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Public Perception on the Health Consequences of an Environmental Disaster: The Case of Lake Urmia Drying up

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Abstract

Background: Drying up of lakes is among the most important environmental disasters, which could have a great impact on human health. Since public perception is important in shaping behavior and policy-making, this study was conducted to evaluate the public perception about the health effects of Lake Urmia drying up.

Methods: In this cross-sectional study, a questionnaire was prepared and validated in 4 phases, including content validity, construct validity, test-retest reliability, and internal consistency. The online version of the questionnaire was designed in the Google Forms section and shared among public groups to be completed. The printed version of the questionnaire was completed by 2 trained interviewers in 6 villages near Lake Urmia using the convenience sampling method. Data analysis was performed using univariate statistics, including the Mann-Whitney and Kruskal-Wallis tests, and multiple linear regression as multivariate statistics.

Results: In total, 475 people completed the online and printed questionnaires, of whom 261 (54.9%) were men. The mean age (SD) of participants was 38.4 years (11.18). The mean (SD) of the overall perceived risk was 3.54 (1.28). For the group of socioeconomic determinants of health, the mean (SD) perceived risk was found to be 3.63 (1.19), while for the group of diseases, it was 3.45. (1.31). In the group of social determinants of health, migration with a mean (SD) of 3.76 (1.24) had the highest perceived risk, followed by income loss (3.63 [1.12]) and job loss (3.49 [1.20]). The highest mean (SD) perceived risk in the group of diseases belonged to lung diseases (3.99 [1.05]), hypertension (3.70 [1.17]), and cancer (3.68 [1.23]), respectively.

Conclusion: The general public had a strong notion that the drying up of Lake Urmia posed health risks.

Keywords: Public Perception, Perceived Risk, Health, Disease, Environmental Disaster, Lakes Drying, Lake Urmia

Conflicts of Interest: *None declared*
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Introduction

Humans have recently made great efforts to identify and control the adverse effects of natural disasters and achieved relative success in this regard (1). Therefore, the adverse effects of earthquakes, floods, hurricanes, volcanoes, and other disasters have decreased compared with the past (2). Reducing the adverse effects of these phe-

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↑What is "already known" in this topic:
Drying of lakes, one of the most important environmental disasters, occurs more frequently than in the past and can adversely affect human life. In addition to the implications on the environment, ecology, socioeconomics, and security, the drying up of Lake Urmia may have negative effects on health, including cancers, cardiovascular diseases, hypertension, and respiratory diseases.

→What this article adds:
In this study, a questionnaire was validated to measure the public perception of direct and indirect health effects of Lake Urmia drying up. Findings demonstrated that the general population had high perceived risk, which was similar in different groups of people.

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nomena on human health is considered a significant success (3, 4). Among the various types of disasters, fewer interventions have been made in lake drying, especially in salt lakes. Thus, little information is available in this regard (5).

Many lakes have dried up or are about to dry up on the earth, the most important of which are the Aral Sea in Central Asia, Lake Urmia (LU) in Iran, the Salton Sea, and Owens Lake in California, the Great Salt Lake in Utah, and the Dead Sea in Israel, Palestine, and Jordan (2, 6). Drying up of lakes is among the most important environmental disasters, which could have a great impact on human health in the region and neighboring countries. Increased prevalence of diseases is among the most important consequences of lake drying that could bring unpleasant experiences to humans (7). The prevalence of diseases in the vicinity of the Aral Sea is an epitome in this regard. Diseases that have increased in this region due to the drying up of lakes include tuberculosis, respiratory diseases, asthma, eye diseases, pharyngeal and laryngeal diseases, kidney and liver diseases, cancers, typhoid, hepatitis, brucellosis, diseases induced by deficiency of minerals and vitamins, diarrhea, infectious diseases, birth defects, arthritis, endocrine disorders, neurological and behavioral changes, immune system disorders, mental retardation, and delayed puberty (8-13). The particulate matter raised from Owens Lake in California contains elements such as sodium sulfate, sulfur, arsenic, chrome, cobalt, nickel, lead, et cetera, which could have side effects such as allergy and respiratory diseases, asthma, sinus infection, headache, ear infection, bronchitis, eye pain, sore throat, coughing, fatigue, lung cancer, and cardiovascular diseases (14, 15).

LU, the largest inland lake in Iran and the sixth largest saltwater lake in the world, is located between East and West Azerbaijan provinces in northwestern Iran, with a population of more than 7 million people (16). The area of this lake was about 6,000 km^2 in 1998 and its level was more than 1278 m. The water level of LU has been declining since the mid-2000s and is currently in danger of drying up completely. According to the available data, the highest volume of LU was equal to 32 billion m^3 in 1995 (17) and reached 2 billion and 730 million m^3 in January 2022, that is, it lost more than 90% of its area (18) (Fig. 1). Many reasons have been mentioned for Lake Urmia Drying up (LUD), including drought, constructing a highway on the lake, improper use of water resources of the lake catchment basin such as unauthorized withdrawals from groundwater resources, and excessive dam construction (19).

In addition to environmental, ecological, socioeconomic, and security effects, LUD could, directly and indirectly, affect human health. Many environmental experts believe that LUD has irreparable consequences for provinces as well as neighboring countries (20). It is estimated that more than 13 million people will be affected by LUD (21, 22). Regional climate change from temperate to tropical, changes in the region's ecosystem, water shortage, reduced agricultural period, decreased fertility of agricultural lands, and reduced number of tourists entering the region, and the resulting irreparable economic losses will lead people to migrate and all these factors will have an indirect adverse impact on health (20). Moreover, LUD increases salt dust, chemicals, and heavy metals suspended in the air due to wind (23, 24). Due to the entry of industrial and agricultural effluents into the lake and their

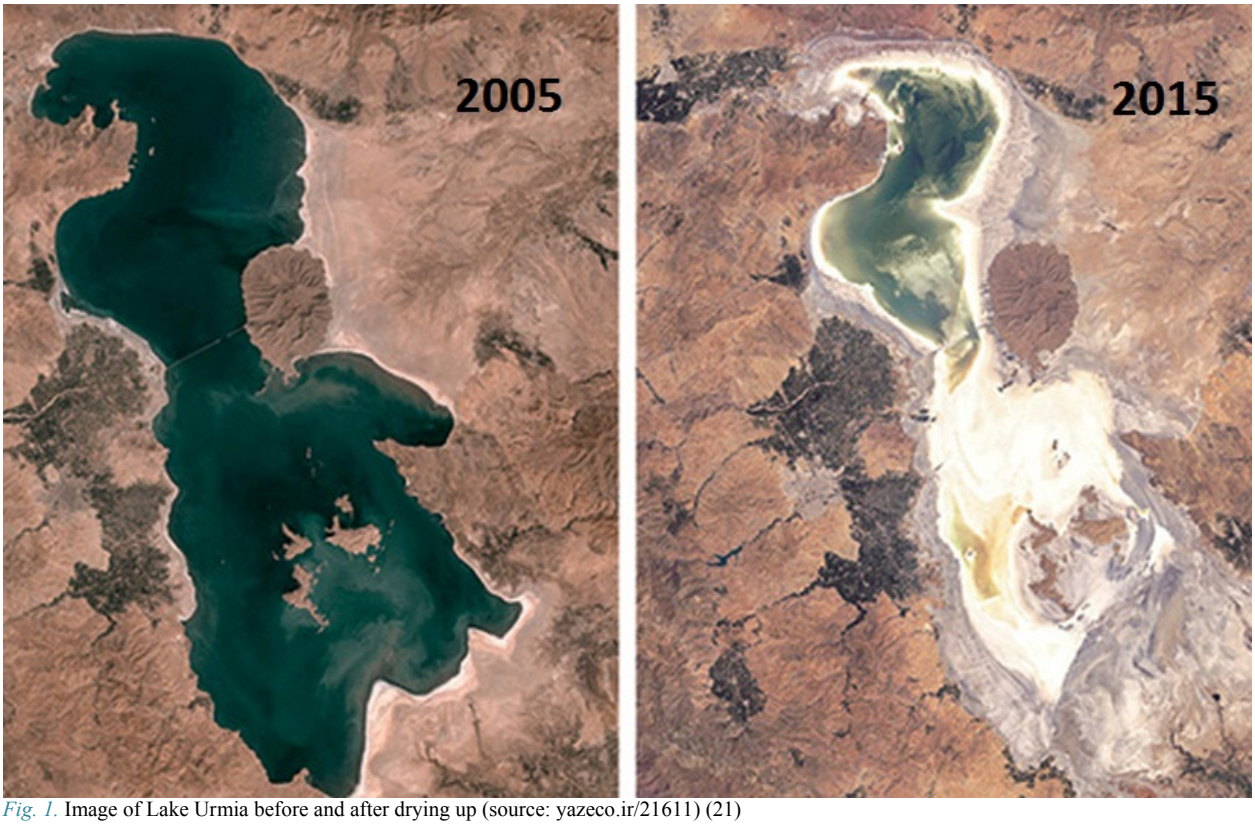

Fig. 1. Image of Lake Urmia before and after drying up (source: yazeco.ir/21611) (21)

[DOI: 10.47176/mjiri.36.136]

sediment in its bed, these dusts would be contaminated with industrial and agricultural toxins (10). Therefore, dust exposure through respiration and skin and accumulation of metals in plants and agricultural products and their concentration in the food chain could cause health problems, including respiratory diseases, cancers, cardiovascular diseases, hypertension, and eye diseases (25-29).

The principle of respecting and responding to public opinion about all problems of society has been accepted by most countries, as human perception is the result of a multidimensional and dynamic process with individual characteristics (30) and reflects individuals' concerns and priorities. Some experts believe that human behavior is mainly driven by thoughts and perceptions rather than facts (31, 32). Knowing public perceptions of extreme weather events as well as environmental crises and their risks is of particular importance in shaping policies, designing risk reduction programs, and increasing adaptation measures (33). Knowing individuals' thoughts and perceptions could encourage people to participate in risk prevention and reduction programs by implementing training and awareness programs, responding to hazards, changing behaviors, and engaging in participatory activities (30). In various societies, the more a public official's social acceptance, the more receptive they are to public opinion. For this purpose, they should pay attention to public opinion and use them in policy-making and planning. Without knowing public opinion and analyzing its various dimensions, proper planning and risk response will be impossible (30, 34).

This research was done to assess public perception and their perceived risks regarding the influence of LUD on health since public opinion about the effect of LUD on health has not yet been studied.

Methods

Research Design

This descriptive, analytical, and cross-sectional study was performed on urban and rural residents of 2 neighboring provinces of LU, that is, East and West Azerbaijan, from December 2021 to February 2022. After preparing and validating the questionnaire, its online version was designed in the Google Forms section and shared among public groups on various social media and sites to be completed.

Validating the Questionnaire

The relevant papers were thoroughly reviewed using the main keywords to design a questionnaire for obtaining public opinion about the effects of LUD on health. A conceptual structure was designed and the questionnaire was developed. The questionnaire was validated in 4 phases, including content validity, construct validity, test-retest reliability, and internal consistency reliability. Then, the final version of the questionnaire was obtained.

Content Validity

The opinions of 14 experts in epidemiology, biostatistics, health education, health in disasters and emergencies, and medical physics were obtained to evaluate the content validity of the questionnaire by the quantitative method. Content validity ratio (CVR) was calculated by a 3-point scale (1 = not essential, 2 = useful but not essential, and 3 = essential) based on the Lawshe method to assess the necessity of items (35). Considering that 14 experts responded to CVR items, the CVR ≥0.51 was considered acceptable (35).

Content validity index (CVI) was calculated at item (I-CVI) and scale (S-CVI) levels using a 4-point scale (1 = not relevant, 2 = requires serious review, 3 = relevant but requires review, 4 = highly relevant) to assess the relevance of items. CVI at the item level (I-CVI) was obtained by dividing the number of experts giving a score of 3 or 4 to each item by the total number of experts. Accordingly, scores above 0.79 were considered acceptable. S-CVI-Ave was calculated by obtaining the mean I-CVI. Then, S-CVI-UA was calculated by dividing the items with I-CVI equal to 1 by the total number of items.

The questionnaire initially included 15 items. Due to the low CVR of item 4 (<0.51), this item was deleted and merged with item 5. The CVR of other items was acceptable (over 0.51) according to Lawshe's table. After performing this step, 14 items remained.

CVI was calculated with the remaining 14 items. This index was acceptable at the item level (I-CVI) for all the items (over 79%). S-CVI/Ave, which is the mean I-CVI, was equal to 0.96 and S-CVI/UA was equal to 7/14 = 0.5.

Construct Validity

Exploratory factor analysis (EFA) with principal component factor in the extraction method was used to evaluate construct validity. The lower bound of the eigenvalue was equal to 1. The uniqueness index was considered to be <0.7 for selecting items with sufficient commonality. About 45% of the data were randomly selected (sample size = 225), and EFA was performed using the varimax rotation. In total, 3 factors were obtained that justified 70.45% of the variance. There were 8, 3, and 3 items in the first, second, and third factors, respectively. The Kaiser-Meyer-Olkin (KMO) value was obtained as 0.909, indicating model adequacy. Bartlett's test of sphericity with the value of 2106.09 was significant (p< 0.001). The uniqueness index of all the items was < 0.7. Table 1 presents factor loadings and the uniqueness of the questionnaire items.

Test-retest Reliability

In total, 22 individuals completed the questionnaire twice with a 3-week interval to evaluate the stability of the questionnaire. The stability of the questionnaire was calculated using the Spearman-Brown formula (36). The mean values of responses of each person in the test and retest were calculated. Then, the Pearson correlation between these 2 variables was obtained as 0.569 (p= 0.007). The Spearman-Brown correlation coefficient was calculated as 0.725 using the Spearman-Brown formula. Since this coefficient was above 0.7, the stability of the questionnaire was confirmed at an acceptable level.

[DOI: 10.47176/mjiri.36.136]

Table 1. Factor loading matrix for items of public opinion questionnaire on health consequences of LUD

Question: The effect of drying of Lake Urmia on … in the inhabitants of two neighboring provinces (East Azerbaijan & West Azerbaijan)	Factor 1 (Diseases)	Factor 2 (General Impacts)	Factor 3 (Social Determinant of Health)	Uniqueness
Eigenvalue	7.59	1.22	1.04	
Pulmonary diseases	0.7895			0.2559
Cancer	0.7635			0.2964
Heart diseases	0.8073			0.2171
Hypertension	0.6970			0.2887
Depression	0.6557			0.3794
Anxiety / Stress	0.6812			0.3941
Allergy	0.6829			0.3972
Generally harmful to human health	0.6424			0.4384
Suicide attempt		0.8427		0.2104
Malnutrition		0.8046		0.2159
Anemia		0.7315		0.2252
Migration			0.6460	0.4296
Income loss			0.8549	0.1977
Job loss			0.8187	0.1927
Variance	54.23%	8.74%	7.48%	

Internal Consistency Reliability

Cronbach's alpha, which is the most common measure of internal consistency, was used to evaluate the internal consistency reliability. The alpha value of 0.7 or higher was considered acceptable. The Cronbach's alpha of this questionnaire was obtained as 0.936. Due to the high alpha values of the whole questionnaire and individual items (all above 0.9), no items were deleted at this stage.

Sample Size and Sampling Method

The sample size was calculated as 384 individuals using $n=Z^2SD^2/d^2$ where the alpha error was considered 0.05 (Z = 1.96), SD (Standard Deviation) was set to 1.5, and d was equal to 0.15. One part of interview was conducted online using the online version of the questionnaire, which was created in the Google Forms section. The other part was performed using the convenience sampling method in 6 villages near LU. The interviewers went to the village and interviewed those who were willing to cooperate. Two male and female interviewers were selected from experienced health care workers in the health system who lived in 2 villages near LU and had a history of interviewing. The interviewers were first trained to become familiar with concepts and inclusion criteria and learn how to ask questions and explain concepts to respondents. The questionnaire was prepared in Persian. Given that all the participants were literate, they responded to the questionnaire and there was no need to read the questions in Turkish. At the beginning of the interview, a connection was made between the interviewers and respondents in Turkish to explain the research objectives and resolve ambiguities about the questions.

Inclusion and Exclusion Criteria

All the individuals aged 16 years and older who lived in 2 provinces adjacent to the lake, that is, East and West Azerbaijan, and were able to respond to the questionnaire were included in the study. The individuals under the age of 16 years old and living in other provinces who completed the online questionnaire were excluded from the study at the analysis stage.

Statistical Analysis

Descriptive analysis of the data was performed using descriptive statistics such as frequency, percentage, mean, and standard deviation. For analytical analysis, the mean value of responses of each individual was calculated. Accordingly, a new variable was obtained and its correlation with contextual variables was investigated. The correlation between this variable and qualitative variables was examined using the Mann-Whitney and Kruskal-Wallis tests. Moreover, Spearman's correlation coefficient was employed to examine the correlation between this new variable and the quantitative variable of age. The normal distribution of quantitative variables was evaluated by the Kolmogorov-Smirnov test. Multivariate analysis was performed using multiple linear regression. The variables that were statistically significant in the univariate analysis were entered into the linear regression model and their correlation with the dependent variable was investigated. As mentioned above, the correlation between individual items and contextual variables was examined as univariate and multivariate. The data were analyzed using SPSS 22.0 and STATA 14.

Results

The online questionnaire was completed by 538 individuals in 58 days from December 12, 2021, to February 7, 2022. After deleting blank rows and duplicate data and excluding those aged under 16 years, 476 individuals remained. In total, 60 people who lived in provinces other than the 2 neighboring provinces of the lake and responded to the questionnaire were excluded from the analysis. Thus, the data of 416 individuals remained. Given that the rural residents were less willing to participate in the online questionnaire, the paper questionnaire was distributed to 59 individuals in 6 villages near LU. Finally, the sample size reached 475. The mean age (SD) of the participants was 38.4 (11.18). The minimum and maximum age of the participants was 16 and 74 years old, respectively. Table 2 presents the demographic characteristics of the participants.

The mean scores of responses ranged from 1 to 5 for each item (Fig. 2). The mean (SD) of the overall perceived

[DOI: 10.47176/mjiri.36.136]

Table 2. The demographic characteristics of participants

		Frequency	Percent
Province	East Azerbaijan	332	69.9
	West Azerbaijan	141	29.7
	Missing	2	0.4
County	Adjacent	224	47.2
	Far	227	47.8
	Missing	24	5.0
Gender	Male	261	54.9
	Female	209	44.0
	Missing	5	1.1
Education (years)	<7	30	6.3
	7-12	104	21.9
	13-16	230	48.4
	16<	106	22.3
	Missing	5	1.1
Residence place	Urban	367	77.3
	Rural	102	21.5
	Missing	6	1.2
Job	Unemployed	7	1.5
	Student	35	7.4
	Employee	205	43.2
	Worker	24	5.1
	Housewife	63	13.3
	Self-employed	90	18.9
	Retired	37	7.8
	Farmer / Rancher	10	2.1
	Missing	4	0.8
Health personnel	Yes	134	28.2
	No	334	70.3
	Missing	7	1.5

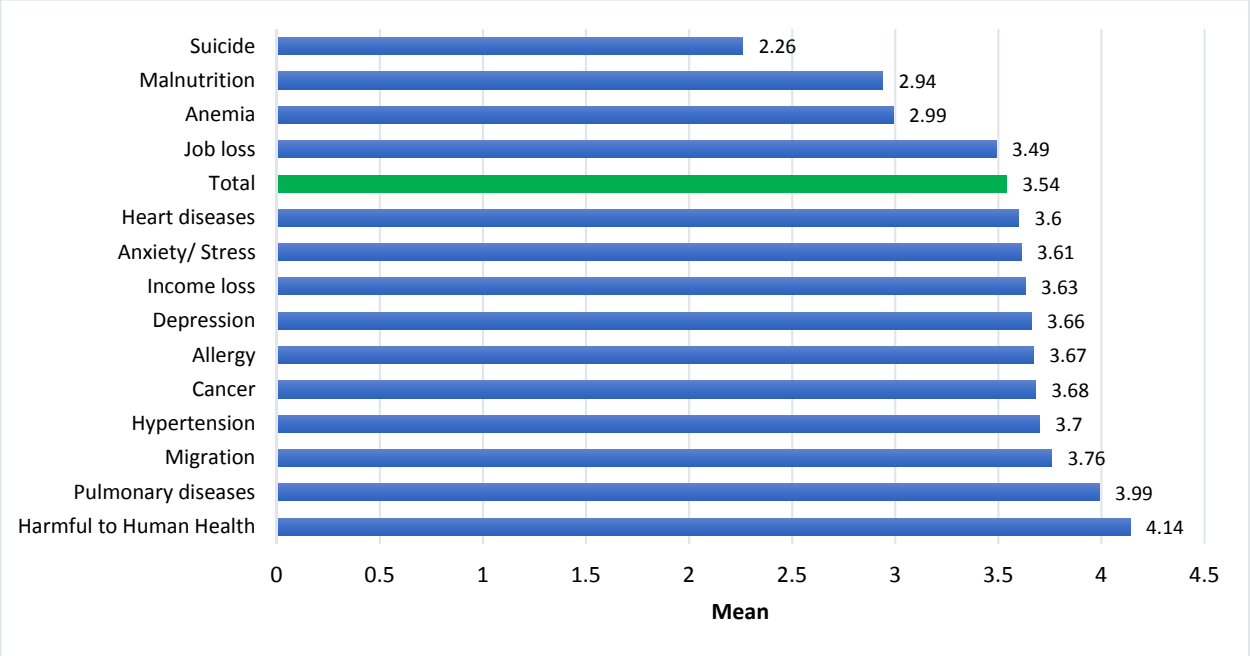

Fig. 2. The average risk perception for each item and total

risk was 3.54 (1.28). The mean (SD) perceived risk for the group of social determinants of health (migration, income loss, and job loss) was obtained as 3.63 (1.19) and for the group of diseases was 3.45 (1.31). The highest perceived risk, with the mean (SD) of 4.14 (1.08), was related to the question of "How much can LUD harm human health in general?" In the group of social determinants of health, migration with a mean (SD) of 3.76 (1.24) had the highest perceived risk, followed by income loss (mean [SD] = 3.63 [1.12]) and job loss (mean [SD] = 3.49 [1.20]). The highest perceived risk in the group of diseases belonged to lung diseases (mean [SD] = 3.99 [1.05]), hypertension (mean [SD] = 3.70 [1.17]) and cancer (mean [SD] = 3.68 [1.23]); and the lowest perceived risk was related to suicide (mean [SD] = 2.26 (1.39)), malnutrition (mean [SD] = 2.94 [1.29]) and anemia (mean [SD] = 2.99 [1.26]).

Results of the multiple linear regression revealed a statistically significant difference among the subgroups of

[DOI: 10.47176/mjiri.36.136]

Table 3. The results of multivariate linear regression analysis for overall perceived risk

Variable	Standardized Beta	t	*P*-value
Constant		14.276	<0.001
Gender (0=Male, 1=Female)	0.135	2.718	0.007
Education (0= <7, 1= 7-12, 2= 13-16, 3= 16<)	-0.157	-3.032	0.003
Residence place (0=Urban, 1=Rural)	0.076	1.499	0.135
Health personnel (0=Yes, 1=No)	0.136	2.620	0.009

gender (Standardized Beta = 0.135; *p*= 0.007), education (Standardized Beta = -0.157; *p*= .003), and health care personnel (Standardized Beta = 0.136; P = 0.009) in the overall perceived risk (Table 3). The Standardized Beta for gender was 0.135. This coefficient value indicates that the mean of overall perceived risk increases by 0.135 given a 1-unit increment in gender (men [code = 0] to women [Code = 1]), adjusted for education, health personnel, and residence place. Therefore, the overall perceived risk of LUD was higher among women, those with a lower level of education and non-health care personnel than men, those with a higher level of education and health care personnel. The perceived risk was similar among the other subgroups.

Results of multiple linear regression indicated a significant difference for the health care personnel in lung diseases (*p*< 0.001), cancer (*p*= 0.005), cardiovascular diseases (*p*= 0.018), hypertension (*p*= 0.007), allergy (*p*= 0.055), and overall health damage (*p*= 0.012). Therefore, the severity of the perceived risk for lung diseases, cancer, cardiovascular diseases, hypertension, allergy, and overall health damage resulting from LUD was higher among non-healthcare personnel than health care personnel. The education variable was significant in the items of migration, income loss, job loss, depression, stress, malnutrition, anemia, allergy, and overall health damage. Therefore, the severity of the perceived risk resulting from LUD in mentioned items was higher among those with a lower levels of education. The variable of gender was significant in the items of income loss (*p*= 0.046), lung diseases (*p*= 0.003), depression (*p*= 0.046), anemia (*p*= 0.003), and allergy (*p*= 0.001) as a result of multivariate analysis. Therefore, the severity of the perceived risk for income loss, lung diseases, depression, anemia, and allergy resulting from LUD was higher among women than men. Similarly, the variable of the place of residence was statistically significant in the items of migration (*p*= 0.028) and cancer (*p*= 0.030), suggesting that the severity of the perceived risk for migration and cancer due to LUD was greater among rural people than urban ones.

No statistically significant difference was observed for variables of age, province, county, and job in the mentioned items. Accordingly, people in different occupational and age groups, residents of East and West Azerbaijan provinces, and residents of counties adjacent to/far from the lake had the same perception regarding the risk of LUD for health.

Discussion

This study was conducted to evaluate the public opinion in the 2 neighboring provinces of LU and their perceived risks regarding the effect of LUD on health. The mean overall perceived risk was 3.54 out of 5. This value was numerically higher than the average, suggesting the overall perceived health risk of LUD was high among the general population of the East and West Azerbaijan provinces.

The mean perceived risks for the group of social determinants of health (migration, income loss, and job loss) and the group of diseases were 3.63 and 3.45, respectively, which are high in both groups. However, this perceived risk for social determinants of health (migration, income loss, and job loss) was slightly higher than that for diseases, the reason for which could be attributed to the point that social determinants of health are more objective for the general population, as they often observe the migration of others around them, income reduction and a job loss of themselves and acquaintances (37-41). Although getting sick is also an objective event and people experience illness, the cause of migration, income loss, and job loss could easily be attributed to LUD. However, attributing diseases to LUD is more complicated both for the general population and professionals working in this field due to the multifactorial nature of risk factors for diseases.

The mean risk that people perceive when asked "How much might LUD affect human health in general? " was equivalent to 4.14, a substantially high value, indicating that persons living in the 2 adjacent provinces of the lake considered the overall health risk of LUD as being very high, both directly and indirectly. The highest perceived risk was related to lung diseases (3.99) and migration (3.76), respectively, indicating high perceived risk for both items. Musapour et al found that the incidence of asthma in areas near the lake was almost twice as high as in areas far from the lake, showing a high risk of LUD for asthma (28). Several studies have demonstrated the effect of LUD on increasing the prevalence of lung diseases (asthma, COPD, bronchitis, and pneumonia) (24, 42, 43). Tabrizi et al reported the prevalence of asthma in areas close to the lake was higher than that in areas far from the lake; however, this difference was not statistically significant (44). Investigations conducted on other lakes have also reported a high risk for the incidence of lung diseases (45, 46). Although migration could be objectively observed, the perceived risk of lung diseases was greater than migration. This finding indicated people have objectively perceived the increased rate of lung diseases. Another reason could be due to the impact of news sites and social media, which mostly highlight the effects of LUD with more emphasis on lung diseases (47, 48).

After lung diseases and migration, the highest mean perceived risk was related to hypertension (3.7), cancer (3.68), allergy (3.67), depression (3.66), income loss (3.63), stress/anxiety (3.61), and cardiovascular diseases

[DOI: 10.47176/mjiri.36.136]

(3.6), respectively, indicating high perceived risk for all these diseases. However, there was no significant difference between the mean perceived risks of these diseases. Studies have indicated adverse effects of LUD on hypertension (44), cancer (25, 26), depression (41), stress/anxiety (41), cardiovascular diseases (29, 42, 43, 49), and income and job loss (38, 50-53). Moreover, several studies have shown the adverse effect of drying up of other lakes on cancer (11, 54) and stress (55).

The perceived risks of anemia (2.99) and malnutrition (2.94) were almost in the middle of the range and lower than other discussed diseases. However, studies have reported an increased prevalence of anemia in areas close to LU (44, 56), the reason for which could be attributed to the point that the general population is not familiar with the nature of anemia and care less about this disease. Another reason could be that news sites and social media rarely report this disease. Tabrizi et al compared the prevalence of overweight, obesity, abdominal obesity, and vitamin D deficiency in areas near and far from the lake and found no statistically significant difference between the 2 areas (44). This finding is consistent with a lower perceived risk of malnutrition in our work if these variables are considered as indicators of malnutrition. However, the mean value of 2.94 for malnutrition in the present study is not considered low risk. The lowest perceived risk was related to suicide (2.26), which seemed to be logical compared with other diseases and due to the indirect effect of LUD.

The severity of the perceived risk for most diseases was higher among non-healthcare personnel and those with a lower level of education than health care personnel and those with a higher level of education, the reason for which could be attributed to the point that health care personnel and those with a higher level of education receive information from more specialized sources and are less influenced by social media. As the reports provided by specialized sources are more accurate and scientific, the lower severity of the perceived risk among health care personnel and people with higher educational levels could be indicative of risk overestimation by non-healthcare personnel and those with lower educational levels.

People in different occupational and age groups, residents of East and West Azerbaijan provinces, and residents of counties adjacent to/far from the lake had the same perception regarding the impact of LUD on health and no statistically significant difference was observed. This finding showed the general population and different groups of people had the same perception regarding the health risks of LUD.

To the best of our knowledge, this study examined public opinion and perception regarding the health risks of LUD for the first time, which was among the strengths of this research.

Conclusion

The results revealed the general population had a high perception of the health risks of LUD and this perception was similar in most of the groups. Due to the general population's high perception of the health risks of LUD, which is consistent with reality in most cases, prompt measures should be taken to restore the lake and reduce health risks.

Acknowledgment

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Ethical Approval

This study was approved by the Ethical Committee of Kerman University of Medical Sciences. The ethics approval code is IR.KMU.REC.1398.532. Verbal consent was obtained from all participants in the study.

Conflict of Interests

The authors declare that they have no competing interests.

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