Contamination of drinking water with *Entamoeba histolytica* in Dhamar city, Yemen

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Abstract

This study was conducted in some areas of Dhamar city between August, 2022 to January, 2023, with the main objective to determine the contamination rate of drinking water with Entamoeba histolytica/disper and associated risk factors. A total of 196 drinking water samples from different houses of Dhamar were collected and examined. The samples were collected randomly and labeled with necessary information in sterilized and dry plastic containers, and brought to Authority of water and sanitation, and Khalid Mohammad Khakid hospital laboratories, Dhamar, for processing and examination. Water samples were examined microscopically for the presence of E. histolytica/disper cysts using direct saline thin smear and concentration sedimentation techniques. Data related to sociodemographic of householders, Physicochemical and environmental characteristics of samples were also collected. The results of the study reveal that out of 196 samples examined, 10 samples were found contaminated with E. histolytica/disper with overa all contamination rate of 5.1%. The distribution of contamination rate according to characteristics of water samples are higher in drinking water obtained from Governmental system or network (4.10%), followed by water Tanks cleaned once per year (3.1%), samples do not treated with chlorine(3.6%), in tanks with capacity range between 4000-7000 liters (2.6%), in tanks made of Iron (4.6%), in water served by pump(3.6%), at distance of <50-100 meter far from sewage(3.1%), in samples with PH values range between 7.1-8(3.1%), with turbidity values of 0.1-1(4.1%), in samples with dissolved solids range between 501-1000 (3.1%), in temperature range from 16-20 °C, in samples collected during months of August and October (2.0%) compared to other variables investigated. The results of the logistic regression analyses show significant association between contamination rate and water treated with chlorine (OR=5.265; 95%: 1.225-22.626; P= 0.026), distance between source of drinking water and sewage (OR=.265; 95%: .065-.6761; P=.009) and water with dissolved solids (OR=2.623; 955Cl:1.01-6.81; P=.048); while, none with other sociodemographic characteristics of householders and characteristics of water samples assessed. In conclusion, drinking water in study areas of Dhamar city is contaminated with E. histolytica/disper. It is strongly recommended to adopt proper water safety measures and providing clean drinking water to community in study areas.

***Keywords**: Contamination, E. histolytica, Drinking water, Dhamar, Yemen*

تلوث مياه الشرب ببكتيريا Entamoeba histolytica في مدينة ذمار، اليمن

الملخص

أجريت هذه الدراسة في بعض مناطق مدينة ذمار خلال الفترة من أغسطس 2022 إلى يناير 2023، بهدف رئيسي هو تحديد معدل تلوث مياه الشرب بالمتحولة الحالة للنسج/المتشتتة وعوامل الخطر المرتبطة بها. تم جمع وفحص 196 عينة من مياه الشرب من منازل مختلفة في ذمار. تم جمع العينات عشوائياً، ووضعت عليها المعلومات اللازمة في عبوات بلاستيكية معقمة وجافة، وأحضرت إلى هيئة المياه والصرف الصحي ومختبرات مستشفى خالد محمد خكيد بذمار للمعالجة والفحص. تم فحص عينات المياه مجهريا لوجود E. histolytica/disper Cys باستخدام مسحة رقيقة ملحية مباشرة وتقنيات الترسيب المركزة. كما تم جمع البيانات المتعلقة بالخصائص الاجتماعية والديموغرافية لأفراد الأسرة والخصائص الفيزيائية والكيميائية والبيئية للعينات. أظهرت نتائج الدراسة أنه من أصل 196 عينة تم فحصها، وجد أن 10 عينات ملوثة ببكتيريا E. histolytica/disper بنسبة تلوث تزيد عن 666ع بنسبة 5.1%. توزيع نسبة التلوث حسب خصائص عينات المياه تكون أعلى في مياه الشرب التي يتم الحصول عليها من النظام أو الشبكة الحكومية (4.10%)، تليها خزانات المياه التي يتم تنظيفها مرة واحدة سنوياً (3.1%)، والعينات غير المعالجة بالكلور (3.6%). ، في خزانات تتراوح سعتها بين 4000-7000 لتر (2.6%)، في خزانات مصنوعة من الحديد (4.6%)، في المياه التي تخدمها المضخة (3.6%)، على مسافة أقل من 50-100 متر بعيداً عن الصرف الصحي (3.1%)) ، في العينات التي تتراوح قيم PH فيها بين 7.1-8(3.1%)، وقيم العكارة 0.1-1(4.1%)، في العينات التي تتراوح فيها المواد الصلبة الذائبة بين 501-1000 (3.1%)، في درجات الحرارة من 16- 20 درجة مئوية في العينات التي تم جمعها خلال شهري أغسطس وأكتوبر (2.0%) مقارنة بالمتغيرات الأخرى التي تم فحصها. تظهر نتائج تحليلات الانحدار اللوجستي وجود ارتباط كبير بين معدل التلوث والمياه المعالجة بالكلور (نسبة الأرجحية = 5.265؛ 95%: 1.225-22.626؛ قيمة الاحتمال = 0.026)، والمسافة بين مصدر مياه الشرب والصرف الصحي (نسبة الأرجحية = 0.265؛ 95). %: .065-.6761؛ (P=.009) والماء مع المواد الصلبة الذائبة (OR=2.623 ؛ 955Cl:1.01-6.81؛ P=.048)؛ في حين لم يتم تقييم أي خصائص اجتماعية ديموغرافية أخرى لأفراد الأسر وخصائص عينات المياه. نستنتج من ذلك أن مياه الشرب في مناطق الدراسة بمدينة ذمار ملوثة ببكتيريا .E. histolytica/disper يوصى بشدة باتخاذ تدابير مناسبة لسلامة المياه وتوفير مياه الشرب النظيفة للمجتمع في مناطق الدراسة.

***الكلمات المفتاحية**: التلوث، الحالة للنسج، مياه الشرب، ذمار، اليمن*

I. INTRODUCTION

Water covers almost 70 % of the earth's surface but most water sources are saline; while drinkable water (fresh water) constitutes only 2.5 % of the earth's water (United Nation. 2008; Nsoh et al., 2016). Yemen is located in a dry and semi-arid region of the Middle East, where the average annual rainfall ranges from 500 to 800 mm in the high lands, 40 to 100 mm in the coastal areas and 50 mm in the desert areas (Al-Omari, 2008). Unlike other Middle-Eastern countries like Lebanon. Yemen has no rivers. It depends on rainwater as well as underground water. Yemen's water shortage is far worse than that of any other country in the Middle East. The average person in the Middle East has 1,250 millimeters (mm) of water per year; whereas, the average person in Yemen has 140 mm of water per year (Class, 2010).

Water is extremely essential for the growth and survival of all living creatures. The availability and accessibility of drinking water is important for the development of any community (Danjuma et al., 2020). Access to safe water is a fundamental human need and it is the basic human right. Nearly, 1.1 billion people remain without access to hygienic sources of drinking water, and about 2.4 billion have no access to improved sanitation services (WHO, 2000)**.** Contaminated water jeopardizes both the physical and social health of human. WHO estimates that more than 3.4 million people die as a result of water-related diseases every year, making it the leading cause of disease and death worldwide. Among these deaths, about 1.4 million are children (Berman, 2009; Abuseir, 2023).

Water quality is influenced by many factors like precipitation, climate, soil type, vegetation, geology, flow conditions, ground water, lack of drinking water sources, the need to maintain the current available sources and human activities. The greatest threat to water quality is posed by industrial and municipalities activities (Florescu et al., 2010). Both developed as well as developing countries are facing water pollution problems with biological and chemical pollutants (Nabizadeh and Faaezi, 1996; Florescu et al., 2010; Danjuma et al., 2020). In Yemen and other countries developing countries, the main contaminants of these water sources come from human excreta due to open field defecation practices, animal waste and effluent from sewage system. Thus, the majority of communities use water from contaminated or doubtful sources, which expose the people to various waterborne diseases (FDRE, 2004, Al-Ubaidi et al,2006; Desalegn and Temesgen, 2020).

Entamoeba histolytica are waterborne diseases and one of the biological pollutant contaminated drinking water and cause amoebasis disease in humans and animals. *E. histolytica* is an aerobic parasitic protozoan belonging to Genus Entamoeba. It is reported that about 450 million infections and 100,000 deaths with *Entamoeba histolytica* per annual in developing countries (Parson, 2006; Pham et al., 2011). The reasons for higher prevalence, incidence and distribution rate of *E. histolytica* parasite are low economic income, lack of hygiene practices, and scant sanitation of the environment, insufficient health system, inadequate awareness about the life cycle patterns and transmission mechanisms of this parasite (Adeyeba and Akinlabi, 2002).

The life of human is related to safe water. Most of the problems in developing countries are mainly due to the lack of safe drinking water. Therefore, this study is designed to determine the contamination rate of *Entamoeba histolytica* and associated risk factors in drinking water at Dhamar city areas.

II. MATERIALS & METHODS

2.1. Study area

The study was conducted between August, 2022 to January, 2023 in Dhamar city, Dhamar Governorate. Dhamar Governorate located to the south east of Sana'a Governorate, to the north of Ibb governorate, to the east of Hudaydah Governorate and to the northern west of Al Bayda'a Governorate in the central highlands of Yemen. The topography of Dhamar area varies from level plain to slopes at elevation between 2400 to 2700 m above sea level. It is irrigated by rainfall and underground water. According to the last Census in 2004, the total population of the governorate is about 1,330,108 which expected to be 3,311,033 in 2034. Agriculture is the main economic activity in the area. Majority of population work in Agriculture (Abbas et al., 2018; Al-Aizari et al., 2018).

Fig: 1. **Map of Dhamar Governorate**; **Source**: NIC. 2021. Map of Dhamar Governorate. Retrieved 29.2.2021 http://www.yemen-nic.info/, from National Information Center, Sana'a.

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2. 2Study and Size of samples

Water samples were obtained from governmental network system and other resources from different homes at Dhamar city areas. The sample size was calculated according to previous studies of Ayaz et al., (2011) and Nsoh et a l., (2016) considering 15% expected prevalence of *Entamoeba histolytica/disper* and 95% confidence interval with a 5% desired absolute precision using the following formula: $N= (Z)^2 P(1-P)/d^2$, where, (p) expected prevalence and (Z) 95% confidence interval (Z= 1.96) and (d) a 5% desired absolute precision. $N= 1.96^2 Pexp (1-Pexp)/D^2$: *Where, Pexp = expected prevalence; d= absolute precision; n=sample size*. Accordingly, 196 samples were collected and examined.

2.3. Study design

A cross-sectional study.

2.4. Collection of samples

In order to achieve the objectives of this study, the geo-localization of homes using water tanks for drinking water were located. 196 samples were collected from the targeted houses. A 500 ml of water sample was collected in dry plastic containers (Polyethylene) or bottles and labeled with necessary information, then were transferred to the Authority of water and sanitation, and Khalid Mohammad Khalid hospital laboratories, Dhamar according the techniques described by Ghasemi et al. (2015). A household-based questionnaire was used to collect sociodemographic characteristics of householders. On all the householders selected, the bio-information such as sex, age, income, family size and availability of medical services were collected. The data regarding the characteristics of water samples and tanks, their capacity (m3), the method and frequency of cleaning, the method used for water serving (manually or pumping) etc. were collected.

Physiochemical information such as temperature, pH, total dissolved solids (TDS) and turbidity measurement were also collected. The environmental information includes water distribution system and the distance between water source and waste disposal sites and month sampling were collected by observation of the sites as well as interviewing the residents.

2.5. Analysis of samples

The collected samples were subjected to the following analyses and examination:

2.5.1. Physicochemical Analysis

Physicochemical Analyses such as temperature, pH, total dissolved solids (Parts Per Million (PPM), turbidity measurements were carried out according to techniques described by Danjuma et al. (2020).

3.5.3. Parasitological Analysis

In laboratory, each sample of water was examined for detection of *E. histolytica/disper*, according to techniques described by Kwakye-Nuako & colleagues (2007) and Nsoh et al. (2016). In brief, each collected sample was shaken and the cap of the water bottle carefully was removed avoiding touching the opening with bare hands. The bottle or plastic containers contents were dispensed into test tubes and centrifuged at 2000 rotations per-minute (rpm) for 3 minutes. Then, the contents of each of these test tubes were pooled together after the supernatant fluid had been discarded. The combined sediment was re-centrifuged under the same conditions as above and the supernatant fluid was again discarded and the sediments examined microscopically. Direct wet/iodine preparation for identification of cysts also was done using the method described by Amer (2012).

Statistical analysis

Data obtained were entered into and analyzed using SPSS version 21. Values were presented as Frequencies, percentage from the total samples count in the corresponding groups. Contamination rate of drinking water with *E. histolytica/disper* considered as the main outcome and socio-demographic, physiochemical and environmental characteristic/ factors as the explanatory variables. All the variables included in the present study were coded. The difference between contamination rate of *E. histolytica/disper* among different categories was compared using Pearson chi-square test. Logistic regression was used to identify factors associated with *E. histolytica/disper* contamination of the drinking water. A *P value* of <0.05 was used as a statistically significant difference.

Ethical approval

This study was approved by ethical committee of Al-Hikma University in Thamar city. Oral consent was obtained from householders that are showed consent to participate in the study after explaining the purpose of the study.

III.RESULTS

3.1. Socio-demographic characteristics of the participated householders

One hundred ninety-six householders from different areas of Dhamar city participated in this study. The socio-demographic characteristics of participants are presented in Table 1. The age of householders ranged between 15-60 years old, 79 (40.3%) were males; whereas, 117(59.7%) were females, regarding the family size, 64.3%, 6.1% and

21.4 having 6-10, 11-15 and 21.4 individuals respectively; the income of individual was ranged between 10000-60000 Yemeni Rials; 164(83.7%) have no medical services while; 32(16.3%) having medical services.

Table 1. General socio-demographic characteristics of participated householders (n = 196)

Characteristic	Categories	Frequency	%
Age	15-30	123	62.8
	31-45	67	34.2
	46 -60	6.0	3.1
Gender	Male	79	40.3
	Female	117	59.7
Family size	6-10	126	64.3
	11-15	12	6.1
	16-20	42	21.4
	21- and above	16	8.2
Family Income	10000-30000	132	67.3
	31000-60000	64	32.7
Medical Service	No	164	83.7
	Yes	32	16.3

Table 2. Physiochemical and environmental characteristics of water samples examined(n=196)

Characteristic **/variable**	**Categories**	**Frequency**	**%**
water sources	truck	45	23.0
	well	11	5.6
	Other sources	4.0	2.0
	Governmental system	136	69.4
Cleaning frequency/year	Never	110	56.1
	once	45	23.0
	Twice	38	19.4
	Thrice	3.0	1.5
Treatment with chlorine	No	179	91.3
	Yes	17	8.7
Tanks capacity	<3000-3000L	65	33.2
	4000-7000L	75	38.3
	8000 -10000 and more	56	28.6
Tank`s type	Iron	178	90.8
	Plastic	16	8.2
	ground	2.0	1.0
Collection of water from tanks	Manually	71	36.2
	Using Pumps	125	63.8
Distance from sewage disposal	<50-100M	43	21.9
	101-150m	102	52.0
	151-200m	26	13.3
	250m and more	25	12.8

water`s pH	6.50-7	12	6.1
	7.1-80	130	66.3
	8.1 and above	54	27.6
Turbidity	0.1-1	173	88.3
	1.1-2	20	10.2
	2.1-3	3.0	1.5
Dissolved solid in water (PPM)	0-500	10	5.1
	501-1000	163	83.2
	1001-1500	18	9.2
	1501 and above	5.0	2.6
Temperature(ºĊ)	<13-15	5.0	2.6
	16-20	98	50.0
	21 and above	93	47.4
Month sampling	Aug	32	16.3
	Sep	39	19.9
	Oct	40	20.4
	Nov	36	18.4
	Dec	23	11.7
	Jan	26	13.3

Table 3. Overall contamination of drinking water *with E. histolytica/disp*er in Dhamar and according to characteristic/variable studied (n=196)

Factor/variable	Categories	No. of positive	Contamination %	*p* value
Water sources	Truck	1	0.5	0.528
	well	0	0.0	
	Other sources	0	0.0	
	Governmental system	9	4.6	
Cleaning frequency/year	Never	3	1.5	.042
	once	6	3.1	
	Twice & More	1	0.5	
Treatment with chlorine	No	7	3.6	0.045
	Yes	3	1.5	
Tanks capacity	<3000-3000L	1	0.5	0.277
	4000-7000L	5	2.6	
	8000 -10000 and above	4	2.0	
Tank`s type	Iron	9	4.6	0.01
	Plastic	0	0.0	
	Land	1	0.5	
Collection of water from tanks	Manually	3	1.5	
	Using Pumps	7	3.6	
Distance from sewage	<50-100M	6	3.1	0.019
	101-150m	4	2.0	
	151-200m	0	0.0	
Water`s pH	6.50-7	1	0.5	0.924
	7.1-80	6	3.1	
	8.1 and above	3	1.5	
Turbidity	0.1-1	8	4.1	0.54
	1.1-2	2	1.0	
	2.1-3	0	0.0	
Dissolved solid in water (PPM)	0-500	0	0.0	0.006
	501-1000	6	3.1	
	1001-1500>	4	2.0	
Temperature(ºĊ)	<13-15	1	0.5	0.003
	16-20	0	0.0	
	21 and above	9	4.6	
Month sampling	Aug	4	2.0	.103
	Sep	1	0.5	
	Oct	4	2.0	
	Nov	1	0.5	
	Dec	0	0.0	
	Jan	0	0.0	
Overall contamination rate	196	10	5.1	

3.2. Physiochemical and environmental Characteristics of water samples examined

the main sources of drinking water for householders in study areas is governmental network supply (136; 69.4%) while; 45 (23.0%)

The Physiochemical and environmental characteristics of water of the samples examined are depicted in Table 2. As shown, L (2.6%), in iron tanks(4.6%), using pump for serving water (3.6%), at distance of <500-100M from sewage(3.1%), with pH value of 7.1-8(3.1%), in turbidity value of 0.1-1(4.1%), in water samples with 501-1000 dissolved solid particles (3.1%), in water sample with temperature ranged from 16-20 °C and in months sampling of August and October(2.0%). Pearson chi-square test shows that, there are significant differences (P<0.5) among contamination rate and samples treated with chlorine, Distance between sources of water and sewage; whereas, none with other characteristics or variables investigated in this study.

3.4. Association between socio-demographic characteristics and contamination rate of drinking water with *E. histolytica/disper*

The results of the logistic regression analysis for the association between contamination rate of drinking water with *E. histolytica* in different areas of Dhamar city and selected socio-demographic characteristics of householders are displayed in Table 4. The logistic regression analysis reveals that there is no significant association(P<0.05) between contamination rate and sociodemographic characteristics of householders participated in this study.

3.5. Association between physiochemical and environmental characteristics of water samples and contamination rate with *E. histolytica/disper*

The results of the logistic regression analysis for Association between characteristics of water samples and contamination rate with *E. histolytica/disper* in different areas of Dhamar city are presented in Table 5. The logistic regression analysis shows significant association between contamination rate and treatment of water with chlorine (OR=5.265; 95%Cl: 1.225-22.626; P= 0.026), Distance

and 11(5.6%) from truck and well sources respectively. Regarding frequency of cleaning tanks, 110(56.1%) never clean their water tank, whereas; 45(23.0%), 38(19.4%) and 3(1.5%) clean their water tanks once, twice and thrice respectively. 179(91.3%) householders do not treat the drinking water by chlorine, while 17(8.7%) did. The capacity storage of tanks used ranges between 3000-10000L and above. 174(90.8) of water tanks are made of iron; while; 16 (8.2%) and 2(1.0%) of plastic and concrete ground storages. 71(36.2%) drinking water were collected from storge tanks manually; whereas, 125(63.8) using pumps. 43(21.9%) of water sources were far from sewage (at a distance from sewage disposal), i.e.50-150m, while; 120(52. %), 26(13.3%) and 25(12.3%) far i.e. 101-150m, 151-200m and 250 and above respectively. The water`s pH, dissolved material, temperature and influence of month sampling were also studied and their frequencies and percentage are determined in Table 2.

3.3. Contamination rate of drinking water with *E. histolytica/disper*

In this study, A total of 196 samples of drinking water were collected from the different houses of Dharam city and examined for *E. histolytica* contamination. The results of the study reveal that, out of 196 samples examined, 10 samples were found contaminated with *E. histolytica* with overall contamination rate 5.1%, as presented in Table 3. In the basis of characteristic/ variable investigated in this study, the contamination rate is higher in drinking water obtained from Governmental system or network (4.10 %), water tanks` cleaning frequency per year is (3.1%) and non-treated samples with chlorine are (3.6%). The results also demonstrate that, the higher contamination rate is recorded in tanks with capacity ranged between 4000-7000

955Cl:1.01-6.81; P=.048); whereas none with other characteristics/factors assessed.

between sources of water and sewage disposal (OR=.265; 95%Cl: .065-.671; P=.009) and dissolved solid in water (OR=2.623;

Table 4. Logistic regression analysis for association between socio-demographic characteristics of householders and water contamination rate with *E. histolytica/disper* (n=196)

Characteristic	Categories	Frequency	OR	95%CI	*P* value
Age	15-30	123	1.4	.463-4.063	0.568
	31-45	67			
	46 >	6.0			
Gender	Male	79	1.0	.277-3.714	0.984
	Female	117			
Family size	6-10	126	1.1	.590-1.911	0.841
	11-15	12			
	16-20	42			
	21>	16			
Family Income	10000-30000	132	0.9	.219-3.514	0.854
	31000-60000	64			
Medical Service	No	164	0.0	undefined	0.998
	Yes	32			

Table 5. Logistic regression analysis for association between characteristics of water samples and contamination rate with *E. histolytica/disper* (n=196)

Characteristic/variable	Categories	Positive samples	contamination %	OR	95% CI	P value
Water sources	Truck	1	0.5	1.597	.76-3.34	0.215
	well	0	0.0			
	Gov. network	9	4.6			
No. of water`s tanks cleaning	Never	3	1.5	1.214	.59-2.49	0.598
	once	6	3.1			
	Twice&More	1	0.5			
Treatment with chlorine	No	7	3.6	5.265	1.22-22.62	0.026
	Yes	3	1.5			
Tanks capacity	<3000-3000L	1	0.5	1.841	.78-433	0.162
	4000-7000L	5	2.6			
	8000 ->10000	4	2.0			
Tank`s type	Iron	9	4.6	1.931	.47-7.80	0.356
	Plastic	0	0.0			
	Underground	1	0.5			
Collection of water fromtanks	Manually	3	1.5	1.345	.33-5.37	0.675
	Using Pumps	7	3.6			
Distance from sewage	<50-100M	6	3.1	0.208	.065-.67	0.009
	101-150m	4	2.0			
	151-200m>	0	0.0			
Water`s pH	6.50-7	1	0.5	0.895	.436-1.84	0.763
	7.1-80	6	3.1			

	8.1 and above	3	1.5			
Water`s turbidity	0.1-1	8	4.1	1.488	.376-5.90	0.571
	1.1-2	2	1.0			
	2.1-3	0	0.0			
Dissolved solid in water (PPM)	0-500	0	0.0	2.623	1.01-6.81	.048
	501-1000	6	3.1			
	1001-1500>	4	2.0			
Temperature(ºĊ)	<13-15	1	0.5	4.635	.97-21.93	0.053
	16-20>	18	4.6			
Month variation	Aug	4	2.0	Undefined	Undefined	.599
	Sep	1	0.5			
	Oct	4	2.0			
	Nov	1	0.5			
	Dec	0	0.0			
	Jan	0	0.0			

IV. DISCUSSION

Water pollution has become a global problem nowadays and ongoing evaluation of water resource policy is needed to overcome this problem. Deaths and diseases are caused worldwide due to water pollution and approximately 14000 people die every day due to water pollution (Letchinger, 2000).

In current the study, the results of microscopic examination reveal that out of 196 examined, 10 samples were positive for cysts of *Entamoeba histolytica / dispar* with overall contamination rate as 5.1%. These results are in agreement with the findings of Hemmati et al. (2015) in Iran and lower than contamination rate reported by Simon-Oke et al., (2020) in Nigeria. The contrary between the results of this study and the previous ones may be attributed to size of the samples examined and diagnostic techniques used. Furthermore, Omowaye, and Audu (2012) suggested that, the detection of intestinal parasitic in drinking water, fruits and vegetables is an indicative of the fecal contamination from human and or animal origin. As in many tropical countries, intestinal parasites are widely distributed not only due to the favorable climatic conditions for the survival and dissemination of the parasites but also due to the unsanitary conditions that facilitate fecal pollution of water, food stuffs, and soil.

In the present study, the results display that, the distribution rate of contamination was higher in samples of water obtained from governmental network, in never cleaned tanks, in drinking water samples not treated with chlorine, in tanks with capacity ranges between 3000-10000L and above, in tanks made of iron, in drinking water samples served manually from tanks, in drinking water obtained from sources far from sewage 50-150m; however, the contamination rate was lower with other categories of same characteristics or variables studied. These results are incompletely or partially in agreement with the findings of Ghasemi et al. (2015); Simon-Oke et al., 2020; Hikal (2020). The consistent or contrast between the results of this study and the findings of the previous ones may be due to the behavior of human, personal hygiene and availability of medical services. Furthermore, Olson (2001) and Wichuk et al. (2007), suggested that, the infected hosts, whether human or animal, shed large numbers of oocysts via the faces into the environment, and these oocysts are very resistant and may survive in the environment for over a year.

Many studies, either using stool or drinking/irrigation water, reported that there was a web of socio-demographic risk factors associated with the high prevalence/contamination rate of protozoa and other parasitic infections which includes age, gander, family number, habit of hand washing before eating, hand washing after defection, personal hygiene, family income, low level of parental education; and characteristics of water samples and environmental factors such as poor geographical areas, untreated water supply, inadequate sanitation, source of water, pH, turbidity, temperature, sampling month and distance between sources of water and sewage (Rajeswari et al. 1994; Blessmann et al., 2002; Adams et al., 2004; Al-Mekhlafi et al., 2007; Ayaz et al., 2011; Ghasemi et al., 2015; Hemmati et al., 2015; Richard et al., 2016; Sakran et al., 2017; Chaudhry, 2017; Al-Areeqi et al., 2017; Saleh et al., 2018; Simon-Oke, 2020; Hikal, 2020; Roro et al., 2022).

The person Chi square analysis reveals that water tanks cleaning frequency per year (P=.042), treatment of water with chlorine (P=0.045), tank`s type (P=0.01), distance between source of water and sewage (P=0.019), dissolved solid particles in water (P=0.006) and temperature (P=0.003) were significantly associated with water contamination rate. However, logistic regression confirmed that, treatment of water with chlorine (OR=5.262; 95%Cl:1.225-22.629; P=0.026) and Distance between source of water and sewage (OR=.0208; 95%CI:065-.671; P=0.009) and dissolved solid particles in water (OR=2.623; 95%Cl:1.01-6.81; P=.048) associated significantly with water contamination rate with *E. histolytica*. These results are incompletely or partially in agreement with the findings of the previous ones. The reasons behind that may be due to diagnostic technique used, sanitation condition, geographical factors, awareness and education level of population.

CONCLUSION

It could be concluded from this study that drinking water in study areas of Dhamar city is contaminated with *Entamoeba spp*., Contamination rate is influenced by risk factors such as water tanks cleaning frequency/ year, treatment of water with chlorine and distance between sources of water and sewage. It is suggested that proper water safety measures should be adapted. Community members need to be educated to treat water before drinking to avoid infection with enteric protozoa.

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Competing interests

The authors declare that they have no competing interests.

Authors' contributions:

IRM AlShaibani initiated the research idea, designed the study, analyzed the data and wrote the first and final version of manuscript. Z Z A Jobran , HAY Daka and SYM Jamah collected the samples, carried out the parasitological analyses and collected the literature. All authors revised and approved the final version of manuscript for publication.

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