.1 | Conclusions

The high prevalence in SA nations of the maternal double burden of overweight and short stature among women is alarmingly prevalent. The maternal double burden of overweight and short stature is a significant marker in SA for increased risk of CB. Our findings suggest that exposure to the maternal double burden of overweight and short stature adversely increases the risk of CB regardless of whether the woman is of low SES or not. For the risk of CB, the negative effect of the maternal double burden of overweight and short stature extends across all economic backgrounds. Findings also illustrated that, exposure to a double malnutrition burden raises the likelihood of CB delivery, regardless of whether the individual has no or low autonomy. These findings underline the critical need to reduce or prevent dual forms of maternal malnutrition in order to minimize the risk of CB. Research on the causal link between maternal phenotype and CB will be critical to the development of interventions to reduce excessive cesarean delivery—a major priority of global public health research.

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ETHICAL APPROVAL

All procedures and questionnaires for standard DHS surveys were reviewed and endorsed by the Opinion Research Corporation (ORC) Macro institutional Review Board. An Ethical Review Board also approved each survey within the country. The respondents provided informed consent for individual interviews and also for anthropometric measurements. This research was considered exempt from a full review because it was based on an anonymous public use of a secondary data set with no identifiable information about the participants in the survey.

DATA AVAILABILITY STATEMENT

Data were available at MEASURE DHS website: http://dhsprogram.com/data/available-datasets.cfm.

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