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ORIGINAL ARTICLE

# Determinants of obesity in Turkey: appetite or disease?

Okan Demir[1] · Nuray Demir[1] · Abdulbaki Bilgic[1]

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## Abstract

**Aim** This study examines the factors affecting obesity prevalence among adult individuals in Turkey using data obtained from the National Health Survey of the Turkish Statistical Institute (TSI).

**Subjects and methods** Nowadays obesity is one of the world's major health problems. Although the proportion of young people remains very high in Turkey, the prevalence of obesity is increasing daily. In this study, we used the National Health Survey data collected by the TSI in 2012. The research was carried out on 14,400 households in 12 regions of Turkey. The study covered socio-demographic characteristics of families and household heads, but included only observations made by household heads. We tested a bivariate probit model with sample selection, which was compatible with the data-generating process to exclude the inherent selection problem. We then applied a simple binary probit model to assess the likelihood of being obese among those who reported their body measures (height and weight).

**Results** The results indicated that living in a city, getting married, being female, being middle-aged, being depressed and having lower education levels increased the probability of obesity prevalence among Turkish subjects, while less obesity prevalence was associated with being male, being well educated, being a regular walker, being a smoker and living in a rural area.

**Conclusions** When combating obesity in Turkey, social risk groups that are more likely to be obese should be identified and awareness training should be carried out for each group with suitable objectives and programs. The aim of such programs should be to encourage adequate and balanced nutrition and regular physical activity and to teach individuals about the adverse effects of obesity on health (cardiovascular disease, diabetes, some types of cancer, hypertension, etc.).

**Keywords** Households · Obesity · Bivariate probit model · Turkey

## Introduction

Obesity is a chronic impairment of energy metabolism resulting from excessive fat accumulation in the body due to environmental, psychological and genetic factors and resulting from erroneous and excessive nutrition. Obesity can also lead to physical and mental health problems that negatively affect the quality of life and life expectancy (İskender et al. 2014).

Obesity also causes many diseases, including heart disease, hypertension, stroke, certain types of cancers, biliary diseases, sleep apnea and other respiratory problems, and it increases all-cause mortality (Berberoğlu 2012; Ergül and Kaklim 2011; İskender et al. 2014). Worldwide, overweight- and obesity-related deaths are higher than deaths due to malnutrition (WHO 2016). In addition to medical problems, many psychological and social problems have also been associated with obesity (Power et al. 1997). Loss of self-esteem, peer relationship avoidance, inward closure, feeling of exclusion, and even depression and anxiety are associated with obesity (Deckelbaum and Williams 2001).

People are physically changing in line with longer life expectancy and in parallel with rapid developments in technology. In former times when technology was less of a substitute for muscle power, the human body had a higher proportion of muscular tissue, but nowadays both the ratio of fat tissue in the human body and unbalanced nutrition resulting from excessive desk work have increased. As a result of today's rapidly changing culture, obesity prevalence is increasing in almost all regions of the world. Genetics, age, gender, education and lifestyle are the most important factors affecting the obesity frequencies in the world. Rapid urbanization, economic development, changes in dietary habits (e.g., eating meals away

✉ Okan Demir
okandemir@atauni.edu.tr

[1] Faculty of Agriculture, Department of Agricultural Economics, Atatürk University, 25240 Erzurum, Turkey

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from home), working conditions, a decrease in physical activity (PA) and advertising have all contributed to changing patterns of food consumption (Beyaz and Koç 2009). The World Health Organization (WHO) reported that in 2014 1.9 billion people of the world's population of over 18 year olds were overweight, with 600 million of them being obese, while 13% of the world's total population, 15% of females and 11% of males are obese. Worldwide, the prevalence of obesity has doubled in the last 3 decades (WHO 2016).

In the past, obesity was a problem for countries with high per capita incomes, but it has now become a major health threat especially in urban areas of low- and middle-income countries (WHO 2016). While obesity is more prevalent among low-income groups in developed countries, it is more common among high-income groups in developing countries (Booth et al. 1999; Bray 1999; Koçoglu et al. 2003; Power and Parsons 2000). Turkey, which has a population of over 80 million and has shown rapid economic growth in recent years, is an important country in its geographical region. Both population growth and the proportion of young people in Turkey are increasing daily, accompanied by concurrent overweight and obesity problems. Erem (2015) reported that the obesity prevalence in studies conducted at different times in Turkey at the national level ranged from 15.6 to 39.7% (Delibasi et al. 2007; Gültekin et al. 2009; Gundogan et al. 2013; Hatemi et al. 2003; Onat et al. 2001; Onat et al. 1996; Onat et al. 1999; Sanisoglu et al. 2006; Satman et al. 2000). While the obesity rate in Turkey was 15.2% in 2008, it reached 19.9% in 2014. The rate of increase was 32.3% for women and 24% for men during this time. Overall, in Turkey, 24.5 and 29.3% of the population are obese and overweight, respectively, while the proportions of obesity and overweight among men are 15.3 and 38.2%, respectively (TSI 2016).

In this study, we aimed to determine the factors affecting the prevalence of obesity among adult individuals in Turkey using data obtained from the National Health Survey of the Turkish Statistical Institute (TSI). For this purpose, we used a bivariate probit model with sample selection[1] and obtained marginal effects of socio-demographic and economic factors of household heads on the probability of being obese. Unfortunately, Turkey as a country has not yet taken any action to tackle the obesity epidemic. Previous studies have tended to be very simplistic, only determining the obesity rates. Knowing the factors affecting the probability of obesity as expressed in terms of their magnitude and directions will help decision-makers in creating more effective health and nutrition policies.

[1] The binary probit model is preferable to this model if the correlation coefficient, rho (ρ), between the probability models is considered to be insignificant.

## Literature review

Especially in recent years, intensive studies have appeared on body mass index (BMI) and the link to health problems. They are usually carried out with cross-sectional data that include the socio-demographic and economic factors of individuals or households related to BMI. In these studies, the BMI variable is used as either a continuous variable or a dummy variable that determines the relationship with other exogenous variables under investigation. In this context, Grujić et al. (2009) determined the overweight and obesity prevalence among the population of the province of Vojvodina, Serbia, and examined the association among obesity, socioeconomic and healthy lifestyle factors. They found that the overweight and obesity prevalence in both sexes in 2006 was 57.4% (35.7% were overweight and 21.7% obese). In their study, men were more prone to overweight (41.1%) than women (30.9%) ($p < 0.001$), while obesity was higher in women (23.1%) than men (20.2%) ($p = 0.035$). They also reported that increasing age, being male, living in a rural area, being unmarried, having a lower educational level, having high income, never or rarely eating breakfast and frequently watching TV were factors more likely to be associated with obesity. On the other hand, Esmaeily et al. (2009), who studied the relationship between socioeconomic factors and obesity within a population from Great Khorasan province in Iran, found that being overweight and obese was significantly more prevalent among women than men as well as among urban compared with rural dwellers. They also reported that high overweight and obesity prevalence was widespread among those who were divorced, widowed, housewives or less educated, while urbanization, age, illiteracy, being female and divorced, and being widowed were among the significant determinants of obesity. Tan et al. (2012) investigated the roles of socio-demographic and healthy lifestyle factors in affecting BMI across ethnic groups in Malaysia. This study highlighted the findings that age and income groups, education level, history of family illness and smoking status were significantly associated with body weight. Similarly, Yen et al. (2009) investigated the effects of lifestyle, demographics and dietary behavior on overweight and obesity. They reported that lifestyle, dietary behavior, social status and other socio-demographic factors affected BMI differently in different weight categories. Similarly, education, employment and income variables were reported to have a strong influence on the likelihood of being overweight and obese. Exercise has been observed as a factor that lowers both the likelihood of being overweight and obese and the level of BMI in overweight individuals; therefore, they suggested that health education programs should be targeted to overweight and obese individuals.

Ward et al. (2015) analyzed a multistage household survey among adults in Belo Horizonte in Minas Gerais State in

Brazil. They reported that the BMI variable was positively associated with household and neighborhood income in men. In addition, both physical inactivity and low fruit and vegetable intake were reported to be inversely related to education and household income in both men and women, whereas physical inactivity was also reported to be inversely associated with neighborhood income among the male population. In parallel, Banterle and Cavaliere (2014) analyzed the socioeconomic variables affecting obesity by means of a survey conducted on a sample of 955 residents of Lombardy, Italy. The results showed that the rate of overweight and obesity increased with age, especially among those who were over 65, where the obesity rate seemed to be quite high. In addition, gender was correlated with the pathology; those affected were more likely to be male. Furthermore, there was an inverse relationship between obesity and education, indicating that obesity decreases with an increase in education level. Overall, the analysis established that disadvantaged social categories were more susceptible to obesity and overweight. Interestingly, results also showed that an inverse relationship existed between obesity and the quality and marketing attributes of food products. Loureiro et al. (2012) also examined the relationship between nutritional label use and obesity utilizing switching regression. They found that nutritional labels played a role in reducing obesity, especially among women. They also indicated that the average BMI for men who read nutritional labels was 0.12 points lower than for men who ignored them, while women who read nutritional labels had a 1.49 point lower BMI than women who did not. Based on these findings, they suggested that health education campaigns could use nutritional labels as one of the obesity-reducing tools. Chen et al. (2005) examined the effects of a Food Stamp Program (FSP) on two separate but related outcome measures: a continuous BMI and a binary obesity indicator. In their final models for women, race, age, education, income and home ownership variables were found to be related to both body weight and FSP participation. They also found that food intake (beer, sugar and beverages) and two lifestyle variables (alcohol use and TV hours) did not affect the decision to participate in FSP, but were probably related to body weight. Non-food expenditure, the monthly amount spent on nonfood items, was found not to be an important factor in determining an individual's current body weight, but was probably related to FSP participation.

In 2003, Kuntz and Lampert (2010) found that around 17 and 20% of men and women over the age of 18 in Germany were obese. Men and women with low education, occupational or income group levels were more prone to obesity than those in very high social welfare groups. Drewnowski et al. (2014) compared the associations between the food environment at the individual level and socioeconomic status (SES) and obesity rates in Seattle and Paris. Their results showed that lower education and income levels were associated with higher obesity risk in both cities, as was shopping in low-priced supermarkets. Meanwhile, Akil and Ahmad (2011) examined the relationship between an increase in BMI and socioeconomic factors in Mississippi, Alabama, Louisiana, Tennessee and Colorado in the US. They found that the factors most closely associated with obesity were as follows: income below the poverty level, receiving food stamps, unemployment and general income level. Dinsa et al. (2012), on the other hand, conducted a systematic review of studies evaluating the relationship between socioeconomic status and measured obesity in children, men and women in low- and middle-income countries. They found that in low-income countries or in countries with a low human development index, the nexus between socioeconomic status and obesity appeared to be positive for both men and women: those with higher education levels tended to be obese. They, however, found that in middle-income countries or in countries with a medium human development index, the link became largely mixed for men and mainly negative for women.

Tan et al. (2013) investigated the relationship between cigarette smoking and BMI in a national sample of Malaysian adults. Their results showed that socio-demographic and healthy lifestyle factors played an important role in body weight categories, conditional upon smoking status. They found that education levels were only inversely proportional to BMI categories among non-smokers, whereas age and income levels were associated with BMI for non-smokers and smokers. They also found that gender, serious illnesses, family history, individual health status (hypercholesterolemia, hypertensive), ethnicity (Malaysia and Indians) and regional (metropolitan) variables were linked with higher body mass index levels, regardless of smoking status. Similarly, Kasteridis and Yen (2014) explored the nexus between occasional smoking on BMI in adults aged 18–50 years. Though it was less than that of daily smoking, occasional smoking was reported to have a negative and significant effect on body weight in their analysis. They also found that the difference in the effect of occasional smoking on body weight in the BMI categories was small. Unlike daily smoking, the effects of occasional smoking on BMI were reported to be greater in women, exceeding 50% of the effects of daily cigarette use on BMI. Likewise, Tan et al. (2015) examined the impact of socio-demographic and lifestyle factors on body weight conditional upon endogenous physical activity (PA) for adults in Malaysia. They found an inverse relationship between body weight and PA at elevated PA levels, while high-level PA with a metabolic equivalent is required for 1500 min per week for healthy changes in body weight. Similarly, they showed that older, less educated individuals and a family history of illness were associated with a higher BMI at PA levels, while Chinese and other ethnic background individuals, males, smokers and those who worked longer hours had lower BMIs at all levels of PA. Yen (2012) investigated the effect of physical activity on body weight and the associated gender differences,

applying the copula approach to an endogenous switching regression. He found that socio-demographic variables differed significantly for both exercise and BMI, and exercises differed greatly between genders related to BMI. His results indicated that regular exercise, on average, decreased BMI by 1.78 for women and 1.01 for men, while prices of food away from home had negative effects on the BMI of both genders.

Chang and Yen (2012) focused on the relationship between depression and obesity among the elderly in Taiwan. In their results, socio-demographic factors, lifestyles and household size played significant roles in depression among the elderly. Body weight has been found to play a slightly different role between elderly sexes. They showed that while low-weight elderly men were far more likely to be depressed, there was no effect among these low-weight elderly women. Finally, they found overweight and obesity had adverse effects on depression in older sexes. More recently, Nichèle and Yen (2016) investigated the roles of socioeconomic characteristics and lifestyle in both obesity and mental health and the interaction between the two for adults in France. They found that overweight and obesity contributed more to men's mental health disorders than to women's; however, men with mental health impairment were less likely to be overweight or obese. Beyond the baccalaureate level, education greatly reduced the likelihood of being overweight and obese for both men and women and significantly improved mental health. Lifestyle, eating habits, income and age were also reproted to be very important determinants of mental health and obesity.

As shown by the above literature review, it is possible to find such research worldwide. Unfortunately, the subject has been neglected in Turkey. Our work was designed to fill this gap in the literature. The results of this study will also be compared with the results of international studies showing both the consistent and divergent aspects.

## Data and econometric model

### Data

In this study, we used the National Health Survey data collected by the Turkish Statistical Institute (TSI-NHS) in 2012. The research was carried out on 14,400 houses (10,656 urban, 3744 rural) in 12 regions of Turkey. In the questionnaire, the socio-demographic characteristics of family members including household heads were examined, but we will only include observations involving household heads.

Table 1 shows the variables and demographic factors examined in the TSI-NHS, including age, gender, marital status, living place (urban-rural), educational status, labor force status, household income and a dummy variable showing whether individuals had at least one of chronic anxiety, depression or some other health problems. The study also included data on the individual's walking habits, frequencies of eating both fruits and vegetables, use of medication for depression or tobacco, and alcohol usage, access to a family doctor and number of visits to family physicians, health condition and possession of a green card.[2] Descriptive statistics including mean and standard deviations are presented in Table 1.

The most common way of measuring obesity is the BMI, which is obtained by dividing an individual's weight in kilograms by his or her height in meters squared ($kg/m^2$). Individuals with a BMI > 30 were assigned the number 1 to identify him/her as obese and 0 otherwise. This binary classification gives us the opportunity to determine factors affecting obesity using probability models (binary logit or probit model). Approximately 91.8% of household heads reported both their own weight and height, of which approximately 21.3% were obese. This figure should be of disturbing health and social concern to the nation. It is necessary to prepare and implement more proactive health policies in an environment where urbanization is growing rapidly with income and where unhealthy, ready-to-eat food ('fast food') is available daily at every corner of the nation.

Many socio-demographic, economic and health factors trigger or prevent obesity. We identified the most relevant of these in the TSI-NHS data set and present their descriptive statistics in Table 1. Approximately 73% of the individuals resided in urban areas, and 46% were male. It is not clear exactly how residing in an urban area affects obesity in an environment where there are plenty of sedentary or desk jobs and fast food is widely available. On the other hand, our a priori expectation was that obesity would be less prevalent in men than in women because the former are more mobile. The proportion of those who had a college or university diploma was low (15.1%), while the proportion of married people was found to be high (79.5%). We expected that obesity would decrease with increasing education because of the accumulated knowledge on the high risk of obesity to health. On the other hand, because of the more balanced, regular and healthy diets of married couples, our primary expectation was that obesity would be less common in married individuals.

Approximately 52% of household head members worked in a job, while the percentages of those aged 45–64 and over 65 years were 38.2 and 41.0%, respectively. We expect that obesity would be lower in working people. At the same time, while young people have less probability of becoming obese, the odds of obesity may increase especially for older women as physical activity decreases gradually with increasing age. While the proportions of low- and middle-income household heads were 32.7 and 34.3%, respectively, the number of days

[2] The green card is a health service provided by the State free of charge to Turkish citizens who have less than one third of the gross minimum wage (676.5 TL).

**Table 1** Descriptive statistics of variables

| Variable | Definition | Mean | S D |
|---|---|---|---|
| y1 | 1 if household head reports both weight and height, 0 otherwise | 0.918 | 0.274 |
| y2 | 1 if household head is obese, conditional on y1 | 0.213 | 0.410 |
| Gender | 1 if householder is male, 0 otherwise | 0.729 | 0.444 |
| Urban | 1 if family lives in urban area, 0 otherwise | 0.733 | 0.442 |
| College graduate | 1 if the householder has a 2-year community college or a 4-year college diploma, 0 otherwise | 0.151 | 0.358 |
| Marital status | 1 if householder is married, 0 otherwise | 0.795 | 0.403 |
| Working status | 1 if householder is in a paid job, 0 otherwise | 0.520 | 0.499 |
| Age 45–64 | Household head's age 45–64 | 0.382 | 0.485 |
| Age > 65 | Household head's age > 65 | 0.410 | 0.491 |
| Income | Household income in Turkish lira divided by 1000 | 1.292 | 0.656 |
| Group 1 | Household income < 1000 TL per month | 0.327 | 0.469 |
| Group 2 | Household income 1000–2000 per month | 0.343 | 0.475 |
| Walking | Number of days per week spent walking for at least 10 min | 3.570 | 3.169 |
| Veg. 1 | 1 if householder consumes vegetables twice a day, 0 otherwise | 0.132 | 0.338 |
| Veg. 2 | 1 if householder consumes vegetables once a day, 0 otherwise | 0.529 | 0.499 |
| Fruit 1 | 1 if householder consumes fruit twice a day, 0 otherwise | 0.099 | 0.299 |
| Fruit 2 | 1 if householder consumes fruit once a day, 0 otherwise | 0.456 | 0.498 |
| Tobacco | 1 if householder is consumes tobacco, 0 otherwise | 0.304 | 0.460 |
| Alcohol | 1 if householder consumes alcohol, 0 otherwise | 0.148 | 0.355 |
| Compulsory health insurance | 1 if household heads have compulsory health insurance, 0 otherwise | 0.864 | 0.342 |
| Green card | 1 if household heads have green card health insurance, 0 otherwise | 0.081 | 0.273 |
| State of health | 1 if household heads are well/very well, 0 otherwise | 0.617 | 0.486 |
| Anemia | 1 if household heads have anemia, 0 otherwise | 0.032 | 0.177 |
| Mental health | 1 if household heads have at least one of chronic anxiety/ depression/mental problem, 0 otherwise | 0.017 | 0.130 |
| Medication use | 1 if individuals on regular medication, 0 otherwise | 0.325 | 0.468 |
| Physician | 1 if individuals have a family physician, 0 otherwise | 0.748 | 0.433 |
| Physician visits | Numbers of times individuals received services from a family physician in a given year | 0.320 | 0.706 |
| Number of observations | | 11,205 | |

in a week where individuals walked for at least 10 min was determined to be 3.57. The effect of increased income on obesity was not completely clear, considering that excessive eating habits prevail as income increases on one hand and that healthier dietary habits may be followed by those with higher incomes on the other. We think that increasing the daily number of regular walks will reduce obesity as it increases the fat-burning function of the body. While the rate of consuming fruits or vegetables twice a day was 13.2 and 9.9%, respectively, the rate of consuming these products once a day was 52.9 and 45.6%, respectively. As expected, vegetable consumption was higher than fruit consumption, perhaps because in Turkish society vegetables are generally eaten with the main meals throughout the day, while fruit is usually served after dinner.

Approximately 30.4% of household heads consumed tobacco, while 14.8% consumed alcohol. The low incidence of alcohol use can be attributed to many factors, such as religious beliefs. Loss of appetite and other health problems caused by cigarette smoking can cause individuals to lose weight, while intense stress and depression in alcohol users can lead to a similar result. The percentage of those who felt their health is good or very good was about 61.7%, while the percentages of those who had compulsory and green card health insurance were 86.4 and 8.1%, respectively. The health costs incurred by household heads with green cards are paid by the state because they have insufficient financial means. It can be assumed that those who think they are healthy are generally those who pay attention to obesity. While it is not known exactly how individuals with compulsory health insurance react to obesity, the likelihood of being obese was generally less when green card holders had very low incomes.

While rates of anemia and chronic depression were found to be relatively low (3.2 and 1.7%, respectively) in our sample, the proportion of household heads on regular medication due to a specific disease or illness was 3.2%. Depression often leads to fatigue and loss of appetite, so obesity was therefore predicted to be very low in such people. While approximately

74.8% of individuals had a family physician, the number of services they received from family physicians during the space of 1 year was rather low (0.32). Therefore, annual general screening of individuals must be encouraged by the state or local government health facilities. We expected that the likelihood of obesity would decrease in individuals receiving constant warnings from a family doctor and having regular health screening compared with those who did not have such opportunities.

## Econometric model

We first chose the sample selection model, compatible with the data structure, to analyze factors affecting obesity in Turkey. Approximately 92% of the entire sample reported their body weight and height, while the remaining 8% failed to report one or both of these values. A natural extension of the probit model would be to allow more than one equation, with correlated disturbances, in the same spirit as the bivariate probit model. In this model, the probability of obesity can be determined by allowing body mass index calculations among those who reported their own weight and height and at the same time, assigning a probability to those who did not report these figures. In this context, there are two error-dependent probabilities in our model: the probability of being obese among reporting individuals and the probability of not reporting weight and height (Greene 2008). Assuming that there is a relationship between the error terms of the two probabilities (for example, they are not independent of each other), the correlation coefficient must be parametrically estimated.

The general specification for a two-equation model would be:

$$\begin{aligned} &y_{1i}^{*} = X_{1i}\beta_1 + \varepsilon_{1i}, \quad y_{1i} = 1 \ \ if\ y_{1i}^{*} > 0; \ \ 0 \ \ otherwise, \\ &y_{2i}^{*} = X_{2i}\beta_2 + \varepsilon_{2i}, \quad y_{2i} = 1 \quad if\ y_{2i}^{*} > 0; \quad 0 \quad otherwise, \\ &(\varepsilon_1, \varepsilon_2 \,|X_1, X_2) \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}\right] \\ &(\mathrm{y}_{1i}, \mathrm{X}_{1i}) \text{ is observed only when } \mathrm{y}_{2\mathrm{i}} = 1, \end{aligned} \tag{1}$$

where $y_{2i}$ indicates whether the individual reported both his/her own height and weight information, while $y_{1i}$ indicates whether the individual was obese or not. $X_1$ and $X_2$ are factors affecting the likelihood of obesity and not reporting both height and weight, respectively, while $\beta_1$ and $\beta_2$ are the corresponding parameter sets to be estimated along with the ρ correlation coefficient between the error terms, $\varepsilon_1$ and $\varepsilon_2$.

The log likelihood for the bivariate probit model with sample selection is as follows (Bilgic 2010; Van de Ven and Van Praag 1981):

$$\begin{aligned} &\log L(y_1, y_2; \theta) \\ &= \textstyle\sum_{y_2=1, y_1=1} \log \Phi_2(X_{1i}\beta_1, X_{2i}\beta_2; \rho) + \sum_{y_2=1, y_1=0} \log \Phi_2 \\ &\qquad (-X_{1i}\beta_1, X_{2i}\beta_2; -\rho) - \textstyle\sum_{y_2=0} \log \Phi(-X_{2i}\beta_2) \end{aligned} \tag{2}$$

where $\Phi_2$ and $\Phi$ represent the bivariate cumulative distribution function and univariate normal distributions, respectively, and $\rho$ represents the correlation coefficient between error terms of $\varepsilon_1$ and $\varepsilon_2$ for obesity and non-reporting observations, respectively.

From properties of the bivariate normal distribution, the conditional probability of obesity ($y_1$) where the probability of reporting physical figures (height and weight) is given, and the marginal probabilities of both obesity and reporting body figures, can be stated, respectively, as follows:

$$\begin{aligned} &Prob\,(y_{1i} = 1 | y_{2i} = 1, X_1, X_2) = \Phi\left[\frac{X_{1i}\beta_1 + \rho X_{2i}\beta_2}{\sqrt{1-\rho^2}}\right], \\ &Prob\,(y_{1i} = 1) = \Phi\,(X_{1i}\beta_1) \text{ and } Prob\,(y_{2i} = 1) = \Phi\,(X_{2i}\beta_2) \end{aligned} \tag{3}$$

When we differentiate each probability model given in Eq. 3 with respect to an independent variable in the model, we can obtain a marginal effect of an exogenous variable on the corresponding probability. Standard errors of these marginal effects were obtained using the delta method. If the correlation coefficient between the two probabilities in Eq. 1 is not statistically significant in the model, then observations for those who did not report their height and weight will not create any statistical sampling problem in the sample. In this case, we can exclude those observations from the model and then re-estimate the parameter set ($\beta_1$) only for the probability of obesity (e.g., from a probit model) on the reported BMI observations. In such a case, only factors that affect obesity will be the subject of analysis. Since the probit model is so widely used, we did not explore it here but only referred to textbook presentations.

## Results and discussion

Table 2 shows the results of the bivariate probit with the sample selection model. In the results of the bivariate probit with the sample selection model, the first model (model I) describes the factors affecting the reporting of height and weight information, while the second model (model II) describes the BMI as a binary dependent variable. Before discussing the results of the bivariate probit with sample selection, we would like to emphasize the statistical significance of the coefficient of correlation in the model. The null hypothesis is that there is no relationship between these two probabilities, that is, the correlation coefficient in the bivariate probit with sample selection model is zero. If this hypothesis proves correct, then parameter estimates of the probability of obesity from those observations, which reported body measurements, do not suffer from sampling bias error. The test statistic is $W = \frac{\hat{\rho}^2}{V(\hat{\rho})}$, where ρ

**Table 2** Bivariate probit model results

| Variables | Model I (BMI report = 1 or 0) | | Model II (obesity = 1 or 0) | | | |
|---|---|---|---|---|---|---|
| | Coef. | S E | Coef. | SE | Marginal effect | SE |
| Constant | 0.880*** | 0.066 | −0.768*** | 0.081 | – | – |
| Gender | 0.483*** | 0.046 | −0.202*** | 0.043 | −0.070*** | 0.012 |
| Marital status | 0.103** | 0.049 | −0.006 | 0.045 | −0.005 | 0.013 |
| Working status | 0.283*** | 0.044 | 0.095** | 0.037 | 0.020* | 0.011 |
| Income group 1 | −0.346*** | 0.055 | – | – | 0.009*** | 0.001 |
| Income group 2 | −0.176*** | 0.056 | – | – | 0.004*** | 0.001 |
| Urban | 0.287*** | 0.039 | 0.052 | 0.034 | 0.008 | 0.010 |
| College graduate | 0.452*** | 0.085 | −0.266*** | 0.045 | −0.088*** | 0.013 |
| Age 45–64 | – | – | 0.026 | 0.049 | 0.008 | 0.014 |
| Age > 65 | – | – | 0.239*** | 0.041 | 0.069*** | 0.012 |
| Compulsory health insurance | – | – | −0.058 | 0.061 | −0.017 | 0.017 |
| Green card | – | – | −0.318*** | 0.080 | −0.091*** | 0.023 |
| Income | – | – | 0.073*** | 0.026 | 0.021*** | 0.008 |
| Walking | – | – | −0.010** | 0.004 | −0.003** | 0.001 |
| Veg. 1 | – | – | −0.085 | 0.051 | −0.024 | 0.015 |
| Veg. 2 | – | – | −0.060* | 0.034 | −0.017* | 0.010 |
| Fruit 1 | – | – | 0.121** | 0.054 | 0.035** | 0.016 |
| Fruit 2 | – | – | 0.055* | 0.032 | 0.016* | 0.009 |
| Tobacco | – | – | −0.236*** | 0.033 | −0.068*** | 0.010 |
| Alcohol | – | – | 0.073* | 0.041 | 0.021* | 0.012 |
| State of health | – | – | −0.144*** | 0.032 | −0.041*** | 0.009 |
| Anemia | – | – | −0.059 | 0.075 | −0.016 | 0.021 |
| Mental health | – | – | 0.071 | 0.110 | 0.004 | 0.021 |
| Medication use | – | – | 0.131*** | 0.032 | 0.038*** | 0.009 |
| Physician | – | – | 0.041 | 0.033 | 0.001 | 0.010 |
| Physician visits | – | – | 0.040** | 0.019 | 0.012** | 0.006 |
| Depression | – | – | 0.156 | 0.143 | 0.044 | 0.040 |
| ρ | 0.902 | 1.358 | | | | |
| Log-likelihood value | −7721.690 | | | | | |

Statistical significance: *** at 1% level; ** at 5% level; * at 10% level

is the estimated correlation coefficient between the probability of reporting height and weight and the probability of obesity in our model, and V(ρ) is its associative variance estimate. The test had an approximate chi-square distribution with one degree of freedom under the null hypothesis. Since the computed test statistic ($W = (0.902/1.358)^2 = 0.441$) was less than the critical value ($\chi^2_{0.95,1} = 3.84$), we rejected the bivariate relationship between the probability of being obese and the probability of reporting height and weight, showing that those who did not report height and weight did not lead to a sample selection problem in our study. Therefore, the probability of obesity can be constructed purely from observations that reported body measurements. Although we will not consider results of the bivariate probit model with sample selection from now on, we can infer that the parameter estimates obtained from this model overlap with our expectations in general.

As the correlation coefficient in the bivariate probit model with sample selection was found to be insignificant, the factors affecting obesity were then determined by using the binary probit model on those individuals who reported body measurements only. Included in Table 3 are the results of the binary probit model along with their marginal impacts on the probability of obesity. They show that many explanatory variables are significantly influential in determining obesity. Since our model was non-linear in nature, parameter estimates of exogenous variables were not indicative of unitary (marginal) impacts on the probability of obesity in our model. The third and fourth columns of Table 3 show the marginal effects and their standard errors on the probability of obesity.

**Table 3** Log-maximum likelihood estimates of the binary probit model

| Variable | Log-maximum likelihood estimates | | Marginal effects | |
|---|---|---|---|---|
| | Coefficient | SE | Coefficient | SE |
| Constant | −0.535*** | 0.083 | – | – |
| Gender | −0.287*** | 0.042 | −0.085*** | 0.013 |
| Marital status | 0.029 | 0.044 | 0.008 | 0.012 |
| Working status | 0.069* | 0.038 | 0.019* | 0.010 |
| Urban | 0.006 | 0.035 | 0.001 | 0.009 |
| College graduate | −0.289*** | 0.047 | −0.074*** | 0.011 |
| Age 45–64 | 0.030 | 0.052 | −0.008 | 0.014 |
| Age > 65 | 0.247*** | 0.043 | 0.070*** | 0.012 |
| Compulsory health insurance | −0.062 | 0.064 | −0.017 | 0.018 |
| Green card | −0.336*** | 0.085 | −0.083*** | 0.018 |
| Income | 0.050* | 0.027 | 0.014* | 0.007 |
| Walking | −0.013** | 0.004 | −0.003** | 0.001 |
| Veg. 1 | −0.088 | 0.054 | −0.024* | 0.014 |
| Veg. 2 | −0.060* | 0.036 | −0.017* | 0.010 |
| Fruit 1 | 0.124** | 0.057 | 0.036** | 0.017 |
| Fruit 2 | 0.057* | 0.034 | 0.016* | 0.009 |
| Tobacco | −0.244*** | 0.034 | −0.066*** | 0.008 |
| Alcohol | 0.077* | 0.042 | 0.022* | 0.012 |
| State of health | −0.149*** | 0.033 | −0.042*** | 0.009 |
| Anemia | −0.063 | 0.081 | −0.017 | 0.021 |
| Mental health | −0.071 | 0.116 | −0.019 | 0.030 |
| Medication use | 0.138*** | 0.033 | 0.039*** | 0.009 |
| Physician | 0.040 | 0.035 | 0.001 | 0.009 |
| Physician visits | 0.044** | 0.020 | 0.012** | 0.005 |
| Depression | 0.160 | 0.153 | 0.047 | 0.047 |
| Log-likelihood value | −4978.905 | | | |

Statistical significance: *** at 1% level; ** at 5% level; * at 10% level

According to the results of marginal effects, the probability of being obese decreases with male gender by almost 8.5%. Although seen in both genders, women are more susceptible to obesity (Erbaş 2007; Onat et al. 2001; Onat et al. 1999; Peker et al. 2000; Satman et al. 2000; Tan et al. 2013).

We found that men were less likely to be obese than women because they are more involved in business life and tend to participate in more physical activity than women, results that coincide with international findings. For example, moderate to high physical activity levels have been associated with lower odds of obesity (Chamieh et al. 2015). Otherwise, Chen et al. (2005) reported that some socio-demographic variables increase the probability of obesity. A woman's consumption of beverages or sugar, spending more time watching TV or playing video games increases body weight and the likelihood of being obese.

Married household heads were 0.8% more likely to be obese than single or widowed household heads. This result overlaps with national study findings, showing that married individuals had a higher prevalence of obesity (Ankara 2016; Erem 2015; İşeri and Arslan 2008). Comparable results have also been reported in other research (Grujić et al. 2009; Peytremann-Bridevaux et al. 2007). Grujić et al. (2009) found marital status had a significant association with obesity, so single examinees (non-married, divorced, widowed) had 26.2% lower odds of obesity compared with married examinees. This result was expected because, in general, single adults want to be fit and have a good physical appearance as they intend to marry and are also more prone to physical activity with irregular eating habits. The higher likelihood of married individuals being obese compared with singles can be seen as a result of the Turkish family lifestyle. According to tradition, married people are more regularly fed and live more stable and sedentary lives than their single peers.

Living in urban areas increases the likelihood of being obese by 0.1%. This result is not surprising because in towns and cities irregular and fast-food style nutrition is more common. The eating habits of people living here are more likely to

include mass-produced foods and large amounts of saturated fats, so urban dwellers may have higher obesity than people living in rural areas (Ankara 2016; Karaoğlan 2015). On the other hand, those living in rural areas are usually engaged in everyday activities involving agriculture, vineyards and livestock and are therefore constantly mobile.

Individuals with university or higher education are less likely to become obese than those who are not so well educated. This is because they are more conscious of nutrition and well-being. Having a university or higher education reduces the probability of obesity by 7.4%. We found a consistent relationship between lower educational level and overweight and obesity. These findings are supported by other studies (Gallus et al. 2013; Grujić et al. 2009; Maruf and Udoji 2015). The association between BMI and education differed by gender. In almost all surveys, women with non-university education were more often overweight and obese than women with a university education (Kriaucioniene et al. 2016). The higher the education level, the more obesity declines as a result of increasing awareness of healthy lifestyles, nutrition and obesity threats to health. These results overlap with previous findings (Ankara 2016; Karaoğlan 2015).

There were mixed findings for the age variables (age 45–64, age > 65 years). While middle-aged people are less likely to be obese (0.8%) than younger people, elderly individuals are more likely to be obese (7.0%) than younger subjects. These results could be expected considering that individuals have more balanced diets. Meanwhile, as people age, their daily physical activities become limited. However, the opposite findings were also obtained in previous studies on obesity in Turkey, which indicated that obesity is positively correlated with age (highest prevalence age 50–69 years) (Ankara 2016; Erem 2015; İşeri and Arslan 2008). In fact, findings for the association among age, sex and body weight in previous similar studies have suggested that age and sex are consistent predictors of body weight, regardless of possible sociocultural and genetic differences across populations (Maruf and Udoji 2015). In this regard, information regarding the health and social risks resulting from overweight should be explained to older individuals as appropriate and in a timely manner by the responsible institutions.

Another factor affecting obesity is the amount of income. The probability of becoming obese increased by 1.4% per increase in income of 1 Turkish lira (TL). Similar results have been found in a variety of studies. Income, contrary to conventional wisdom, increases a woman's body weight (Chen et al. 2005).

The likelihood of obesity decreases for individuals with green card health insurance. This decline is about 8.3%. Although this is a gratifying outcome, the fact that these individuals are faced with unbalanced nutrition should not be ignored as they may be living on very low incomes. A supplemental nutrition assistance program like the food stamp program in the United States, which provides balanced nutrition by buying healthy food, should be also implemented in Turkey. Reviews of socioeconomic status (SES) and obesity in developing countries have found a direct relationship between the prevalence of obesity and increased SES (Abubakari et al. 2008; Sobal and Stunkard 1989) but our study only indicated an association between obesity and green card holding.

However, individuals who regularly walk are 0.3% less likely to be obese than those who do not. This result is expected, since walking burns calories. In this context, irrespective of gender and age group, such activities should be encouraged by relevant health institutions through visual and written media, including the views of health personnel on the positive effects of daily walking on human health. In addition, local municipalities must offer appropriate walking areas to the public.

We found that people who ate fruit twice a day or more were 3.6% more likely to be obese than those who did not. This result is surprising, since Tan et al. (2015) reported that adhering to a healthy diet of five servings of fruits and vegetables daily has a positive effect on BMI. Although consumption of fruit is considered to be one of the healthy and balanced nutrition indicators, daily consumption of more fruit than required by the body can likely cause overweight. Another important point is that those who frequently eat fruit are likely in the upper income group.

Individuals who currently smoked were less likely (6.6%) to be obese than those who did not. This can be explained by the decline of regular eating habits that begins with smokers' lack of appetite. Our findings coincide with those from similar studies, which found smokers were less likely to have high body weight than nonsmokers (Gallus et al. 2013; Kasteridis and Yen 2014; Tan et al. 2015). This should not be misunderstood: Although the risk of obesity in smokers tends to be lower, the burden of cigarette smoking and alcohol-related diseases is high in the economy of every country worldwide.

As expected, the likelihood of obesity was reduced by 4.2% in individuals who stated that their health status was good. On the other hand, the probability of being obese in those taking treatments is about 3.9% higher than for those not currently taking medication. It is well known that some drugs can increase the appetite and therefore cause weight gain. Patients should consult their physicians before using such medications and possibly should avoid those likely to cause weight gain. At the same time, the Ministry of Health in Turkey should organize programs that include health campaigns to make the public more sensitive to such issues. Interestingly, the prevalence of obesity increased the higher the number of services that individuals received from family doctors within a year. Perhaps this is because those who visited a family physician more often mistakenly perceived themselves as being better protected in terms of health as the

number of visits increased. Since in Turkey the number of patients per doctor is very high, physicians cannot be expected to examine their patients properly and initiate appropriate treatment accordingly as is the case in developed countries. In this context, most patients going to the doctor are only given medication check-ups. Thus, the health service sector in Turkey needs to be improved in terms of the number and quality of medical personnel, including the number of physicians. Patients should be made aware of the health threats caused by obesity.

## Conclusion

Obesity, which has become one of the most pressing health problems in many countries in recent years, has also reached epidemic proportions in Turkey. In this study, factors affecting the prevalence of obesity were determined using data from the 2012 TSI-NHS. The conducted test revealed that the binary probit model was more compatible with the data than the bivariate probit model with sample selection. According to our results, people living in urban areas, who are married, female, middle-aged, depressed and have less than an undergraduate level education were more likely to be obese. Obesity is an important problem for Turkey and must be effectively tackled. To combat obesity, social risk groups that are more likely to be obese should be identified, and awareness training should be provided for each group with appropriate methods to suit the differing needs. The aim of such a program should be to encourage individuals to adopt adequate and balanced nutrition and regular physical exercise and to teach them about the adverse effects of obesity on health (cardiovascular disease, diabetes, some types of cancer, hypertension, etc.). Recent studies have shown that when started in early life, many chronic diseases such as cancer and cardiovascular disease are preventable by reducing obesity and excess weight and increasing physical activity.

Social and media pressure to maintain a slim body image also may influence weight status, especially in women (Kriaucioniene et al. 2016). Awareness-raising training should be supported through visual and written media campaigns. Arikan et al. (2014) stated that these programs have lower success rates in modifying the behavior of subjects who are elderly, non-obese, living in rural areas and male with inadequate knowledge. These groups may need additional preventive services for obesity.

In addition to educational and awareness activities, governments should also carry out physical and economic measures, such as the development of sports infrastructures, prevention of the spread of fast-food establishments and promotion of traditional food consumption.

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## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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