ORIGINAL RESEARCH

Health Consequences of Lake Urmia in Crisis in the Disaster Area: A Pilot Study

Jafar Sadegh Tabrizi, MD, PhD; Mostafa Farahbakhsh, MD; Homayoun Sadeghi-Bazargani, MD, PhD; Hossein Mashhadi Abdolahi, PhD; Zeinab Nikniaz, PhD; Mahdieh Abbasalizad Farhangi, PhD; Leila Nikniaz, PhD

ABSTRACT

Objective: This study investigated the health effects of Lake Urmia's drought on adjacent urban and rural areas and people.

Methods: The data for sociodemographic status, physical activity, dietary pattern, smoking, and angina of the subjects living in areas adjacent to and far from Lake Urmia were collected through validated questionnaires. Physical examinations, including blood pressure, anthropometrics, and biochemical measurements, were performed.

Results: There were no significant differences between 2 areas in the case of age, sex, educational, and physical activity and smoking status ($P > 0.05$). The mean systolic and diastolic blood pressures and the prevalence of hypertension, prehypertension, and anemia in cases living in the adjacent areas were significantly higher than those in the control group ($P < 0.05$). No significant differences were observed between 2 districts in the prevalence of hyperlipidemia, overweight/obesity, asthma, angina, infraction, diabetes, and vitamin D insufficiency/deficiency.

Conclusions: Our data showed that Lake Urmia's drought has serious effects on hypertension and anemia. More longitudinal and well-designed studies are needed to confirm these results.

Key Words: anemia, health, hypertension, Lake Urmia crisis, non-communicable disease

Lake Urmia is located in the northwest of Iran and is the second largest saline lake in the world. Altitude of the lake is about 1276 m, and the salt amount varies from 185 to 220 g/liter. Lake Urmia regulates the temperature and humidity of the district and offers an appropriate place for agricultural activities.

During the last decade, images show a quick and distinct shrinking pattern in the lake area, especially in the eastern and southern parts,[1] and this leads to the appearance of 1800 km^2 salt marsh on the adjacent lands.[2] The main reasons for water surface slump of the lake include excessive groundwater extraction, lack of efficient water management, climate changes, dam constructions, and devoting uncontrolled water sources to agricultural, industrial, and domestic uses.[2,3]

The Lake Urmia drought could result in health, ecological, and social problems. Appearing as a salt desert with a huge area of more than 5000 km^2 and carrying out these salts and chemicals deposited in the lake basin to adjacent areas with wind will impair agricultural lands, pollute the ecosystem, and cause a variety of diseases in adjacent urban and rural areas. The similar procedure occurred in the nearly dried Aral Lake where salt and transformed chemicals caused respiratory diseases, malnutrition, and anemia.[2,4,5] Dried Lake Ebinur in China is another example. It is estimated that 4.8 billion tons of salty dust is being carried from the dried surface of this lake every year.[6] Also, raised dust storms from the basin of Lake Owens in California, United States, contained elements like sodium sulfate, sulfur, arsenic, chrome, cobalt, nickel, lead, and so on, and caused allergy and respiratory diseases, asthma, sinus infection, headache, ear infection, bronchitis, eye pain, sore throat, cough, fatigue, lung cancer, and cardiovascular diseases.[7]

Currently, there are no data available regarding the possible health consequences of Lake Urmia drying. Therefore, this paper investigates the effects of a shrinking Lake Urmia on some health parameters in adjacent urban and rural areas.

METHODS

Patient and Public Involvement

In this population-based cross-sectional study, the age range of the target population was 15 to 64 years. These people were living in urban and regional areas of districts adjacent (Bonab, Oskou, Ilkhichi) to Lake Urmia and districts (Mianeh, Varzegan, Khodafarin) far from (at least 400 km) the lake. This study was conducted by probability proportional to size multistage stratified cluster sampling through which 26 clusters were selected from each region. In this type of sampling, the selection probability for each component is set to be proportional to its size measure. The sampling frame was based on the postal code setting of the national post office, which is updated annually. The clusters were selected in this system based on postal code. Each address in this system was summarized in a 10-digit postal code number. In urban areas, clusters included 1 to several blocks or parts of blocks. Blocks were usually attached buildings. After determining the cluster start point, enrollment and data collection were started. In each cluster, 20 participants (10 male and 10 female) with the age of 15–65 years were enrolled (a total of 1040 participants: adjacent areas [520] and regions far from the Lake [520]). This begins from the household at the cluster start point and continues toward the other houses until the required numbers of participants are enrolled. Consecutive households were selected based on the geographical location of buildings to the right-hand side of each building. Research survey and examination teams visited households according to previously agreed arrangements. The large sample size and the sampling design and framework mean that the sample was representative of the whole study population. In this project, adults ages 15–64 years were included. Adults with severe chronic illnesses requiring bedrest, subjects with communication barriers, and pregnant women were excluded.

All procedures performed in this study were in accordance with the ethical standards of the Ethics Committee of Tabriz University of Medical Sciences, as well as the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Also, an informed consent letter was obtained from all individual participants included in the study.

Data were collected based on interviews, physical assessments, and anthropometric and biochemical measurements by a team of health experts.

Sociodemographic Status

This questionnaire included questions concerning the sociodemographic characteristics such as age, gender, educational level, marriage status, employment status, family size, and residential area.

Angina

The history of any chest pain was assessed using the Persian translated Rose questionnaire. Rose angina had been designed for participants who had chest pain during exertion. Rose questionnaire data were interpreted according to previously published guidelines.[8]

Cigarette Smoking Status

Different categories of cigarette smoking status were defined according to WHO advice.[9] A person who "smokes cigarettes at least once a day" is defined as a daily smoker; "who smokes cigarettes but not every day" is known as an occasional smoker; an ex-smoker is defined as somebody who "formerly smoked daily or occasionally but is not a smoker now"; and a nonsmoker is defined as somebody who "is not smoking now and has never smoked in the past."

Physical Activity Levels

The International Physical Activity Questionnaire (IPAQ) was used for determining physical activity levels. The validity of the translated form of this questionnaire was tested in a previous study on Iranian subjects.[10] Physical activity levels were also classified into 3 categories: inactive, minimally active, and health-enhancing physically active, according to the scoring system provided by the IPAQ.[11]

Dietary Assessment

A dietary assessment was performed by means of quantitative food frequency questionnaires (FFQ), which were completed through face-to-face personal interviews by expert dietitians. The reported frequency of each food item was converted into a daily consumption and the mean intakes of 26 main food groups *were* calculated and used to establish *dietary patterns* by a principal component analysis.

Anthropometric Measurements

Body mass index (BMI) was calculated from height and weight data as kg/m^2. Overweight was defined as BMI $\geq$ 25, and obesity was defined as BMI $\geq$ 30 kg/m^2. Body-weight was measured to the nearest 0.1 kg on a Seca digital weighing scale, and a stadiometer was used for measuring height to the nearest 0.1 cm with bare feet. Waist circumferences (cm) were measured in duplicate while the subjects were wearing light clothing with an anthropometric tape. Waist circumference was measured at the minimum circumference between the iliac crest and the rib cage and conicity index was calculated.

Blood Pressure Measurement

After a 5-minute rest, the blood pressure was measured 2 times in each arm in sitting position by a trained nurse using a mercury sphygmomanometer (Richter, Germany). After 2 measurements, blood pressure was measured a third time if there was a difference of more than 10 mmHg in systolic readings and/or 5 mmHg in diastolic readings, and the 2 readings with the least difference were documented. According to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, having either a systolic blood pressure (SBP) of 120 to 139 mmHg and/or diastolic blood pressure (DBP) of 80 to

https://doi.org/10.1017/dmp.2019.61 Published online by Cambridge University Press

TABLE 1

General Characteristics of Participants in Urban and Regional Areas

	Lake Urmia Adjacent Areas (n = 514)	Areas Far From the Lake (n = 509)	Total (n = 1023)
Age, % (n)			
15–25	10.2 (52)	9.5 (48)	9.8 (100)
26–35	23.0 (118)	21.4 (109)	22.2 (227)
36–45	27.7 (143)	31.9 (162)	29.8 (305)
46–55	22.6 (116)	24.0 (122)	23.3 (238)
56–65	16.5 (85)	13.3 (68)	14.9 (153)
Sex			
Men	49.4 (254)	47.7 (243)	48.5 (497)
Marital status, % (n)			
Married	88.7 (456)	86.5 (440)	87.6 (896)
Occupational status, % (n)			
Employed or self-employed	40.8 (210)	43.2 (220)	41.9 (430)
Student	6.1 (31)	6.5 (33)	6.3 (744)
Unemployed	53.1 (273)	50.3 (256)	51.7 (529)
Educational status, % (n)			
Illiterate	12.7 (65)	9.2 (47)	10.9 (112)
Undergraduate	72.2 (371)	73.3 (373)	72.7 (744)
College	15.1 (78)	17.5 (89)	16.3 (167)
Smoking habit, % (n)			
Yes	11.8 (61)	10.5 (53)	11.1 (114)
Occasionally	1.4 (7)	2.3 (12)	1.8 (19)
No	86.8 (446)	87.2 (444)	87.0 (890)
Physical activity, % (n)			
Inactive	18.2 (94)	23.6 (120)	20.9 (214)
Minimally active	29.0 (149)	33.6 (171)	31.3 (320)
Health enhancing activity	52.8 (271)	42.8 (218)	47.8 (489)
Adherence to healthy dietary pattern			
Lowest	31.4 (162)	31.9 (162)	31.6 (324)
Modest	35.8 (184)	34.4 (175)	35.2 (359)
Highest	32.8 (168)	33.7 (172)	33.2 (340)
***24-hour urinary salt* excretion (gr/day)**[a]	14.6 ± 5.0	12.9 ± 4.1	13.7 ± 4.5

[a] ($P < 0.05$); differences tested by an independent t-test.

89 mmHg was considered prehypertension in persons who were not on antihypertensive medication.[12] Hypertension was defined as SBP ≥ 140 and/or DBP ≥ 90 mmHg or current use of antihypertensive medication for the management of hypertension, at the time of interview.

Biochemical Measurements

A blood sample was taken after an overnight fast. FBS, total cholesterol, LDL-C, HDL-C, TG, hemoglobin (Hb), ferritin, and serum vitamin D were measured. The levels of serum TC, HDL-C, and TG were measured by enzymatic colorimetric methods with a commercially available kit (Pars Azmone, Tehran, Iran) on an automatic analyzer (Abbott, model Alcyon 300, USA). Serum LDL-C was calculated by the Friedewald equation.[13] Chemiluminescent immunoassay technology was used for the quantitative determination on 25(OH) D and other hydroxylated metabolites in human serum (DiaSorin, Saluggio, Italy). An automated counter (SYSMEX, Japan) was applied for measuring the levels of Hb. Serum ferritin levels were measured by an ELISA test kit (Biochek Inc., India).

Urinary Salt Excretion

The first-morning spot urine sample was collected from first voided morning urine. The sodium concentration was measured by an ion-selective electrode method (Modular DPE chemistry; Roche Diagnostics, Mannheim, Germany). Creatinine levels were measured by the Jaffe reaction (Kinetic colorimetric assay; Roche Diagnostics). Kawasaki's formula was used to estimate urinary salt excretion over 24 hours.[14] No additional data are available to share.

Statistical Analysis

Data were analyzed using SPSS (version 18; IBM Corp, Armonk, NY). The normality of distribution of the continuous variables was examined using histograms and Kolmogorov-Smirnov test.

https://doi.org/10.1017/dmp.2019.61 Published online by Cambridge University Press

TABLE 2

The Comparison of High Total Cholesterol, High LDL-C, High TG, Low HDL-C, and Dyslipidemia in Case and Control Areas

Variables	Lake Urmia Adjacent Areas	Areas Far From the Lake	*P* Value
Mean total cholesterol, mg/dl (mean ± SD)[a]	174.2 ± 33.4	169.3 ± 40.0	0.38
Mean LDL-C, mg/dl (mean ± SD)[a]	88.2 ± 30.0	82.7 ± 27.5	0.22
Mean TG, mg/dl (mean ± SD)[a]	179.3 ± 113.7	156.0 ± 133.5	0.23
Mean HDL-C, mg/dl (mean ± SD)[a]	41.2 ± 8.8	40.6 ± 9.6	0.68
Prevalence of borderline high and high TC (%)[b]	20.5	17.9	0.90
Prevalence of borderline high and high LDL-C (%) [b]	8.0	5.1	0.68
Prevalence of borderline high and high TG (%)[b]	48.3	37.2	0.45
Prevalence of low HDL-C (%)[b]	69.3	75.6	0.11
Prevalence of dyslipidemia (%)[b]	85.2	85.9	0.36

[a] Differences tested by an independent t-test.
[b] Differences tested by a chi-square test.

Mean values and SDs were calculated for continuous variables, and proportions were calculated for categorical variables. Between-group comparisons were made using an independent *t*-test and chi-square test. *P* values less than 0.05 were considered as significant.

RESULTS

Table 1 shows the demographic characteristics of participants stratified by region. About 48.5% of participants were male. The mean age of participants was 42 ± 12.4 years, and the mean BMI was 27.82 ± 5.3 kg/m^2. About 21% of males and 1% of females were a current smoker, and 47.8% of the population had health-enhancing physical activity. The rates of age, sex, educational and physical activity status, dietary pattern, and smoking habit were not significantly different in Lake Urmia's adjacent areas and control ones ($P > 0.05$). The amount of 24-hour urinary salt excretion was significantly high in Lake Urmia's adjacent areas compared with the control ones.

The comparison of high total cholesterol, high LDL-C, high TG, low HDL-C, and dyslipidemia prevalence in Lake Urmia's adjacent areas and control ones is presented in Table 2. The mean serum total cholesterol, LDL-C, HDL-C, and TG were not significantly different in Lake Urmia's adjacent areas and control ones ($P > 0.05$). Also, no significant difference was observed in the prevalence of high total cholesterol, high LDL-C, high TG, low HDL-C, and dyslipidemia in both groups ($P > 0.05$).

Table 3 represents the comparison of prehypertension, stage I and stage II hypertension, and overall hypertension prevalence in both regions. The mean systolic (119.44 ± 15.37 vs 117.59 ± 17.67 mmHg) and diastolic (77.92 ± 10.51 vs 76.33 ± 11.66 mmHg) blood pressures in Lake Urmia's adjacent areas were significantly higher than the other regions ($P < 0.05$). Moreover, in regions near Lake Urmia, the prevalence of total hypertension (24.3% vs 21.1%), prehypertension (13.9% vs 13.3%), and stage II hypertension (5.8% vs 5.1%) was significantly higher than the regions far from the lake ($P < 0.05$).

The mean of BMI and waist circumference and the prevalence of overweight/obesity and abdominal obesity was not significantly ($P < 0.05$) different in both regions (Table 4).

Table 5 illustrates the comparison of non-communicable diseases prevalence in both areas. The prevalence of anemia was significantly higher in regions near Lake Urmia in comparison with regions far from the lake ($P = 0.04$). However, no significant differences were observed in the prevalence of asthma, angina, infraction, diabetes, and vitamin D insufficiency and deficiency between the 2 districts ($P > 0.05$).

DISCUSSION

The shrinking of Lake Urmia in the northwest of Iran is considered one of the instances of damaging human activities that destroy ecosystems and may have lots of health consequences. The results of this study showed that this shrinking process had harmful health effects on people living in the areas adjacent to the lake. Based on the results of this study, in regions near Lake Urmia, the prevalence of total hypertension, prehypertension, and stage II hypertension was significantly higher than that of the regions far from the lake. Some major confounders such as age, employment status, education level, smoking, dietary pattern, physical activity status, and obesity/abdominal obesity were not different in both regions. It seems that salt storms

https://doi.org/10.1017/dmp.2019.61 Published online by Cambridge University Press

TABLE 3

The Comparison of Prehypertension, Stage I and Stage II Hypertension, and Overall Hypertension Prevalence in Case and Control Areas

Variables	Lake Urmia Adjacent Areas	Areas Far From the Lake	*P* Value
Systolic blood pressure, mmHg (mean ± SD)[a]	118.1 ± 19.3	111.6 ± 17.1	< 0.001
Diastolic blood pressure, mmHg (mean ± SD)[a]	74.9 ± 13.6	72.5 ± 12.2	< 0.001
Prevalence of prehypertension (%)[b]	41.6	36.5	0.03
Prevalence of stage 1 hypertension (%)[b]	11.4	11.0	0.85
Prevalence of stage 2 hypertension (%)[b]	6.3	3.7	0.04
Prevalence of total hypertension (%)[b]	22.0	17.8	0.04

[a] Differences tested by an independent t-test.
[b] Differences tested by a chi-square test.

TABLE 4

The Comparison of BMI and Waist Circumference, and the Prevalence of Overweight/Obesity and Abdominal Obesity in Case and Control Areas

Variables	Lake Urmia Adjacent Areas	Areas Far From the Lake	*P* Value
BMI, kg/m^2 (mean ± SD)[a]	26.89 ± 5.2	26.93 ± 6.0	0.91
Waist circumference, cm (mean ± SD)[a]	91.0 ± 12.6	91.4 ± 13.7	0.57
Prevalence of overweight and obesity (%)[b]	63.1	61.3	0.56
Prevalence of abdominal obesity (%)[b]	84.6	87.4	0.22

[a] Differences tested by an independent t-test.
[b] Differences tested by a chi-square test.

TABLE 5

Comparison of Non-Communicable Diseases Prevalence in Case and Control Areas

Variables	Lake Urmia Adjacent Areas	Areas Far From the Lake	*P* Value
Prevalence of asthma (%)	1.4	1.1	0.22
Prevalence of angina (%)	6.4	6.8	0.68
Prevalence of infraction (%)	7.5	8.7	0.51
Prevalence of diabetes (%)	3.4	7.7	0.36
Prevalence of anemia (%)[a]	11.1	7.1	0.04
Prevalence of vitamin D insufficiency and deficiency (%)	87.5	88.5	0.84

[a] Differences tested by a chi-square test.

raised from the lake.[15] may be a reason for the higher prevalence of hypertension among people living in the adjacent areas to the lake. The wind can cause salt particulates migration in the region. This would cause an increase in the salt content of the soil in the whole region, which can cause environmental and health problems.[3] Also, the results of Haldiya et al. showed that the prevalence of hypertension and blood pressure was found to be higher in non-brine salt workers occupationally exposed to salt particles in the air of the breathing zone.[4] This is in line with the hypothesis that salt may be absorbed from the respiratory tract after being inhaled.[16,17] or the mucociliary current may transport it to

https://doi.org/10.1017/dmp.2019.61 Published online by Cambridge University Press

the pharynx, where it is swallowed and can be absorbed from the gastrointestinal tract. Subsequent increases in plasma sodium may be responsible for increases in the blood pressure.[18] Conforming to the previous hypotheses, the results of this study showed that 24-hour urinary salt excretion was significantly high in the Lake Urmia adjacent areas compared with the control ones.

In addition, the results of this study showed that the prevalence of anemia was significantly higher in regions near Lake Urmia in comparison with regions far from the lake ($P = 0.04$).

The results of previous studies showed that heavy metals may induce changes in the metabolism of essential metals like Fe and consequently result in anemia.[1,19,20]

Unfortunately, there are no data available on the environmental consequences of Lake Urmia shrinking; however, a similar study on the case of the Aral Sea shrinking showed that organic substances (the dissolved organic substances, benzene, xylene, and phenol) and heavy metal (nickel, lead, mercury, and zinc) contents in the air and water resources of a residual Aral reservoir had been increased.

In this study, no significant differences were observed in the prevalence of obesity, dyslipidemia, asthma, angina, infraction, diabetes, and vitamin D insufficiency and deficiency between the 2 groups. Studies in the Aral Sea basin showed that the rates of tuberculosis, anemia, respiratory infections, kidney and liver diseases, cancer, and allergies had been increased. An analysis of specific non-infectious morbidity dynamics in the Aral Sea area inhabitants indicates that the increasing trend of the morbidity by such pathologies as cardiovascular (blood vessel) diseases and diseases of the urogenital system (reproductive system) was noted in recent years. Taking into account the results of studies on the Aral Sea, it seems that, in the case of Lake Urmia, if the drying pattern continues, more prevalence of the communicable and non-communicable diseases would be expected.[5]

Strengths and Limitations of This Study

The main strength of the current study was the large sample size from different urban and regional areas that provides new data regarding the impact of Lake Urmia drying on some health parameters. Various potential confounders were accessible, and the results could be interpreted regarding the confounders. One of the main limitations of this study is the cross-sectional design that restricts examining causal associations.

CONCLUSION

In conclusion, the results of this study showed that the drying of Lake Urmia has serious health effects such as hypertension and anemia. We hope that this article would increase awareness for this serious disaster and capture the attention of international and national health organizations. Additionally, more longitudinal and well-designed studies are desired to investigate the environmental consequences of Lake Urmia shrinking such as water and air pollution.

About the Authors

Tabriz Health Services Management Research Center, Faculty of Management and Medical Informatics, Tabriz University of Medical Sciences, Tabriz, Iran (Dr Tabrizi); Research Center of Psychiatry and Behavioral Sciences, Tabriz University of Medical Sciences, Tabriz, Iran (Dr Farahbakhsh); Road Traffic Injury Research Center, Department of Statistics and Epidemiology, Tabriz University of Medical Sciences, Tabriz, Iran (Dr Sadeghi-Bazargani); Tabriz Health Services Management Research Center, Tabriz University of Medical Sciences, Tabriz, Iran (Drs Abdolahi, L. Nikniaz); Liver and Gastrointestinal Diseases Research Center, Tabriz University of Medical Sciences, Tabriz, Iran (Dr Z. Nikniaz) and Drug Applied Research Center, Tabriz University of Medical Sciences, Tabriz, Iran (Dr Abbasalizad Farhangi).

Correspondence and reprint requests to Leila Nikniaz, NPMC, Tavanir Exit, Valiasr St., Tabriz, Iran (e-mail: nikniazleila@gmail.com).

Acknowledgments

The authors wish to thank the East Azerbaijan Provincial Health Center, Tabriz Health Services Management Research Center at Tabriz University of Medical Sciences, and Eastern Azerbaijan Governor General for financial support.

Author Contributions

JST designed and directed the project, and contributed in interpreting the results; MF and LN developed the theoretical framework and drafted the manuscript; HA and ZN manufactured the samples, characterized them, and performed the analysis. EE edited the final version of the manuscript and contributed in interpreting the results. All authors provided critical feedback and helped shape the research, analysis, and manuscript.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

REFERENCES

1. Turgut S, Hacioglu S, Emmungil G, Turgut G, Keskin A. Relations between Iron deficiency anemia and serum levels of Copper, Zinc, Cadmium and Lead. *Polish Journal of Environmental Studies*. 2009; 18(2):273–7.
2. Hoseinpour M, Fakheri Fard A, Naghili R, editors. *Death of Urmia Lake, a silent disaster investigating causes, results and solutions of Urmia Lake drying. 1st International Applied Geological Congress*, Department of Geology, Islamic Azad University, Islamic Azad University-Mashad Branch, Iran; 2010.
3. Garousi V, Najafi A, Samadi A, Rasouli K, Khanaliloo B. Environmental crisis in Lake Urmia, Iran: a systematic review of causes, negative consequences and possible solutions. Proceedings of the 6th International Perspective on Water Resources & the Environment (IPWE) Izmir, Turkey. 2013.
4. Haldiya KR, Mathur ML, Sachdev R, Saiyed HN. Risk of high blood pressure in salt workers working near salt milling plants: A cross-sectional and interventional study. *Environmental Health*. 2005;4(1):1.

https://doi.org/10.1017/dmp.2019.61 Published online by Cambridge University Press

5. Kulmatov R, Soliev I. The crisis of Aral Sea and health of the population in the disaster zone. *In: Proceedings of the 13th World Lake Conference*. National University of Uzbekistan; 2008:10.
6. Abuduwaili J, Gabchenko M, Junrong X. Eolian transport of salts—a case study in the area of Lake Ebinur (Xinjiang, Northwest China). *Journal of arid environments*. 2008;72(10):1843–52.
7. Ono D, Hardebeck E, Parker J, Cox B. Systematic biases in measured PM10 values with US Environmental Protection Agency-approved samplers at Owens Lake, California. *Journal of the Air & Waste Management Association*. 2000;50(7):1144–56.
8. Rose G, McCartney P, Reid D. Self-administration of a questionnaire on chest pain and intermittent claudication. *British journal of preventive & social medicine*. 1977;31(1):42–8.
9. Organization WH. *Guidelines for controlling and monitoring the tobacco epidemic*: World Health Organization; 1998.
10. Vasheghani-Farahani A, Tahmasbi M, Asheri H, Ashraf H, Nedjat S, Kordi R. The Persian, last 7-day, long form of the International Physical Activity Questionnaire: translation and validation study. *Asian journal of sports medicine*. 2011;2(2):106.
11. IPAQ Research Committee. Guidelines for data processing and analysis of the International Physical Activity Questionnaire (IPAQ)–short and long forms. Retrieved September. 2005;17:2008.
12. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo Jr JL, et al. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report. *Jama*. 2003;289(19):2560–71.
13. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clinical chemistry*. 1972;18(6):499–502.
14. Rhee M-Y, Kim J-H, Shin S-J, Gu N, Nah D-Y, Hong K-S, et al. Estimation of 24-hour urinary sodium excretion using spot urine samples. *Nutrients*. 2014;6(6):2360–75.
15. Abbaspour M, Javid A, Mirbagheri S, Givi FA, Moghimi P. Investigation of lake drying attributed to climate change. *International Journal of Environmental Science and Technology*. 2012;9(2):257–66.
16. Boucher RC. Human airway ion transport. Part two. *American Journal of Respiratory & Critical Care Medicine*. 1994;150(2):581–93.
17. Knowles MR, Boucher RC. Mucus clearance as a primary innate defense mechanism for mammalian airways. *The Journal of clinical investigation*. 2002;109(5):571–7.
18. He FJ, MacGregor GA. Plasma sodium and hypertension. *Kidney international*. 2004;66(6):2454–66.
19. Järup L. Hazards of heavy metal contamination. *British medical bulletin*. 2003;68(1):167–82.
20. Rondó PH, Carvalho MdFH, Souza MC, Moraes F. Lead, hemoglobin, zinc protoporphyrin and ferritin concentrations in children. *Revista de Saúde Pública*. 2006;40(1):71–6.

https://doi.org/10.1017/dmp.2019.61 Published online by Cambridge University Press