Factors Affecting the Overweight and Obesity of Students Aged 11 to 17 in Low and Middle-Income Countries Based on GSHS Questionnaire Data

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Abstract

Background: Obesity and overweight in early life arebeingone of the challenges of public health in both developed and developing societies.

Methods: This cross-sectional study was designed on the Global School-based Student Health Survey (GSHS) data from the WHO, in collaboration with UNAIDS, UNESCO, and UNICEF. The countries of low- and middle-income in the six WHO regions were included.BMIis classified into three classes: overweight, normal-weight, and underweight based on length/height, weight, and age.

Results: Of the 187893 students aged 11 to 17 years, 43220 (23.0%) were overweight. The prevalence of obesitywas higher in boys (23.67% and 22.39% in boys and girls respectively).The probability of obesity decreases by the age of the students. There was a positive relationship between following personal hygieneprinciples and overweight so that the use of soap and washing hands after going to the toilet increased the odds of overweight by 17% and 11%, respectively.Each unit increased the prevalence of overweight in adulthood (1.07 - 1.04 OR = 1.06), and each unit increase in Gini Index (OR = 1.03,1.00-1.05) on average increased the odds of overweight in students aged 11 to 17 years, but for the prevalence of overweight in children less than 5 years old, GDP and SDGs did not have any significant effect onoverweight in children aged 11 to 17 years.

Conclusion: The country-level Gini index and the prevalence of overweight and obesity in adults had a significant role in overweight and obesityin students. Due to the different situation of the countries, it is required to plan specific programs to tackle overweight in children.

Background

The increasing trend of obesity is one of the main challenges of health across the world[1]. It is reported that more than 1.1 billion adults are overweight globally. Based on the International Obesity Task Force, at least 155 million children are overweight and obese [2]. Meanwhile, overweight and obesity in early life are being one of the challenges of public health in both developed and developing societies[3]. The available evidence shows that most of the time, obesity in childhood persists into adulthood. The apparent association between obesity and wide ranges of health problems, persistence into adulthood, its interrupting effect on the economy, and increase in the hospital-related costs, are among the primary sources of worry about overweight and obesity in young ages [3, 4]. The importance of imbalance in nutritional behaviors of families and its related obesity is one of the severe problems in the current century. Because of such problems, the World Health Organization (WHO) named the year 2013 as a year of control of obesity in young and adult population[5, 6, 7].

Researchers introduce socioeconomic and geographical location as risk factors of childhood obesity the same as other known factors such as lack of physical activity, unhealthy dietary pattern, type of parenting, family and school conditions[8–11]. Most of the studies conducted in the area of factors associated with overweight and obesity are limited to adults in developed countries. Few studies are available examining simultaneously overweight and obesity among adolescents in different countries taking into account geographical location, cultural conditions, nutritional habits, and attitudes at the individual and national levels. This study aimed to assess the factors affecting overweight and obesity in students aged 11 to 17 years in low-and middle-income countries based on the Global School-based Student Health Survey (GSHS) questionnaire.

Methods

Study population and Sampling Framework

This cross-sectional study was performed using a School-based Student Health Survey questionnaire developed by WHO in collaboration with the United Nations Children's Fund, the United Nations Educational, Scientific and Cultural Organization, and with technical and financial assistance from the United States Centers for Disease Control and Prevention in Atlanta, GA[12]. This study is a collaborative surveillance project designed to help countries measure and assess the behavioral risk factors and protective factors in 10 key areas: alcohol use, dietary behaviors, drug use, hygiene, mental health, physical activity, protective factors, sexual behaviors, tobacco use, and violence and unintentional injury among students aged 11–17 years. All the questionnaires are self-administered.

Quality Control And Quality Assurance:

In this analysis, we pooled data from 82 countries, which have not been included as high-income countries. A two-stage cluster sampling strategy was used to produce a representative sample of the students. The response rate was various between schools (71%-99%) and students (83%-100%). From a total of 82 countries, those with a sample size less than 200, were excluded in the analysis (Antigua, Barbuda,

Botswana, Grenada, Kenya, Niue, Saint Lucia, St. Vincent, and the Grenadines, United Republic of Tanzania (Dar Es Salaam) Zambia, etc.). More details are shown in the appendix file (Table 1).

Table 1
Characteristics of adolescents aged 11 to 17 by overweight and obesity

Variable		Total N (%)	Overweight N (prevalence)	P value
Sex	Boy	90113 (47.96)	21328 (23.67)	< 0.001
	Girl	97780 (52.04)	21892 (22.39)	
Age group	≤ 11 years old	1724 (0.92)	712 (41.30)	< 0.001
	12 years old	11413 (6.07)	3602 (31.56)	
	13 years old	37869 (20.15)	10368 (27.38)	
	14 years old	48646 (25.89)	11294 (23.22)	
	15 years old	45380 (24.15)	9427 (20.77)	
	≥ 16 years old	42861 (22.81)	7817 (18.24)	
Activity	No favorable	123744 (69.57)	28867 (23.33)	0.019
	Favorable	54133 (30.43)	12353 (22.82)	
Brush teeth	No favorable	50632 (29.66)	11069 (21.86)	< 0.001
	Favorable	120101 (70.34)	27832 (23.17)	
Close friend	No	10967 (6.59)	2433 (22.18)	0.007
	Yes	155466 (93.41)	36251 (23.32)	
Cigarette	Never smoked	117381 (75.90)	25801 (21.98)	< 0.001
	Smoked	37275 (24.10)	8985 (24.10)	
Fast food	No favorable	19262 (13.37)	4737 (24.59)	0.107
	Favorable	124775 (86.63)	30019 (24.06)	
Fruit	No favorable	115728 (62.00)	25621 (22.14)	< 0.001
	Favorable	70921 (38.00)	17287 (24.38)	
SHS exposure	No favorable	90906 (55.81)	20684 (22.75)	0.005
	Favorable	71989 (44.19)	15955 (22.16)	
Soft drink	No favorable	39815 (27.65)	10360 (26.02)	< 0.001
	Favorable	104179 (72.35)	24354 (23.38)	
Times spent sitting	No favorable	64831 (36.79)	16307 (25.15)	< 0.001
	Favorable	111366 (63.21)	24406 (21.92)	
Use soap	No favorable	47753 (28.00)	9777 (20.47)	< 0.001
	Favorable	122774 (72.00)	29329 (23.89)	
Vegetable	No favorable	146211 (78.39)	33477 (22.90)	0.127
	Favorable	40309 (21.61)	9375 (23.26)	
Wash hand before eat	No favorable	35674 (20.95)	8768 (24.58)	< 0.001
	Favorable	134622 (79.05)	30300 (22.51)	
Wash hand after toilet	No favorable	23388 (13.73)	4975 (21.27)	< 0.001
	Favorable	146946 (86.27)	34111 (23.21)	

Measurements

To the estimation of overweight and obesity between the students, students were classified into three classes: overweight, normal-weight, and underweight based on length/height, weight, and age according to WHO Child Growth Standards [13]. underweight students were excluded from the analysis. Individual variables at level-1 are classified at the general five classes such as demographic factors, physical activity factors, and diet habits. Country variables at level-2 were nested and included Gross domestic product (GDP) per capita based on purchasing power parity (PPP), Gini Index, Percentage of adults defined as obese, Maternal mortality ratio (MMR), Prevalence of overweight among adults, weight for height (% of children under 5), Sustainable Development Goals (SDGs) Index. More details about country variables and individual variables are shown in appendix files Tables 1 & 2, respectively.

Table 2
Two-level random intercept logistic regression for modeling of overweight between 187893 participants

Level	Variable		prevalence (min - max)	Ecological correlation*	Rescaled tau^2	tau^2	Model 0	Model 1	Model 2
Individuals	Sex (ref: Male)	Female	51.13 (24.80–61.30)	-0.02	0.43	0.49		0.85 (0.82–0.88)[a]	0.85 (0.82–0.88)[a]
	Age group (ref:≤ 11 years old)	12 years old	6.35 (0.03–23.30)	-0.10	0.46	0.53		0.55 (0.46–0.67)[a]	0.55 (0.46–0.67)[a]
		13 years old	20.33 (0.20–46.6)					0.46 (0.38–0.55)[a]	0.46 (0.38–0.55)[a]
		14 years old	26.31 (2.22–41.40)					0.38 (0.31–0.46)[a]	0.38 (0.31–0.46)[a]
		15 years old	24.11 (6.40–37.50)					0.33 (0.28–0.40)[a]	0.33 (0.28–0.40)[a]
		≥ 16 years old	21.73 (1.20–88.40)					0.31 (0.26–0.38)[a]	0.31 (0.26–0.38)[a]
	Activity (ref: Favorable)	Unfavorable	70.42 (51.81–100)	-0.04	0.44	0.50		1.03 (1.00-1.05)[a]	1.03 (1.00-1.05)[a]
	Times spent sitting (ref: Favorable)	Unfavorable	36.36 (0.00-65.56)	0.47	0.58	0.70		1.19 (1.17–1.22)[c]	1.17 (1.18–1.22)[c]
	Brush teeth (ref :Favorable)	Unfavorable	30.81 (6.94–81.78)	-0.21	0.47	0.55		0.92(0.90–0.95)[a]	0.92 (0.88–0.95)[a]
	Fruit (ref:Favorable)	Unfavorable	62.44 (40.64–82.52)	-0.07	0.57	0.69		0.88 (0.86–0.90)[a]	0.85 (0.82–0.98)[a]
	Vegetable (ref: Favorable)	Unfavorable	78.71 (56.28–91.10)	0.05	0.57	0.69		0.97 (0.95-1.00)	0.99 (0.97–1.04)
	Soft drink (ref :Favorable)	Unfavorable	78.71 (41.11–93.39)	0.50	0.58	0.70		1.15 (1.12–1.18)[b]	1.13 (1.11–1.20)[b]
	Fast food (ref: Favorable)	Unfavorable	86.55 (51.60–96.70)	0.50	0.57	0.69		1.02 (0.99–1.07)[a]	1.05 (0.98–1.20)[a]
	Use soap (ref: Favorable)	Unfavorable	71.92 (26.08–94.36)	-0.20	0.57	0.69		0.82 (0.79–0.84)[a]	0.85 (0.78–0.91)[a]
	Wash hand before eat (ref: Favorable)	Unfavorable	21.16 (6.63–38.91)	0.52	0.58	0.70		1.12 (1.09–1.15)	1.03 (1.01–1.07)

[a] $p \leq 0.001$, [b] $p \leq 0.01$, [c] $p \leq 0.0$

Level	Variable		prevalence (min - max)	Ecological correlation*	Rescaled tau^2	tau^2	Model 0	Model 1	Model 2
	Wash hand after toilet (ref: Favorable)	Unfavorable	14.11 (3.92–38.90)	0.02	0.58	0.70		0.89 (0.86–0.92)[a]	0.90 (0.88–0.95)[a]
	Close friend (ref :no)	Yes	93.03 (82.80–98.50)	-0.01	0.50	0.59		0.93 (0.89–0.98)	0.98 (0.89–0.93)
	Cigarette (ref: no)	Yes	23.82 (2.59–50.18)	-0.47	0.53	0.64		0.89 (0.86–0.91)	0.87 (0.83–0.90)
	SHS exposure (ref: no)	Yes	45.01 (15.70-83.59)	0.25	0.57	0.69		1.03(1.01–1.05)	1.03 (1.01–1.05)
Countries	**GDP (PPP)**								1.00 (1.00–1.00)
	Gini Index								1.03 (1.00-1.05)[c]
	MMR								1.00 (0.99-1.00)
	Obese adults								1.06 (1.04–1.07)[a]
	Overweight under 5years								1.01 (0.97–1.05)
	SDGs Index								1.00 (0.99–1.01)
Goodness of fit index	**AIC**						191047.60	102377.80	102342.60
	BIC						191067.90	102596.60	102618.50
	ICC (%)						14.00	16.00	4.00
	Tau-intercept						0.52	0.63	0.15
	Likelihood- Ratio test							**47.19[a]**	

[a] $p \leq 0.001$, [b] $p \leq 0.01$, [c] $p \leq 0.0$

The Multilevel Logistic Regression Model

To the modeling of associated factors with overweight (normal or overweight), logistic regression is a natural choice for modeling. The structure of GSHS data is hierarchical, and a sample can be viewed as a multistage sample. For multistage-clustered samples, the dependence among observations often comes from several levels of the hierarchy. In this case, the use of single-level logistic regression is not valid and reasonable. In contrast, multilevel logistic regression is applicable and can draw appropriate inferences. Within this study, the units at a lower level (level-1) are individuals who are nested within units at a higher level (countries: level-2). Moreover, single-level logistic regression (traditional) has assumptions such as uncorrelated residual errors. The assumptions are not always met when analyzing nested data. In this situation, traditional logistic regression decreased the effective sample size and increased type one error. But the multilevel logistic regression considers the variations due to hierarchy structure in GSHS data and therefore, the two-level mixed-effects logistic model with random intercept was used for modeling of GSHS data. Random intercept two-level logistic model introduces only one random parameter for the entire population of countries and allows the simultaneous estimation of measures of the association at different levels

of the data hierarchy (e.g., individuals and countries). All of the parameters in the model were estimated by the Marginal Quasi Likelihood (MQL) method:

$$\text{logit}(\Pr(Y_{ij} = 1)) = \alpha_0 + \alpha_{0j} + \alpha_1 x_{1ij} + \cdots + \alpha_k x_{kij} + \beta_1 z_{1j} + \cdots + \beta_m z_{mj}$$
$$\alpha_{0j} \sim N(0, \tau^2)$$

$$i = 1,2,\ldots,258159; j = 1,2,\ldots,73; m = 1,2,\ldots, total\ number\ of\ explanatory\ variables$$

Statistical Analysis

Continuous variables are presented as mean ± standard deviation, and categorical variables are presented as N (%). Univariate and multivariable random intercept multilevel logistic regression were used to examine the effects of associated factors on overweight. The univariate association between each of the risk factors and overweight and obesity was assessed by the chi-square test. Moreover, the odds ratio (OR) as the effect size with 95% confidence intervals (95% CI) was calculated. Interclass Correlation Coefficient (ICC) for a multi-level logistic regression model was calculated. The goodness of fit of the models was assessed by the Akaike information criterion (AIC) and Bayesian information criterion (BIC). All data were analyzed using STATA version 14.2 (College Station, Texas 77845 USA). A two-sided P-value less than 0.05 was considered statistically significant.

Results

For this study, 258159 students aged 11–17 years from 73 countries were included in the study. The response rate of the students was 72.7 %: the lowest response rate was 17.98 % in Senegal, and the highest response rate was 93.36 % in Chile. From 187893 students who completed the survey, 43220 (23%) had overweight. From 21328 and 21892 boys and girls, the prevalence of overweight and obesity was 23.67% and 22.39%, respectively (*P-value < 0.001*). The characteristics of the participants at the individual level were shown in Table 1. There was a significant negative correlation between overweight and obesity prevalence and age (*P-value < 0.001*). Besides, the proportion of overweight students among those who had close friends or smoked cigarettes or brushing teeth or consume more fruit, or exposed to SHS(second-hand smoking) was more (Table 1).

Among the countries, the maximum prevalence of overweight was observed in Samoa, Kuwait, Tuvalu, and the minimum prevalence of overweight was observed in Myanmar, Namibia, Pakistan (Appendix file Table 1).

Two-level random intercept logistic regression for modeling of overweight and obesity

Table 2 consisted null model (model without any individual/or country variables), the individual-level model, and the country-level model indicated as models 0 to 2, respectively. Intraclass correlation coefficient (ICC) was 14% (null model), 16% (individual-level model) and 4% (country-level model). Based on the ICC values for the individual-level model and country-level model, there is variability between the students but there is a little variability between the countries. Akaike information criterion (AIC) for the country-level model as the best model was the lowest compared with other models. According to the individual-level model (model 1), the odds of overweight among girls were less than boys (OR = 0.85, 95% CI: 0.82–0.88) and the odds of overweight were decreased in the upper age categories (*P-values < 0.001*).

The odds of Obesity and overweight in students who drink more soft drink were more than the student who drink adequate soft drink (OR = 1.13, 95% CI: 1.11–1.20). Besides, the odds of overweight in the students who had favorable activities and favorable teeth brushing were 9% higher than their counterparts. Washing hands before eat and after the toilet increased the odds of overweight in the students.

Using the variables of the country-level in model 2, there were no significant changes in the association between individual-level variables and overweight. Among six country-level variables, obese adults and the Gini index had increased the likelihood of overweight (Table 2). According to the likelihood- ratio test for comparison of the goodness of fit between the models, the country-level model had the best fitting compared to the individual-level model (LRT = 47.19, P-value < 0.001).

Discussion

The WHO defines obesity as one of the most important and widely spreading non-communicable diseases, accounting for about 10 to 20 percent of the country's health costs, directly and indirectly, each year. [14, 15]. In fact, in the absence of prevention and control of overweight

and premature obesity in adolescence, this condition will be accompanied by cardiovascular diseases and other non-communicable diseases in adulthood. Besides, the adolescences will be prone to type 2 diabetes, stroke, and high lipid profile. [15,16].

While in very less developed countries such as Samoa and Tuvalu, higher use of imported canned meat which has convenient and cheaper accessibility, are one of the possible cause of the prevalence of obesity [17]. Overall, based on the findings of this study and other reports from elsewhere, the prevalence of obesity in the South Pacific is more than the rest of the world [18].

As age increased, the prevalence of overweight decreased, with the highest prevalence of overweight in students under the age of 11 years. [19]. Evidence suggests that overweight and obesity in adolescents are associated with feelings of embarrassment and, consequently, reduce self-esteem [20]. Therefore, the possible causes of such a negative association between overweight and age may be attributed to the higher awareness among older adolescents regarding the disadvantages of overweight and their attitude to a better physical image during puberty [21].

In most studies, the proportion of overweight was higher in boys than in girls [22–26], which was consistent with the present study. [27–29]. In a study among African black teenage girls, two-thirds of them considered overweight as a sign of happiness and wealth and believed that obesity was more socially acceptable [30]

The findings of this study showed that the use of soft drinks in children aged 11 to 17 years old increases the odds of obesity, which is consistent with studies conducted in this area [31–36]. Soft drinks, in two ways, increase the odds of being overweight: one due to having sugar, which is high in calories, resulting in obesity and overweight; and the other, in children who consume a lot of soft drinks, the consumption of fruits and vegetables and dairy products decreases [37]. Therefore, excessive consumption of soft beverages in children and adolescents may have additional effects on the occurrence of other morbidities such as type 2 diabetes, osteoporosis, and calcium deficiency, and cardiovascular disease in adulthood. Therefore, there should be a way to stop drinking soft beverages in children and adolescents. In England, a program to reduce the use of soft drinks [33], Many studies have shown that fast food consumption is associated with adolescents overweight [38–40]. In a single-variable study, the odds of overweight students who consume excessive fast food were higher than those who did not consume at all. However, after adjusting other influential factors, the odds of overweight in students who consume less fast food were higher than those who consumed more fast food, although not statistically significant. Previous studies have shown that overweight participants tend to report less than what they eat [41,42]. A study in Boston and Mass, between July 2002 and March 2003, found that it is likely that the adolescent participants with a healthy weight underreport the consumption of fast food and this causes the contradiction [42].

There was a reverse relationship between the high consumption of vegetables and the odds of overweight, although it was not statistically significant. In most studies, there is an inverse relationship between high consumption of vegetables and overweight, but there are conflicting results[43]. In general, replacing vegetables rather than using ready-made foods can lead to a decrease in overweight. [44].

The trend towards idle hobbies, long hours watching TV, as well as computer games, has slowed down the lifestyle of today. Our study showed that doing long sit-in activities would increase about a 19 percent chance of overweight and obesity in students, consistent with similar studies[45]. Therefore, to overcome the overwhelming growth of obesity, students need to make fundamental changes in their behavior. Encouraging children to participate in sport classes and the preparation and availability of healthy food for them can play a crucial role in having healthy children in the future.

Another influential factor in weight loss was hand washing after the toilet. According to the Centers for Disease Control and Prevention (CDC), hand washing is the most essential way to prevent the spread of infection[46]. Probably, because students who wash their hands after using the toilet are less likely to suffer from diarrhea, such as bloody diarrhea, hepatitis A, salmonella, etc., such a group of students is less likely to lose their weight because of such diseases.

Our study showed that increasing the Gini index at the national level, increased the odds of obesity among students by 1.03 times, which was similar to other studies[47]. It is likely that a decrease in the Gini index and, consequently, nutritional insecurity, and the inappropriate diet in very less developed countries, will increase obesity.

Another factor that increased the chance of obesity in adolescents was obese adults. Perhaps, lifestyle along with obese adults and patterns of malnutrition are the reason to increase the prevalence of obesity among students. Researchers believe that, Obesity is more likely in adolescents who have even one obese parent[48].

Weaknesses And Strengths:

The present study has positive features, including a large sample size, the examination of the more influential factors at both individual and country-Besides based on a standard questionnaire. On the other hand, this study had limitations that need to be addressed. Because the information has been obtained by adolescents from a completed self-reporting questionnaire, they may have underreported the consumption of herbs and fruits and over-report the amount of physical activity, which can be due to several reasons such as: feeling ashamed or embarrassed or concealment of some facts about their nutritional status. The response rate was close to 70%, which reduces the universality of the study, and we cannot generalize the study result in all six regions.

Conclusion

our study showed that fast food and vegetable(if the consumption of fruits and vegetables replace the other food groups) use does not cause obesity. At the individual health level, students who brush their teeth, wash their hands after toilets and use soap have a higher chance of obesity. Indicators such as the Gini index and obese adults, also play an important role in increasing the overweight in students at the national level. Since the problems of different countries are different, in order to eliminate this dilemma in any society, special plans are required in those countries.

It is advisable to provide information about nutrition and healthy life for the family and students. Future studies should address the design of interventional studies concerning the variables that affect individuals, groups and societies, in order to help policymakers in planning and to legislate to control overweight and obesity in adolescents. Losing weight and preventing weight gain should be included in the list of severe country commitments.

Abbreviations

World Health Organization (WHO)

Global School-based Student Health Survey (GSHS)

Gross domestic product (GDP)

purchasing power parity (PPP)

Sustainable Development Goals (SDGs)

Marginal Quasi Likelihood (MQL)

odds ratio (OR)

Interclass Correlation Coefficient (ICC)

Bayesian information criterion (BIC)

Akaike information criterion (AIC)

Disease Control and Prevention (CDC)

Declarations

• **Ethics approval and consent to participate**: spiritual of Research and Technology at the of Kermanshah University of Medical Science

• **Consent for publication: not applicable**

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