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Effect of Obesity on Asthma Among Adult Indian Women

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ABSTRACT

Objective. Both obesity and asthma are on the rise worldwide. This study examined the association between obesity and asthma prevalence in adult women in India.

Methods. Analysis used information on 82,464 non-pregnant, ever-married women age 15–49, included in India's 1998–99 National Family Health Survey. Effects of measured Body Mass Index (BMI) on reported asthma were estimated using logistic regression, after adjusting for tobacco smoking (active and passive), cooking smoke, age, education, work status, media habits, food habits, house type, separate kitchen, indoor crowding, religion, caste/tribe, household living standard, urban/rural residence, and geographic region.

Results. Obese women (BMI$\geq$30.0 kg/m^2) were about twice as likely as those with a normal BMI (18.5–25.0 kg/m^2) to report suffering from asthma (OR=1.92; 95%CI: 1.40–2.65). The association between obesity and asthma remained strong and statistically significant even when the effects of other selected risk factors and potential confounders were controlled (OR=1.85; 95%CI: 1.30–2.63). Overweight women (25.0$\leq$BMI<30.0 kg/m^2) also reported significantly higher adjusted asthma prevalence than those with a normal BMI (OR=1.32; 95%CI: 1.07–1.63). Results hold in separate analysis for younger (15–29) and older (30–49) women.

Conclusion. The study finds a strong positive association between obesity and asthma among adult Indian women. To validate this relationship and to establish causality, prospective epidemiological studies, with better measures of overweight conditions and clinical measures of asthma, are needed in developing-country settings.

Key words (MeSH): Asthma, obesity, overweight, nutritional status, women, India

INTRODUCTION

Rapidly changing diets, physical activity patterns, and lifestyles are fueling the global obesity epidemic.[1] Already, there are more than one billion overweight people worldwide, and some 300 million of these are estimated to be obese.[2,3] In many developed countries, obesity epidemic has already reached crisis proportions. According to the 1999–2000 National Health and Nutrition Examination Survey (NHANES), the proportion of overweight or obese adults in the United States has risen to 64%.[4] Once considered a problem related to affluence, obesity is now fast growing in many developing countries and in poor neighborhoods of the developed countries.[1,5]

In many developing countries, with increasing urbanization, mechanization of jobs and transportation, availability of processed and fast foods, and dependence on television for leisure, people are fast adopting less physically active lifestyles and consuming more "energy-dense, nutrient-poor" diets.[1,6-10] As a result, overweight and obesity and associated chronic health problems, such as diabetes, hypertension, cardiovascular disease, and cancer, are increasing rapidly, particularly among the middle-class, urban populations.[1,11-19] Even in countries like India, which are typically known for high prevalence of undernutrition, significant proportions of overweight and obese now coexist with the undernourished.[7]

The growing prevalence of obesity has been accompanied by rapidly rising asthma rates worldwide in both adults and children.[20-24] A rapid increase in asthma in recent years cannot be ascribed to changes in genetic (heritable) factors; the focus, therefore, should

be on behavioral and environmental factors. Many hypotheses have been put forth to explain the rising prevalence of asthma, but there is no consensus.[21,22,24] The parallel increase in the prevalence of obesity and asthma in the past 2–3 decades has led some researchers to postulate a causal relationship between the two conditions.[25] Tantisira and Weiss[26] in a recent review article discuss various plausible causal mechanisms relating obesity to asthma.

A number of studies have associated obesity and asthma in adults[27-36] and in children.[37] Obesity has also been linked with impaired pulmonary function and airway hyperresponsiveness,[38-41] but not in all studies.[30,42] The most convincing evidence of a causal link between obesity and asthma in adults is provided by a large prospective cohort study of 85,911 nurses followed during 1991 and 1995, in which obese women had a much greater risk of asthma, and weight gain was positively associated with the risk of developing asthma.[43] Another recent prospective study of 10,597 adult twins in Finland followed for 9 years has found obesity to be associated with the risk of adult-onset asthma.[44] Convincing evidence of obesity causing asthma onset is also provided by at least two prospective cohort studies of children. The Growing Up Today study of 16,862 children found that BMI has a positive, independent risk of incident asthma in both boys and girls, concluding that increasing prevalence of obesity may partly explain rising asthma prevalence in children.[45] The Children's Health Study in Southern California also found that overweight and obesity were associated with new-onset asthma in both boys and girls.[46] Moreover, several prospective studies of obese asthmatics have

shown that weight reduction leads to improved pulmonary function, and reduced severity and frequency of asthma symptoms.[47-51]

The evidence of a relationship between obesity and asthma is not conclusive, however. Several studies find a relationship between obesity and asthma in females but not in males.[33,52-59] Others have found no relationship between obesity and asthma.[60,61] Still others have concluded the reverse relationship that asthma is a risk factor for obesity.[62-64]

Much of the research linking obesity and asthma to date has been carried out in developed countries. Most developing countries, with continuing high levels of undernutrition and high prevalence of communicable diseases, have paid little attention to the rapidly growing problems of obesity and asthma. This lack of attention is usually coupled with poor quality and availability of data on the two conditions. To my knowledge, only three studies in developing countries have associated overweight conditions with wheezing and asthma—one study in a high-altitude area in Korea linked high BMI to wheezing among the elderly;[65] a second study in the Anhui province in China linked overweight condition with asthma in adults;[31] and a third study among Mexican adults linked measured obesity to asthma diagnosis in both men and women.[66]

Previous research in India has related obesity with diabetes, hypertension, and heart disease,[67-70] but there are no studies linking obesity and asthma. A recent survey in India collected anthropometric data from a nationally representative sample of more than 90,000 ever-married women of reproductive age.[71] The survey also collected data on

reported asthma prevalence, and on a number of behavioral, demographic and socioeconomic factors. These data provide an opportunity to examine the association between obesity and asthma in a developing country setting—India.

METHODS

Data

Data are from India's second National Family Health Survey (NFHS-2) conducted in 1998–99. NFHS-2 collected demographic, socioeconomic, and health information from a nationally representative probability sample of 92,486 households. All states of India are represented in the sample, covering more than 99 percent of country's population. The sample is a multi-stage cluster sample with an overall response rate of 98 percent. Details of sample design, including sampling frame and sample implementation, are provided in the basic survey report for all India.[71] The analysis here is based on 82,464 non-pregnant, ever-married women age 15–49 living in the sample households.

Response Variable

The survey asked several questions relating to the current health status of household members, including whether each member suffered from asthma. The question was (referring to the listing of persons in the household), "Does anyone listed suffer from asthma?" The household head or other knowledgeable adult in the household reported for each household member. The survey was conducted using an interviewer-administered questionnaire in the native language of the respondent using a local, commonly understood term for asthma. A total of 18 languages were used in the survey. No

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physician diagnosis of asthma was obtained and no effort was made to clinically test for the disease. In the analysis, this reported prevalence of asthma is the response variable.

Primary Predictor Variable

In NFHS-2, each ever-married women age 15–49 was weighed using a solar-powered scale with an accuracy of ±100 g. Their height was measured using an adjustable wooden measuring board, specifically designed to provide accurate measurements (to the nearest 0.1 cm) in a developing-country field situation. The weight and height data were used to calculate the BMI. Women who were pregnant at the time of the survey or women who had given birth during the two months preceding the survey were excluded. BMI can be used to estimate the prevalence of underweight, as well as the prevalence of overweight and obesity.[1] A BMI<18.5 kg/m^2 is defined as underweight, indicating chronic energy deficiency. A BMI in the range of 18.5 and 25.0 kg/m^2 is defined as normal; 25.0 and 30.0 kg/m^2 as overweight; and ≥30.0 kg/m^2 as obese. Based on these cut-offs, a four-category variable of nutritional status of women was created, indicating underweight, normal BMI, overweight, and obese.

Confounding Factors

Because the effects of nutritional status are likely to be confounded with the effects of other risk factors, it is necessary to statistically control, or adjust, for such factors. Confounding factors included in this study are: exposure to cooking smoke (measured by cooking fuel type), exposure to tobacco smoke (both active and passive), age, education, work status, media habits, food habits, house type, availability of a separate kitchen in the

house, crowding in the household (measured by number of persons per room), religion of household head, caste/tribe of household head, living standard of the household (measured by an index based on household ownership of assets), urban-rural residence, and geographic region. For definition of variables, see Table 1.

Statistical Analysis

Because the response variable—prevalence of asthma—is dichotomous, logistic regression method was used to estimate the effects of BMI on asthma after controlling for exposure to cooking smoke (high pollution fuels, medium pollution fuels, low pollution fuels), tobacco smoke (both active and passive) and the other 18 demographic and socioeconomic variables mentioned above as controls. Because there are large differentials in the life conditions of younger (age 15–29) and older (age 30–49) women and because prevalence of obesity is much higher in the older group, the analysis was also carried out separately for younger and older women.

Results are presented in the form of odds ratios (OR) with 95% confidence intervals (95%CI). The estimation of confidence intervals takes into account design effects due to clustering at the level of the primary sampling unit. The logistic regression models were estimated using the STATA statistical software package.[72] In the survey, certain states and certain categories of households were over sampled. In all analysis in this study, weights are used to restore the representativeness of the sample.[71]

Human Subjects Informed Consent

The analysis presented in this study is based on secondary analysis of existing survey data with all identifying information removed. The survey obtained informed consent from each respondent before asking questions.

RESULTS

Prevalence of Overweight and Obesity

According to the NFHS-2, about 11% of ever-married women (15–49) in India are overweight or obese—8.4% overweight and 2.3% obese (Table 1). The prevalence of obesity is much higher in urban areas, where about one in four (24%) women are overweight or obese.

<center><Table 1 about here></center>

Characteristics of Women

Majority of women in India cook with high pollution biomass fuels, but few (2.3%) smoke tobacco or have ever smoked tobacco regularly in the past. Forty-five percent live in households where someone else smokes. About three-fifths are illiterate, and a similar proportion does not work (other than household work). About one-half watch television at least once a week, but only one in five read a newspaper or magazine at least once a week. Majority do not consume milk product, fruits, or green, leafy vegetables on a daily basis, and a large majority are vegetarians, not consuming eggs, chicken, fish, or meat at least once a week. One in two live in houses with a separate kitchen, and about one in two live in houses with more three persons per room. Four-fifths are Hindu and three-

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fourths live in rural areas. There are considerable urban-rural differences in these characteristics, with urban women being more educated, more likely to be employed, more likely to watch television and read newspapers and magazines, more likely to consume each food types, less likely to live in crowded households, and less likely to live in low standard of living households.

Prevalence of Asthma

Overall, 2.3% ever-married women reported suffering from asthma, slightly higher in rural areas (2.5%) than in urban areas (1.9%) (Table 2). The prevalence of asthma was lowest among women with a normal BMI, and highest among the obese. Underweight and overweight women also reported considerably higher asthma rates than those with a normal BMI.

<center><Table 2 about here></center>

Women cooking with high pollution biomass fuels were considerably more likely to report suffering from asthma than those using low pollution electricity, LPG, or biogas. As expected, tobacco smoking was strongly associated with asthma prevalence. Women who were current smokers or smoked regularly in the past were more than twice as likely to report suffering from asthma as those who never smoked and lived in a household where no one else smoked regularly. This association between active tobacco smoking and asthma was much stronger in rural areas than in urban areas.

Older women were much more likely to report suffering from asthma than younger women. By education, illiterate women had much higher prevalence than those with

middle school or higher education. Women regularly exposed to mass media had somewhat lower prevalence of asthma than other women. Women living in the North region had the lowest prevalence and those in the South had the highest prevalence of asthma. Asthma prevalence did not vary much by work status, food habits, crowding, living standard, and other factors. Differentials in the asthma prevalence by urban-rural residence are similar to those discussed above for both urban and rural women combined.

Effect of Obesity on Asthma

Model I in Table 3 shows that unadjusted odds of suffering from asthma are almost two times higher among obese women than among women with a normal BMI (OR=1.92; 95%CI: 1.40–2.65). Both overweight (OR=1.39; 95%CI: 1.14–1.69) and underweight (OR=1.35; 95%CI: 1.19–1.53) women are also at a significantly higher risk of suffering from asthma. Controlling for exposure to cooking smoke and tobacco smoke (in Model II), which are known to aggravate asthma, further sharpens the effects of overweight (OR=1.62; 95%CI: 1.32–1.98) and obesity (OR=2.40; 95%CI: 1.72–3.33). Effects of overweight and obesity are reduced somewhat when woman's characteristics (age, education, work status, media habits, and food habits) are controlled in Model III, but the effects remain large and statistically significant. Controlling for the household characteristics (house type, availability of a separate kitchen, crowding, religion, caste/tribe, and living standard) in Model IV also sharpens the effects of overweight and obesity on asthma. In the full model (Model V), when the effects of all 20 demographic and socioeconomic variables are controlled, the adjusted effect of obesity on asthma remains large and statistically significant (OR=1.85; 95%CI: 1.30–2.63). Overweight and

underweight women also have significantly higher risks of asthma than women with a normal BMI (OR=1.32; 95%CI: 1.07−1.63 for overweight, and OR=1.31; 95%CI: 1.15−1.49 for underweight).

<Table 3 about here>

Effects of Smoke Exposure on Asthma

With the effects of BMI, tobacco smoking, and other socioeconomic factors controlled, women who cook with high pollution biomass fuels have a significantly higher asthma prevalence (OR=1.34; 95%CI: 1.03−1.74) than those who cook with electricity, LPG, or biogas (Model V, Table 3). Women using a mix of biomass and cleaner fuels or coal/coke/lignite, charcoal, or kerosene also have higher prevalence of asthma than those using cleaner fuels (OR=1.24; 95%CI: 0.98−1.56). Adjusted odds of suffering from asthma are also considerably higher among women who currently smoke tobacco or have ever smoked regularly in the past (OR=1.78; 95%CI: 1.33−2.38) than among those who have never smoked and do not live in a household with other smokers. Effect of passive smoking on asthma is much smaller (OR=1.12; 95%CI: 0.99−1.26).

Effects of the Control Variables on Asthma

In the full model (Model V) in Table 3, age has a large positive effect on asthma prevalence. Odds of suffering from asthma are 3.7 times greater among women age 35−49 than among women age 15−24 (95%CI: 3.02−4.63). Women with middle school or higher education are significantly less likely to suffer from asthma than illiterate women. Women working outside the home, having a separate kitchen, living in more

crowded households, and those belonging to backward and scheduled castes and scheduled tribes have significantly lower asthma prevalence than other women (ORs range from 0.81 to 0.86). Women living in the North, Central, and East regions have significantly lower asthma prevalence than those living in the South region. With other factors controlled, effects of media habits, food habits, house type, religion, living standard, and urban/rural residence are small and not significant statistically.

Separate Analysis by Age

Because the prevalence of asthma increases rapidly with age and because the covariates of overweight and obesity are likely to change with age, the above analysis was repeated separately for women age 15−29 and 30−49. Only adjusted effects in full models are presented in Table 4. Overweight and obesity have large effects on the risk of asthma in both groups of women. The effects of overweight and obesity are somewhat greater among the younger women (OR=2.11 for overweight and OR=2.32 for obese) than among the older women (OR=1.27 for overweight and OR=1.83 for obese). All of these effects are statistically significant, except the effect of obesity in women age 15−29, where large standard errors result mainly due to small numbers of cases in the sample. Also consistent with results in Table 3, underweight women have significantly higher risk of asthma than those with a normal BMI in both groups of women (OR=1.31; 95%CI: 1.03−1.67 for women age 15−29, and OR=1.29; 95%CI: 1.11−1.50 for women age 30−49).

<Table 4 about here>

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DISCUSSION

The study finds that obese women in India have a substantially higher risk of asthma than women with a normal BMI (OR=1.85; 95%CI: 1.30–2.63), independent of exposure to cooking smoke, tobacco smoke, age, education, food habits, living standard, and other factors. Overweight women also have significantly higher asthma prevalence than normal BMI women. The effects of overweight and obesity on asthma hold when the analysis is done separately for women age 15–29 and 30–49. These findings are consistent with other growing evidence, some from prospective cohort studies,[27-37,43-46] and provide further evidence, from a developing country setting, that obesity may increase the risk of asthma in adult women.

The finding that active tobacco smoking is associated with significantly increased risk of asthma is consistent with previous research.[73-81] However, active tobacco smoking is not a major confounder in this study because only a small proportion of women in India smoke tobacco (only 2.3% in the NFHS-2 sample). A positive significant effect of biomass fuel use on asthma is also consistent with previous research linking cooking smoke to asthma.[73,82-85]

Both the amount of body fat and its distribution are important in determining health risks associated with overweight conditions. In Asian populations, abdominal or central obesity is more common than obesity defined by BMI,[86] and health risks associated with overweight and obesity occur at lower levels of BMI than in North America or Europe.[12,87] A study in India observed that about 20% of adults who were not overweight

or obese as per the BMI definition still had abdominal obesity.[88] It is now being suggested that lower cutoff points for BMI be used to categorize overweight and obese conditions for Asian populations.[5] The NFHS-2 only measured height and weight of the respondents, so it was not possible to consider other measures of obesity, such as waist circumference and waist-hip ratio, which may be more relevant for linking obesity to asthma and other health conditions.

Several other measurement constraints should be kept in mind when considering the findings of this study. First, the analysis is based on reported asthma, which is not as accurate as physician-diagnosed, clinical measures of asthma. Because the disease carries a stigma in India, reported prevalence of asthma may be an underestimate due to intentional concealment or lack of knowledge, especially for children and young adults. For married adults, however, there is not much stigma attached to the disease and it is not considered contagious like tuberculosis, so underreporting due to intentional concealment should not be a major problem in this study. There is also a possibility of overreporting because some other disease condition with similar symptoms, such as chronic bronchitis or chronic obstructive pulmonary disease, may be reported as asthma. Our estimated effect of obesity is biased to the extent such underreporting or overreporting of asthma is correlated with BMI.

Second, to the extent some other disease condition with asthma like symptoms was reported as asthma, the results of this study represent the association of obesity with chronic respiratory disorders in adult women, including asthma. In cases where asthma

might have been confused with some other chronic respiratory disorder, it is not possible from the NFHS-2 data to separate the effect on asthma from the effect on some other condition with similar symptoms.

Third, the analysis is based on cross-sectional data, where both prevalence of obesity and prevalence of asthma are measured at the time of the survey. It is possible that in some cases asthma may cause reduced physical activity, which in turn may lead to overweight condition.[62-64] To the extent this occurs, the estimated effect of obesity on asthma may be overestimated. However, given that several prospective cohort studies have linked obesity and weight gain to onset asthma both in adults[43,44] and children,[45,46] the causation is likely to be primarily from obesity to asthma. There is clearly need for prospective cohort studies of obesity and asthma in developing countries.

Fourth, the study could not control directly for the extent of use of medical services in connection with obesity and asthma, although the set of control variables used in the study includes several measures of socioeconomic status, which is correlated with access to and use of medical services.

Despite these limitations in the measurement of obesity and asthma, the consistency in the size of crude and adjusted effects of obesity on asthma suggests a possible causal relationship. Moreover, in developing countries such as India, where data on BMI and clinical data on asthma are usually not available, very weak, or not available for same

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sets of people, the NFHS-2 data provided a unique opportunity to study the relationship between obesity and asthma.

To validate this relationship and to better understand the pathogenesis of asthma, carefully designed longitudinal epidemiological studies with better measures of overweight conditions and clinical measures of asthma are needed. Such research is especially important in the light that both the prevalence of obesity and asthma are rising rapidly in the developing countries.

ACKNOWLEDGEMENTS

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Table 1 Sample distribution by selected characteristics, ever-married women age 15-49, India 1998-99

Variable	Urban	Rural	Total
Body mass index[1]			
Underweight	22.7	41.1	36.2
Normal	53.6	53.0	53.2
Overweight	17.7	5.0	8.4
Obese	5.9	0.9	2.3
Household cooking fuel[2]			
High pollution fuel	12.7	72.9	56.8
Medium pollution fuel	32.9	24.1	26.4
Low pollution fuel	54.4	3.0	16.8
Tobacco smoking[3]			
Active smoking (current or ever)	0.8	2.9	2.3
Passive smoking	36.2	48.7	45.4
No active or passive smoking	63.0	48.5	52.3
Age			
15-24	18.2	26.3	24.1
25-34	38.2	36.9	37.2
35-49	43.6	36.8	38.6
Education			
Illiterate	33.3	67.2	58.2
Literate, <middle complete	21.9	18.6	19.5
Middle complete	12.1	6.7	8.1
High school or more	32.7	7.5	14.2
Work status			
Works at home	8.3	5.9	6.6
Works outside	16.7	37.2	31.7
Does not work	74.9	56.9	61.7
Media habits			
Watches TV every week			
Yes	80.9	33.7	46.3
No	19.1	66.3	53.7
Reads newspaper/magazine every week			
Yes	43.7	12.7	21.0
No	56.3	87.3	79.0
Food habits			
Milk or curd daily			
Yes	47.5	33.9	37.5
No	52.5	66.1	62.5
Fruits daily			
Yes	17.7	4.5	8.0
No	82.3	95.5	92.0
Green, leafy vegetables daily			
Yes	44.9	40.7	41.8
No	55.1	59.3	58.2
Eggs at least weekly			
Yes	39.6	23.8	28.0
No	60.4	76.2	72.0
Chicken, meat, or fish at least weekly			
Yes	41.6	28.8	32.2
No	58.4	71.2	67.8
House type[4]			
Pucca	66.9	20.3	32.7
Semi-pucca	23.9	39.7	35.5
Kachha	9.2	39.9	31.8

Separate kitchen			
Yes	66.4	47.6	52.6
No	33.6	52.4	47.4
Crowding			
< 3 persons per room	62.5	53.6	56.0
≥ 3 persons per room	37.5	46.4	44.0
Religion			
Hindu	76.6	84.0	82.1
Muslim	15.9	10.9	12.2
Other[5]	7.5	5.1	5.7
Caste/tribe			
Scheduled caste or scheduled tribe[6]	18.2	30.2	27.0
Other backward class	30.2	34.4	33.3
Other	51.5	35.5	39.8
Standard of living[7]			
Low	12.5	40.0	32.7
Medium	45.1	47.2	46.7
High	42.4	12.8	20.6
Residence			
Urban	100.0	0.0	26.6
Rural	0.0	100.0	73.4
Region[8]			
North	9.9	5.6	6.7
West	27.7	16.7	19.6
Central	19.3	24.2	22.9
East	13.3	25.2	22.1
Northeast	1.7	4.1	3.5
South	28.0	24.2	25.2
Number of women[9]	21925	60539	82464

[1] Underweight: BMI< 18.5 kg/m2; normal weight: 18.5-24.9; overweight: 25.0-29.9;obese: ≥ 30.0.

[2] High pollution fuels: wood, animal dung, or crop residues; medium pollution fuels: mix of biomass fuels and cleaner fuels, or coal/coke/lignite/charcoal, or kerosene; low pollution fuels: electricity, petroleum gas, or bio-gas.

[3] Active smoking: woman currently smokes or has smoked regularly in the past; passive smoking: one or more other household members smoke currently; no smoking: woman has never smoked regularly and no other person in the household smokes currently.

[4] Other religion includes Sikh, Buddhist, Christian, Jain, Jewish, Zorastrian, etc.

[5] Scheduled castes (SC) and scheduled tribes (ST) are those castes and tribes identified by the Government of India as socially and economically backward and in need of protection from social injustice and exploitation.

[6] *Pucca* houses are made from high-quality materials (such as bricks, tiles, cement, and concrete) throughout, including roof, walls, and floor. *Kachha* houses are made from mud, thatch or other low-quality materials. Semi-*pucca* houses are made from partly low-quality materials and partly high-quality materials.

[7] Standard of living index (SLI) is calculated by adding the scores assigned to the durable goods in the household as following: 4 for a car or tractor; 3 each for a moped/scooter/motorcycle, telephone, refrigerator, or color television; 2 each for a bicycle, electric fan, radio/transistor; and 1 each for a mattress, pressure cooker, chair, cot/bed, table, or clock/watch. Index scores range from 0-5 for low SLI, 6-15 for medium SLI, 16-42 for high SLI.

[8] North: Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, and Rajasthan; Central: Madhya Pradesh and Uttar Pradesh; East: Bihar, Orissa, and West Bengal; Northeast: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Sikkim; West: Goa, Gujarat, and Maharashtra; South: Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu.

[9] Excludes women pregnant at the time of the survey and those who gave birth in the 2 months preceding the survey. Number of women varies slightly for individual variables depending on the number of missing values.

Table 2 Prevalence of asthma by body mass index (BMI) and other selected characteristics of ever-married women age 15-49, India 1998-99

	Asthma prevalence (%)		
Variable	Urban	Rural	Total
Body mass index			
Underweight (BMI<18.5)	2.08	2.77	2.65
Normal (18.5≤BMI<25.0)	1.58	2.13	1.98
Overweight (25.0≤BMI<30.0)	2.32	3.27	2.73
Obese (BMI≥30.0)	3.72	3.79	3.74
Household cooking fuel			
High pollution fuel	2.08	2.53	2.51
Medium pollution fuel	2.13	2.31	2.25
Low pollution fuel	1.77	1.77	1.77
Tobacco smoking			
Active smoking (current or ever)	2.40	5.53	5.25
Passive smoking	1.99	2.50	2.39
No active or passive smoking	1.91	2.24	2.13
Age			
15-24	0.81	0.98	0.95
25-34	1.34	2.11	1.90
35-49	2.94	3.87	3.59
Education			
Illiterate	2.26	2.72	2.65
Literate, <middle complete	2.16	2.28	2.24
Middle complete	1.60	1.49	1.53
High school or more	1.60	1.51	1.56
Work status			
Works at home	2.43	2.21	2.28
Works outside	2.20	2.70	2.63
Does not work	1.83	2.34	2.17
Media habits			
Watches TV every week			
Yes	1.85	2.24	2.06
No	2.32	2.58	2.55
Reads newspaper/magazine every week			
Yes	1.71	2.05	1.86
No	2.12	2.52	2.45
Food habits			
Milk or curd daily			
Yes	1.90	2.43	2.25
No	1.97	2.48	2.37
Fruits daily			
Yes	1.45	2.75	1.99
No	2.05	2.45	2.35
Green, leafy vegetables daily			
Yes	1.81	2.13	2.04
No	2.05	2.68	2.52
Eggs at least weekly			
Yes	1.87	2.48	2.25
No	1.99	2.46	2.36
Chicken, meat, or fish at least weekly			
Yes	1.94	2.66	2.42
No	1.94	2.38	2.28
House type			
Pucca	1.78	2.58	2.14
Semi-*pucca*	2.36	2.48	2.45
Kachha	2.08	2.40	2.37
Separate kitchen			

Yes	1.84	2.36	2.18
No	2.12	2.57	2.48
Crowding			
< 3 persons per room	1.94	2.61	2.41
≥ 3 persons per room	1.95	2.30	2.22
Religion			
Hindu	1.92	2.45	2.32
Muslim	1.82	2.38	2.19
Other	2.37	2.78	2.64
Caste/tribe			
SC/ST	2.02	2.43	2.36
OBC	1.91	2.40	2.28
Other	1.95	2.55	2.34
Standard of living			
Low	1.78	2.68	2.59
Medium	1.99	2.37	2.27
High	1.91	2.12	2.01
Region			
North	0.99	1.40	1.24
West	2.40	2.92	2.72
Central	1.31	2.01	1.85
East	1.42	2.18	2.05
Northeast	2.69	2.75	2.74
South	2.46	3.10	2.91
All India	1.9	2.5	2.3
Number of women	21915	60518	82433

Table 3 Effects (odds ratios) of body mass index (BMI) and other factors on the prevalence of asthma among women age 15-49, India: 1998-99

	Odds Ratio (95% CI)														
Characteristic	Model I			Model II			Model III			Model IV			Model V		
	OR	LL	UL	OR	LL	UL	OR	LL	UL	OR	LL	UL	OR	LL	UL
Body mass index															
Underweight (BMI<18.5)	1.35	1.19	1.53	1.26	1.11	1.42	1.35	1.20	1.54	1.32	1.16	1.49	1.31	1.15	1.49
Normal (18.5≤BMI<25.0)†	1.00	-	-	1.00	-	-	1.00	-	-	1.00	-	-	1.00	-	-
Overweight (25.0≤BMI<30.0)	1.39	1.14	1.69	1.62	1.32	1.98	1.27	1.03	1.56	1.50	1.22	1.85	1.32	1.07	1.63
Obese (BMI≥30.0)	1.92	1.40	2.65	2.40	1.72	3.33	1.75	1.25	2.46	2.10	1.50	2.96	1.85	1.30	2.63
Household cooking fuel															
High pollution fuel				1.57	1.30	1.89							1.34	1.03	1.74
Medium pollution fuel				1.40	1.14	1.71							1.24	0.98	1.56
Low pollution fuel†				1.00	-	-							1.00	-	-
Tobacco smoking				2.24	1.70	2.95									
Active smoking (current or ever)				1.09	0.97	1.22							1.78	1.33	2.38
Passive smoking				1.00	-	-							1.12	0.99	1.26
No active or passive smoking†													1.00	-	-
Age															
15-24†							1.00	-	-				1.00	-	-
25-34							2.01	1.62	2.50				2.00	1.61	2.49
35-49							3.87	3.14	4.77				3.74	3.02	4.63
Education															
Illiterate†							1.00	-	-				1.00	-	-
Literate, <middle complete							0.87	0.73	1.03				0.85	0.71	1.01
Middle complete							0.66	0.49	0.90				0.63	0.47	0.86
High school or more							0.64	0.49	0.83				0.69	0.52	0.90
Work status															
Works at home							0.94	0.75	1.18				0.88	0.70	1.11
Works outside							0.98	0.85	1.11				0.82	0.71	0.94
Does not work†							1.00	-	-				1.00	-	-
Media habits															
Watches TV every week							0.89	0.77	1.02				0.92	0.78	1.08
Reads newspaper/magazine every week							1.06	0.85	1.32				1.07	0.86	1.33
Food habits															
Milk or curd daily							1.06	0.93	1.21				1.00	0.87	1.15
Fruits daily							0.92	0.72	1.17				0.95	0.74	1.22
Green, leafy vegetables daily							0.82	0.73	0.93				0.97	0.85	1.11
Eggs at least weekly							0.93	0.79	1.09				0.91	0.76	1.07
Chicken, meat, or fish at least weekly							1.19	1.02	1.39				1.10	0.93	1.30

	OR	LL	UL	OR	LL	UL
House type						
Pucca	1.00	0.83	1.21	1.05	0.86	1.28
Semi-*pucca*	1.12	0.96	1.29	1.17	1.00	1.36
Kachha†	1.00	-	-	1.00	-	-
Separate kitchen						
Yes	0.87	0.76	1.00	0.81	0.70	0.93
No†	1.00	-	-	1.00	-	-
Crowding						
< 3 persons per room†	1.00	-	-	1.00	-	-
≥ 3 persons per room	0.80	0.70	0.91	0.83	0.72	0.95
Religion						
Hindu†	1.00	-	-	1.00	-	-
Muslim	0.97	0.80	1.19	0.95	0.77	1.17
Other	1.15	0.92	1.45	1.17	0.93	1.48
Caste/tribe						
SC/ST	0.89	0.76	1.04	0.85	0.72	1.00
OBC	0.93	0.81	1.08	0.86	0.74	1.00
Other†	1.00	-	-	1.00	-	-
Standard of living						
Low†	1.00	-	-	1.00	-	-
Medium	0.86	0.74	1.00	0.96	0.82	1.12
High	0.70	0.55	0.87	1.05	0.83	1.34
Residence						
Urban				0.89	0.74	1.07
Rural†				1.00	-	-
Region						
North				0.38	0.29	0.49
West				0.94	0.77	1.15
Central				0.58	0.46	0.72
East				0.61	0.49	0.75
Northeast				0.86	0.66	1.12
South†				1.00	-	-

| Number of women | 76279 | | 75747 | 76127 | 74859 | 74218 |

† Reference category
LL: Lower Limit; UL: Upper Limit

Table 4 Adjusted effects (odds ratios) of body mass index (BMI) on the prevalence of asthma among women by age 15-29 and 30-49, India: 1998-99

| | Odds Ratio (95% CI) | | | | | |
| | 15-29 | | | 30-49 | | |
Characteristic	OR	LL	UL	OR	LL	UL
Body mass index						
Underweight (BMI<18.5)	1.31	1.03	1.67	1.29	1.11	1.50
Normal (18.5≤BMI<25.0)†	1.00	-	-	1.00	-	-
Overweight (25.0≤BMI<30.0)	2.11	1.19	3.73	1.27	1.02	1.58
Obese (BMI≥30.0)	2.32	0.55	9.80	1.83	1.29	2.60
Household cooking fuel						
High pollution fuel	1.42	0.81	2.50	1.30	0.97	1.75
Medium pollution fuel	1.02	0.60	1.75	1.30	1.01	1.68
Low pollution fuel†	1.00	-	-	1.00	-	-
Tobacco smoking						
Active smoking (current or ever)	2.36	1.07	5.18	1.89	1.40	2.55
Passive smoking	1.08	0.84	1.38	1.12	0.98	1.28
No active or passive smoking†	1.00	-	-	1.00	-	-
Education						
Illiterate†	1.00	-	-	1.00	-	-
Literate, <middle complete	0.66	0.46	0.95	0.89	0.72	1.08
Middle complete	0.36	0.19	0.66	0.74	0.53	1.05
High school or more	0.50	0.29	0.88	0.74	0.55	0.99
Work status						
Works at home	1.53	0.98	2.38	0.74	0.56	0.97
Works outside	1.04	0.76	1.42	0.77	0.65	0.90
Does not work†	1.00	-	-	1.00	-	-
Media habits						
Watches TV every week	0.98	0.72	1.35	0.90	0.75	1.08
Reads newspaper/magazine every week	1.05	0.67	1.63	1.06	0.82	1.36
Food habits						
Milk or curd daily	0.89	0.66	1.21	1.04	0.89	1.21
Fruits daily	1.24	0.72	2.14	0.87	0.66	1.14
Green, leafy vegetables daily	1.03	0.79	1.34	0.96	0.82	1.12
Eggs at least weekly	1.56	1.12	2.17	0.73	0.60	0.90
Chicken, meat, or fish at least weekly	0.92	0.66	1.29	1.17	0.96	1.42
House type						
Pucca	0.85	0.56	1.29	1.15	0.92	1.43
Semi-*pucca*	0.91	0.67	1.24	1.28	1.08	1.53
Kachha†	1.00	-	-	1.00	-	-
Separate kitchen						
Yes	1.01	0.76	1.34	0.76	0.65	0.90
No	1.00	-	-	1.00	-	-
Crowding						
< 3 persons per room†	1.00	-	-	1.00	-	-
≥ 3 persons per room	0.76	0.58	1.00	0.83	0.71	0.97
Religion						
Hindu†	1.00	-	-	1.00	-	-
Muslim	0.85	0.58	1.26	0.96	0.75	1.23
Other	1.14	0.64	2.00	1.20	0.94	1.53
Caste/tribe						
SC/ST	0.66	0.48	0.91	0.91	0.75	1.11
OBC	0.65	0.47	0.88	0.94	0.79	1.12
Other†	1.00	-	-	1.00	-	-
Standard of living						

Low†	1.00	-	-	1.00	-	-
Medium	1.05	0.77	1.43	0.95	0.79	1.14
High	1.02	0.59	1.78	1.09	0.84	1.43
Residence						
Urban	0.83	0.55	1.25	0.90	0.73	1.11
Rural†	1.00	-	-	1.00	-	-
Region						
North	0.31	0.17	0.56	0.38	0.29	0.51
West	0.80	0.55	1.17	0.97	0.77	1.22
Central	0.51	0.34	0.79	0.59	0.46	0.76
East	0.59	0.40	0.87	0.61	0.48	0.77
Northeast	0.87	0.54	1.41	0.82	0.62	1.09
South†	1.00	-	-	1.00	-	-
Number of women		30816			43402	

† Reference category
LL: Lower Limit; UL: Upper Limit