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Valentina Alvarez-Saavedra, Pierre Levasseur & Suneha Seetahul

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The Role of Gender Inequality in the Obesity Epidemic: A Case Study from India

VALENTINA ALVAREZ-SAAVEDRA[*], PIERRE LEVASSEUR[**] &
SUNEHA SEETAHUL[†,‡]
[*]Bordeaux School of Economics, Université de Bordeaux, Bordeaux, France, [**]SADAPT, INRAE, AgroParisTech, Université Paris-Saclay, Paris, France, [†]The University of Sydney, Sydney, Australia, [‡]The World Bank, Washington, DC, USA

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ABSTRACT *Recent empirical evidence emphasizes the higher prevalence of overweight and obesity for women, especially in developing countries. However, the potential link between gender inequality and obesity has rarely been investigated. Using longitudinal data from India (IHDS 2005–11), we implement Hausman-Taylor and fixed-effect models to estimate the effect of different dimensions of gender inequalities on female overweight. This study demonstrates that the form of gender inequality or women's mistreatment differently affects female bodyweight. Indeed, we show that some forms of women's mistreatments (such as perceived community violence and age difference with husband) increase the risk of female overweight, whereas more severe forms of abuse such as child marriage increase the risk of underweight. Moreover, we also find that higher decision-making power and autonomy about outings are risk factors of weight gain and obesity, especially in urban settings, perhaps indicating a higher exposure to urban obesogenic lifestyles. To conclude, our results suggest that, although improving women's status in society may be a key action to address the epidemic of obesity, policies must also target hazardous habits that emancipation may imply in urban (obesogenic) environments.*

KEYWORDS: India; gender inequality; obesity; Hausman-Taylor estimations; fixed effects estimations

1. Introduction

The rising epidemic of obesity and related non-communicable diseases (NCD) are one of the major contemporary global health challenges, causing 71 per cent of worldwide deaths in 2016 (Bennett et al., 2018), and constitute an important economic cost for countries (Cawley, 2015). By 2025, it is estimated that half of the worldwide population will be overweight, and one-fifth will be obese (NCD-Risk Factor Collaboration, 2016). The empirical literature shows that women are globally more affected by this epidemic (De Soysa & Lewin, 2019; Ferretti & Mariani, 2017; Garawi, Devries, Thorogood, & Uauy, 2014; WHO,

Correspondence Address: Pierre Levasseur, AgroParisTech SADAPT, 16 rue Claude Bernard, 75231 Cedex 05, Paris, France. Email: pierre.levasseur@inrae.fr
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2020). Currently, there are around three obese women for two obese men worldwide (Wells, Marphatia, Cole, & McCoy, 2012). Furthermore, the gender obesity gap appears to be much higher in developing countries, especially middle-income economies (Ameye & Swinnen, 2019), where women suffer from substantial levels of inequality and deprivation (Dhar, Jain, & Jayachandran, 2019; Jayachandran, 2015). There are even extreme cases, such as South Africa, where the prevalence of obesity for women is five times higher than for men (Case & Menendez, 2009). Surprisingly, the gender obesity gap and women's risk of malnutrition could be due to similar mechanisms (De Soysa & Lewin, 2019; Ferretti & Mariani, 2017), that is, lower rights and liberties (including physical mobility) and lower access to economic resources, education, health, labour market and a healthy lifestyle (De Soysa & Lewin, 2019). Hence, improving women's status in society may be a key policy avenue to address the global obesity epidemic.

As the world's second most populated country, India is an interesting middle-income economy to study in terms of health and gender inequalities. Despite high levels of economic growth in the past few decades, India has one of the largest gender gaps in health, cumulating one of the highest rates of underweight population with a growing overweight population and low-quality diets with major micronutrient deficiencies (Kulkarni, Kulkarni, & Gaiha, 2017).[1] In urban India, the prevalence of overweight was around 31.3 per cent for women and 26.6 per cent for men in 2015–2016 (IIPS & ICF, 2017). Furthermore, Indian women suffer from high levels of inequality in socioeconomic opportunities and outcomes (Dhar et al., 2019), partly explained by the socially constructed gender roles with deep religious, cultural, and historical roots (Barcellos, Carvalho, & Lleras-Muney, 2014; Batra & Reio, 2016). India is also an interesting case to study given that the female labour force participation has been declining between 2005 and 2020, dropping from 31.8 to 20.3 per cent (Sundari, 2020), highlighting the discrepancy between economic growth and women's economic empowerment and agency. Not only does this low and declining labour market participation rate implies lower financial empowerment for women, but a large share of women (ranging from 17 to 41% depending on studies) also face important forms of daily discrimination and mistreatment, such as domestic violence (Menon, 2020).

Given the particular context of India, this research aims to assess how gender inequalities affect female adult Body Mass Index (BMI). Even though gender and obesity are two well-studied topics in the economics and public health literature, the potential link between gender inequality and obesity has rarely been investigated. Most previous studies are correlational and limited by the lack of longitudinal data allowing to control for time-invariant heterogeneity. On the one hand, cross-country studies report a positive association between gender inequality and the gender obesity gap. Countries with low gender inequality (almost exclusively high-income countries) are characterized by smaller gender differences in obesity rates (De Soysa & Lewin, 2019; Garawi et al., 2014; Wells et al., 2012).[2] On the other hand, country-specific studies analysing the association between within-country economic inequality (at the community level) and obesity find stronger positive associations for women than for men (Wells et al., 2012). However, the frontier between gender and socioeconomic inequalities in society is fuzzy, both effects being difficult to disentangle from each other. Analysing the gender inequality-obesity association at the individual level, while controlling for socioeconomic and demographic characteristics of the household, would allow to isolate the effect of gender inequality from the effect of socioeconomic inequality. Hence, this study provides within-country micro-economic level evidence on the matter.[3] Indeed, gender inequality is not only expected to restrict women's mobility (lack of freedom) and affect access to information and public services (lack of opportunity to care for oneself) but is also expected to have major socio-psychological consequences (lack of self-esteem and -confidence). We can reasonably assume that these mechanisms change women's time allocation, physical activity, consumption patterns, and thus their weight.

Using nationally representative longitudinal data for India from 2004 to 2005 and 2011 to 2012, we analyse the effect of gender inequality, measured at the individual level, on female BMI (and BMI-based clinical classification) by estimating two complementary panel data models, namely, individual fixed effects and Hausman-Taylor estimators. Our main interest is to analyse the association between gender inequality and overweight/obesity in a context where high levels of gender inequality persist. Nevertheless, by construction, our analysis also sheds light on the relationship between gender inequality and weight in general (including underweight), allowing a more comprehensive understanding of the dynamics of the nutrition transition in India. To capture different dimensions of gender inequality at the individual level, we consider several proxies of these inequalities, which translate into factors disfavouring women in society. The first group of proxies are factual indicators: (1) a wife's age of marriage, and (2) the age difference with her husband. The second group of indicators are self-rated gender norms indicators: (1) restricted mobility, (2) decision-making power in the household, and (3) community acceptance of domestic violence.

The paper is organized as follows. Section 2 explains the methods, detailing the mechanisms through which gender inequality can affect women's weight. Section 3 reports the results, and Section 4 concludes.

2. Methods

2.1. Data and sample

This research relies on the India Human Development Survey (IHDS), which is a nationally representative panel survey collected by the University of Maryland and the National Council of Applied Economic Research. Econometric estimations are conducted on a sample of non-pregnant women aged between 18 and 49 years old in 2004–2005. This sample is composed of 23,328 women in 2004–2005 and 23,030 women in 2011–2012. Textbox A1 in the Appendix provides detailed descriptions of the data source and the estimation sample.

2.2. Measuring women's nutritional status

We mainly use individual BMI to measure women's nutritional status. This standard measure of general body fat is calculated as the weight divided by the squared height (kg/m^2). Height and weight data were collected by trained staff using weighting machines and stadiometers. Individual BMI can be classified into four nutritional ranges, following the international WHO classification: underweight ($<$18 kg/m^2), normal weight (18–25 kg/m^2), overweight (25–30 kg/m^2), and obesity ($>$30 kg/m^2). In addition to considering individual BMI as a continuous nutritional outcome, we alternatively test the relationship between gender inequality and the BMI-based clinical classification, that is, underweight status (=1) and overweight/obesity status (=1).

2.3. Measuring gender inequality

The IHDS gender module contains rich data allowing to create five indicators of gender inequality. First, we use the binary variable *child marriage* as a factual measure of women's mistreatment, which is equal to 1 if an adult woman got married before 18 and 0 otherwise. In our sample, in 2011–2012, half of women were married before 18, as shown in Figure S1 in Supplementary Materials. Child marriage is a clear reflection of rooted gender inequality and is internationally recognized as a violation of human rights (Burn & Evenhuis, 2014; UNICEF, 2019).[4] We also constructed the variable *age difference with husband* accounting for the age gap between spouses (age of the husband minus age of the wife). A large age gap generally implies that the younger spouse will have less decision-making power and/or autonomy in the marital relation (Carmichael, 2011). Evidence from the US found that time allocation behaviour is affected by the marital age gap, especially regarding labour market participation: the older the husbands are compared to their wife, the lower the labour supply of married women (Shephard, 2019). In the sample, in 2011–2012, 99 per cent of women are younger than their husbands, 31 per cent of women have an age difference of 6–10 years with their husband, and 7 per cent of women have an age gap higher than 10 years (Figure S1 in Supplementary Materials).

We complete these factual indicators with three measurements of gender norms previously used by the literature as proxies of gender inequalities in India (Choudhuri & Desai, 2020; Sinha, McRoy, Berkman, & Sutherland, 2017; Stroope, 2015): (i) the need for a woman to ask permission to her husband or another household member to go out (*restricted mobility*); (ii) the woman's *decision-making* power in the household; (iii) the *community's acceptance of domestic violence* of husbands towards their wives (perceived by the respondent). These three indicators are constructed as follows. First, the *restricted mobility* indicator is a 3-point composite index. This index results from the sum of the three-following binary-response variables about restricted permissions to go to health centres (=1), grocery shopping (=1) and visit a friend or family member (=1), calculated for each woman. The restricted mobility indicator takes the value 3 if a woman needs to ask permission for these three types of outings and 0 if no mobility restriction is imposed to her. In 2011–2012, 46 per cent of adult women declare that they need permissions to go out for those three reasons (Figure S2 in Supplementary Materials). The *decision-making* indicator is a 5-point composite index summing the following tasks for which the woman 'has the most say': cooking (=1), big purchases (=1), number of children (=1), seeking medical care for an ill child (=1), and children's marriage arrangement (=1). If this index is equal to 5, it means that a woman has a power of decision concerning all economic, health, and food aspects in the household. Conversely, if this index equals 0, a woman has no decision-making power in the household. In 2011–2012, 19 per cent of women do not have a say in any of the five decisions, and 44 per cent have most say in one type of decision, and for most of them it is about what to cook (Figure S2 in Supplementary Materials). Finally, the *community acceptance of domestic violence* indicator is a 5-point composite index that sums if, in the community, the respondent perceives the use of physical violence of husbands towards their wife as usual, for the five following reasons: a woman goes out without permission (=1), dowry was not respected by her family (=1), a woman neglects the house or the children (=1), a woman doesn't cook properly (=1), and a woman has an extramarital relationship (=1).[5] Since we do not have access to information about domestic violence in the household, we argue that the community acceptance of domestic violence works as a good proxy (Uthman, Moradi, & Lawoko, 2011). In 2011–2012, 29 per cent of women claim it is common in their community for husbands to beat up their wives for at least four of those reasons (Figure S2 in Supplementary Materials).

As robustness checks, we also implement a Principal Component Analysis (PCA) to create three continuous indices of *mobility restrictions*, *decision-making*, and *acceptance of community violence*. Each index relies on the first component of the PCA, with higher values reflecting higher levels of mobility restriction, decision-making power, and acceptance of domestic violence. Each index is standardized to vary between 0 and 1, allowing to measure each dimension with a continuous variable instead of an ordinal one.[6] We also create a synthetic index of multidimensional gender discrimination (that is, simultaneously including information on mobility restrictions, decision-making, and acceptance of community violence), based on the first component predictions. The first component is particularly relevant to create a synthetic index because it clearly opposes several forms of gender discrimination (relative to domestic violence and mobility restrictions) against women's emancipation (measured by decision-making items).

We standardize this index from 0-to-1. Tables and figures regarding this synthetic index PCA are available in Supplementary Materials (Tables S3 and S4, and Figure S3).

Finally, we also test a non-linear specification of gender norms indicators considering that the intensity of women's mistreatment within the household and the community could have heterogeneous impacts on female BMI. For instance, one might expect higher risks of mental troubles associated with changing eating behaviours when women face intensive discrimination (that is, a convex trend in the case of weight gain and a concave trend in the case of weight loss). To test for such non-linearities, we transform each indicator of gender norms into categorical variables accounting for the number of restrictions women face (that is, number of mobility restrictions, number of items a woman has a decision power over, and number of reasons that justify domestic violence in the community).

2.4. *Assumptions about the tested associations*

Based on the literature, we are able to make several assumptions regarding potential links between our measurements of gender inequality and female BMI. For instance, an empirical study in India found that both women's seclusion (veiling or limitation of social interactions with men who are not family members) and lower decision-making increase the risk of hypertension, the latter being directly associated with overweight and obesity (Stroope, 2015). Women's restricted mobility and lack of decision-making power can therefore be expected to have a positive relationship with BMI. Nonetheless, since India is experiencing increasing urbanization and incorporation of western food habits, restricted mobility could also appear to 'protect' women from an obesogenic environment. Such an environment promotes obesity by encouraging physical inactivity and unhealthy food choices (Swinburn, Egger, & Raza, 1999). This implies that having decision-making power and autonomy does not necessarily mean that women's attitudes will be healthier since their new freedom will also expose them to a new and westernized environment.

Gender inequality can also encourage different acts of violence against women, which can have dramatic physical and mental health outcomes. In fact, women tend to be particularly vulnerable in terms of mental health, inducing depression, demoralization, and reducing their self-esteem (De Soysa & Lewin, 2019; Stroope, 2015). Eating disorders and depression are more common for women (Garawi et al., 2014), and several studies found a significant relationship between depression and weight gain, because of a neglect of physical appearances and changes to eating patterns (for example, compensation by food) (Case & Menendez, 2009; Haukkala & Uutela, 2000). Trauma theory also claims that women's experience of domestic violence may initiate immediate and long-lasting psychological symptoms which can affect eating practices, activity levels, and general health care practices. For instance, evidence from Egypt shows that exposure to domestic physical and sexual violence significantly increases the risk of female obesity (Yount & Li, 2011). The authors claim that domestic violence can create psychological after-effects in the form of compensation by food with an excess energy intake and/or a decrease in levels of physical activities leading to weight gain. However, evidence on this subject is ambiguous. Other studies found positive associations between domestic violence and underweight status (Ackerson & Subramanian, 2008; Lentz, 2018).

2.5. *Accounting for confounding variables*

Given the multiple mechanisms that have an impact on both gender inequalities and weight gain, our analysis includes potential confounders allowing us to disentangle the effect of gender inequality on the dependent variables by limiting the likelihood of an omitted variable bias.

Gender inequality arises from historical socially constructed norms of male domination and female subordination in many aspects of life (Godelier, 1981), which makes socio-cultural norms one of the most important dimensions of gender inequality. The Indian society is characterized by caste which is a form of social structure finding its roots in historical and religious practices (Batra & Reio, 2016). Religious personal laws are very common in India[7] and most of these laws imply that women have fewer rights than men (Parashar, 2008). As a result, many practices that arise from caste and religion, such as veiling and the restriction of women's mobility, decision-making power, and access to resources can also have a direct relationship with women's access to physical activities, restraining their possibilities to participate in sport or outdoor activities and limiting women's interactions (Stroope, 2015). Therefore, our estimations include controls of caste and religion heterogeneity. We also include controls for education (highest education level achieved) and labour market participation (binary variable indicating if a woman is currently working or not).

2.6. *Empirical models*

The relationship between gender inequality and BMI-based indicators might be prone to endogeneity issues (for example, omitted variables bias or reverse causality) that could overstate or understate cross-sectional estimates (Wooldridge, 2010). First, omitted variables, such as personal motivation, self-esteem, or soft skills could be associated with both BMI and our gender inequality indicators. Women who have low self-esteem can be less preoccupied with their appearance and weight, in addition to being prone to accepting mobility restrictions, lower decision-making power, and even domestic violence. Hence, such socio-psychological characteristics may overstate the positive effect of gender inequality on obesity. Moreover, reverse causality can also be an issue: overweight and obesity could influence gender inequality outcomes. For instance, one can assume that being overweight might delay the age of marriage for a girl, and thus reduce the risk of child marriage, which could understate the real impact of child marriage on excess weight. Likewise, since the social stigma related to obesity is usually higher for women (Rothblum, 1992; Warin, Moore, Zivkovic, & Davies, 2011), women with high BMI might have their mobility or decision-making power more restrained by their husbands than thinner women, as well as suffering more from domestic violence; which could overstate the real impact of gender norms disfavouring women on obesity.

To robustly analyse the relationship between gender inequality and BMI-based indicators, we use two complementary estimators: fixed effects (*within* model) and Hausman-Taylor (*hybrid* model) estimators. First, we perform fixed-effect model estimations at the individual level to neutralize potential time-invariant variations that could be related to changes in BMI and gender inequality and bias the results.

$$BMI_{it} = \alpha + \beta_1 * Gender\ inequality_{it} + \beta_2 * X_{it} + \varepsilon_{it} \quad (1)$$

In Equation (1), BMI-based indicators are factors of gender inequality indicators (that is, *restricted mobility*, *decision-making power*, and *community acceptance of domestic violence*) for each adult woman i at a time t ($t = 1$ for 2004–2005 and $t = 2$ for 2011–2012).[8] X_{it} refers to individual and household characteristics, such as age categories (18–30, 31–40, 41–50), educational dummies (incomplete primary, primary, incomplete secondary, secondary, high secondary, and graduate), caste/religion, employment status, marital status, number of children, and logarithm of per capita income.[9] Finally, ε_{it} represents the time-varying error term. Since only a within-individual variation is considered in *within* fixed-effect estimations, potential differences across individuals are ignored. Therefore, we also tested random-effects estimations, which combine estimations both *within* and *across* individuals. However, conducting a Hausman test to identify which of both models (fixed effect or random effect) is the most appropriate, we concluded that random effects estimations were inconsistent and fixed effects should be preferred (Baltagi, Bresson, & Pirotte, 2003). Hence, we only report fixed-effect estimations.

We complement the fixed effect estimations with Hausman-Taylor estimations, which has the advantage of combining fixed and random effects with a structural instrumentation approach. Hence, in addition to considering within- and between-variations across individuals, this hybrid estimator structurally constructs instruments using solely the strictly exogenous variables from the model (Hausman & Taylor, 1981). This means that there is no need to search for valid external instruments to solve endogeneity problems. Another advantage of the Hausman-Taylor estimator is that it allows to integrate time-invariant variables in addition to time-varying variables. Hence, we can analyse additional indicators of gender inequality, such as child marriage or age difference with husband, and control for further characteristics that do not change across time, such as area of residence.

$$BMI_{it} = \alpha + \gamma_1 * Gender\ \ inequality\ _{it} + \gamma_2 * X_{it} + \gamma_3 * Z_i + v_i + e_{it} \tag{2}$$

The Hausman-Taylor estimator splits time-varying and time-invariant variables into two sets of variables: ones assumed to be exogenous and others assumed to be endogenous. $Gender\ \ inequality\ _{it}$ represents an endogenous time-varying variable correlated with v_i. X_{it} identifies exogenous time-varying explanatory variables, such as age categories, educational dummies, caste/religion,[10] marital status, employment status, and the logarithm of per capita income. Z_i represents all time-invariant explanatory variables like area (rural or urban) and state of residence. State fixed effects account for heterogeneities across states, such as different levels of area income and development. v_i and e_{it} represent unobservable random variables that have an impact on BMI but are independent of each other: v_i represents unobservable time-invariant individual effect distributed independently across individuals, with zero mean and constant variance (σ_v^2). The error term e_{it} is also assumed to be uncorrelated with the independent variables, with zero mean and constant variance (σ_e^2) conditional on $Gender\ \ inequality_{it}$, X_{it} and Z_i.

3. Results

3.1. Descriptive statistics

Table A1 in the Appendix presents the summary statistics for each variable considered in the study. We observe a clear increase in the rates of overweight and obesity between 2004–2005 and 2011–2012 among Indian women (from 16 and 3% to 27 and 7%, respectively). While *child marriage* and *decision-making* power indicators remain practically unchanged between both waves, the *age difference with husband*, *restricted mobility*, and *community acceptance of domestic violence* indicators increase in the same period (respectively from 5.28 to 5.40 years, from a score of 1.94/3 to 1.99/3 and from a score of 2.09/5 to 2.45/5).

Table A1 also shows that most of the gender inequality indicators decrease with age, except for the *age difference with husband*. Moreover, women living in urban areas have higher levels of *decision-making* and lower levels of *restricted mobility* than women living in rural settings. Likewise, the share of *child marriage* and *community acceptance of domestic violence* are higher in rural areas than in urban areas. Nonetheless, spouses have a higher age difference in urban settings. Table A1 also exhibits socioeconomic differences according to gender inequality. Each indicator of gender inequality is the strongest among the low-income group, except once again for the *age difference with husband*. Finally, gender inequality tends to be lower among the Christian, Sikh, and Jain religious groups and to a lesser extent among higher castes.

3.2. Econometric estimates

Fixed effects (Equation 1) and Hausman-Taylor (Equation 2) estimates are presented in Table 1. Estimates show that several measures of gender inequality result in significant weight changes between 2004–2005 and 2011–2012 for Indian adult women. These results are globally

Table 1. Regressions of female bodyweight on gender inequality and covariates—whole sample

	BMI (kg/m^2)		Underweight (dummy)		Overweight (dummy)	
	Fixed Effects	Hausman-Taylor	Fixed Effects	Hausman-Taylor	Fixed Effects	Hausman-Taylor
Married when minor (dummy)		−0.140*** (0.057)		0.021*** (0.007)		0.002 (0.007)
Observations		40,746		40,746		40,746
Number of households		23,087		23,087		23,087
Within R-square		0.045		0.011		0.025
Between R-square		0.217		0.095		0.156
Overall R-square		0.189		0.075		0.126
Age difference with husband (in years)		0.053*** (0.010)		−0.002** (0.001)		0.005*** (0.001)
Observations		39,904		39,904		39,904
Number of households		22,375		22,375		22,375
Within R-square		0.046		0.011		0.026
Between R-square		0.220		0.096		0.159
Overall R-square		0.191		0.075		0.128
Restricted mobility index (0-to-3 score)	−0.019 (0.018)	−0.023 (0.018)	−0.002 (0.002)	−0.001 (0.002)	−0.004** (0.002)	−0.005*** (0.002)
Observations	40,720	40,720	40,720	40,720	40,720	40,720
Number of households	23,082	23,082	23,082	23,082	23,082	23,082
Within R-square	0.053	0.045	0.012	0.010	0.031	0.025
Between R-square		0.217		0.095		0.155
Overall R-square		0.189		0.075		0.126
Decision-making index (0-to-5 score)	0.052*** (0.018)	0.061*** (0.018)	0.000 (0.002)	0.000 (0.002)	0.008*** (0.002)	0.009*** (0.002)
Observations	40,702	40,702	40,702	40,702	40,702	40,702
Number of households	23,076	23,076	23,076	23,076	23,076	23,076
Within R-square	0.052	0.045	0.012	0.010	0.031	0.026
Between R-square		0.217		0.095		0.156
Overall R-square		0.190		0.075		0.126
Community acceptance of domestic violence (0-to-5 score)	0.067*** (0.013)	0.059*** (0.013)	−0.004*** (0.002)	−0.003** (0.002)	0.005*** (0.002)	0.004** (0.002)
Observations	40,536	40,536	40,536	40,536	40,536	40,536
Number of households	23,050	23,050	23,050	23,050	23,050	23,050
Within R-square	0.052	0.045	0.012	0.010	0.031	0.025
Between R-square		0.216		0.095		0.156
Overall R-square		0.189		0.075		0.126
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	No	Yes	No	Yes	No
State FE	No	Yes	No	Yes	No	Yes

Notes: Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Standard errors were clustered at a household level for robustness.
Source: Authors' calculations from IHDS I-II database.
Standard errors were clustered at a household level for robustness. Since HT model specification does not report R-squared values, we computed those obtained in a random model specification.

consistent when comparing time fixed-effect and Hausman-Taylor estimates. However, the direction of the effect (positive or negative) clearly depends on the indicator of gender inequality considered.

First, both *age difference with husband* and *community acceptance of domestic violence* are significantly associated with weight gain by women, increasing the risk of overweight and decreasing the risk of underweight. Second, the *decision-making* power index is positively correlated with weight gain and overweight. Third, there is a significant reduction in overweight risks for higher levels of *mobility restriction* (lower autonomy). Finally, *child marriage* is negatively correlated with women's weight gain and increases the risk of underweight.

In a nutshell, our findings highlight a complex relationship between gender inequality and female BMI. While some aspects of gender discrimination (such as *domestic violence* and *age difference with husband*) tend to be associated with weight gain and overweight (as assumed by the literature), it seems that women's emancipation (measured by *decision-making*) also increases both risks of weight gain and overweight, perhaps because of a higher exposure to an obesogenic environment. For similar reasons, an increase in *mobility restrictions* decreases the risk of female overweight, suggesting that a lack of autonomy could have a 'protective effect' against hazardous weight gain. In contrast, it appears that some forms of gender inequality, like those arising from *child marriage*, result in a significant weight loss and a higher underweight risk.[11]

Table 2 presents Hausman-Taylor estimates for specific subsamples of rural/urban and poor/non-poor women,[12] which allow us to better understand the results from Table 1. First, Table 2 shows a stronger positive association between *decision-making* power and female BMI in urban areas compared to rural areas. Consistently, we also find effects that are exclusively significant for non-poor women. The positive effects of *community acceptance of domestic violence* and *age difference with husban*d on female BMI are only significant for non-poor women and are stronger in urban areas than in rural areas. Finally, for *child marriage*, we detect a significant and negative effect on female BMI for rural and non-poor samples only.

Control variables also provide consistent results in accordance with the literature regarding the determinants of BMI in India (Kulkarni et al., 2017; Siddiqui & Donato, 2020). Full regression tables of Equations (1) and (2) are available in Supplementary Materials (Tables S7 and S8). As expected, namely because we exclusively focus on relatively young women (aged 18–50), age is positively correlated to female BMI. Moreover, as found by Kulkarni et al. (2017), women with a high level of completed education have a higher BMI on average than less educated women, whereas working women tend to have a lower BMI than unemployed women. Regarding the caste and religious hierarchy in India, our results show non-linear associations with female BMI (Kulkarni et al., 2017; Siddiqui & Donato, 2020). Compared to higher Hindu castes, Muslim women have a higher BMI, while intermediate and lower castes (OBC and SC/ST) exhibit a lower BMI. Likewise, per capita income does not follow a linear relationship with female BMI. Women are significantly thinner among middle-income households compared to women from poorer and richer households. This result echoes the empirical literature that finds a relative protection from overweight for the upper middle class in middle income countries, such as China and Mexico (Bonnefond & Clément, 2014; Levasseur, 2015).

4. Discussion

Obesity and related comorbidities are alarmingly increasing in low- and middle-income countries. This global issue is especially worrying for women who are disproportionally affected by this epidemic. Hence, understanding the role of gender inequality in the emergence of obesity among women in developing countries appears as an important research question to prevent this global epidemic. Based on a longitudinal dataset and applying complementary econometric approaches, our results confirm that some indicators of gender inequality measured at the

Table 2. Hausman-Taylor regressions of female BMI on gender inequality and covariates—by subsamples

Dep. Var.: Female BMI (kg/m^2)	Rural	Urban	Poor	Not poor
Married when minor (dummy)	−0.128* (0.066)	−0.182 (0.111)	0.274 (0.209)	−0.180*** (0.071)
Observations	27,365	13,381	7,102	33,629
Number of individuals	15,585	7,502	6,080	20,984
R-squared[a]				
- Within	0.040	0.060	0.048	0.045
- Between	0.172	0.140	0.099	0.209
- Overall	0.149	0.126	0.095	0.187
Age difference with husband (in years)	0.050*** (0.012)	0.061*** (0.020)	0.015 (0.034)	0.052*** (0.013)
Observations	26,825	13,079	6,930	32,960
Number of individuals	15,117	7,258	5,912	20,399
R-squared[a]				
- Within	0.041	0.061	0.048	0.046
- Between	0.175	0.145	0.101	0.211
- Overall	0.151	0.129	0.097	0.188
Restricted mobility index (0-to-1 score)	−0.015 (0.022)	−0.040 (0.033)	−0.041 (0.070)	−0.032 (0.022)
Observations	27,346	13,374	7,099	33,606
Number of individuals	15,579	7,503	6,075	20,978
R-squared[a]				
- Within	0.040	0.059	0.047	0.045
- Between	0.172	0.140	0.099	0.210
- Overall	0.149	0.126	0.095	0.187
Decision-making index (0-to-1 score)	0.057*** (0.021)	0.070*** (0.034)	0.084 (0.066)	0.069*** (0.022)
Observations	27,342	13,360	7,097	33,590
Number of individuals	15,580	7,496	6,073	20,964
R-squared[a]				
- Within	0.040	0.059	0.049	0.045
- Between	0.172	0.140	0.099	0.210
- Overall	0.149	0.127	0.095	0.188
Community acceptance of domestic violence (0-to-1 score)	0.046*** (0.015)	0.086*** (0.024)	0.053 (0.046)	0.060*** (0.015)
Observations	27,238	13,298	7,064	33,457
Number of individuals	15,555	7,495	6,043	20,937
R-squared[a]				
- Within	0.040	0.060	0.050	0.045
- Between	0.172	0.139	0.100	0.209
- Overall	0.149	0.126	0.096	0.187
Control variables	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes

Notes: Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Standard errors were clustered at a household level for robustness.

Source: Authors' calculations from IHDS I–II database.

[a]Since HT model specification does not report R-squared values, we computed those obtained in a random model specification.

individual level lead to hazardous weight gain among Indian women, even when controlling for a comprehensive set of demographic and socioeconomic factors and individual time-invariant characteristics.

The commonness of domestic violence in the community and higher age difference between spouses increase both female BMI and overweight risk. According to the literature, gender norms and inequality have important psycho-social consequences for women. In Bangladesh, Lentz (2018) shows that women living in contexts of violence may choose to lower the quantity or quality of food consumed to avoid domestic violence. Our study suggests that this type of precautionary mechanism to avoid violence, which implies inadequate feeding behaviours, may in some contexts cause weight gain and overweight. In addition, domestic violence towards women is associated with major mental health disorders like depression, anxiety, post-traumatic stress disorders, and loss of self-esteem and self-confidence (Trevillion, Oram, Feder, & Howard, 2012). In some conditions, mental illness can result in compulsive snacking, overeating, risky non-food intakes (for example, alcohol, tobacco, and narcotics), reduction in mobility and physical activity, leading to weight gain (Brunner, Chandola, & Marmot, 2007; Yount & Li, 2011). Recent studies show that (negative) emotions are related to risky attitudes, namely in terms of health (Meier, 2022), which may also explain unhealthy food choices for women facing domestic violence. Consequently, public policy interventions, oriented to reduce domestic violence against women and its acceptance, can improve not only women's mental health but also their nutritional health.

Another contribution of this study is the result of women's empowerment and autonomy. Indeed, we surprisingly find that higher decision-making power and low levels of restricted mobility are both associated with women's weight gain and overweight in India, especially among urban areas and privileged social groups for the former. This innovative finding is likely to highlight a higher exposure to obesogenic environments and behaviours associated with women's emancipation and empowerment. In other words, women's lack of autonomy and restricted mobility may have a 'protective effect' against Western lifestyles and food consumptions related to weight gain, such as eating more outside, higher access to high-calorie processed food, or higher attendance at fast-food outlets and bars. In comparison to developed countries where these lifestyle choices tend to increase the obesity risks of low SES groups (Ball & Crawford, 2005), these Western lifestyles are more likely to impact urbanized middle-class and upper-class groups in developing countries (Daran & Levasseur, 2022).

Moreover, increasing empowerment and autonomy for any individual does not necessarily mean that their actions and decisions will be healthier. Indeed, cross-country evidence from 190 countries over a period of 30 years shows that women's political empowerment (measured through women's civil liberties, civil society participation, and political participation) is positively associated with increasing BMI in both high and low income countries (Fox, Feng, & Asal, 2019). Even though the study does not use a measure of decision-making in the household, the authors declare that it correlated highly with other women's empowerment measures. Higher levels of empowerment would counteract the exposure to an obesogenic environment if women were more likely to exercise, but in the case of India, gender norms are still very entrenched when it comes to women engaging in physical exercise (Mathews, Lakshmi, Ravindran, Pratt, & Thankappan, 2016; Podder et al., 2020), especially in urban areas (Tripathy et al., 2016). Consequently, since Indian women are not culturally invited to engage in physical activity, the empowerment of women in obesogenic (urban) contexts might encourage the adoption of a sedentary way of living and unhealthy consumptions associated with weight gain.

Finally, our results show that child marriage decreases female BMI and increases the risk of underweight. One can assume that child marriage implies strong mental health troubles and lead women to lose weight because of exacerbated levels of violation of human rights (as observed for high levels of domestic violence in Bangladesh by Lentz, 2018). Since child marriage is extremely concerning in India, 7 per cent of Indian married women being married before 15 (UNICEF, 2019), limiting this phenomenon appears as a concrete action to counter female malnutrition, but also mental depression. An interesting research avenue would be to further explore the heterogeneity in child marriage and its effects on women's health and nutritional status. For instance, assessing the impact of the 2006 Prohibition of Child Marriage Act on the prevalence of female malnutrition in India can be a good entry point.

To conclude, this article shows that the use of compound indicators to measure the impact of gender inequality on health outcomes, such as BMI may hide more nuanced mechanisms that can only be unveiled by looking at specific dimensions of gender inequality. As demonstrated, severe forms of gender inequality have negative impacts on women's mental health and nutrition (that is, weight loss), including child marriage and mobility restrictions (Case & Menendez, 2009). Paradoxically, women's lack of freedom, autonomy, and decision-making power may reduce the exposure to urban and obesogenic environments, and 'protect' women against weight gain; considering that the process of urbanization is concomitantly associated with the introduction of westernized lifestyles and overweight-related diets (Wells et al., 2012). These results prove that public health policy should systematically consider gender inequality as one of the main drivers of risky nutritional behaviours when anti-obesity programs are implemented.

Notes

1. The co-occurrence of these three nutritional issues is referred as the Indian triple burden of malnutrition (Meenakshi, 2016).
2. Most of the studies analysing the association between gender inequality and obesity use multidimensional indexes based on levels of empowerment, health, life expectancy, economic status, access to rights, education, among others, like the Gender Inequality Index (GII) or the Global Gender Gap (GGG) (De Soysa & Lewin, 2019; Wells et al., 2012). Some studies also account for discriminatory social institutions such as early marriage, or son preference like the OECD Social Institutions and Gender Index (SIGI) (Garawi et al., 2014).
3. To our knowledge, only Sinha et al. (2017) propose a within-country study investigating the relationship between local gender inequality and child starvation. They find that higher gender equality (measured at the state level) in India increases the probability of normal growth.
4. In 1929, the Indian Child Marriage Restraint Act (CMRA) prohibited child marriage of girls below 15 years old. In 1978, the legal age of marriage increased to 18 years old for women. However, child marriages continued to take place. To address this issue, the government passed the Prohibition of Child Marriage Act in 2006 and defined the legal age for marriage as 18 for women and 21 for men. An important decline is observed, and child marriage declined from 47% in 2006 to 27% in 2017 but it is still dramatically high (UNICEF, 2019).
5. Note that the wording of the question explicitly asks respondents from the women module to report community-level acceptance rather than personal experiences: 'I would now like to ask you some questions about your community, NOT about your own family. In your community is it usual for husbands to beat their wives in each of the following situations?'
6. Details of the PCAs available upon request.
7. Religious personal laws are laws applied to a certain group of people based on religion and culture. They originated during the colonization period in order to 'save' religious laws (Parashar, 2008).
8. Since the age of marriage and age difference with the husband are time-invariant variables, we cannot use the child marriage nor the age difference dummy as indicators of gender inequality when fixed-effects estimations are considered.
9. Per capita income was calculated dividing the total household income by the number of persons in the household.
10. Education and caste are time-varying in our sample, given that there are 6 to 7 years gap between both waves of the survey (see Tables S1 and S2 in Supplementary Materials).
11. Additional regressions based on alternative ways to measure gender norms are presented in Tables S5 and S6 of Supplementary Materials. First, looking at the effect of the multidimensional gender inequality index on weight (Table S5) shows that some of the dimensions of gender inequality may cancel each other out on average. Indeed, the Hausman-Taylor regression coefficients are non-significant and close to zero in magnitude. Only the fixed effect estimations show a significant and positive effect of the gender inequality index on BMI and a significant negative effect on the probability of being underweight. These results justify the need to analyse each dimension of gender inequality independently. Second, looking at potential non-linearities in the relationship between each indicator of gender norms and BMI (Table S6) provides more precisions about the form of tested

associations. Indeed, Table S6 shows a negative and convex relationship between the number of mobility restrictions and female BMI, which may explain the lack of linear significance observed in Table 1. This result suggests that the 'protective effect' of mobility restrictions on weight gain (potentially due to a lower exposure to obesogenic environments) might be true up to a certain level of mobility restrictions. One this level is reached, one can indeed assume that the lack of physical activity (and also the risk of severe mental health troubles) offsets this protective effect. Table S6 also shows a convex relationship between the number of subjects over which women have a decision power within the household and BMI, suggesting that women's empowerment needs to be relatively high (at least four decision-making power items) to be associated with weight gain. Finally, a convexity is also observed in the association between the level of acceptance of violence in the community and female BMI. Compared to the reference group, we observe that a low level of acceptance of violence (in only one of the situations) is associated with lower BMI, whereas higher acceptance of violence is positively associated with BMI.

12. IHDS includes a poverty variable computed using monthly consumption per capita data and national poverty lines (that is, the Planning Commission poverty line for 2004–2005 and the Tendulkar Committee poverty line for 2011–2012).

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ORCID

Suneha Seetahul http://orcid.org/0000-0003-4393-0550

Data availability statement

This database is publicly available, anonymous, and does not contain personal information. Please see the website for more information about the data: https://ihds.umd.edu. The authors are responsible for all remaining errors. Data and codes are publicly available in the following data repository: Alvarez Saavedra, Levasseur, and Seetahul (2022).

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Appendix 1

Textbox A1. Data source description

The IHDS survey was conducted in two waves: one in 2004–2005 and one in 2011–2012, respectively covering 41,554 and 42,152 households residing in urban and rural areas across 33 Indian states. The primary sampling unit (PSU) are villages and urban blocks from which the households were selected. In the last wave, 85 per cent of the household were re-interviewed. 2,114 households were added in the second wave to refresh the sample. This survey is the only nationally representative panel dataset available for India, which makes it a valuable asset for our study. Another advantage of this survey is that it was conducted through face-to-face interviews, organized into two separate questionnaires for households and for women, with women interviewing women and men interviewing men. The subset of question from which we created some of the gender inequality variables are from the women's questionnaire, which is specifically responded by ever-married women from 15 to 49 years old. In the analyses, we consider an unbalanced panel sample, with individuals interviewed at one or both waves. To avoid confounders like menopause or other age-related hormonal issues, and to be able to follow the evolution of the women interviewed in both waves, we restrict our sample to non-pregnant women between 18 and 49 years old in 2004–2005. Our final sub-sample is composed of 23,328 in 2004–2005 and 23,030 in 2011–2012

Table A1. Summary statistics

	Married under 18 (binary)		Age difference with husband (years)		Decision-making power (0–1 score)		Restricted mobility (0–1 score)		Community acceptance of violence (0–1 score)		Overweight prevalence (%)		Obesity prevalence (%)	
	2004–2005	2011–2012	2004–2005	2011–2012	2004–2005	2011–2012	2004–2005	2011–2012	2004–2005	2011–2012	2004–2005	2011–2012	2004–2005	2011–2012
All subsample	0.52	0.51	5.28	5.40	1.45	1.44	1.94	1.99	2.09	2.45	0.16	0.27	0.03	0.07
Age														
18–30	0.52	0.55	5.11	5.24	1.22	1.27	2.06	2.08	2.16	2.54	0.09	0.17	0.02	0.03
31–40	0.53	0.50	5.33	5.24	1.55	1.44	1.90	2.02	2.09	2.45	0.18	0.26	0.04	0.06
40–50	0.51	0.51	5.52	5.62	1.70	1.51	1.81	1.97	1.95	2.43	0.24	0.31	0.05	0.08
p-Value (χ^2)	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.039	0.000	0.000	0.000	0.000
Urban														
Urban	0.41	0.39	5.59	5.68	1.59	1.52	1.80	1.98	1.79	2.25	0.27	0.42	0.06	0.12
Rural	0.58	0.57	5.15	5.28	1.39	1.41	2.01	2.00	2.22	2.53	0.11	0.20	0.02	0.04
p-Value (χ^2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Education														
None	0.68	0.68	5.06	5.14	1.42	1.42	2.03	2.02	2.31	2.59	0.10	0.18	0.02	0.04
1–4	0.57	0.57	5.71	5.71	1.49	1.48	1.91	1.92	2.27	2.49	0.14	0.22	0.03	0.06
Primary	0.54	0.52	4.99	5.16	1.44	1.47	1.98	2.04	1.97	2.36	0.19	0.30	0.04	0.08
6–9	0.42	0.42	5.64	5.87	1.46	1.46	1.90	1.97	1.96	2.40	0.19	0.32	0.04	0.08
Secondary	0.25	0.24	5.64	5.72	1.52	1.40	1.82	1.99	1.76	2.30	0.26	0.41	0.06	0.13
Higher secondary	0.14	0.16	5.61	5.57	1.42	1.47	1.78	1.94	1.57	2.11	0.26	0.42	0.05	0.12
Graduate 15+	0.05	0.06	4.84	4.90	1.61	1.57	1.62	1.90	1.30	1.96	0.36	0.51	0.09	0.15
p-Value (χ^2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Per capita income														
1st tercile	0.64	0.62	5.12	5.12	1.37	1.37	2.05	2.01	2.43	2.61	0.08	0.16	0.01	0.03
2nd tercile	0.56	0.56	5.25	5.40	1.43	1.46	2.00	2.01	2.19	2.49	0.12	0.23	0.02	0.05
3rd tercile	0.41	0.40	5.42	5.60	1.53	1.48	1.83	1.97	1.77	2.29	0.24	0.38	0.05	0.10
p-Value (χ^2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Poverty line														
Poor	0.64	0.61	5.04	5.11	1.34	1.40	2.01	2.00	2.19	2.55	0.08	0.14	0.01	0.03
No poor	0.49	0.50	5.35	5.46	1.48	1.45	1.93	1.99	2.06	2.42	0.18	0.29	0.04	0.08
p-Value (χ^2)	0.000	0.000	0.000	0.000	0.000	0.197	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Caste														
High caste	0.42	0.40	5.32	5.56	1.45	1.42	1.82	1.94	1.82	2.23	0.22	0.35	0.05	0.10
OBC	0.54	0.55	5.39	5.44	1.43	1.43	1.96	2.04	2.18	2.55	0.13	0.24	0.03	0.06
SC/ST	0.60	0.60	5.17	5.28	1.49	1.44	1.98	2.03	2.22	2.53	0.11	0.22	0.02	0.05
Muslim (w/o caste)	0.57	0.54	5.47	5.57	1.40	1.49	2.02	1.96	2.20	2.60	0.18	0.32	0.04	0.08
Christian, Sikh, Jain (w/o caste)	0.15	0.10	4.44	4.59	1.49	1.46	1.78	1.94	1.52	2.07	0.36	0.51	0.09	0.17
p-Value (χ^2)	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

(*continued*)

Table A1. (*Continued*)

	Married under 18 (binary)		Age difference with husband (years)		Decision-making power (0–1 score)		Restricted mobility (0–1 score)		Community acceptance of violence (0–1 score)		Overweight prevalence (%)		Obesity prevalence (%)	
	2004–2005	2011–2012	2004–2005	2011–2012	2004–2005	2011–2012	2004–2005	2011–2012	2004–2005	2011–2012	2004–2005	2011–2012	2004–2005	2011–2012
Employed														
Yes	0.61	0.58	5.25	5.31	1.54	1.46	2.01	2.01	2.29	2.58	0.10	0.19	0.02	0.04
No	0.46	0.46	5.31	5.48	1.39	1.43	1.90	1.98	1.95	2.33	0.21	0.34	0.04	0.09
p-value (χ^2)	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Descriptive statistics for our sample: non-pregnant ever-married women between 18 and 49 years old in 2004–2005. Pearson's chi-square test results are presented (H0 is the independence hypothesis across groups).
Source: Authors' calculations from IHDS I-II database.