Spatial Distribution of Various forms of Malnutrition Among Reproductive Age Women in Nepal: A Bayesian Geoadditive Quantile Regression Approach

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Research

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Abstract

Background: Confronting the poor nutritional status of women is a major challenge for a developing country like Nepal. This paper presented a critical analysis of factors associated with malnutrition using a Bayesian ge additive quantile regression approach and assessed spatial variations of malnutrition among Nepalese women.

Methods: Data drawn from the 2016 Nepal Demographic and Health Survey was used to assess the spatial distributions of four forms of malnutrition at the provincial level. Spatial and nonlinear components were estimated using Markov random fields and Bayesian P-splines, respectively.

Results: Analysis of 6,159 reproductive age-group women suggests the existence of severe thinness and underweight in rural and among women residing in provinces 2, 5, and Sudurpashchim. Similarly, the likelihood of being obese was prominently high in urban residents and women in Bagmati, and Gandaki. Richest quintile women, followed by women in richer households, were more likely to be obese and overweight. Consistent findings were reported for underweight (e.g., women from poorer households, and women from households without improved toilet facility). Accessibility of mass media (e.g., newspaper, radio, TV) had inconsistent association with the forms of malnutrition. As women aged, likelihood of being overweight and obese became higher.

Conclusion: Inconsistent distribution of various forms of malnutrition existed across provinces in Nepal, revealing dissimilar influence of other socio-economic variables. Health policy precisely addressing province- and location-specific under- and over-nutrition is, therefore, recommended. Elements of hygiene using mass media could be helpful to reach younger and the most impoverished sect of population.

Background

Nutrition is an essential requirement for the well-being of every individual. Due to physiological needs, nutritional requirements of children and women are unique, and once depleted, nutritional status is hard to be restored. Malnutrition is not only characterized by insufficient energy intake as per caloric needs but also a state of deficiency of vitamins, minerals, and trace elements [1]. Usually, women bear a considerable burden in household errands, including taking care of children. Age-group between 15 to 49 years is the most critical phase, and the nutritional status of women is more likely to be affected while caring for children and other family members. Malnutrition among women does not only impact their health but also on their children. Past studies have suggested that the child born from a malnourished woman is probably undernourished, which continues to repeat over generations [2].

Globally, nearly two billion people are affected by different forms of malnutrition, which accounts for 11% of the global burden of different diseases. In 2018, 462 million adults were underweight, while 1.9 billion were either overweight or obese. The magnitude of malnutrition among women remained between 10% and 40% in most of the LMICs [3]. Studies conducted in South Asian countries identified several factors associated with both women undernutrition and overweight/obesity. A study conducted using Demographic and Health Survey datasets from North Africa, sub-Saharan Africa, Asia, and Latin America found that the urbanization, poverty, households with many children, low levels of education, and work in agricultural farms, are the significant risk factors of different forms of women malnutrition [2].

Socio-demographic factors such as place of residence, literacy, religion, wealth index, sanitation, source of drinking water are also associated with the women's malnutrition [3,4]. Undernutrition risk factors are common among women who consume low dietary intake and experience frequent illnesses (interference with ingestion, absorption, utilization, or excretion of nutrients) [5]. Exposure to a sedentary lifestyle such as eating junk food and lack of physical exercise are some of the risk factors of overweight/obesity [6,7]. Despite continuous investment in women's health, the prevalence of undernutrition, and recently overweight/obesity in the LMICs remain disproportionately high [8–10]. Rapid demographic and socio-economic transitions in the last few decades have contributed to a sharp increase in the trend of overweight and obesity in LMICs [8,11]. Countries in South Asia face a double burden of malnutrition, coexistence of both under-and over-nutrition, and an exponential upsurge of risk factors of non-communicable diseases (NCDs) [12]. Many studies have estimated various forms of malnutrition in women using various statistical methods, either by summary statistics or regression models [13,14]. There are very few studies that accounted for the spatial dependence while estimating prevalence and risk factors of body mass index (BMI). Our study has assessed the determining factors, including a spatial structure, of four forms of malnutrition—severely thin, underweight, overweight, and obesity, in Nepal using a Bayesian ge additive quantile regression method [15,16]. This semiparametric method considers the combined effect of various independent variables, spatial random effects, and nonlinear effects of metrical covariates simultaneously in a single modeling framework. The method considers the regression of covariates on conditional quantiles of a response variable, unlike the traditional methods of regression, which only focuses on modeling the conditional mean. Thus, it also allows extreme ends of the response variables-distribution to vary according to changes in the covariates. Hence, this method is suitable to outline a broad effect of multiple outcomes and can be used to describe the effect of the different types of covariates available [17]. The categories of malnutrition, severe thinness, and obesity, fall into the extreme ends of BMI distribution. Hence, the method may be considered as more appropriate in modeling and analyzing malnutrition through BMI. This study also investigated the spatial patterns of the different categories of malnutrition in women after accounting for the exposure effects of observed variables. The estimates from the spatial effects of malnutrition would be helpful to the government stakeholder or non-government organization to develop policies to minimize different forms of malnutrition and its risk factors in women.

Method

Data source and study participants

Nationally representative Demographic and Health Survey (DHS) dataset of Nepal for the year 2016 was used for this study. The Nepal DHS was conducted with ethical approval from the DHS program (http://www.dhsprogram.com) and the Nepal Health Research Council. The DHS program is a United States Agency for International Development (USAID) funded program authorized to collect data related to the demography, population health, and nutrition using standard DHS Program protocols and materials [18]. Nepal DHS is collected by interviewing ever-married women and men using a stratified sample of
households based on a two-stage cluster design in rural areas and three stages cluster sampling in urban with a response rate of 98%. From 383 primary sampling units (wards), 30 households per cluster were selected with an equal probability systematic selection from the households listing. A total of 11,040 households were interviewed in Nepal DHS. After excluding non-response and missing data for anthropometric measurements, our analysis included a subsample of 6,159 women of reproductive age group. Details of the sampling procedure and methodology for the survey are available in the NDHS country report [19].

**Study outcomes**

The nutritional status of all eligible women with measured BMI was collected. Different quantiles of the measured BMI data were calculated and categorized as severely thin (< 16 kg/m²) with the BMI quantile value 1.65%, underweight (< 18.5 kg/m²) with 16.59%, overweight (> 25 kg/m²) with 0.801 and obese (BMI > 30.00 kg/m²) with 95.95%. The grouping of BMI data into the different categories of malnutrition is based on the WHO definitions. These cut off point has been used to allow the comparison with other studies [20–23].

**Explanatory variables**

Socio-demographic variables included in this study were place of residence (urban/rural), five-scaled household wealth quintiles (poorest/poorer/middle/richer/richest), women's education status categorized as no education, primary, secondary, and higher and women's working status. Household characteristics such as availability of electricity, source of water (protected/unprotected), and toilet facility (improved/unimproved), were also included. Exposures to mass media (whether the woman read any newspapers/magazines, listened to the radio, or watched television at least once a week) were dichotomized into yes and no. Province of women was used as the unit for spatial analysis.

**Statistical method**

We considered a Bayesian geadditive quantile regression model to estimate the effects of explanatory variables on the categories of malnutrition through analysing different quantiles of the BMI data. Let $Y_i$ be the BMI, $X_i$ the continuous covariates, age, $Z_i$ the vector of categorical covariates, and $W_i$ be the spatial covariate, province, corresponding to the individual, the considered model based on these notations is defined as,

$$
Y_i = m(X_i, Z_i) + W_i + e_i
$$

The subscript stands for the quantiles of on 0–1 scale. The terms and denote a smooth non-linear function and a spatial effect, respectively. The term refers to the errors in the model with distribution and are assumed to uncorrelated and defined such that . The notation stands for the vector of regression coefficients related to quantile.

For Bayesian analysis, we chose vague priors on the regression coefficients. We modeled the unknown smooth non-linear function with Bayesian p-splines [24]. Further, we considered a Gaussian Markov random field as prior density to model the spatial covariate [25].

**Statistical analysis**

We employed the Bayesian estimation approach to perform geadditive quantile regression analysis using software tool BayesX and implemented using the R-package, BayesXsrc [16]. As a prerequisite for applying the method, quantiles of BMI were calculated for each type of malnutrition. We computed quantiles as the proportion of women with BMI below the threshold for each category of BMI relating to the forms of malnutrition. We found severe thinness and underweight relating to BMI at its 1.65% and 16.59% quantiles, respectively. On the other hand, overweight and obesity were constructed at 80.15% and 95.95% quantiles of BMI, individually.

**Result**

Out of 6,159 women, 64.56% lived in urban areas. More than one-third of women (34.73%) were illiterate, and only 13.05% had higher-level education. The highest percentage of women belonged to the poorest wealth quintile, and 16.93% of women were from the richest quintile. Approximately 60% of women were currently working. A total of 92.48% had access to improved water sources, and 86.40% used improved sanitation facilities. Out of total women, 90.05% and 28.84% watched television and listened to radio, respectively, while less than seven percent read newspapers (Table 1).
Table 1  
Frequency distribution of selected characteristics of reproductive age-group women (N = 6,159)  

| Variables        | N    | Percent |
|------------------|------|---------|
| **Type of residence** |      |         |
| Urban            | 3976 | 64.56   |
| Rural            | 2183 | 35.44   |
| **Wealth quintile** |      |         |
| Poorest          | 1321 | 21.45   |
| Poorer           | 1266 | 20.56   |
| Middle           | 1271 | 20.64   |
| Richer           | 1258 | 20.43   |
| Richest          | 1043 | 16.93   |
| **Educational level** |      |         |
| No Education     | 2139 | 34.73   |
| Primary          | 985  | 15.99   |
| Secondary        | 2231 | 36.22   |
| Higher           | 804  | 13.05   |
| **Working Status** |      |         |
| No               | 2497 | 40.54   |
| Yes              | 3662 | 59.46   |
| **Water Source** |      |         |
| Protected        | 5696 | 92.48   |
| Unprotected      | 463  | 7.52    |
| **Toilet Facility** |    |         |
| Improved         | 5273 | 86.40   |
| Unimproved       | 830  | 13.60   |
| **Electricity** |      |         |
| No               | 613  | 9.95    |
| yes              | 5546 | 90.05   |
| **Reads Newspaper** |    |         |
| No               | 5773 | 93.73   |
| yes              | 386  | 6.27    |
| **Listens to Radio** |  |         |
| No               | 4383 | 71.16   |
| yes              | 1776 | 28.84   |
| **Watches Television** | |         |
| No               | 3355 | 54.47   |
| yes              | 2804 | 45.53   |

The posterior mean estimates and 95% credible intervals (CI) of linear effects of categorical covariates on the quantiles of BMI relating to the forms of malnutrition are shown in Table 2. It should be noted that a positive effect of covariates on upper quantiles of BMI relates to overweight and obesity positively. On the other hand, a negative effect of explanatory variables on the lower quantiles of BMI reflects positive relationships with severely thin and underweight. Results showed that women residing in urban areas were more likely to be obese; however, the effects on severe thinness, underweight, and overweight were not significant. Women from the richest wealth quintile were less likely to be severely thin and underweight than the women from the poorest households; however, they were significantly more likely to be overweight and obese. A significant association was observed between poor household wealth and undernutrition, reporting a higher likelihood of being severely thin and underweight among women from poorer and middle wealth quintiles. Women from
richer households were more likely to be obese and underweight; however, results are not significant for severely thin and overweight. Mainly, women with primary and secondary education were significantly less likely to be severely thin and underweight, and more likely to be overweight and obese. Those with higher education were significantly less likely to be overweight and obese and more likely to be severely thin. Currently-working women were significantly less likely to be obese; however, the effects of employment on other categories of malnutrition were not significant. Women from households with no access to improved toilet facilities were more likely to be severely thin or underweight and less likely to be overweight and obese.

### Table 2

| Variables           | Severely thin | Underweight | Overweight | Obese    |
|---------------------|---------------|-------------|------------|----------|
|                     | Mean 95% CI   | Mean 95% CI | Mean 95% CI| Mean 95% CI|
| Residence           |               |             |            |          |
| Urban               | -0.03 -0.09, 0.03 | -0.05 -0.14, 0.02 | -0.03 -0.14, 0.07 | 0.15 0.04, 0.26 |
| Wealth Index        |               |             |            |          |
| Poorer              | -0.16 -0.27, -0.06 | -0.34 -0.49, -0.20 | -0.75 -0.94, -0.55 | -0.94 -1.15, -0.72 |
| Middle              | -0.15 -0.27, -0.03 | -0.16 -0.29, -0.03 | -0.49 -0.67, -0.31 | -0.81 -0.99, -0.64 |
| Richer              | 0.03 -0.10, 0.14 | -0.20 -0.35, -0.04 | 0.18 -0.03, 0.38 | 0.69 0.46, 0.93 |
| Richest             | 0.47 0.33, 0.61 | 0.96 0.77, 1.14 | 2.17 1.92, 2.41 | 2.84 2.55, 3.14 |
| Education           |               |             |            |          |
| Primary             | 0.17 0.03, 0.30 | 0.17 0.01, 0.33 | 0.61 0.41, 0.78 | 0.72 0.50, 0.93 |
| Secondary           | 0.31 0.20, 0.42 | 0.36 0.23, 0.49 | 0.35 0.18, 0.51 | 0.45 0.27, 0.64 |
| Higher              | -0.21 -0.36, -0.07 | -0.04 -0.22, 0.14 | -0.38 -0.61, -0.13 | -0.51 -0.76, -0.23 |
| Currently working   |               |             |            |          |
| Yes                 | 0.01 -0.05, 0.08 | 0.00 -0.07, 0.08 | -0.07 -0.17, 0.02 | -0.21 -0.31, -0.10 |
| Water sources       |               |             |            |          |
| Protected           |               |             |            |          |
| Unprotected         | 0.14 0.00, 0.26 | 0.19 0.07, 0.32 | 0.15 -0.04, 0.35 | 0.01 -0.15, 0.18 |
| Toilet facilities   |               |             |            |          |
| Improved            |               |             |            |          |
| Unimproved          | -0.34 -0.48, -0.21 | -0.25 -0.37, -0.14 | -0.43 -0.57, -0.28 | -0.39 -0.56, -0.23 |
| Electricity         |               |             |            |          |
| Yes                 | 0.14 0.01, 0.27 | 0.18 0.04, 0.31 | 0.36 0.19, 0.52 | 0.21 -0.00, 0.41 |
| Mass media newspaper|               |             |            |          |
| Yes                 | -0.11 -0.201, -0.011 | 0.00 -0.18, 0.18 | -0.06 -0.29, 0.16 | -0.44 -0.65, -0.19 |
| Radio               |               |             |            |          |
| Yes                 | 0.16 0.088, 0.225 | 0.09 0.01, 0.18 | -0.07 -0.17, 0.04 | 0.01 -0.11, 0.12 |
| Television          |               |             |            |          |
| Yes                 | 0.13 0.053, 0.194 | 0.20 0.12, 0.28 | 0.14 0.04, 0.25 | -0.01 -0.13, 0.12 |

One the other hand, women from households that used unprotected water sources were significantly less likely to be severely thin or underweight; however, the results are not significant for overweight and obesity. Results suggested that women who read newspapers were protective against obesity, but they were also more likely to be severely thin. However, the effect of reading newspaper was not significant on under- and over-weight. Further, women who listened to the radio and watched television were less likely to be severely thin or underweight. While, these mass media had no significant effect on obesity, watching television has a positive effect on overweight. Availability of electricity in the households had an insignificant effect on obesity, however it was less likely to affect severe thinness and undernutrition, and more likely to influence overweight, significantly.

Figure 1 represents the spatial effects of provinces on four forms of malnutrition. The set of maps in the left-hand side demonstrates the posterior mean estimates of these effects. The right-hand side of the figure is the graphs of 95% credible intervals of the posterior estimates reflecting the significance of their effects on the categories of malnutrition. The black colour on the map shows the provinces with significant negative posterior mean estimates. It reflects positive and negative significant associations of provinces with severely thinness and underweight, and with overweight and obesity, respectively. The case is just reverse for the white colour on the map, whereas the grey colour indicates the non-significance of the spatial effects.
The spatial effects estimates showed that the likelihood of being malnourished varies according to women's geographical locations. Figure 1 depicts that women from provinces Bagmati and Gandaki were less likely to be underweight and/or severely thin but were more likely to be overweight and/or obese. Province 1 was also more likely to be having overweight and/or obese women; however, the individual results were not significant for severe thinness and underweight. Provinces 2 and Sudurpaschim were more likely to be having underweight and/or severely thin women, but the women native to these provinces were less likely overweight and/or obese. The women from province 5 were more likely to be underweight and/or severely thin, and less likely to be overweight; however, the corresponding result for obesity was not significant. Women in Karnali were less likely to be obese; however, the individual results for severe thinness, underweight, and overweight were not significant.

The nonlinear effects of the woman's age for severe thinness, underweight, overweight, and obesity are presented in Fig. 2a–d, respectively, along with posterior means (solid black lines) and 80% and 95% credible intervals (dashed lines). The figures depict that the forms of malnutrition were non-linearly affected by the age covariate. The women below age 30 were more likely to be underweight and/or severely thin than overweight and/or obese, as reflected by the figures. The figures showed a positive effect on overweight and/or obesity as women age beyond 30 years. Figure 2c and d depicted that the likelihood of being overweight or obese increases gradually with every unit increase after age 30, which shows a minimal decline after 45 years. But Fig. 2a and b reflect that the ages above 28 had a negative influence on underweight and/or severely thinness, except that the women of ages around 35–38 were likely to be severely thin.

**Discussion**

This study aimed to examine the spatial distributions of four forms of malnutrition; severely thin, underweight, overweight and obesity, among women of reproductive age-group in Nepal. It explored a complete understanding of covariates' effects on different categories of malnutrition among women using a Bayesian geostatistical quantile regression method. The study used data from a nationally representative survey to assess different forms of malnutrition as per the WHO recommended cut-offs criteria: severely thin (<16 kg/m²) underweight (<18.5 kg/m²), overweight (>25 kg/m²) and obese (>30 kg/m²) [26]. Several earlier studies that investigated underweight and overweight/obesity among adult men and women population in Nepal used the conventional logistic regression analysis [27,28], thus limiting to convey evidence beyond prevalence and associated risk factors of malnutrition. Using a Bayesian geostatistical quantile regression technique this study explored the effects of covariates on different forms of malnutrition associated with different quantiles of BMI [17]. To overcome the limitations of earlier studies, we fitted spatial effects across provinces and nonlinear smoothing effects of women's age to provide a complete picture of malnutrition simultaneously controlling for several covariates under study. Interestingly, our study reported that women in Nepal face a double burden of malnutrition, as suggested by the spatial effects. Based on the analysis of nonlinear effects, an apparent nonlinear relationship was observed between the effects of women's age and under- and over-nutrition.

We included women as our study population, keeping in mind that women in the LMICs are at higher risk of undernutrition. Studies from Nepal [27], and from other south Asian countries, including Bangladesh [22], and Pakistan [29] corroborated a high prevalence of poor nutritional status among women than compared to males. Despite concerted programmatic interventions aiming at improving the nutritional status of women, this has always been a challenge in Nepal. Rural women are more prone to underweight due to several underlying factors such as poverty and inequity that influence dietary patterns, including low dietary diversity and food insecurity [30]. The undernutrition (BMI <18.5 kg/m²) status of women of reproductive ages slightly declined over the past decade. Though the decline is not uniform across the country and ubiquitous inequities exist across provinces [19,31].

Similarly, the spatial effect demonstrated that women from provinces 2, 5, and Sudurpaschim were more likely to be undernourished. Women in Bagmati and Gandaki had a higher likelihood of being overweight and/or obese. These heterogeneous findings across provinces are supported by a study that involved geospatial analyses revealing a higher likelihood of women to be overweight and obese in Bagmati and Gandaki [32]. Notably, these are wealthier provinces and constitute many affluent cities and districts having high Human Development Index. Contrarily, most of the districts in provinces 2 and Sudurpaschim lag behind in achieving targets of health indicators due to the high prevalence of poverty, low education attainment, socio-cultural norms and practices affecting healthcare seeking behaviours, and inequalities in health service utilization [33]. Hence, women in these regions are more vulnerable to nutritional deficiencies due to these factors contributing to higher undernutrition. It infers that women in these provinces need urgent nutrition support programs to intervene in the aggravating situation of undernutrition.

Undernutrition among women is in a declining trend, and overweight and obesity, on the other hand, are rising among urban residents. Our study findings indicated that women from urban areas were more likely to be obese. A study conducted in Nepal using STEPS data revealed a significant association between high BMI among urban residents implying that the nation is amid a double burden of under- and over-nutrition [34]. These are known facts that factors such as rapid urbanization, sedentary lifestyles, consumption of junk food, and high-energy drinks are concurrently contributing to a surge in rates of overweight and obesity in LMICs, and Nepal is not an exception to it. Our estimates are comparable with previous studies from other South Asian nations, which reported a higher prevalence of overweight and obesity in urban areas than in the rural [21,22,35]. The consequences of obesity, followed by its long-term health conditions such as heart disease, hypertension, stroke, and diabetes, would be detrimental to the fragile public health systems in LMICs [36], including in Nepal [37]. It is estimated that developing countries account for 60% of the burden of chronic diseases globally [12]. Undernourished women are at increased risk of common infectious diseases. Adequate nutrition not only prevents malnutrition but also reduce the risk of chronic diseases [38]. Dealing with both under- and over-nutrition in LMICs requires political commitment, a practical integrated approach, and radical reform in policies and programmes.

Our study findings further corroborated that women in wealthier households and women with primary and secondary education were less likely to be severely thin and more likely to be obese compared to the poorest wealth quintile and among women with no education, respectively. Our finding is comparable with the study reporting a positive association between wealth and obesity and between higher-level education and underweight [28]. Better education can be taken as a proxy indicator of having knowledge of nutritious food, which can eventually lead to an optimal health. However, women in wealthier households can afford to purchase varieties of food and have access to buy widely available sugary and energy-rich commercialized foods resulting in over-nutrition [38]. On
the contrary, women in poor socio-economic status have a low opportunity of attaining better education and cannot afford wide-varieties of a nutritious diet and poor access to health services leading to undernutrition. Similarly, currently-working women were less likely to be obese. This evidence is consistent with study findings from Bangladesh that currently-working women had a higher likelihood of being undernourished [39]. Mostly women in Nepal in rural areas work in agriculture and mostly work at home. These women are likely to eat diet lacking nutrition, which makes them at a high risk of being underweight.

Our study included variables of mass media access to women since mass media is a useful and readily available source of information to impart health information on adequate nutrition, and healthy behaviour and lifestyle. Study findings showed that women who listened to the radio and watched television had a lower likelihood of being severely thin and underweight. This finding is in agreement with the study done in Botswana [40], which reported women were less likely to be thin or underweight and had access to mass media. However, the findings concerning access to newspapers were not significant for under- and overweight. It could be due to the inaccessibility of newspapers which are not available in rural areas, while other media sources such as radio and television are readily available than newsprints in the countryside.

As expected, our study showed that unimproved toilet facility was positively associated with undernutrition. It implies that women without improved toilet facilities were more at risk of being severely thin and underweight. A study from Nigeria involving spatial analysis of malnutrition showed similar results, which indicated that women without access to improved toilet facilities suffer from undernutrition [41]. Unimproved toilet facility and unprotective sources of drinking water, mainly in low-income countries, are the primary causes of infectious diseases which contribute to 7% of the total disease burden [42]. A vicious interaction between malnutrition and infection was reported in a study stating that malnutrition aggravates the pathway of infectious disease, which further conduces malnutrition [43].

The output of nonlinear models showed an increased likelihood of being overweight and obese with a surge in every year of age. On the other hand, a tendency of being underweight was low in younger age-group. Although studies from Ethiopia [44], Pakistan [29] and Bangladesh [22] showed a similar observation, our study purports unbiased estimation showing more likelihood of being overweight and obesity in older women. Younger age-group women reported having low BMI in developing countries than compared to the developed countries. These age groups are involved more in physical activity. As age increases, people tend to have a sedentary lifestyle contributing to an increase in mass body composition in the long run. A study conducted among black and white women reported that BMI increased significantly with the increase in age indicating a linear correlation between body fat percentage [45].

Conclusion

In conclusion, the application of Bayesian quantile regression analysis and spatial effects allowed us to study a complete picture of different forms of malnutrition along with its various socio-economic determinants among reproductive-age women in Nepal. The spatial analysis confirmed that there is an urgent need for provincial level intervention of supplementary nutritional programmes for women using mass media, especially in provinces 2, 5, and Sudurpashchim where the likelihood of women being severely thin and underweight is high. The policy in Nepal often neglects the prevention program of overweight and obesity. Our study findings suggest that the strategic intervention of overweight and obesity is eminent with massive preventive health measures focused on urban areas to address the growing burden of non-communicable diseases attributed to overweight and obesity.

List Of Abbreviations

BMI; Body Mass Index, CI; Credible Interval, LMICs; low- and middle-income countries, MCMC; Markov chain Monte Carlo, NCDs; non-communicable diseases, NDHS; Nepal Demographic and Health Survey, USAID; United States Agency for International Development, WHO; World Health Organization

Declarations

Consent for publication

Consent for the use of data and publication of this manuscript was taken from the Measure DHS program website (https://dhsprogram.com/).

Availability of data and materials

All data of the Nepal Demographic and Health Survey are publicly available in the DHS program website and can be retrieved after requesting for a specific study.

Ethics approval and consent to participate

Ethical approval for the 2016 Nepal Demographic and Health Survey was granted by the Nepal Health Research Council, Ramshah Path, Kathmandu, Nepal. As per the protocol, a written consent was obtained from the study participants before interviewing.

Conflicts of interests

The authors declare that they have no competing interests.

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Authors’ Contributions

UG and RV have conceived the concept; RV conducted the statistical analysis; UG drafted the background, results, discussion, and conclusion; RV wrote Methods and thoroughly revised the manuscript; UG and RV critically evaluated the paper and agreed on the final version of the manuscript.

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Figures
Figure 1
Maps of Nepal showing the spatial effects of a) severe thinness and b) its 95% CI; c) underweight and d) its 95% CI; e) overweight and f) its 95% CI; g) obesity and h) its 95% CI
Figure 2

Nonlinear effects of respondent's age for a) severe thinness, b) underweight, c) overweight, and d) obesity