

Association of consumption of excess hard water, body mass index and waist circumference with risk of hypertension in individuals living in hard and soft water areas

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Received: 9 July 2018 / Accepted: 17 October 2018 / Published online: 2 November 2018
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Abstract Chronic exposure to soft drinking water increases the risk of hypertension. We conducted a cross-sectional study in 2017 in two study areas in the Poldasht County to assess the relation of hardness, body mass index and waist circumference with risk of hypertension. Total water hardness was measured by gravimetric methods. Hardness of > 180 ppm was considered to be hard drinking water. The Shibli and Gharghologh areas had a four times higher mean total hardness level in drinking water (968.69 mg/L as CaCO_3) than the Sarisoo and Agh Otlogh (180 mg/L as CaCO_3) areas. According to the results of the study, the prehypertension prevalence in areas with high and low water hardness was calculated as 23.15% (18.11–29.15) and 46.84% (37.61–57.64),

respectively. Moreover, the result showed the prevalence of hypertension and prehypertension was higher in regions with low hardness than those with high hardness, which was statistically significant ($P < 0.001$). The results of logistic regression showed that age, body mass index, waist circumference and hardness of drinking water were significantly related to hypertension. Accordingly, hypertension was low in people of regions with high hardness (OR 0.26, 0.17–0.42). This report examined whether total hardness in drinking water was protective against hypertension. This is an important finding for the ministry of human health as well as for the water and sewage company.

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Keywords Water hardness · Body mass index · Waist circumference · Hypertension

Introduction

One of the most important issues in monitoring water chemical parameters is the relationship between the concentration of these parameters and non-communicable diseases such as cardiovascular diseases (Reimann et al. 2003). Cardiovascular diseases are the main reason for mortality, which annually lead to death of 17 million people around the world. In Iran, we see that 46% of overall deaths and 27.2% of the lost years of life are due to cardiovascular diseases in 18 provinces of the country and a large part of the health system resources is spent on their treatment (Sepanlou et al. 2015). Today, hypertension is one of the most important and expanding worldwide public health problems, especially in developing countries, due to its high prevalence and association with cardiovascular diseases (Rasic-Milutinovic et al. 2012). Until 2005, one billion people with high blood pressure existed in the world, and four million people died as a result of high blood pressure. By 2025, the prevalence of high blood pressure is expected to increase by 60% and reach 1.56 billion people. The data show the emergency of prioritizing for screening, early detection and management of worldwide hypertension through the plans based on society (Rasic-Milutinovic et al. 2012; Chockalingam et al. 2006). In assessing risk factors for non-communicable diseases of the country in 2009, about 16% of 15–64-year-old people had hypertension. Some factors such as obesity, high level of cholesterol, low physical activity, positive experience of cardiovascular and kidney diseases and diabetes are effective in creating hypertension. Other risk factors for hypertension include race, gender, smoking, aging, hereditary background and water chemical quality (Yousefi et al. 2018a; Mohammadi et al. 2017; Yousefi et al. 2017). In recent years, different studies have investigated the effect of elements of calcium, magnesium, potassium and sodium on hypertension (Rasic-Milutinovic et al. 2012). An inverse correlation between hardness of drinking water and cardiovascular diseases has been reported by a number of studies in Japan, USA, England, Finland, Sweden, Canada, South Africa, etc. (Nerbrand et al. 2003). The study of Bostick et al. (1999) showed that increased intake of calcium,

magnesium and potassium was associated with a decrease in blood pressure and caused a reduction of 30–35% in ischemic diseases or heart failure. Different epidemiological studies have shown a clear relationship between different drinking waters and cardiovascular diseases, which is 10–30% higher in soft water areas than in hard water areas (Woodman et al. 2002). In some studies, mineral water consumption for 4 weeks reduced systolic blood pressure by about 5 mmHg. In a study on 76 metropolitan Sweden areas, a significant difference was observed between the rate of mortality and soft water consumption compared to low mortality in regions with high hardness water consumption (Luft et al. 1990). The wide prevalence of cardiovascular diseases is different in diverse geographical regions around the world, and epidemiologic studies have been carried out to identify variables which can explain this reality (Jenkins 1988; Sengupta 2013). The effect of water hardness has been widely investigated on prevalence of cardiovascular diseases. Previous studies have approved the relationship between hypertension and diet and water containing calcium and magnesium (Rasic-Milutinovic et al. 2012; Crawford et al. 1971; Gumashta et al. 2012; Tubek 2006; Leurs et al. 2009). For example, in a study conducted as a control study on the rate of hardness taken from drinking water, the results showed that the rate of mortality of acute infarction decreased. Today, the concerns of obesity problem are increasing in epidemic proportions worldwide and also are growing in developing countries. High blood pressure is associated with obesity. Among the indicators of obesity, we can mention body mass index (BMI) and waist-to-hip ratio (WHR) (Yousefi et al. 2018a). Most studies in this regard have been carried out in advanced countries, and there is insufficient information about the less developed countries. Therefore, the main purpose of this study was to investigate the relationship between blood pressure with hardness, BMI and WHR in people living in two regions of the West Azerbaijan Province in northwest Iran.

Materials and methods

Study area

Two study areas were selected in the West Azerbaijan Province in the northwest part of Iran, including Agh

Otlogh and Sarisoo with high water hardness and Shiblou Olia and Sofla as well as Gharghologh Olia and Soufla with soft drinking water that have similar socioeconomic status and dietary habits (Fig. 1).

Study population

The population studied in the villages of Agh Otlogh, Sarisoo (soft drinking water), Shiblou Olia and Sofla as well as Gharghologh Olia and Sofla included 462, 779, 278, 277, 271 and 348 people, respectively (Yousefi et al. 2018a, b). The data on the incidence were derived from the health records of the areas being investigated. Based on the results of the study, 501 of over 30-year-old people with hypertension were studied based on the history of health in the two regions of the West Azerbaijan Province with high and low hardness. The rates of hardness of the existing resources were classified based on the standard state of water resources as

Data collection

The data related to hypertension patients were collected by referring to the registration offices for hypertension patients in the health centers of the region. The data were also collected based on gender and place of residence for individuals of over 30 years old through screening. Then, the hypertension status sample was calculated and classified based on gender,

infection percentage and location. If the mean score of maximum blood pressure was 140 mmHg or more and that of minimum blood pressure was 90 mmHg or more in several times and states, it was considered as hypertension. The understudy villages were in a similar situation in terms of race as well as economic and social circumstances, and their drinking water was provided from underground resources. All the samples with hypertension were over 30 years old, who lived in the village since birth time and used their village water resources and also had similar situation in terms of healthcare status. People having chronic kidney disease or diabetes and those taking antihypertensive drugs/oral calcium supplements were excluded.

Determination of hardness in drinking water

The total hardness (TH) of drinking water of the understudy village was determined based on 10-year results of standard experiments of the Water and Sewage Company in the village. (In this study, 132 samples were analyzed by descriptive and analytical statistics.) Ten percent of overall water resources was assessed in terms of chemical parameters by standard methods and calibrated devices; the assessment was repeated twice to insure data accuracy (Rice et al. 2012).



Fig. 1 Location of the study areas in the Poldasht County, the West Azerbaijan, Iran

Statistical method

To present data, we used mean, standard deviation, median and range. To compare the results between the

two groups, we used independent sample *t* test and Mann–Whitney test and Chi-square test. To evaluate the simultaneous effect of variables on the hypertension (HTN), we used logistic regression analysis. The

Table 1 Classification hardness in the two study areas

Village name	Population	Classification hardness
Sari Soo	779	Soft drinking water (0–180 mg/L)
Agh Otlogh	462	
Shiblo Olia	278	Hard drinking water (< 180 mg/L)
Shiblo Sofla	277	
Gharghologh Olia	271	
Gharghologh Sofla	348	

Table 2 Basic characteristics of the study subjects

	Total	Hardness		<i>P</i> [†]
		Low	High	
Age				
Mean ± SD	43.1 ± 9.6	44.5 ± 11.2	42.3 ± 8.4	0.014 [†]
Median (range)	43 (27–78)	43 (29–78)	42 (27–63)	
≤ 30.0	37 (7.4%)	16 (8.4%)	21 (6.8%)	0.488*
31.0–40.0	171 (34.1%)	59 (31.1%)	112 (36.0%)	0.256*
41.0–50.0	188 (37.5%)	69 (36.3%)	119 (38.3%)	0.662*
51.0–60.0	87 (17.4%)	29 (15.3%)	58 (18.6%)	0.332*
61.0+	18 (3.6%)	17 (8.9%)	1 (0.3%)	< 0.001**
Sex				
M	232 (46.3%)	85 (44.7%)	147 (47.3%)	0.582*
F	269 (53.7%)	105 (55.3%)	164 (52.7%)	0.582*
BMI				
Mean ± SD	27.5 ± 4.5	26.9 ± 4.6	27.9 ± 4.4	0.027 [†]
Median (range)	27 (15.9–42)	26 (18.3–41.4)	27.4 (15.9–42)	
Normal + underweight	133 (26.6%)	69 (36.3%)	64 (20.6%)	< 0.001*
Overweight	231 (46.2%)	77 (40.5%)	154 (49.7%)	0.050*
Obese	131 (26.2%)	41 (21.6%)	90 (29.0%)	0.069*
Extreme obese	5 (1.0%)	3 (1.6%)	2 (0.6%)	0.563**
Waist circumference				
Mean ± SD	95 ± 12	98 ± 12	93 ± 11	< 0.001
Median (range)	95 (11–130)	98 (11–130)	93 (65–125)	
Normal	254 (50.8%)	79 (41.8%)	175 (56.3%)	0.001*
Abnormal	246 (49.2%)	110 (58.2%)	136 (43.7%)	0.001*
Hip				
Mean ± SD	103 ± 29	104 ± 11	102 ± 36	0.384
Median (range)	101 (65–706)	103 (85–136)	100 (65–706)	
WHR				
Mean ± SD	0.94 ± 0.08	0.95 ± 0.09	0.94 ± 0.07	0.116
Median (range)	0.95 (0.1–1.14)	0.96 (0.1–1.09)	0.94 (0.13–1.14)	

BMI body mass index, *WHR* waist-to-hip ratio

[†]Based on *t* test, [‡]based on Mann–Whitney test, *based on Chi-square test, **based on Fisher's exact test

Table 3 Comparison of the prevalence of the ISH, IDH, SDH, prehypertension and HTN in the two areas with different hardness of drinking water

	Total	Hardness		Diff	95% CI		P
		Low	High		Low	High	
SBP							
Mean ± SD	115 ± 15	170 ± 119	160 ± 113	5	3	8	< 0.001 [†]
Median (range)	120 (80–170)	15 (120–90)	15 (110–80)				
DBP							
Mean ± SD	72 ± 11	100 ± 74	100 ± 70	4	2	6	< 0.001 [†]
Median (range)	70 (40–100)	11 (80–60)	11 (70–40)				
MAP							
Mean ± SD	101 ± 13	147 ± 104	137 ± 99	5	2	7	< 0.001 [†]
Median (range)	103 (73–147)	13 (107–80)	13 (97–73)				
HTN status							
Normal	229 (45.7%)	71 (37.4%)	158 (50.8%)	– 13.4%	– 22.4%	– 4.5%	0.003*
Prehypertension	214 (42.7%)	88 (46.3%)	126 (40.5%)	5.8%	– 3.2%	14.8%	0.204
Hypertension	58 (11.6%)	31 (16.3%)	27 (8.7%)	7.7%	1.9%	13.5%	0.009

DBP diastolic blood pressure, MAP mean arterial pressure, SBP systolic blood pressure, SDH systolic–diastolic hypertension, IDH isolated diastolic hypertension, ISH isolated systolic hypertension

[†]Prehypertension or hypertension, [†]based on *t* test, *based on Chi-square test

precision of the statistics were presented by 95% confidence interval (CI). All the statistical methods were performed by SPSS software (Version 24.0). *P* values less than 0.05 were considered statistically significant. The association between hypertension death with calcium and magnesium levels in drinking water was measured using odds ratios (OR) and their 95% confidence intervals (95% CIs) from conditional logistic regression models.

Results

Anthropometric features, systolic and diastolic blood pressure and total hardness of the two groups are provided with high and low water hardness in Tables 1 and 2. In the two regions with the average high and low water hardness, the Shibli and Gharghologh area had a four times higher mean total hardness level in drinking water (968.69 as CaCO₃) than the Sarisoo and Agh Otlogh area (180 mg/L as CaCO₃). As it can be observed, the mean systolic and diastolic blood pressure was significantly higher in areas with a low level of hardness in drinking water (*P* < 0.001).

The two groups had a significant difference in terms of age groups, BMI, waist circumference and mean arterial pressure (MAP) (Table 2).

According to the results of the study, the overall prevalence of the HTN in areas with high and low water hardness was 6.11% (3.67–9.54) and 12.63% (8.09–18.79), respectively. The prehypertension prevalence in areas with high and low water hardness was calculated as 23.15% (18.11–29.15) and 46.84% (37.61–57.64), respectively. The prevalence of the HTN and prehypertension was higher in regions with low hardness than those with high hardness, which was statistically significant (*P* < 0.001) (Table 3).

Adjusted for other variables in the model, the population in high hardness area has 0.6 times odds to have non-normal hypertension compared to low hardness area (95% CI 1.2–3.0, *P* = 0.011) Table 4.

As it can be observed from the Fig. 2, the abnormal hypertension was higher in the low hardness area compared to that in the high hardness area separated for the BMI and abdominal obesity status (Fig. 2).

Table 4 Abnormal hypertension status (including prehypertension and hypertension) prevalence and simultaneous effect of the related risk factors

Parameter	Abnormal HTN	AOR	95% CI		<i>P</i>
			Low	High	
Total	272 (54.3%)				
Group					
Low hardness	119 (62.6%)	1			
High hardness	153 (49.2%)	0.6	0.4	0.9	0.021
Age					
≤ 30.0	11 (29.7%)	1			
31.0–40.0	75 (43.9%)	1.8	0.8	3.9	0.159
41.0–50.0	113 (60.1%)	3.0	1.4	6.7	0.006
51.0–60.0	56 (64.4%)	3.9	1.7	9.1	0.002
61.0+	17 (94.4%)	25.0	2.9	217.4	0.004
Sex					
M	127 (54.7%)	1			
F	145 (53.9%)	0.6	0.4	1.0	0.047
BMI					
Normal + underweight	57 (42.9%)	1			
Overweight	131 (56.7%)	1.8	1.1	2.9	0.017
Obese	79 (60.3%)	1.7	1.0	3.1	0.071
Extreme obese	5 (100.0%)	–			
Waist circumference					
Normal	117 (46.1%)	1			
Abnormal	154 (62.6%)	1.8	1.1	3.0	0.023

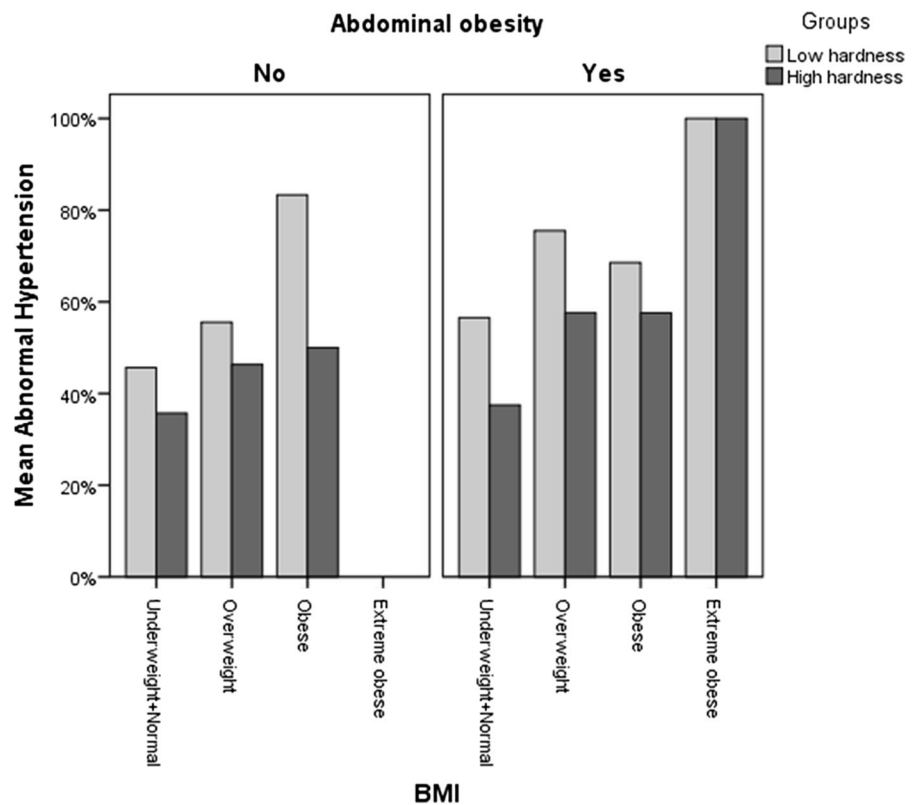
AOR adjusted odds ratio, based on multiple logistic regression

Discussion

According to the results of the study, the overall prevalence of the HTN in areas with high and low water hardness was 6.11% and 12.63%, respectively. The prehypertension prevalence in areas with high and low water hardness was calculated as 23.15% and 46.84%, respectively. The prevalence of the HTN and prehypertension was higher in regions with low hardness than those with high hardness, which was statistically significant ($P < 0.001$). Moreover, in order to eliminate the effects of other variables and risk factors, a multivariate logistic regression analysis was used to investigate the relationship between hardness and blood pressure. The results of this analysis showed that the population in areas with high water hardness had 0.6 percent higher odds ratio of having non-normal hypertension compared to areas with low water hardness (95% CI 1.2–3.0, $P = 0.011$). Overall, in our study, we found a significant association between total hardness concentrations and the HTN and prehypertension prevalence. To compare the

findings obtained in the present study with those in the literature, results of some studies were described. For example, in a study on the association of blood pressure and metabolic syndrome, it was reported that areas with hard drinking water and adequate supply of Mg from drinking water may prevent hypertension and help maintaining normal triglyceride levels in healthy adults (Rasic-Milutinovic et al. 2012). Many epidemiological studies in Canada and Italy reported an inverse relation between cardiovascular diseases and water hardness; this can be confirmed with the role of water hardness concentration in the etiology of hypertension. However, these results are not consistent with the results obtained in the current study (Anderson et al. 1975; Leoni et al. 1985). Moreover, the analytical research revealed little evidence that drinking water hardness caused cardiovascular risks (Anderson et al. 1975; Leoni et al. 1985). In another research, the influence of calcium and magnesium in drinking water on cardiovascular risk factors was studied in individuals living in hard and soft water areas. The findings showed that individuals living in

Fig. 2 Comparison of abnormal hypertension in different regions with high and low hardness separated for the BMI and abdominal obesity status



soft and hard water areas showed significant correlations between the content of calcium in water and major cardiovascular risk factors (Derry et al. 1990; Galan et al. 2002; Yang and Chiu 1999; Monarca et al. 2006). In a study conducted by Momeni et al. (2014) on the association between drinking water hardness and cardiovascular diseases in the Khansar County in the Isfahan Province, it was found that increasing Mg hardness level above 31 mg/L in 2010 and above 26 mg/L in 2011 was associated with a decreased number of CVDs in 1000 people (Momeni et al. 2014). The study of Bostick et al. (1999) showed that increased intake of calcium, magnesium and potassium was associated with a decrease in blood pressure and caused a reduction of 30–35% in ischemic diseases or heart failure. In a study on the effect of drinking water hardness on decreasing cardiovascular and kidney diseases in the Samirom city using RS and GIS technologies, Bahramian et al. (2013) showed that due to low calcium and magnesium in drinking water compared to optimal limitation of the elements, the percentage of cardiovascular diseases (hypertension) was significant relative to the region population, which

is consistent with the results of our study. In contrast, in a case study, hypertension was evaluated in people consuming hard water in Haji Samoa in Pakistan. Based on this study, hypertension was no more common in people taking freshwater than in those consuming hard water; however, the underground well water in the area of Keti Bandar had high levels of hardness (Razzaque et al. 2015). In a study carried out in Iran, the concentration effect of chemical parameters such as hardness, TDS, sodium and chloride on the prevalence of hypertension was studied. However, other risk factors such as hereditary and family background in hypertension, unnecessary consumption of salt, obesity and diabetes can be effective in creating hypertension (Hojatzade 2012).

Conclusion

In this study, the association between consumption of excess hard water, BMI and waist circumference with risk of hypertension was investigated in individuals living in hard and soft water areas. The results proved

that the Shibli and Gharghologh areas had a four times higher mean total hardness level in drinking water (968.69 as CaCO₃) than the Sarisoo and Agh Otlogh areas (180 mg/L as CaCO₃). Moreover, the result revealed that the prevalence of HTN and prehypertension was significantly higher in regions with low water hardness than those with high water hardness. Logistic regression showed that age, BMI, waist circumference and hardness of drinking water was significantly related to hypertension. Accordingly, hypertension was low in people of regions with high hardness. We believe that the use of water with high hardness up to the recommended standard limitation is effective in decreasing hypertension prevalence and consequently in decreasing cardiovascular diseases. As food is the major source of magnesium and calcium intake, the main limitation of our study was the lack of individual data on dietary and water intake. This, of course, requires constant monitoring and periodic conduction of epidemiological studies that will allow permanent assessment of environmental and dietary influences on a population living in a particular region.

Acknowledgements The authors want to thank authorities of Neyshabur University of Medical Sciences for their comprehensive support for this study.

Compliance with ethical standards

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

References

- Anderson, T., Neri, L., Schreiber, G., Talbot, F., & Zdrojewski, A. (1975). Ischemic heart disease, water hardness and myocardial magnesium. *Canadian Medical Association Journal*, *113*(3), 199–203.
- Bahramian, M. (2013). Evaluating the effect of water hardness in reducing heart and kidney diseases in Samirom using the RS & GIS technologies. *KAUMS Journal (FEYZ)*, *16*(7), 637–638.
- Bostick, R. M., Kushi, L. H., Wu, Y., Meyer, K. A., Sellers, T. A., & Folsom, A. R. (1999). Relation of calcium, vitamin D, and dairy food intake to ischemic heart disease mortality among postmenopausal women. *American Journal of Epidemiology*, *149*(2), 151–161.
- Chockalingam, A., Campbell, N. R., & Fodor, J. G. (2006). Worldwide epidemic of hypertension. *The Canadian Journal of Cardiology*, *22*(7), 553–555.
- Crawford, M., Gardner, M., & Morris, J. (1971). Changes in water hardness and local death-rates. *The Lancet*, *298*(7720), 327–329.
- Derry, C., Bourne, D., & Sayed, A. (1990). The relationship between the hardness of treated water and cardiovascular disease mortality in South African urban areas. *South African Medical Journal = Suid-Afrikaanse tydskrif vir geneeskunde*, *77*(10), 522–524.
- Galan, P., Arnaud, M., Czernichow, S., Delabroise, A.-M., Preziosi, P., Bertrais, S., et al. (2002). Contribution of mineral waters to dietary calcium and magnesium intake in a French adult population. *Journal of the American Dietetic Association*, *102*(11), 1658–1662.
- Gumashta, J., Gumashta, R., & Sadawarte, S. (2012). Hard water and heart: The story revisited. *IOSR Journal of Pharmacy and Biological Sciences*, *1*, 07–20p.
- Hojatzade, A. (2012). *Manual of blood pressure measurement*. The Ministry of Health and Medical Education, Department of Health of non-communicable diseases (**in Persian**).
- Jenkins, C. D. (1988). Epidemiology of cardiovascular diseases. *Journal of Consulting and Clinical Psychology*, *56*(3), 324–332.
- Leoni, V., Fabiani, L., & Ticchiarelli, L. (1985). Water hardness and cardiovascular mortality rate in Abruzzo, Italy. *Archives of Environmental Health: An International Journal*, *40*(5), 274–278.
- Leurs, L. J., Schouten, L. J., Mons, M. N., Goldbohm, R. A., & van den Brandt, P. A. (2009). Relationship between tap water hardness, magnesium, and calcium concentration and mortality due to ischemic heart disease or stroke in the Netherlands. *Environmental Health Perspectives*, *118*(3), 414–420.
- Luft, F. C., Zemel, M. B., Sowers, J. A., Fineberg, N. S., & Weinberger, M. H. (1990). Sodium bicarbonate and sodium chloride: Effects on blood pressure and electrolyte homeostasis in normal and hypertensive man. *Journal of Hypertension*, *8*(7), 663–670.
- Mohammadi, A. A., Yousefi, M., Yaseri, M., Jalilzadeh, M., & Mahvi, A. H. (2017). Skeletal fluorosis in relation to drinking water in rural areas of West Azerbaijan, Iran. *Scientific Reports*, *7*(1), 17300.
- Momeni, M., Gharedaghi, Z., Amin, M. M., Poursafa, P., & Mansourian, M. (2014). Does water hardness have preventive effect on cardiovascular disease? *International Journal of Preventive Medicine*, *5*(2), 159–163.
- Monarca, S., Donato, F., Zerbini, I., Calderon, R. L., & Craun, G. F. (2006). Review of epidemiological studies on drinking water hardness and cardiovascular diseases. *European Journal of Cardiovascular Prevention & Rehabilitation*, *13*(4), 495–506.
- Nerbrand, C., Agréus, L., Lenner, R. A., Nyberg, P., & Svärdsudd, K. (2003). The influence of calcium and magnesium in drinking water and diet on cardiovascular risk factors in individuals living in hard and soft water areas with differences in cardiovascular mortality. *BMC Public Health*, *3*(1), 21.
- Rasic-Milutinovic, Z., Perunicic-Pekovic, G., Jovanovic, D., Gluvic, Z., & Cankovic-Kadijevic, M. (2012). Association of blood pressure and metabolic syndrome components with magnesium levels in drinking water in some Serbian municipalities. *Journal of Water and Health*, *10*(1), 161–169.

- Razzaque, S., Aidrus, F., Kumar, A., Kumar, A., Ghauri, I., & Ullah, S. (2015). Hypertension in people consuming hard water in Haji Samoa Goth Ketu-Bundar Sindh. *Annals of Abbasi Shaheed Hospital & Karachi Medical & Dental College*, 20(1), 17.
- Reimann, C., Bjorvatn, K., Frengstad, B., Melaku, Z., Teklehaimanot, R., & Siewers, U. (2003). Drinking water quality in the Ethiopian section of the East African Rift Valley I—Data and health aspects. *Science of the Total Environment*, 311(1–3), 65–80.
- Rice, E., Baird, R., Eaton, A., & Clesceri, L. (2012). *Standard methods: For the examination water and wastewater* (22 Ed.). American Public Health Association, American Water Works Association, Water Environmental Federation. ISBN: 978-087553-013-0, ISSN: 55-1979.
- Sengupta, P. (2013). Potential health impacts of hard water. *International Journal of Preventive Medicine*, 4(8), 866–875.
- Sepanlou, S. G., Newson, R. B., Poustchi, H., Malekzadeh, M. M., Asl, P. R., Etemadi, A., et al. (2015). Cardiovascular disease deaths and years of life lost attributable to non-optimal systolic blood pressure and hypertension in Northeastern Iran. *Archives of Iranian Medicine*, 18(3), 144–152.
- Tubek, S. (2006). Role of trace elements in primary arterial hypertension. *Biological Trace Element Research*, 114(1–3), 1–5.
- Woodman, R. J., Mori, T. A., Burke, V., Puddey, I. B., Watts, G. F., & Beilin, L. J. (2002). Effects of purified eicosapentaenoic and docosahexaenoic acids on glycemic control, blood pressure, and serum lipids in type 2 diabetic patients with treated hypertension. *The American journal of clinical nutrition*, 76(5), 1007–1015.
- Yang, C.-Y., & Chiu, H.-F. (1999). Calcium and magnesium in drinking water and the risk of death from hypertension. *American Journal of Hypertension*, 12(9), 894–899.
- Yousefi, M., Ghoochani, M., & Mahvi, A. H. (2018a). Health risk assessment to fluoride in drinking water of rural residents living in the Poldasht city, Northwest of Iran. *Ecotoxicology and Environmental Safety*, 148, 426–430.
- Yousefi, M., Mohammadi, A. A., Yaseri, M., & Mahvi, A. H. (2017). Epidemiology of drinking water fluoride and its contribution to fertility, infertility, and abortion: an ecological study in West Azerbaijan Province, Poldasht County, Iran. *Fluoride*, 50, 343–353.
- Yousefi, M., Yaseri, M., Nabizadeh, R., Hooshmand, E., Jalilzadeh, M., Mahvi, A. H., et al. (2018b). Association of hypertension, body mass index, and waist circumference with fluoride intake; Water Drinking in Residents of Fluoride Endemic Areas, Iran. *Biological Trace Element Research*, 185, 282–288.