Geographic risk of general and abdominal obesity and related determinants in Iranian children and adolescents: CASPIAN-IV Study

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Abstract

Background: Obesity, as a risk factor for many noncommunicable diseases, is a common public health problem in developed and developing countries. Among Iranian children and adolescents, the prevalence of being overweight has increased by almost 50% in the past two decades.

Aims: To visualize the geographic differences in general and abdominal obesity risks and related determinants among Iranian children and adolescents.

Methods: Participants consisted of 14 880 students, aged 7–19 years, living in urban and rural areas of the Islamic Republic of Iran. Spatial patterns of obesity and its association with related risk factors were identified using Bayesian spatial modeling.

Results: The highest spatial risks of general obesity (odds ratio 1.21–1.66 for males and 1.81–2.02 for females) and abdominal obesity (odds ratio 1.20–1.82 for males and 1.25–1.78 for females) were observed in the north, northwest and southwest of the country. Risk of obesity was significantly higher in areas with a higher rate of urban residence, active current smokers and prolonged screen time.

Conclusion: Identification of high-risk regions for obesity and spatially related risk factors can be used as informative tools for decision-making and planning in health systems at national and subnational levels.

Keywords: geographical mapping, obesity, paediatrics, risk factors, spatial modelling

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Introduction

Obesity, as a risk factor for many noncommunicable diseases, is a common public health problem in developed and developing countries. It has several adverse consequences on different body organs (*1*). Obesity is one of the most complex clinical disorders in the paediatric age group (*2*, *3*). Among Iranian children and adolescents, the prevalence of being overweight has increased by almost 50% in the past two decades. In 2011, 11.9% of Iranian children and adolescents had general obesity and 19.1% had abdominal obesity (*4*).

Most studies about obesity have focused on determinants of obesity at the individual level. For example, any association of obesity with socioeconomics and lifestyle-related variables has been investigated in different populations (*9*–*11*). However, it would be useful to recognize how these factors contribute to geographic variations. Some recent studies have investigated the association and geographic clustering of obesity risk factors (*12*–*16*). For instance, spatial clustering of obesity and moderate physical activity attributes have been investigated at regional levels without considering the relevant determinants (*14*). In one study, spatial clustering of cardiovascular risk factors revealed a significant correlation between high-body mass index (BMI) clusters and low socioeconomic status (SES) of the surrounding community, as well as between elevated BMI and high frequency of smoking in the clustered region (*13*).

A global overview of obesity indicates a large geographic variation in the prevalence rates (*17*); therefore, knowledge of changes in distribution of obesity helps to identify populations at risk of future noncommunicable diseases. However, few studies have assessed the geographic distribution of general and abdominal obesity (*18*). BMI has been used frequently in clinical settings and population studies in order to assess obesity. BMI is imprecise, but useful for measuring overall adiposity (*5*). It has become evident that body fat distribution is also important in predicting obesity-related health risks. It is well known that abdominal obesity is strongly associated with cardiovascular and metabolic risks (*6*). Abdominal obesity is mainly investigated using waist circumference (WC), waist-to-hip ratio or weight to height ratio (WHtR) (*1*, *5–8*). Whether these measures should be used to assess obesity-related risks is still unclear. Yan et al. reported WHtR as an accurate measurement of obesity (*8*).

To visualize geographic variation in outcome, mapping is most frequently performed, using an ordinary Poisson or logistic model; however, this approach has some disadvantages. This model does not take into account any spatial pattern in outcome; that is, the tendency for geographically close areas to have similar outcome rates (*19*). In this regard, considering prior information on the rates, local geographic dependence could induce the spatial patterns. Hence, Bayesian estimates of the rate in an area is shrunk toward a local mean according to the rates in the neighbouring areas (*20*). Also, in this modelling framework, covariates as spatial risk factors can be accounted for by describing variations of rates between areas. A fully Bayesian approach via Markov Chain Mont Carlo (MCMC) methods is efficient to estimate prevalence rates and risk of obesity and modelling-associated risk factors (*19*,*20*). While the national prevalence rate of different types of obesity is an important tool for policy-makers, investigating the distribution of obesity among geographic areas is equally important for informed decision-making in the allocation of resources for prevention programmes.

The present study aimed to visualize the geographic differences in general and abdominal obesity risk and prevalence rates, and to determine, using spatial modelling, some environmental and socioeconomic risk factors in a large sample of 7–19-year-old children and adolescents in the Islamic Republic of Iran. The maps of general and abdominal obesity were extracted from smoothed spatial odds ratios (ORs), representing spatial obesity risk in different areas of the country, adjusted by local autocorrelation and uncorrelated heterogeneity.

To the best of our knowledge, this is the first and largest epidemiological study in the Middle East and North Africa, examining the geographic variation at the provincial level, concerning the prevalence rate of general and abdominal obesity in a nationally representative sample of children and adolescents.

Methods

Study population and sampling

This study was conducted in 2011 and 2012 as part of a national school-based project entitled Childhood and Adolescence Surveillance and Prevention of Adult Non-Communicable Disease (CASPIAN-IV) in urban and rural areas in different Iranian provinces. The study population consisted of 14 880 school students aged 7–19 years. Data were collected in a multistage sampling framework in 30 provinces. Stratification was carried out in each province, according to the area of residence (urban/rural) and school grade (elementary/intermediate/high school). The study protocol was approved by the Ethics Committee of Tehran University of Medical Sciences and Isfahan University of Medical Sciences. After a complete explanation of the study objectives and protocols, written informed consent and verbal consent were obtained from the parents and students, respectively. More details can be found elsewhere (*4*).

Anthropometric measurements

In the CASPIAN-IV study, all anthropometric measures were obtained under standard protocols, using calibrated instruments. Body weight was measured in light clothing to the nearest 0.1 kg, and height was recorded barefoot, to the nearest 0.1 cm. BMI was calculated as a measure of obesity. WC was measured using a nonelastic tape to the nearest 0.1 cm, at a point midway between the lower border of the rib cage and the iliac crest at the end of normal expiration. The World Health Organization (WHO) growth charts categorize BMI, based on obese and nonobese groups (*21*). Abdominal obesity was also determined as WHtR > 0.5 (*22*).

Covariates assessment

Students' information was collected through the students' healthcare system. The questionnaires were prepared according to the WHO Global School-based Student Health Survey (WHO-GSHS). The validity and reliability of the questionnaire had been reported elsewhere (*23*). Students completed the questionnaire under the supervision of healthcare experts. Information was entered into a checklist by a trained team. The student' parents answered part of the questionnaire.

Screen time (ST), defined as the hours spent per day at weekends and weekdays in watching television and using computers, was assessed by the WHO-GSHS questionnaire. The weighted average of ST in a day was obtained by calculating the sum of $1/7 \times$ ST on a weekend day and $6/7 \times$ ST on a weekday. This weighted average was divided into quartiles, and the fourth quartile, 4 hours/day, was considered as prolonged ST.

SES was calculated through an approved method in the International Reading Literacy Study (PIRLS) (*24*). The SES score was calculated, using the principal component analysis (PCA) method based on a questionnaire; asking parents about their level of education and occupation, type of school (private or public), type of home (rented or owned), and family assets (private car and computer). The first tertile of SES score was considered low.

Physical activity was assessed by 3 self-report questions. (1) During the past week, how many days have you been physically active, for 30 minutes/day? (2) Do you have regular sports classes at school? (3) How much time do you spend on regular sports classes at school every week? A total physical activity score was extracted by PCA. The first tertile was considered to be low physical activity (*25*). Current smoking status of children and adolescents was also considered as a covariate.

Statistical analysis

The percentage of obesity and its determinants were calculated and compared between the sexes. Due to significant differences between males and females, subsequent analyses were carried out by sex using the χ^2 test. To visualize spatial variations in general and abdominal obesity, the Bayesian spatial model represented by Besag, York and Mollie was used to detect the ORs of obesity in 30 provincial clusters, compared with the global odds of the whole country (*19*,*20*).

The estimated ORs implied spatial pattern of obesity risk across the regions. In addition, in this modelling approach, the risk factors associated with provincial prevalence rate of general and abdominal obesity were investigated spatially.

The model was fitted using OpenBUGS version 3.2.2 (MRC Biostatistics Unit, Cambridge, United Kingdom of Great Britain and Northern Ireland). In performing the MCMC algorithm, each parameter was observed to converge within 50 000 iterations of Gibbs sampler, so after discarding the initial 50 000 burn-in values, an additional 20 000 samples were generated for the Bayesian inference, by choosing the 10th iteration to avoid possible autocorrelation. The convergence of model parameters was, moreover, evaluated by tracing and autocorrelation plots, and Gelman–Rubin criterion. Estimated ORs and 95% confidence intervals (CIs) for general and abdominal obesity were calculated and shown through geographic maps, using the map option in GeoBUGS. Statistical significance was indicated when 95% CIs did not include 0.

Results

Table 1 shows the prevalence of obesity and related risk factors in the Islamic Republic of Iran by sex. The rate of general and abdominal obesity in males was 10 and 14%, respectively, which was significantly lower than the corresponding rate in females (18% and 20%, respectively). The rate of obesity-related risk factors, including current smoker and prolonged ST, were significantly higher in males than females ($P < 0.05$). In contrast, physical activity rate in females was significantly less than in males ($P < 0.05$).

Figure 1 depicts spatial distribution of selected obesity risk factors across the Islamic Republic of Iran. Urban residence was the dominant lifestyle in most provinces. Central provinces, including the capital, compared to other areas, had the highest rates of low physical activity, prolonged ST, current smokers and higher SES.

For evaluating the association of obesity-related risk factors and prevalence rates of obesity in different geographic areas, the Bayesian spatial regression was used (Table 2). According to 95% CIs, in provinces with significantly higher rates of obesity (general and abdominal), there was a higher rate of urban residence. Urban residence had a stronger impact on the occurrence of general obesity in females. Low physical activity did not show a significant association with any type of obesity. Furthermore, there was no significant association between high SES and obesity. Abdominal and general obesity rates in males had a direct significant association with prolonged ST. Those provinces with higher rates of active current smokers had significantly higher rates of male abdominal obesity.

To obtain a geographic map of obesity, a mixed conditional autoregressive model was considered, without using covariates. Figures 2 and 3 show the variation in ORs of general and abdominal obesity in different provinces for males and females. The spatial ORs were smoothed for spatial autocorrelation and unstructured over dispersion. Spatial risk of abdominal and general obesity is geographically varied and there were sex differences in the distribution of general and abdominal obesity.

The geographic variation of ORs denoted that the risk of general obesity for males and females was higher in the north, northwest, and southwest Iranian provinces, compared with the whole country. The provinces with the highest ORs for males were Gilan (1.66), Mazandaran (1.63), East Azerbaijan (1.54), Qazvin (1.56), Tehran (1.21), Qom (1.48) and Bushehr (1.29). The provinces with the highest ORs for females were Ardebil (1.81), East Azerbaijan (1.31), Gilan (1.66), Mazandaran (1.70), Kermanshah (1.32), Bushehr (2.02) and Khuzestan (1.50). The south and southeast provinces had the lowest ORs for general obesity in both male and female groups.

The risk of abdominal obesity was also higher for females and males in the north, northwest and southwest Iranian provinces, compared with the whole country. The highest ORs for abdominal obesity for males were in Ardebil (1.82), East Azerbaijan (1.44), Isfahan (1.39), Gilan (1.59), Hamedan (1.27), Kermanshah (1.20), North Khorasan (1.34), Markazi (1.30), Mazandaran (1.83), Semnan (1.25) and Qazvin (1.33). In females, the highest ORs occurred in Ardebil (1.52), East Azerbaijan (1.36), Qazvin (1.37), Kermanshah (1.25), Gilan (1.28), Golestan (1.42), Mazandaran (1.78), Tehran (1.46) and Bushehr (1.33).

Discussion

In this large epidemiological study based on a representative sample of children and adolescents aged 7–19 years in the Islamic Republic of Iran, we investigated using the Bayesian spatial model the geographic variation at the provincial level of the rate of general and abdominal obesity. The maps were extracted from smoothed spatial ORs, representing the risk of obesity in different regions according to local autocorrelation and uncorrelated heterogeneity. Both types of obesity had a large geographic variation. The higher risks of general and abdominal obesity were found in the north, northwest and southwest regions. Possible explanations for this variation are: (1) differences in subjects' characteristics, such as dominant lifestyle behaviour, eating habits or dietary patterns, and SES; (2) dissimilarities in healthcare accessibility of different provinces; and (3) differences in health policy-making by authorities who support a healthy lifestyle.

The rate of abdominal obesity was higher than general obesity. The overall rates of both types of obesity were higher in males than females, which is in line with CASPIAN-IV data from 2003 (*26*), although the distribution of general and abdominal obesity in males and females differed throughout the country.

The Bayesian spatial regression model was used to model the provincial level determinants of obesity in 30 provinces. The risk factors included urban residence, low physical activity, active current smokers, low SES and prolonged ST. A few studies have investigated the determinants of geographic obesity variation (*12–15*). The current study showed no significant relationship between the rate of low physical activity in different areas and obesity, which is in line with the study of Schuurman et al. in Vancouver, Canada (*14*). They found no significant clustering, based on obesity and physical activity association. However, in contrast to the data obtained by Ford et al. (*27*) about adults' obesity-related determinants, in 100 metropolitan areas in the United States of America, we found a significant association between physical activity and obesity rate, using Poisson regression. This discordance might be due to a different age range of their target population and the statistical methods, compared to ours.

The effect of urban residence on obesity has been investigated in some recent national studies in the Islamic Republic of Iran, for age 7–19 years (*11*,*26*,*28*). Our results identified the spatially direct association between urban residence and obesity in females. Provinces with more urban residents had significantly higher rates of obesity. Qom, a province in the centre of the country, had the highest number of urban residents, while Hormozgan, in the south, had the lowest number.

Smoking is recognized as a critical risk factor for obesity (*28*,*29*). Our results demonstrated that abdominal obesity in females was significantly more prevalent in provinces with higher rates of active current smokers. This is in agreement with Chiolero et al. (*29*) but in contrast with Bakhshi et al. (*28*). Tehran, the capital, had the highest rate of female current smokers.

In line with previous studies (*9*,*10*), our results revealed that prolonged ST was significantly associated with higher rates of abdominal and general obesity among males. The ethnicity of individuals in this study has been considered, as a part of geographic variations that substantially are latent in spatially random parts of the model. One study of Iranian school children indicated that residents of Baluch ethnicity in the southeast had the lowest BMI, whereas residents of Turk ethnicity in the northwest had the highest BMI, among male children. Moreover, Arab female residents in the southwest had the highest BMI (*30*), which is in line with our extracted maps, based on estimated obesity rates.

One of the limitations of the current spatial epidemiological study was the occurrence of confounding bias, which is a common feature in epidemiological studies. For example, socioeconomic factors are strong predictors of the majority of health outcomes, but when exposed to some environmental factors, the confounding impact occurs. Lack of many other determinants of obesity, such as major nutritional habits was another limitation that could be considered in future investigations. Our results were based on information from 30 provinces, in which Alborz was considered as part of Tehran; however, in the latest country divisions, Alborz was separated from Tehran and there are now 31 provinces. The main advantages of the current study were using data from a large population-based survey and providing up-to-date estimates of rates of general and abdominal obesity in 30 Iranian provinces. Longitudinal studies are suggested for determining the trends in general and abdominal obesity, and examining precise determinants that can be useful for health policy-makers.

Conclusion

We estimated the rates of abdominal and general obesity, and specified the local risk of obesity across Iranian provinces, using a spatial Bayesian model that considered spatial autocorrelation and heterogeneity. In the same modelling framework, we evaluated the spatial impact of obesity risk factors. Indeed, environmental and lifestyle-related risk factors, including urban residence, current smoking and prolonged ST were spatially associated with increased risk of obesity in children and adolescents aged 7–19 years. As a result, the spatial Bayesian regression model could be effectively used to identify spatial risk factors and spatial patterns of obesity. The geographic mapping of high-risk regions for general and abdominal obesity presented could be useful for decision-making and planning in health systems. A high incidence rate of obesity-related disorders is expected in the future, imposing a considerable economic burden on the health system; therefore, identifying high-risk regions, spatial pattern of obesity and the spatial risk factors could be applied to epidemiological prediction and optimal allocation of health resources among different regions.

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References

1. Kelishadi R. Childhood overweight, obesity, and the metabolic syndrome in developing countries. Epidemiol Rev. 2007;29:62–76. http://dx.doi.org/10.1093/epirev/mxm003 PMID: 1747844
2. Hruby A, Hu FB. The Epidemiology of Obesity: A Big Picture. Pharmacoeconomics. 2015 Jul;33(7):673–89. http://dx.doi.org/10.1007/s40273-014-0243-x PMID:25471927
3. Hu F. Obesity epidemiology. Oxford: Oxford University Press; 2008.
4. Kelishadi R, Ardalan G, Qorbani M, Ataie-Jafari A, Bahreynian M, Taslimi M, et al. Methodology and early findings of the Fourth Survey of Childhood and Adolescence Surveillance and Prevention of Adult Non-Communicable Disease in Iran: the CASPIAN-IV Study. Int J Prev Med. 2013 Dec;4(12):1451–60. PMID:24498502
5. Revicki DA, Israel RG. Relationship between body mass indices and measures of body adiposity. Am J Public Health. 1986 Aug;76(8):992–4. http://dx.doi.org/10.2105/ajph.76.8.992 PMID:3728773
6. Sadeghi M, Roohafza H, Shirani S, Poormoghadas M, Kelishadi R, Baghaii A, et al. Diabetes and associated cardiovascular risk factors in Iran: the Isfahan Healthy Heart Programme. Ann Acad Med Singapore. 2007 Mar;36(3):175–80. PMID:17450262
7. Wang Z, Hoy WE. Waist circumference, body mass index, hip circumference and waist-to-hip ratio as predictors of cardiovascular disease in Aboriginal people. European journal of clinical nutrition. 2004;58:888-93.10.1038/sj.ejcn.1601891
8. Yan W, Bingxian H, Hua Y, Jianghong D, Jun C, Dongliang G, et al. Waist-to-height ratio is an accurate and easier index for evaluating obesity in children and adolescents. Eur J Clin Nutr. 2004 Jun;58(6):888–93. http://dx.doi.org/10.1038/oby.2007.601 PMID:15164109
9. Epstein LH, Roemmich JN, Robinson JL, Paluch RA, Winiewicz DD, Fuerch JH, et al. A randomized trial of the effects of reducing television viewing and computer use on body mass index in young children. Arch Pediatr Adolesc Med. 2008 Mar;162(3):239–45. http://dx.doi.org/10.1001/archpediatrics.2007.45 PMID:18316661
10. Kelishadi R, Ardalan G, Gheiratmand R, Gouya MM, Razaghi EM, Delavari A, et al. Association of physical activity and dietary behaviours in relation to the body mass index in a national sample of Iranian children and adolescents: CASPIAN Study. Bull World Health Organ. 2007 Jan;85(1):19–26. http://dx.doi.org/10.2471/blt.06.030783 PMID:17242754

11. Kelishadi R, Alikhani S, Delavari A, Farshid A, Safaie A, Hojatzadeh E. Obesity and associated lifestyle behaviours in Iran: findings from the First National Non-communicable Disease Risk Factor Surveillance Survey. Public Health Nutr. 2008 Mar;11(3):246–51. http://dx.doi.org/10.1017/S1368980007000262 PMID:17625028
12. Hajizadeh M, Campbell M K, Sarma S. Does spatial heterogeneity influence adult obesity in Canada? Spatial Panel Data Analysis. 11th Annual Canadian Health Economists' Study Group Meeting; University of Alberta; 2012.
13. Mobley LR, Finkelstein EA, Khavjou OA, Will JC. Spatial analysis of body mass index and smoking behavior among WISEWOMAN participants. J Womens Health. 2004 Jun;13(5):519–28. http://dx.doi.org/10.1089/1540999041281034 PMID:15266669
14. Schuurman N, Peters PA, Oliver LN. Are obesity and physical activity clustered? A spatial analysis linked to residential density. Obesity. 2009 Dec;17(12):2202–9. http://dx.doi.org/10.1038/oby.2009.119 PMID:19390521
15. Zhou J, Lurie M N, Barnighause T, McGarvey S T, Newell M L, Tanser F. Determinants and spatial patterns of adult overweight and hypertension in a high HIV prevalence rural South African population. Health Place. 2012 Nov;18(6):1300–6 https://doi.org/10.1016/j.healthplace.2012.09.001
16. Mahaki B, Mehrabi Y, Kavousi A, Schmid VJ. A spatio-temporal multivariate shared component model with an application in Iran cancer data. arXiv preprint 2017 Jul 19:170706075. https://arxiv.org/abs/1707.06075
17. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. Geneva: World Health Organization; 2000 (WHO Technical Report Series 894; https://www.who.int/nutrition/publications/obesity/WHO_TRS_894/en/, accessed 26 March 2020).
18. Lahti-Koski M, Taskinen O, Simila M, Mannisto S, Laatikainen T, Knekt P, et al. Mapping geographical variation in obesity in Finland. Eur J Public Health. 2008 Dec;18(6):637–43. doi: 10.1093/eurpub/ckn089 PMID:18854358
19. Mollié A. Bayesian mapping of disease. In: Gilks WR, Richardson S, Spiegelhalter D. Markov Chain Monte Carlo in practice. Chapman & Hall/CRC; 1995:359–79.
20. Besag J, York J, A M. Bayesian image restoration, with two applications in spatial statistics. Ann Inst Stat Math. 1991;43:1–20. https://doi.org/10.1007/BF00116466
21. WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards based on length/height, weight and age. Acta Paediatrica 2006;Suppl. 450:76–85.
22. Li C, Ford ES, Mokdad AH, Cook S. Recent trends in waist circumference and waist-height ratio among US children and adolescents. Pediatrics. 2006 Nov;118(5):e1390–8. http://dx.doi.org/10.1542/peds.2006-1062 PMID:17079540
23. Kelishadi R, Majdzadeh R, Motlagh ME, Heshmat R, Aminaee T, Ardalan G, et al. Development and evaluation of a questionnaire for assessment of determinants of weight

disorders among children and adolescents: the Caspian-IV Study. Int J Prev Med. 2012 Oct;3(10):699–705. PMID:23112896

24. Rideout VJ, Foehr UG, Roberts DF. Generation M^2: media in the lives of 8- to 18-year-olds. Menlo Park, CA: Henry J Kaiser Family Foundation; 2010.

25. Ahadi Z, Qorbani M, Kelishadi R, Ardalan G, Motlagh M, Asayesh H, et al. Association between breakfast intake with anthropometric measurements, blood pressure and food consumption behaviors among Iranian children and adolescents: the CASPIAN-IV study. Public Health. 2015 Jun;129(6):740–7. http://dx.doi.org/10.1016/j.puhe.2015.03.019 PMID:26043966

26. Kelishadi R, Ardalan G, Gheiratmand R, Majdzadeh R, Hosseini M, Gouya MM, et al. Thinness, overweight and obesity in a national sample of Iranian children and adolescents: CASPIAN Study. Child Care Health Dev. 2008 Jan;34(1):44–54. http://dx.doi.org/10.1111/j.1365-2214.2007.00744.x PMID:18171443

27. Ford ES, Mokdad AH, Giles WH, Galuska DA, Serdula MK. Geographic variation in the prevalence of obesity, diabetes, and obesity-related behaviors. Obesity research. 2005 Jan;13(1):118–22. http://dx.doi.org/10.1038/oby.2005.15 PMID:15761170

28. Bakhshi E, Mohammad K, Eshraghian M R, Seifi B. Factors related to obesity among Iranian men: results from the National Health Survey. Public Health Nutr. 2010 Sep;13(9):1389–94. http://dx.doi.org/10.1017/S1368980010000108 PMID:20441659

29. Chiolero A, Faeh D, Paccaud F, Cornuz J. Consequences of smoking for body weight, body fat distribution, and insulin resistance. Am J Clin Nutr 2008 Apr;87(4):801–89. http://dx.doi.org/10.1093/ajcn/87.4.801 PMID:18400700

30. Mirmohammadi J, Hafezi R, Mehrparvar A H, Rezaeian B, Akbari H. Prevalence of overweight and obesity among Iranian school children in different ethnicities. Iran J Pediatr. 2011 Dec;21(4):514–20. PMID 23056841

Table 1. Prevalence rates of obesity and related risk factors in males and females aged 7–19 years: the CASPIAN-IV Study

Risk factors	Female	Male	*P**
General obesity	630(0.10)	859(0.14)	0.043
Abdominal obesity	1105(0.18)	1290(0.20)	0.023
Low physical activity	2440(0.40)	1816(0.29)	0.014
Prolonged ST	931(0.15)	1379(0.22)	<0.001
Current smoking	102(0.02)	231(0.04)	0.034
High socioeconomic status	1867(0.33)	2015(0.34)	0.143

χ^2 test

Table 2. Association of prevalence rates of obesity and risk factors throughout 30 Iranian provinces: the CASPIAN-IV Study

Risk factors	General obesity		Abdominal obesity	
	Male	Female	Male	Female
Living in urban area	1.33* (0.46–2.20)	2.76* (1.65–3.88)	1.34* (0.43–2.26)	1.40* (0.32–2.49)
Low physical activity	1.20 (−5.89 to 8.32)	0.06 (−10.20 to 10.83)	3.01 (−4.42 to 10.29)	2.81 (−5.75 to 11.44)
High socioeconomic status	2.78 (−3.51 to 9.09)	3.41 (−4.88 to 11.46)	5.47 (−0.56 to 11.39)	5.39 (−0.83 to 11.42)
Prolonged ST	10.50* (2.04–18.72)	2.79 (−6.54 to 12.0)	10.12* (1.87–18.45)	6.39 (−0.63 to 13.38)
Current smoking	2.18 (−3.14 to 7.44)	0.73 (−3.71 to 5.12)	6.41* (1.77–11.05)	3.14 (−0.23 to 6.41)

*Regression coefficients and 95% confidence intervals, in Bayesian spatial modelling. * Statistical significance level 0.05.*

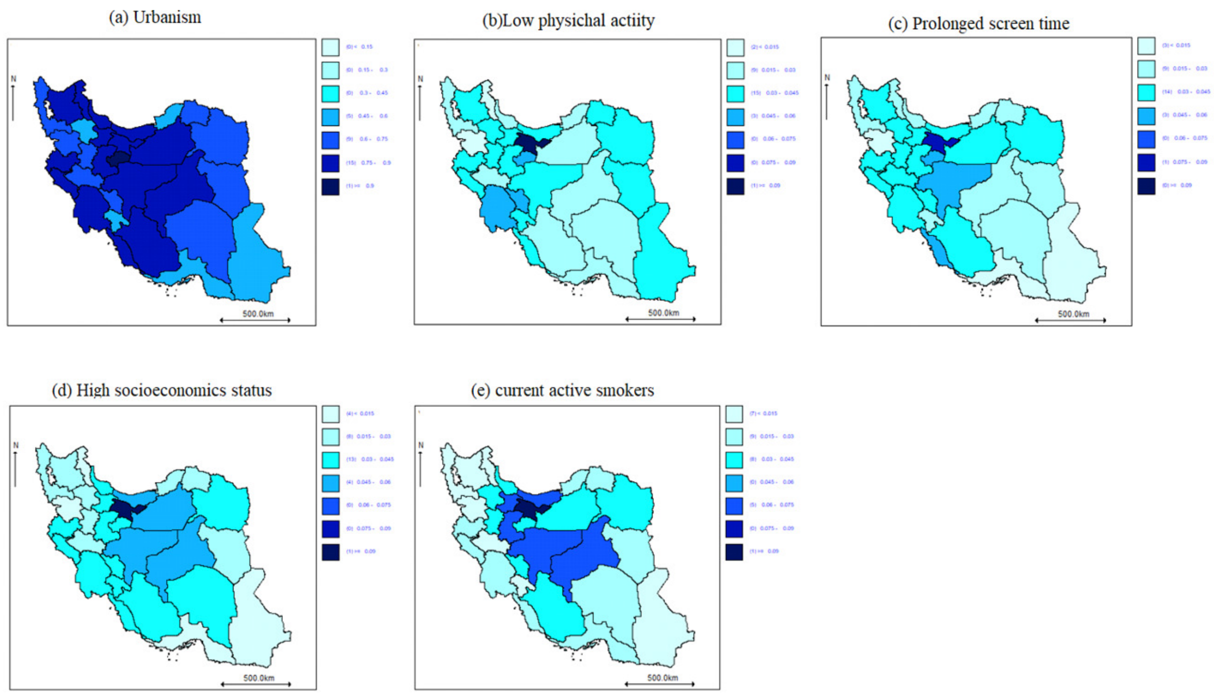

Figure 1. Distribution of selected obesity risk factors at provincial level.

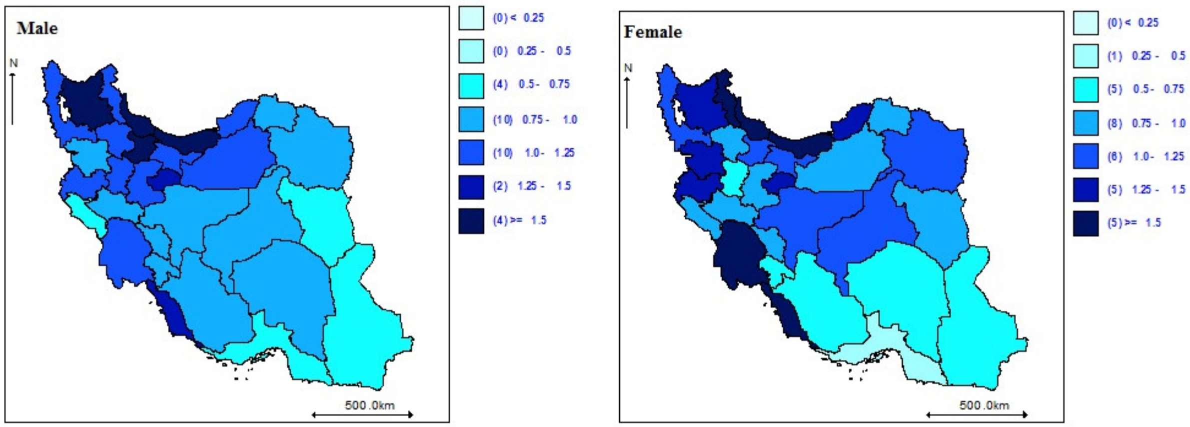

Figure 2. General obesity risks at provincial levels for males and females aged 7–19 years

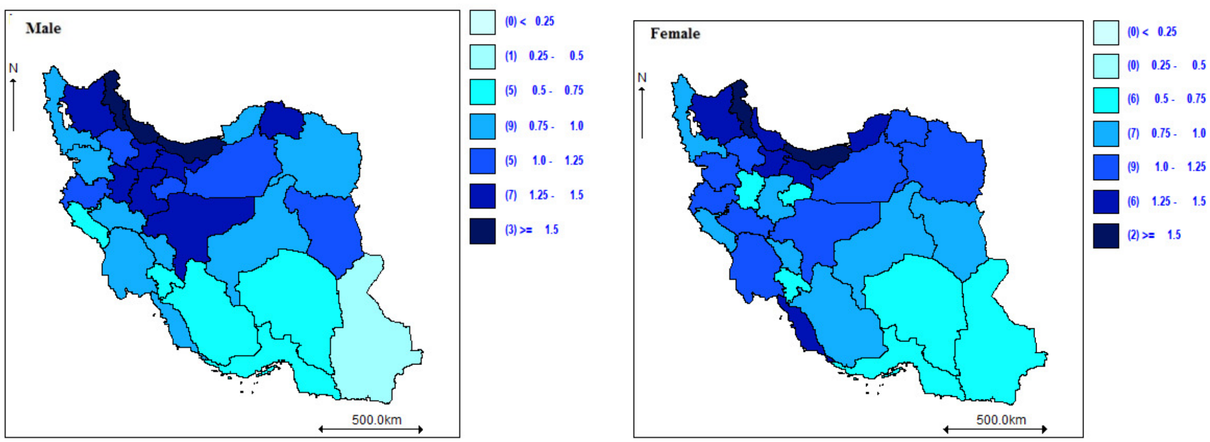

Figure 3. Abdominal obesity risks at provincial levels for males and females aged 7–19 years.