Original Article

Prevalence and factors affecting underweight, overweight and obesity using Asian and World Health Organization cutoffs among adults in Nepal: Analysis of the Demographic and Health Survey 2016

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A B S T R A C T

Objective: There is a little published data on prevalence and determinants of underweight, overweight and obesity among adults in Nepal. This study analysed the cross-sectional Nepal Demographic and Health Survey (NDHS) 2016 to obtain these using the World Health Organization (WHO) and Asian-specific cutoffs of body mass index (BMI).
Methods: The 2016 NDHS used a multistage cluster-sampling design to obtain data on major health indicators in Nepal. The BMI cutoffs for underweight was <18.5 kg/m^2. The BMI cutoffs for overweight/obesity as per the Asian and WHO classifications were $\geq$23, and $\geq$25 kg/m^2, respectively. After reporting the prevalence according to sex and background characteristics, multilevel logistic regression was conducted to estimate odds ratios.
Subjects: This analysis included 12,652 adults (5283 males and 7369 females) with a median age of 40 years (interquartile range [IQR]: 28–54).
Results: The overall median BMI was 21.5 kg/m^2 (IQR:19.3–24.3). The overall prevalence of underweight was 16.7% (15.1% among males and 17.1% among females). The Asian-specific BMI cutoffs found the prevalence of overweight and obesity as 26.4% (27.4% among males and 25.6% among females) and 11.0% (7.7% among males and 13.3% among females), respectively. The WHO-recommended BMI cutoffs found 18.2% people overweight (16.7% among males and 19.3% among females) and 4.3% (2.5% among males and 5.6% among females) people obese. The prevalence and odds of extreme body weight categories (i.e., underweight, overweight and obesity) varied according to age, sex, education level, household wealth status, place, ecological zone and provinces of residence as per both recommended cutoffs. Overall, higher education level and wealth status were positively associated with overweight/obesity and inversely associated with underweight as per both cutoffs.
Conclusion: A large proportion Nepalese adults have either underweight, overweight or obesity, and could be at a greater risk of mortality and morbidity due to these extreme body weight categories. It is essential to address the factors or characteristics that are associated with the higher prevalence and likelihood of these extreme body weight categories to reduce the overall burden of underweight and overweight/obesity in Nepal.

Introduction

Globally, more than one-third of adults have higher than normal body weight (i.e., overweight and obesity) [1,2]. This is one of the leading risk factors for global deaths and disabilities due to various non-communicable diseases including type 2 diabetes, hypertension, cancers, cardiovascular and nephrotic diseases [3–5]. An additional 10% people have lower than normal weight (i.e., underweight) [1,2], which is also a risk factor for increased deaths and disabilities [6,7]. Over the past few decades, although the prevalence of underweight is decreasing, the overall proportion of people with overweight and obesity is increasing in most developing countries due to epidemiologic and demographic transitions in these countries [8]. Most developing countries are also facing 'double' or 'twin' nutrition burden with a concomitant increased prevalence of both under and over-nutrition due to the transitions

mentioned above [8,9]. Another major concern about developing countries is that there is a lack of recent data about the prevalence or determinants of different body weight categories [2,9].

The Nepal Demographic and Health Survey 2016 (2016 NDHS) is one of the few recent surveys conducted in a developing country that included body mass index (BMI) as a component for both males and females [10]. The BMI is the ratio of weight (in kilograms) and height squared (in metres), commonly expressed as kg/m^2, and has widely been used to categorise body weight [11]. Nepal is a South Asian developing country with an estimated population of 29 million and a land mass of 143,351 square-kilometres [10,12]. This country has seven administrative provinces (Provinces 1–7) [10]. Nepal is also dealing with the double nutrition burden, and recent estimates show that the proportion of overweight/obese people is increasing [10,13]. However, similar to other developing countries, there is a lack of recent nationally representative data that estimates the prevalence and associated factors for underweight, overweight and obesity or reports their prevalence in relation to sociodemographic characteristics [13–16].

Furthermore, there have been several proposed cutoffs to classify obesity and overweight [11]. Based on using a cutoff, the prevalence could substantially differ [11,17]. For instance, the World Health Organization (WHO) recommends BMI 25–29.9 and $\geq 30 \, kg/m^2$ as overweight and obesity, respectively. On the other hand, based on cardiovascular and type 2 diabetes risks among Asian population, the cutoff has been set to 23–27.4 kg/m^2 for overweight and $\geq 27.5 \, kg/m^2$ for obesity by another panel of experts [11]. The revised recommendation did not set any new cutoff for the underweight range (Supplemental Table 1), <18.5 kg/m^2. However, considering the significance of using universal cutoffs and variations among different ethnic groups in Asian nations, the WHO recommends using their cutoffs to define overweight and obesity [18]. In addition, the WHO recommends reporting the prevalence on a broad range of BMI categories so that the overall prevalence could be estimated from the broad BMI groups [11,18]. Besides this, the majority of the recent studies have estimated prevalence or determinants of overweight/obesity in Asian countries using the classification with the lower cutoff [19–23].

Taking into account the importance of international recommendations, significance of nutrition status, and growing relevance of the Asian cutoffs given the specific high mortality risk among the Asian people with a BMI lower than the international overweight/obesity cutoff, it is crucial to estimate the prevalence of underweight, overweight and obesity in Nepal using both cutoffs [11,18–23]. Since the prevalence of different body weight categories is different in females compared to their male counterparts, it requires separate estimation for both sexes [1,2]. Lastly, as the prevalence or likelihood varies according to characteristics of a person such as age, wealth status or place of residence, estimating the prevalence or associated factors for extreme body weights is also important [16,19,22]. This study estimates the prevalence of three extreme body weight categories (i.e., underweight, overweight and obesity) as per both Asian and WHO cutoffs among adults in Nepal from the nationally representative 2016 NDHS dataset. Additionally, it investigates the associated factors of 'underweight' and 'overweight/obesity' using these two cutoffs.

Methods

Data source

The 2016 NDHS was a cross-sectional survey. It was the fifth DHS in Nepal implemented as a part of the worldwide DHS program. New Era, a private research organisation in Nepal, conducted it from June 2016 to January 2017. The primary objective of this survey was to provide nationally representative, updated and reliable estimates of health indicators. The survey protocol was approved by the Nepal Health Research Council and ICF International's institutional review board [10]. ICF international provided electronic approval to use this dataset in June 2018.

The sampling frame was obtained from an updated version of the 2011 Population and Housing Census. The 2016 NDHS used two-stage and three-stage cluster sampling designs in rural and urban areas, respectively. The primary sampling unit or cluster was a ward in both rural (n = 199) and urban (n = 184) regions. In rural regions, the households were selected from wards. In urban regions, one enumeration area (EA) was selected randomly from each ward; that EA was considered as a cluster. Then, households were selected from an EA. Each EA (i.e., cluster) aimed to obtain thirty households. The expected number of households was 11,490. All men and women residing in one-third of these households with an age of ≥15 years were eligible for measurement of blood pressure [10].

Similar to earlier DHS, the 2016 NDHS had a high response rate, approximately 96%. The survey teams made tremendous efforts to improve survey participation through multiple visits. If a respondent was absent within the household on the first visit, then the next visits were conducted at a time when the respondents were more likely to be present [24]. On behalf of the participants, the head of each household provided written informed consent. Furthermore, although the 2016 NDHS reported the BMI for 15–49 years age group, the present estimation was not limited into that age group to have an overall estimation across all adults age groups. Since all men and women eligible for blood pressure measurement were also eligible for BMI measurement, a secondary analysis was conducted among them considering the large sample size [10]. Among interviewed persons, the current analysis was restricted among individuals aged ≥20 years, as there has been a different indication for measurement of BMI for <20 years age group [11]. A total of 5283 males and 7369 females from that age group (i.e., ≥20 years) participated in the survey. The details of the 2016 NDHS including survey design, methodologies, sample size calculation, and findings have been reported elsewhere [10].

Measurements

The height of each respondent was measured in centimetres using a calibrated measuring board. The weight was measured with a calibrated SECA scale. Both measurements were rounded to the nearest tenth decimal point. Participants reported their age, sex, education level, place (i.e., rural or urban), ecological zone, and the province of residence. The 2016 NDHS employed principal component analysis of the primary household construction materials and household elements to obtain the household wealth status; then, the status was stratified into quintiles [10].

Statistical analysis

First, descriptive analysis was done to report background characteristics of the respondents by their 'underweight' and 'combined overweight & obese' status according to both cutoffs as well as the overall survey population. Continuous variables were described with median and interquartile ranges (IQR). Categorical variables were reported with numbers and percentages. The prevalence of BMI categories using the WHO-recommended categories was estimated separately for males and females in addition to the overall prevalence [18]. Then, the overall prevalence of underweight, overweight and obesity was reported as per background characteristics; these variables were selected based on published reports and data structure of the 2016 NDHS. At last, multilevel logistic regression analysis was conducted to obtain the odds ratios (OR) for the association of 'underweight' and 'combined overweight & obese' with

Table 1
Background characteristics of the survey participants, 2016 Nepal Demographic and Health Survey 2016.[a]

Characteristics	All participants (N = 12,652)	Underweight (N = 2113)	Overweight/obese[b] Asian (N = 4725)	WHO (N = 2851)
BMI, median (IQR)	21.5 (19.3–24.3)	17.4 (16.5–18.0)	25.6 (24.1–27.8)	27.3 (26.0–29.2)
Age, year				
Median (IQR)	40 (28–54)	48 (29–63)	39 (30–51)	48 (29–63)
20–29	3487 (27.6)	553 (26.2)	1065 (22.5)	558 (19.6)
30–39	2874 (22.7)	288 (13.6)	1367 (28.9)	893 (31.3)
40–49	2158 (17.0)	240 (11.4)	1004 (21.3)	644 (22.6)
50–64	2643 (20.9)	536 (25.4)	940 (19.9)	576 (20.2)
≥65	1490 (11.8)	496 (23.5)	349 (7.4)	180 (6.3)
Sex				
Male	5283 (41.8)	796 (37.6)	1856 (39.3)	1018 (35.7)
Female	7369 (58.2)	1317 (62.4)	2869 (60.7)	1833 (64.3)
Education				
No formal education	5548 (43.9)	1336 (63.2)	1582 (33.5)	889 (31.2)
Primary	2191 (17.3)	305 (14.4)	874 (18.5)	520 (18.2)
Secondary	3190 (25.2)	324 (15.3)	1458 (30.8)	927 (32.5)
College or above	1718 (13.6)	147 (7.0)	811 (17.2)	515 (18.1)
Household wealth status				
Poorest	2297 (18.1)	481 (22.8)	464 (9.8)	186 (6.5)
Poorer	2479 (19.6)	557 (26.4)	692 (14.6)	364 (12.8)
Middle	2489 (19.7)	520 (24.6)	772 (16.3)	391 (13.7)
Richer	2736 (21.6)	414 (19.6)	1102 (23.3)	674 (23.6)
Richest	2651 (21.0)	141 (6.6)	1695 (35.9)	1236 (43.4)
Place of residence				
Urban	7691 (60.8)	1089 (51.5)	3296 (69.8)	2115 (74.2)
Rural	4961 (39.2)	1024 (48.5)	1429 (30.2)	736 (25.8)
Ecological zone				
Mountain	845 (6.7)	138 (6.5)	243 (5.1)	140 (4.9)
Hill	5516 (43.6)	635 (30.1)	2329 (49.3)	1459 (51.2)
Terai	6291 (49.7)	1340 (63.4)	2153 (45.6)	1252 (43.9)
Province				
1	2227 (17.6)	310 (14.7)	876 (18.6)	549 (19.2)
2	2601 (20.6)	733 (34.7)	684 (14.5)	351 (12.3)
3	2736 (21.6)	245 (11.6)	1399 (29.7)	933 (32.7)
4	1299 (10.3)	120 (5.7)	623 (13.2)	395 (13.9)
5	2076 (16.4)	344 (16.3)	762 (16.0)	442 (15.5)
6	661 (5.2)	126 (6.0)	141 (3.0)	66 (2.3)
7	1052 (8.3)	235 (11.1)	240 (5.0)	115 (4.0)

BMI: body mass index in kg/m², WHO: World Health Organization.

[a] Column percentage.

[b] Asian and WHO cutoffs to categorise overweight/obesity are BMI ≥23 and ≥25 kg/m², respectively.

selected factors using normal BMI range as the reference category for both cutoffs. Variables with a predetermined significance level of <0.2 in crude analysis were incorporated into the multivariable models. Variance inflation factors were obtained with a fake linear regression model to estimate multicollinearity among study variables.

The cluster sampling design of the 2016 NDHS was accounted to estimate all weighted prevalence and determinants. The 95% confidence intervals (CI) were reported with prevalence and OR. Stata 14.0 (College Station, Texas, USA) was used to analyse data.

Results

Table 1 describes the study sample. Of the total 12,652 survey participants, 2113 were underweight, 4725 and 2851 were 'overweight/obese' according to Asian and WHO recommendations, respectively. Nearly one-third of the participants were ≥50 years old, 32.7% (n = 4133), as were almost half of the underweight participants, 48.9% (n = 1022). About 58.2% (n = 7369), 62.4% (n = 1317), 60.7% (n = 2869), and 64.3% (n = 1833) of the overall population, underweight and overweight/obese as per the Asian and WHO cutoffs were females, respectively. About two-thirds of underweight

respondents had no formal education, 63.2% (n = 1336). Nearly half of the overweight/obese using both cutoffs had a secondary or higher level of education; a similar pattern was observed for wealth quintile groups. The proportion of rural residents was higher among underweight people compared to overweight/obese classified by both Asian and WHO cutoffs, 48.5% (n = 1024), 30.2% (n = 1429) and 25.8% (n = 736), respectively. Nearly half of the respondents were from Terai region, 49.7% (n = 6291); this region had the highest proportion of underweight people, 63.4% (n = 1340). More than one-third of the underweight respondents were from Province 2, 34.7% (n = 733).

Table 2 reports the prevalence of BMI sub-groups among males and females. Females had a greater prevalence of both below normal (i.e., <18.5 kg/m²) and above normal (i.e., ≥25.0 kg/m²) BMI based on the WHO-recommended classifications compared to males. The overall prevalence of underweight was 16.7%; 17.9% for females and 15.1% for males. The prevalence of BMI in the normal range (i.e., 18.5–22.99 kg/m²) as per the Asian cutoff was 46.0% (95% CI: 45.1–46.8). This prevalence was 50.8% as per the WHO cutoff (i.e., 18.5–24.99 kg/m²). The overall prevalence of overweight was about 26.3% and 18.2% using the Asian (i.e., 23–27.49 kg/m²) and WHO (i.e., 25–29.99 kg/m²) cutoffs, respectively. With the Asian

Table 2
Prevalence (with 95% confidence interval) of BMI categories among adult men and women, Nepal Demographic and Health Survey 2016.

BMI cut-off points	Men	Women	Overall
<16.00	2.1 (1.7–2.5)	3.5 (3.1–4.0)	2.9 (2.6–3.2)
16.00–16.99	2.9 (2.5–3.4)	3.9 (3.5–4.4)	3.5 (3.2–3.8)
17.00–18.49	10.1 (9.3–10.9)	10.5 (9.8–11.2)	10.3 (9.8–10.9)
18.50–22.99	49.8 (48.5–51.2)	43.2 (42.0–44.3)	46.0 (45.1–46.8)
23.00–24.99[a]	15.9 (14.9–16.9)	14.1 (13.3–14.9)	14.8 (14.2–15.4)
25.00–27.49[b]	11.5 (10.7–12.4)	11.6 (10.9–12.3)	11.5 (11.0–12.1)
27.50–29.99[a]	5.2 (4.6–5.8)	7.7 (7.1–8.3)	6.7 (6.2–7.1)
30.00–32.49[b]	1.9 (1.6–2.3)	3.4 (3.0–3.8)	2.8 (2.5–3.1)
32.50–34.99	0.1 (0.0–0.7)	1.5 (1.3–1.8)	1.1 (0.9–1.3)
35.00–37.49	0.1 (0.0–0.7)	0.5 (0.3–0.7)	0.3 (0.2–0.4)
37.50–39.99	0.1 (0.0–0.2)	0.1 (0.1–0.2)	0.1 (0.0–0.2)
≥40.00	0.1 (0.0–0.1)	0.1 (0.0–0.2)	0.1 (0.0–0.1)

BMI: body mass index in kg/m^2, IQR: Inter-quartile range.
[a] Asian cutoffs for overweight and obesity start from these ranges, respectively.
[b] World Health Organization cutoffs for overweight and obesity start from these ranges, respectively. Both cutoffs define underweight as <18.5 kg/m^2.

cutoff (i.e., ≥27.5 kg/m^2), the overall prevalence of obesity was 11.0%. Only 4.4% of people were obese as per the WHO recommended cutoff (i.e., BMI ≥30 kg/m^2); 2.3% for males and 5.6% for females. Fig. 1 summarises the overall prevalence among both sexes.

In Table 3, the overall prevalence according to background characteristics has been summarised. The prevalence of underweight was highest among people ≥65 years of age, followed by 50–64, 40–49, 20–29, and 30–39 years age groups; 33.3% (95% CI: 30.9–35.7), 20.3% (95% CI: 18.8–21.8), 11.1% (95% CI: 9.9–12.5), 15.9% (95% CI: 14.7–17.1), and 10.0% (95% CI: 9.0–11.2), respectively. In contrast, the prevalence of overweight and obesity was greater among age groups below 65 years for both cutoffs. Males had a higher prevalence of overweight than their female counterparts only using the Asian cutoff, 27.4% (95% CI: 26.2–28.6) and 25.6% (95% CI: 24.6–26.6), respectively; however, females had increased prevalence in all four other weight categories. The prevalence of body weight categories also differed with education and wealth status where people with higher wealth status and education levels had a greater prevalence of overweight and obesity classified by both cutoffs. Approximately 20.6% (95% CI: 19.5–21.8) of rural people were underweight; this prevalence was 14.1% (95% CI: 13.4–15.0) in urban regions. The prevalence of underweight in Terai region was 21.3% (95% CI: 20.3–22.3), the highest among all three ecological zones. Hill regions had a greater prevalence of overweight and obesity according to both cutoffs compared to other two regions. About one-third people were overweight in Provinces 3 and 4 based on the Asian cutoff, 32.5% (95% CI: 30.7–34.2) and 32.7% (95% CI: 30.2–35.4), respectively. About one-fourth of them had overweight according to the WHO cutoff. The prevalence of obesity was also higher in these two provinces by both cutoffs.

Table 4 shows the stratified determinants of underweight and overweight/obesity according to two BMI classifications. As per both cutoffs, age groups ≥50 years had positive associations with underweight while age groups between 30–49 years had inverse associations with it. All age groups ≥30 years were associated with increased likelihood of overweight/obesity. Females had higher odds of both underweight (adjusted OR (AOR): 1.4; 95% CI: 1.2–1.6, and AOR: 1.3; 95% CI: 1.2–1.5 for Asian and WHO cutoffs, respectively) and overweight/obesity (AOR: 1.5; 95% CI: 1.4–1.7, and AOR: 1.8; 95% CI: 1.6–2.0 for Asian and WHO cutoffs, respectively) compared to males. Although education level did not show any consistent pattern for underweight, educated people had increased odds of overweight/obesity compared to people with no formal education. Richer wealth quintiles showed inverse relationships with underweight and positive relationships with

overweight/obesity by both cutoffs. As prevalence, residence in some provinces also had significant associations with both underweight and overweight/obesity classified by two cutoffs.

Discussion

This study estimated the prevalence of underweight, overweight, and obesity among Nepalese adults using two recommended cutoffs to categorise them. Additionally, it reported the prevalence on a wide range of BMI groups for both sexes. The prevalence and odds of association differed according to age, sex, education level, wealth status, place, ecological zone, and province of residence as per both cutoffs.

The overall prevalence of underweight in this study was 16.7%; although this prevalence was higher than the global prevalence, it is comparable to the prevalence in South Asia [1,2]. Furthermore, the prevalence of overweight and obesity using the Asian cutoffs was 26.3% and 11.0%, respectively. On the other hand, the WHO cutoffs found 18.2% people as overweight and 4.4% people as obese; 22.6% combined, lower than the overall global prevalence [1,2]. Currently, the WHO has a target to halt the BMI rise from its 2010 level [25]; the Nepal government or the WHO could take 22.6% as the baseline value considering the lack of recent data about the overall prevalence of overweight and obesity in Nepal. Overall, the prevalence of people who were either above or below the normal range was 54.0% and 35.3% as per the Asian and WHO cutoffs, respectively. Considering the higher risk of adverse events such as hypertension, diabetes and other chronic diseases among Asian people who do not have a healthy BMI as per the Asian cutoffs range (i.e., <18.5 and ≥23 kg/m^2), more than half of the adults in Nepal could be at increased risks of disability and death associated with having an abnormal BMI [11].

The prevalence of underweight, overweight, and obesity observed by this study is also in agreement with other studies conducted in Nepal [13,15,16] and other South Asian countries with comparable sociodemographic characteristics [19,22]. However, a majority of prior studies had a narrow age range or was conducted only among a specific sociodemographic group; the present study incorporated a wide range of sociodemographic groups. Similar research in other countries estimating the prevalence of different body weight categories could be helpful for estimating the overall global burden and developing country-specific strategies. As stated previously, due to globalisation, epidemiologic and demographic transitions, the prevalence of overweight and obesity are expected to rise in most developing countries [1,2]. To reduce or halt the overall prevalence, each country needs to set its own strategy due to unique sociodemographic conditions within each country. It is essential to prioritise the characteristics that have higher prevalence or likelihood of overweight/obesity with an aim to halt the rising of overweight and obesity from the current levels [25].

Consistent with earlier studies, females had higher prevalence and odds of both underweight and overweight/obesity compared to their male counterparts according to both cutoffs. Females BMI is usually more skewed than men [26]. Excess body weight among females could be due to the difference in fat mass. Accumulation of body fat could occur due to hormonal changes in menopause [26,27]. Furthermore, lower body weight could result from undernourishment at a younger age or due to socioeconomic condition of the family [28]; this might be a significant risk factor for adverse perinatal outcomes including the high perinatal mortality rate in Nepal [10]. The increased prevalence and likelihood of overweight/obesity among females could be associated with other non-communicable diseases including diabetes and hypertension [29,30]. Although there are many ongoing nutritional interventions
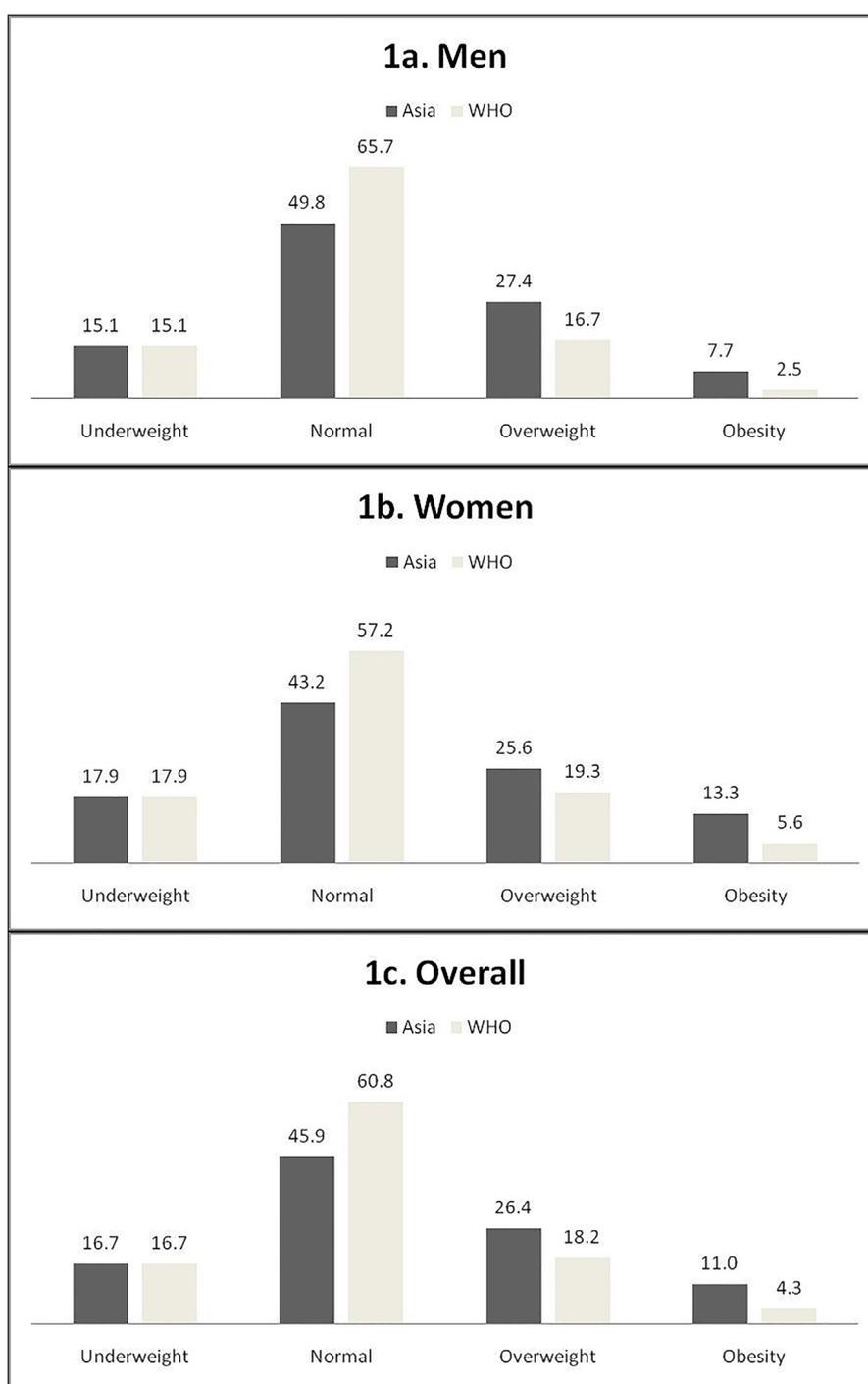
1a. Men

■ Asia □ WHO

1b. Women

■ Asia □ WHO

1c. Overall

■ Asia □ WHO

Fig. 1. Prevalence (%) of body weight categories among men and women according to cutoffs.

programs to improve nutritional status of women in Nepal, the higher prevalence of all abnormal body weight categories among women indicate that that these programs are insufficient to reduce the burden of these abnormal weight categories [31]. Addressing underweight or overweight of females is essential not only for reducing burden of noncommunicable diseases but also to reduce the burden of adverse maternal and child health events in Nepal.

Older people had higher prevalence and likelihood of underweight as per both cutoffs; this could be due to the reduction in muscle mass with increasing age among older people [32,33].

Age is one of the known determinants of body weight [16,19,20]. This finding is also consistent with previous studies in Nepal and other countries [13,15,19]. Although both underweight and overweight/obesity have increased risks of disability and death, overweight is better than underweight for older adults considering the mortality risks [34,35]. Despite a higher prevalence of underweight among elderly people, there have been limited nutritional interventions targeting this high-risk group [36]. Moreover, due to ongoing demographic transitions, the proportion of elderly people is expected to increase in most LMICs including Nepal [37]. It is vital to design and implement interventions specifically to address

Table 3
Prevalence (with 95% CI) of underweight, overweight and obesity among adults according to background characteristics, Nepal Demographic and Health Survey 2016.

Characteristics	Underweight[a]	Overweight		Obese	
		Asian[b]	WHO[c]	Asian[b]	WHO[c]
Age, year					
20–29	15.9 (14.7–17.1)	23.8 (22.4–25.3)	13.9 (12.8–15.0)	6.7 (6.0–7.7)	2.1 (1.7–2.7)
30–39	10.0 (9.0–11.2)	32.3 (30.6–34.0)	24.8 (23.2–26.4)	15.3 (14.0–16.6)	6.3 (5.4–7.2)
40–49	11.1 (9.9–12.5)	30.2 (28.3–32.2)	22.5 (20.8–24.3)	16.3 (14.8–17.9)	7.4 (6.4–8.6)
50–64	20.3 (18.8–21.8)	25.0 (23.4–26.7)	17.9 (16.5–19.4)	10.6 (9.5–11.8)	3.9 (3.2–4.7)
≥65	33.3 (30.9–35.7)	17.8 (15.9–19.8)	10.1 (8.8–11.9)	5.6 (4.6–6.9)	1.8 (1.3–2.7)
Sex					
Male	15.0 (14.1–16.0)	27.4 (26.2–28.6)	16.7 (15.8–17.8)	7.7 (7.0–8.5)	2.5 (2.1–3.0))
Female	17.9 (17.0–18.8)	25.6 (24.6–26.6)	19.3 (18.4–20.2)	13.5 (12.5–14.1)	5.6 (5.1–6.1)
Education					
No formal education	24.1 (23.0–25.2)	20.6 (19.5–21.7)	12.9 (12.1–13.8)	7.9 (7.2–8.7)	3.1 (2.7–3.6)
Primary	13.9 (12.5–15.4)	28.1 (26.3–30.0)	19.0 (17.5–20.8)	11.8 (10.5–13.2)	4.7 (3.9–5.6)
Secondary	10.1 (9.1–11.2)	32.0 (30.4–33.6)	23.4 (21.9–24.9)	13.7 (12.5–14.9)	5.7 (4.9–6.5)
College or above	8.5 (7.3–10.0)	32.4 (30.2–34.6)	24.7 (22.7–26.8)	14.8 (13.2–16.5)	5.2 (4.3–6.4)
Household wealth status					
Poorest	20.9 (19.3–22.7)	17.7 (16.2–19.3)	7.5 (6.5–8.7)	2.5 (2.0–3.2)	0.6 (0.3–1.0)
Poorer	22.5 (20.9–24.2)	22.2 (20.6–23.9)	12.9 (11.6–14.2)	5.7 (4.8–6.7)	1.8 (1.4–2.5)
Middle	20.9 (19.3–22.5)	24.2 (22.5–25.9)	13.5 (12.2–14.9)	6.8 (5.9–7.9)	2.2 (1.7–2.8)
Richer	15.1 (13.9–16.5)	29.1 (27.4–30.8)	20.6 (19.1–22.1)	11.2 (10.1–12.4)	4.1 (3.4–4.9)
Richest	5.3 (4.5–6.2)	37.0 (35.2–38.8)	34.5 (32.7–36.4)	26.9 (25.3–28.7)	12.1 (10.9–13.4)
Place of residence					
Urban	14.1 (13.4–15.0)	28.5 (27.5–29.5)	21.7 (20.8–22.7)	14.3 (13.6–15.1)	5.8 (5.3–6.3)
Rural	20.6 (19.5–21.8)	23.1 (21.9–24.3)	12.8 (11.9–13.7)	5.7 (5.1–6.4)	2.1 (1.7–2.5)
Ecological zone					
Mountain	16.3 (13.9–18.9)	21.9 (19.3–24.9)	13.7 (11.5–16.2)	6.8 (5.3–8.7)	2.9 (1.9–4.3)
Hill	11.5 (10.7–12.4)	28.6 (27.5–29.8)	20.6 (19.5–21.7)	13.6 (12.7–14.5)	5.8 (5.3–6.5)
Terai	21.3 (20.3–22.3)	25.0 (23.9–26.1)	16.7 (15.8–17.7)	9.2 (8.5–10.0)	3.2 (2.8–3.6)
Province					
1	13.9 (12.5–15.4)	27.8 (25.9–29.6)	20.0 (18.4–21.7)	11.6 (10.3–13.0)	4.6 (3.8–5.6)
2	28.2 (26.5–29.9)	20.4(18.9–22.0)	11.9 (10.7–13.2)	5.9 (5.0–6.8)	1.6 (1.2–2.2)
3	9.0 (7.9–10.1)	32.5 (30.7–34.2)	25.8 (24.2–27.5)	18.7 (17.3–20.2)	8.2 (7.3–9.3)
4	9.2 (7.8–10.9)	32.7 (30.2–35.4)	24.0 (21.8–26.4)	15.2 (13.4–17.3)	6.4 (5.2–7.9)
5	16.5 (15.0–18.1)	27.1 (25.2–29.0)	18.2 (16.6–20.0)	9.6 (8.4–11.0)	3.0 (2.4–3.9)
6	19.0 (16.3–22.2)	17.4 (14.7–20.5)	8.5 (6.6–10.9)	4.0 (2.7–5.7)	1.5 (0.8–2.7)
7	22.5 (20.1–25.1)	18.7 (16.4–21.2)	9.2 (7.6–11.1)	4.1 (3.0–5.5)	1.7 (1.1–2.7)

CI: confidence interval; BMI: body mass index in kg/m^2, WHO: World Health Organization.

[a] Both Asian and World Health Organization cutoff to categorise underweight is BMI <18.5 kg/m^2.

[b] Asian cutoffs to categorise overweight and obesity are BMI ≥23 and ≥27.5 kg/m^2, respectively.

[c] World Health Organization cutoffs to categorise overweight and obesity are BMI ≥25 and ≥30 kg/m^2, respectively.

nutritional issues of elderly people to reduce their risk of mortality and morbidity.

Higher education level or wealth quintiles also had positive association with overweight/obesity as per both cutoffs; a finding that is consistent with earlier studies [13,16,19,21,23]. Associations of these two socioeconomic status (SES) related variables with body weight are consistent with the factors associated with risk of noncommunicable diseases [29,30,38]. In developing countries, people with higher socioeconomic status mostly follow sedentary lifestyles and consume more calorigenic foods that could result in higher body weight [16,39,40]. However, people from lower SES also have higher prevalence and odds of underweight in this study. People with higher SES need to increase physical activity level and reduce consumption of less calorigenic foods to maintain ideal body weight. Furthermore, people with lower SES need adequate intake of nutritious foods to maintain ideal body weight.

Among the ecological zones, Terai region had the highest prevalence of underweight while Hill region had the highest prevalence of overweight/obesity using both cutoffs. The prevalence and odds of weight categories also differed according to province and place of residence. Differences in SES, population structure, lifestyle and dietary habits between regions such as place, ecological zone or provinces of residence could be responsible for the differences in prevalence and likelihood of BMI categories between these regions as per both cutoffs [10,16]. For instance, the SES of urban people is usually higher than rural people. Urban people in LMICs also do less labour-intensive works compared to rural people. The overall SES of people in Hill region is relatively higher than other two regions. Moreover, among the seven administrative provinces, Province 3 had the lowest prevalence of underweight and highest prevalence of overweight/obesity. Kathmandu, the largest city (and capital city) of the country, is located in this province; the higher prevalence may result from the higher SES of the people in this province [10]. It is essential to formulate different intervention plans by prioritising the regions that have increased prevalence or odds of underweight and overweight/obesity to reduce the prevalence of both extreme body weight categories.

The present study has several notable strengths. First, it estimated the prevalence on a wide age range among both sexes from a survey that covered all ecological regions and provinces. Using standardised survey methods, validated data collection instruments, calibrated measuring devices, and highly trained staff increased the authenticity of the results. The response rate of the survey was also high. To the best of this researcher's knowledge, this is the first epidemiological study that investigates the overall

Table 4
Results of logistic regression analyses to investigate factors associated with underweight and overweight/obesity among adults, Nepal Demographic and Health Survey 2016.

Characteristics	Underweight vs normal weight				Overweight/obesity vs normal weight[a]			
	Asian cutoff		WHO cutoff		Asian cutoff		WHO cutoff	
	COR (95% CI)	AOR (95% CI)[b]	COR (95% CI)	AOR (95% CI)[b]	COR (95% CI)	AOR (95% CI)[b]	COR (95% CI)	AOR (95% CI)[b]
Age, year								
20–29	Ref.	Ref.	Ref	Ref.	Ref.	Ref.	Ref	Ref.
30–39	0.8*** (0.6, 0.9)	0.7*** (0.6, 0.8)	0.7*** (0.6,0.8)	0.6*** (0.5,0.8)	2.0*** (1.8,2.3)	2.2*** (1.9,2.5)	2.4*** (2.1,2.7)	2.5*** (2.2,2.9)
40–49	0.9 (0.7, 1.1)[1]	0.8* (0.7, 1.0)	0.8* (0.7,1.0)	0.7*** (0.6,0.9)	2.0*** (1.8,2.3)	2.4*** (2.1,2.7)	2.4*** (2.0,2.7)	2.8*** (2.4,3.3)
50–64	1.6*** (1.4, 1.9)	1.5*** (1.2, 1.8)	1.6*** (1.3,1.8)	1.4*** (1.2,1.6)	1.5*** (1.3,1.7)	2.0*** (1.7,2.3)	1.8*** (1.5,2.1)	2.4*** (2.0,2.8)
≥65	2.9*** (2.4, 3.4)	2.7*** (2.2, 3.2)	2.9*** (2.5,3.4)	2.6*** (2.2,3.1)	0.9 (0.8,1.1)	1.3** (1.1,1.6)	1.0 (0.8,1.2)	1.5*** (1.2,1.9)
Sex								
Male	Ref.	Ref.	Ref	Ref.	Ref.	Ref.	Ref.	Ref.
Female	1.3*** (1.2, 1.5)	1.4*** (1.2, 1.6)	1.3*** (1.2,1.5)	1.3*** (1.2,1.5)	1.3*** (1.2,1.4)	1.5*** (1.4,1.7)	1.5*** (1.3,1.6)	1.8*** (1.6,2.0)
Education								
No education	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Primary	0.6*** (0.5, 0.7)	0.9 (0.8, 1.1)	0.6*** (0.5,0.7)	0.9 (0.7,1.0)	1.3*** (1.2,1.5)	1.5*** (1.3,1.7)	1.3*** (1.1,1.4)	1.5*** (1.3,1.7)
Secondary	0.5*** (0.4, 06)	0.8* (0.7, 1.0)	0.5*** (0.4,0.5)	0.8** (0.7,0.9)	1.4*** (1.2,1.5)	1.6*** (1.4,1.8)	1.4*** (1.2,1.5)	1.6*** (1.4,1.9)
College or above	0.4*** (0.3, 0.5)	0.9 (0.7,1.1)	0.4*** (0.3,0.5)	0.9 (0.7,1.1)	1.2* (1.0,1.4)	1.3** (1.1,1.5)	1.1 (0.9,1.3)	1.3** (1.1,1.6)
Household wealth status								
Poorest	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Poorer	1.0 (0.9, 1.2)	1.0 (0.8, 1.1)	1.0 (0.8,1.1)	0.9 (0.8,1.1)	1.6*** (1.4,1.9)	1.6*** (1.4,1.8)	2.2*** (1.8,2.7)	2.1*** (1.7,2.6)
Middle	0.9 (0.8, 1.1)	0.8* (0.7, 0.9)	0.8** (0.7,0.9)	0.7*** (0.6,0.8)	2.1*** (1.8,2.4)	2.1*** (1.8,2.4)	2.5*** (2.0,3.1)	2.5*** (2.0,3.1)
Richer	0.7** (0.6, 0.9)	0.6*** (0.5, 0.8)	0.6*** (0.5,0.7)	0.6*** (0.5,0.7)	2.9*** (2.5,3.4)	2.8*** (2.4,3.4)	4.1*** (3.4,5.0)	4.1*** (3.3,5.0)
Richest	0.4*** (0.3, 0.5)	0.4*** (0.3,0.6)	0.3*** (0.2,0.4)	0.3*** (0.3,0.4)	6.2*** (5.2,7.3)	5.5*** (4.6,6.6)	8.6*** (7.0,10.5)	7.8*** (6.2,9.8)
Place of residence								
Urban	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Rural	1.2* (1.0, 1.4)	1.0 (0.9, 1.2)	1.3** (1.1,1.5)	1.0 (0.9,1.2)	0.6*** (0.5,0.7)	0.9 (0.8,1.1)	0.5*** (0.4,0.6)	0.9 (0.8,1.0)
Ecological zone								
Mountain	1.2 (1.0, 1.6)[1]	1.0 (0.8, 1.3)	1.4* (1.0,1.8)	1.0 (0.8,1.4)	0.5*** (0.4,0.7)	1.0 (0.8,1.2)	0.5*** (0.3,0.8)	1.0 (0.8,1.4)
Hill	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Terai	1.6 (1.4, 1.8)	1.5*** (1.3,1.9)	1.6*** (1.4,1.9)	1.6*** (1.3,1.9)	1.0 (0.8,1.2)	0.9 (0.8,1.1)	1.0 (0.8,1.2)	0.8* (0.7,1.0)
Province								
1	1.5** (1.1, 1.9)	1.3 (0.9, 1.7)	1.6*** (1.2,2.1)	1.3* (1.0,1.8)	0.7** (0.5,0.9)	0.8 (0.7,1.0)	0.8 (0.6,1.1)	1.0 (0.8,1.3)
2	2.9*** (2.2, 3.7)	2.2*** (1.6, 3.0)	3.3*** (2.6,4.3)	2.5*** (1.8,3.4)	0.5*** (0.4,0.6)	0.5*** (0.4,0.7)	0.4*** (0.3,0.6)	0.6*** (0.4,0.8)
3	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
4	1.0 (0.8, 1.4)	0.9 (0.7, 1.3)	1.1 (0.8,1.4)	1.0 (0.7,1.3)	0.9 (0.7,1.2)	1.1 (0.9,1.3)	1.0 (0.7,1.3)	1.1 (0.9,1.4)
5	1.7*** (1.3, 2.3)	1.5** (1.1, 2.0)	1.8*** (1.4,2.4)	1.6** (1.2,2.1)	0.7** (0.5,0.9)	0.7** (0.6,0.9)	0.6** (0.5,0.9)	0.8* (0.6,1.0)
6	1.6*** (1.2, 2.1)	1.6*** (1.2, 2.1)	1.9*** (1.5,2.5)	1.8*** (1.4,2.4)	0.3*** (0.3,0.4)	0.6*** (0.5,0.7)	0.3*** (0.2,0.4)	0.6*** (0.5,0.8)
7	2.1*** (1.6, 2.7)	1.8*** (1.4, 2.4)	2.5*** (1.9,3.2)	2.0*** (1.5,2.7)	0.3*** (0.2,0.4)	0.4*** (0.4,0.6)	0.3*** (0.2,0.4)	0.4*** (0.3,0.6)

BMI: body mass index in kg/m^2, WHO: World Health Organization; COR: crude odds ratio; AOR: adjusted odds ratio.

[a] Asia and WHO cutoffs to categorise overweight/obesity are BMI ≥23 and ≥25 kg/m^2, respectively. Both cutoffs define underweight as BMI <18.5 kg/m^2.

[b] Adjusted for variables with significance levels less than 0.20 from crude analysis.

[1] $p < 0.2$.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

prevalence and associated factors for underweight, overweight and obesity in Nepal using two cutoffs.

However, the limitations of this study should also be discussed. The 2016 NDHS relied on verbal reports to obtain some background characteristics including age or the elements of principal component analysis; this could cause some misclassification. The observed association might not be causal due to uncertainty about temporal association as this data was cross-sectional. Several known risk factors for extreme body weights such as dietary habits, physical activity or comorbid diseases were not adjusted due to limitations of the dataset.

Conclusion

This study investigated prevalence and determinants of underweight, overweight and obesity among adults in Nepal. A large proportion of adults could have abnormal body weight categories. Based on the findings of this study, it is crucial to address the characteristics that were associated with higher prevalence and likelihood of three extreme body weight groups. Similar studies in other coun-

tries could also be helpful for estimating the overall global burden and for developing a global prevention strategy.

Author contribution

Concept, literature search, writing and statistical analysis: GMAK.

Conflicts of interest

The author has no conflicts of interest to disclose.

Ethical statement

The survey protocol was approved by the Nepal Health Research Council and the ICF International's institutional review board. The ICF international provided electronic approval to use this dataset in June 2018.

Data sharing and availability

Data may be available upon request from ICF International (https://dhsprogram.com/data/available-datasets.cfm).

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.orcp.2019.01.006.

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