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Prevalence of Water-borne Diseases based on seasonal variations in Shendi Town, River Nile State, Sudan

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Abstract:

Water is one of the most important requirements for human health and life. It's the most effective carrier of pathogens causing a number of infectious diseases in developing countries particularly in rural areas; about 80% of illnesses in developing countries are attributed to unsafe drinking water and waterborne diseases. Waterborne diseases remain a major global public health issue and a great environmental concern and the outbreak is common in African countries. The aim of this descriptive and cross sectional study was to investigate for safety of water and the prevalence of waterborne diseases in Shendi Town (Sudan). Water samples were collected according to WHO Guidelines for drinking water quality per season from all sources that used directly for drinking purpose in the community at study area. Water samples were examined for total coliforms, fecal coliforms, and E. coli. Then Standardizing questionnaire was used to collect information about water-borne diseases , also searched in records at health units to know and identify the confirmed cases of water-borne diseases. The study revealed that Indicator of feacal pollution in drinking water was discovered in all seasons and its exceed than WHO and SSMO guidelines for drinking water quality, where the highest rate of water contamination in autumn than other seasons and seasonal variations had been occurred a great effect on prevalence of water borne diseases, where the highest prevalence rate of water borne diseases in autumn, while typhoid and diarrhea diseases have highest cases. Based on the findings of this study we recommended that: Civil Water Corporation should be improving the quality of currently drinking water by treatment it to remove pollution to be fit for drinking, and health authorities should be raise awareness and knowledge level about water-borne diseases among community.

Key words: Water Quality; Pollution; Water-borne Diseases; Season; Ground water, Guidelines

1. Introduction:

Countries throughout the world are concerned with the effects of unclean drinking water because water-borne diseases are a major cause of morbidity and mortality [1,2]. Clean drinking water is important for overall health and plays a substantial role in our health and survival [3,4,5,6]. Water is important to human life and public health. However, much of the world's population lacks access to adequate and safe drinking water. Currently, water scarcity is a global challenge that affects more than 40% of the total global population [7]. In addition, it is estimated that around 3 billion people will not have access to fresh water by 2025 and will be living in a water stressed environment [8]. Waterborne disease is where a pathogen is transmitted by ingestion of contaminated water, these diseases may include gastroenteritis caused by different varieties of bacterial, viral, and protozoan pathogens found in faeces [9, 10,11,12]. These pathogens cause diarrhea typhoid, cholera, dysentery amongst others. These diseases are predominantly caused by the use of contaminated water, poor sanitation facilities and hygiene behaviour [13, 14]. These primary factors are major determinants of individual or household's susceptibility to waterborne diseases, which can however be aggravated by the poor level of an individual's income and educational status [15]. Basically, waterborne diseases can be transmitted through four main routes: Waterborne route, Water-washed route, Water-based route and Insect vector route or water related route [16, 17, 18, 19]. As a result, water-related diseases and deaths continue to be a global burden in both developed and developing countries. Though most cases are reported in less developed countries, developed countries also experience waterborne diseases outbreaks [20,21,22,]. Waterborne diseases are caused by drinking water mostly contaminated by human or animal excrement which contain pathogenic micro-organisms. Globally, waterborne diarrhea illness is leading among diseases that cause mortality and morbidity, killing 1.8 million people and causing approximately 4 billion cases of illness annually[23,24] . Moreover, in less developed countries waterborne diarrhea continues to be a leading cause of death and illness among children with 90% of diarrheal deaths being borne by children under five years [25]. Poor sanitation, inadequate safe drinking water and poor hygiene practices are major attributable factors to waterborne diseases occurrence, [26, 27,28,29,30,31]. Besides, WHO estimates that, 6.3% of all deaths are caused by limited access to safe drinking water, improved sanitation facilities and hygiene practices as well as water management that reduce transmission of waterborne illness [32]. According to [25], 780 million of the total global population do not have access to safe water, and an estimated 2.5 billion people in developing world live without access to adequate sanitation. However, supply of clean drinking water is one of the main challenges facing most of the African countries today [33]. In Africa, it is estimated that only 22% of the population has adequate sanitation facilities [34]. Additionally, 28% of the population of sub-Saharan Africa defecates in the open and an additional 23% use "unimproved" sanitation facilities that do not ensure hygienic separation of human excreta from human contact, [35]. Moreover, even where clean water and flush toilets are available in Africa, lack of hygiene awareness continues to result in outbreaks of water related diseases [30]. In developing countries, accessibility of safe drinking water is still a problem and people are forced to use available unimproved water sources. These water sources are often microbiologically unsafe and as a result, the most well-known waterborne diseases such as cholera, amoebic dysentery and typhoid are reported from almost all African countries especially in tropical areas of the region including Sudan [36]. The Safe Drinking Water Foundation (SDWF 2018) highlighted that 80% of all illnesses in developing countries are attributed to unsafe drinking water and the spread of waterborne diseases. About 3 million people die from water-related diseases every year [37, 38]. WHO considered climate change as an important environmental risk factor to estimate global burden of disease. WHO estimates that 80% of all health problems in the world are attributable to inadequate water supply or sanitation, climate change can affect human health [39, 40, 41, 42]. Especially when infectious diseases are concerned [43, 44, 45]. Overall, climate conditions constrain the geographic and seasonal distributions of infectious diseases, and weather affects the timing and intensity of disease outbreaks [46, 47]. The effects of climate change on water security are the greatest negative human health impact in the developing world [39, 48]. While excess rainfall has been associated with drinking-water-related outbreaks [49,50] . Humans are exposed to a wide range of climate sensitive pathogens (bacteria, viruses, parasites, and algae) through drinking water consumption, and recreational water use. At elevated temperatures, some pathogens proliferate, whereas other (often enteric waterborne) pathogens show faster die off or inactivation [51, 52]. Humans may be exposed to these pathogens through drinking water consumption or recreational water use. Interdisciplinary links between climate variability and the pathogens in water have been identified and warrant further quantification [53]. Many studies reported a positive association between increased temperature or rainfall and distribution and patterns of human exposures to pathogens. Several outbreaks of water borne diseases have been reported due to groundwater contamination by pathogens as a consequence of drought that has lowered the water table, resulting in changes in groundwater flows of surface water into groundwater [54,55] . A subsequent case-control study in the Nordic countries found that extreme rainfall events were significantly associated with the occurrence of enteric disease outbreaks [56]. A review of the relationships between groundwater contamination and outbreaks of acute gastrointestinal infection (enteric disease) identified 649 studies globally [57]. The authors estimated that between 35 and 59 million cases of enteric disease were attributable to the consumption of groundwater annually. The main pathogens identified were Campylobacter, Shigella, hepatitis A, Giardia and norovirus. Cryptosporidiosis has also been the cause of several large outbreaks [58, 59]. Research indicates that increased ambient temperatures are often correlated with water-borne disease outbreaks in developing countries [60 ,61,62] Heavy rainfall increases the risk of waterborne diseases. Many studies have found high levels of fecal contamination in water sources during rainy seasons[63,64]. These studies help to explain the high rates of diarrheal diseases [63, 65,66]. And waterborne disease outbreaks during fall season [67,68 ,69].

2. Materials and Methods:

2.1. Study Design

A descriptive –cross sectional study.

2.2. Study Area

Shendi Town is well known historically, and it is the third largest Town in River Nile State. It is in River Nile State, where the Headquarter of Shendi locality is located.

Shendi is located about 176 km north of Khartoum , and 130 km south of El damer(capital of River Nile State). It is bound by River

Nile in the west and Kasala State in the East, also bound by south Shendi administrative unit in the South and Shendi administrative unit in the North. Geographically it lies between line 36 East to 31 West longitudinal and line 19 North to 15 South latitudinal. It is in the arid zone of Sudan with annual rain fall ranging between 0 and 119mm per year. Shendi town has no sewerage system, the population depend on septic tanks, aqua privies, pour flush latrines and traditional pit latrines for disposal of fecal waste and other liquid waste. Shendi town has a distribution system of drinking water; more than 95% of study population depend on ground water as source of drinking.

2.3. Study Population

Water supply system and community based.

2.4. Sample Size Determination

Sample size was determined according to WHO guidelines, as below: (one sample for each 5000 of population monthly, total population of Shendi Town is 97486 so sample size = 97486/ 5000 = 19.5 ≈ 20 for a year n= 20 *12 equal 240 samples.

2.5. Data Collection

The data were collected by the following methods.

2.5.1. Standardized Questionnaire

Was designed according to aims of study, its content on closed questions and filled with population of Shendi Town.

2.5.2. Records

Searched in records at health units like Elmmak Nimer hospital, Shendi teaching hospital, Shendi military hospital and centers of health insurance to know the confirmed cases of water-borne diseases.

2.5.3. Laboratory

Samples were collected from the identified sites of drinking water supply (source, network and storage facilities).

2.6. Water Sample Collection

Water samples were collected according to the WHO Guidelines for drinking water quality assessment [72, 73]. The samples were collected from ground water sources (wells), distribution system and storage facilities, that are used directly for drinking purpose in the community per seasons. Closed sterilized 500 ml glass containers were used to collect samples. Before taking sample from wells, pipes and taps, the pipes water was flushed for 5 minutes and then the mouth of the pipe and tap was sterilized with a spirit of lamp flame and then cooled by running water. Sample from hand dung wells were collected by attaching a piece of string to the sampling bottle together with a clean heavy material that sink down the bottle into the well and unwinding the string slowly. Stored water samples were collected after 1 to 3 h of storage using the usual cups households use to draw the water from the storage container. All samples were transported to the laboratory on ice box, kept at 4°C and analyzed within 4 h.

2.7. Water Sample Analysis:

Microbiological analyses of water samples were performed as described in Standard Methods for the Examination of drinking water [70,71]. Total and fecal coliforms were determined by the presence - absence (P-A) per 100 ml sample using (lauryl treptose media) And Put the bottle somewhere with a constant temperature (25 – 35°C) for 24 to 48 hours. Then Checked the bottle after 24 hours to see if there is a colour change. If there is no colour change, then let the bottle for another 24 hours. For samples which gave positive results for coliforms test, further identification was done by inoculated in brilliant green bile broth and peptone water, all samples were incubated at 44°C for 24 hours, any sample that shows colour change (red ring) and gas production is positive for coliform presence truly. For isolation E. coli, all positive results of previous test were taken and Each sample was cultured on Earthen methylene blue (EMB) media in petri dish and all petri dishes were incubated at 37°C for 24 hours. Then any sample that shows green metallic shine colonies are E. coli presence.

2.8. Data Analysis:

Data were analyzed by computer using both Microsoft Excel and Statistic Package for Social Sciences program (SPSS version 11), then was followed by testing for the significance between different factors by subjecting some data to statistical examinations, like T test and chi square test to find P values, and the results are presented in percentage tables and other statistical graphs.

3. Results:

season	NO of tested samples	E. coli positive	Percentage %
Summer	80	25	31.3
Autumn	80	33	41.3
Winter	80	29	36.3
Total	240	87	36.3

Table 1. Bacteriological analysis for drinking water samples per seasons.

The above table shows that the highest pollution in autumn season 41.3% and then in winter season 36.3%

Age/ year	Frequency	Percent %
20-25	61	25.4
26-30	48	20.0
31-35	43	17.9
36-40	47	19.6
Above 40	41	17.1
total	240	100

Table 2. Age distribution of study population.

The above table shows that 25.4%, 17.9% and 17.1% of study populations, their ages ranged 20-25, 31-35and more than 40 years of age respectively.

Level	Frequency	Percent %
illiterate	15	6.2
Basic	27	11.3
intermediate secondary	27 67	11.3 27.9
university	92	38.3
postgraduate	12	5.0
Total	240	100

Table 3. Educational level of study population.

The above table shows that 38.3% of study populations their education level is university and 6.2%, 11.3% of them are illiterate, basic and intermediate levels respectively.

Source	Frequency	Percent %
Ground	230	95.8
Surface	10	4.2
Rain	0	0.0
Total	240	100

Table 4. Source of drinking water in study area.

The above table shows that 95.8% of study populations depend on ground water and 4.2% of them depend on surface water

Quality	Frequency	Percent %
excellent	13	5.4
Good	88	36.7
acceptable	99	41.2
unacceptable	40	16.7
Total	240	100

Table 5. Water quality based on study population respondents.

The above table shows that 36.7%, 41.1 and 16.7% of the study populations said that drinking water quality is good, acceptable and unacceptable respectively.

Disease	Frequency	Percent %
Dysentery	28	32.3
Typhoid	39	44.8
Amoebaisis	7	8
Giardiasis	6	6.9
Hepatitis A	3	3.4
Hepatitis E	1	1.2
Helminthes	3	3.4
Total	87	100

Table 6. Results of diagnosis of water-borne diseases at health units.

The above table shows that highest rates of water-borne diseases are typhoid (44.8%) and dysentery (32.3%)

Season	Frequency	Percent %
Autumn	211	87.9
Winter	2	0.8
summer	27	11.3
Total	240	100

Table 7. Prevalence of water-borne diseases per seasons.

The above table shows that 87.9 % of the study population is said that the prevalence of water borne-diseases is increasing in autumn and 11.3% of them said in summer.

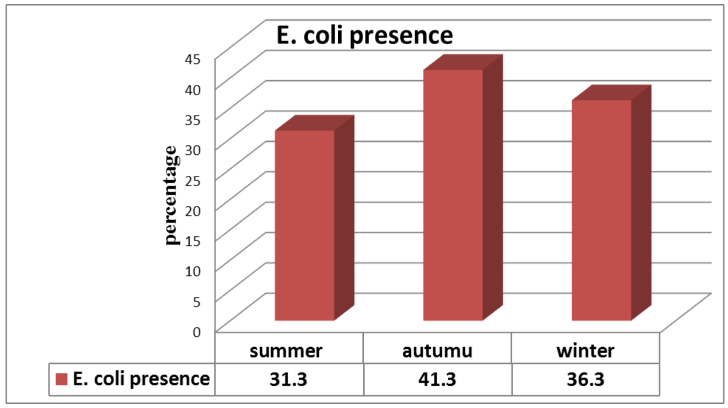

Figure 1. Comparison of E. coli presence per seasons.

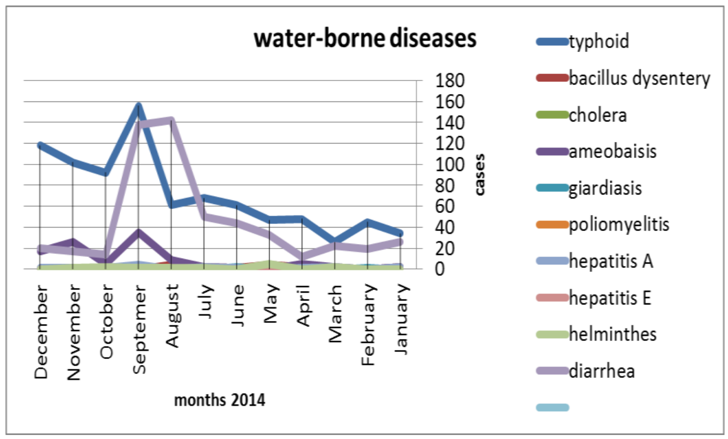

Figure 2. Shows that the more incidences of water-borne diseases are typhoid and diarrhea in rain fall months.

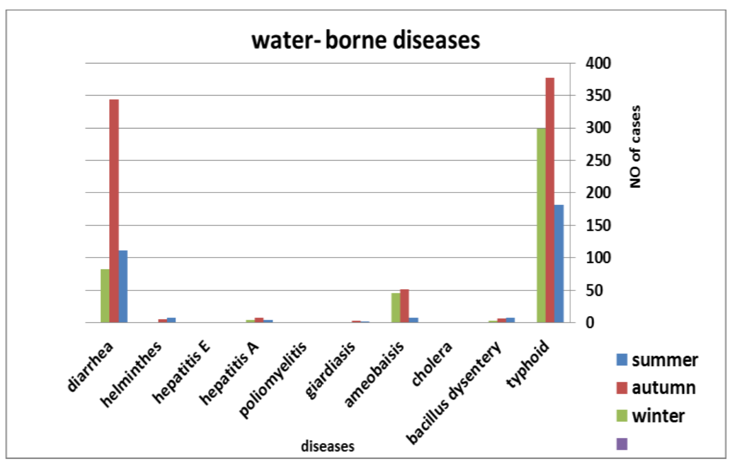

Figure 3. Shows that the prevalence of water-borne diseases increases in autumn.

Family size		Consumption per season			Total	p.value
		Autumn	Winter	Summer		
2-4 person	Count	1	4	88	93	0.033 *
	% of Total	.4%	1.7%	36.7%	38.8%	
5-7 person	Count	1	0	109	110	
	% of Total	.4%	.0%	45.4%	45.8%	
8-10person	Count	3	1	30	34	
	% of Total	1.2%	.4%	12.5%	14.2%	
>10 person	Count	0	0	3	3	
	% of Total	.0%	.0%	1.2%	1.2%	
Total	Count	5	5	230	240	
	% of Total	2.1%	2.1%	95.8%	100%	

Table 8. The relation between the family size and consumption of water per season.

Chi-Square Tests
* Significant at P.value ≤ 0.05**.**
** Highly significant at P.value ≤ 0.01
The table shows that there is a relation between family size consumption of water and the season (p. value = 0.033< 0.05).

Education level		Seasonal variation effect		Total	P.value
		Yes	No		
Illiterate	Count	12	3	15	0.411
	% of Total	5.0%	1.2%	6.2%	
basic	Count	23	4	27	
	% of Total	9.6%	1.7%	11.2%	
Intermediate	Count	19	8	27	
	% of Total	7.9%	3.3%	11.2%	
Secondary	Count	59	8	67	
	% of Total	24.6%	3.3%	27.9%	
University	Count	79	13	92	
	% of Total	32.9%	5.4%	38.3%	
Post graduate	Count	10	2	12	
	% of Total	4.2%	.8%	5.0%	
Total	Count	202	38	240	
	% of Total	84.2%	15.8%	100%	

Table 9. The relation between the education level and knowledge effect of seasonal variations.

Chi-Square Tests
*Significant at P.value ≤ 0.05**.**
** Highly significant at P.value ≤ 0.01
The above table shows that there is no relation between educational level and knowledge of seasonal variations effect (p. value=0.411> 0.05).

Education level		Washing of hands							
		At prayer	Before eating	After eating	Before bed	Before cooking	After toilet	Total	p.value
Illiterate	Count	0	5	4	0	0	6	15	0.624
	% of Total	.0%	2.1%	1.7%	.0%	.0%	2.5%	6.2%	
Basic	Count	0	11	11	0	0	5	27	
	% of Total	.0%	4.6%	4.6%	.0%	.0%	2.1%	11.2%	
Intermediate	Count	1	9	9	0	1	7	27	
	% of Total	.4%	3.8%	3.8%	.0%	.4%	2.9%	11.2%	
Secondary	Count	0	20	23	1	3	20	67	
	% of Total	.0%	8.3%	9.6%	.4%	1.2%	8.3%	27.9%	
University	Count	1	22	43	0	5	21	92	
	% of Total	.4%	9.2%	17.9%	.0%	2.1%	8.8%	38.3%	
Post graduate	Count	0	1	9	0	0	2	12	
	% of Total	.0%	.4%	3.8%	.0%	.0%	.8%	5.0%	
Total	Count	2	68	99	1	9	61	240	
	% of Total	.8%	28.3%	41.2%	.4%	3.8%	25.4%	100%	

Table 10. The relation between the education level and washing of hands.

Chi-Square Tests
*Significant at P.value ≤ 0.05.
** Highly significant at P.value ≤ 0.01
The above table shows that there is no relation between educational level and washing of hand (p. value = 0.624> 0.05).

gender		Result of diagnosis				
		D.	Dysentery	Typhoid	Amoebaisis	Giardiasis
Male	Count	83	13	16	3	3
	% of Total	34.6%	5.4%	6.7%	1.2%	1.2%
Female	Count	70	15	23	4	3
	% of Total	29.2%	6.2%	9.6%	1.7%	1.2%
Total	Count	153	28	39	7	6
	% of Total	63.8%	11.7%	16.2%	2.9%	2.5%

gender		Result of diagnosis			Total	P.value
		hepatitis A	hepatitis E	helminthes		
Male	Count	0	1	1	120	.431
	% of Total	.0%	.4%	.4%	50%	
Female	Count	3	0	2	120	
	% of Total	1.2%	.0%	.8%	50%	
Total	Count	3	1	3	240	
	% of Total	1.2%	.4%	1.2%	100%	

Table 11. The relation between gender and infection by water-borne diseases.

Chi-Square Tests
*Significant at P.value ≤ 0.05.
** Highly significant at P.value ≤ 0.01
The above table shows that there is no relation between gender and infection by water-borne diseases (p. value =0.431> 0.05).

4. Discussion:

The current study revealed that the bacteriological quality of drinking water varied from season to another, where 36.3% of tested samples are indicated feacal pollution and E. coli presence, while the highest contamination in autumn season 41.3% (table 1), Occurrence of pathogenic microorganisms in fresh water bodies demands routine assessment as a means of forestalling future outbreaks. Indicators of bacteriological quality of water in all seasons are above guidelines of WHO and SSMO, (all water intended for drinking E. coli or thermo tolerant coli form must not detectable in any 100 mg /l sample, treated water entering distribution system E. coli, thermo tolerant coli form bacteria must not be detectable in any 100mg/ sample, in case of large supplies system when sufficient samples were examined E. coli bacteria must not be detectable in 95% of samples SSMO) [70, 73, 74, 75]. So according to these results the quality of water is poor and it's not suitable for drinking without appropriate treatment process. Our study showed that feacal pollution was found in all seasons but in autumn is higher than other seasons, (Figure 1), this may be due to absence of sewerage system in Shendi Town and runoff during rainfall, also raise of level of water in aquifer or water table, especially 95.8 of study population depend on ground water as a main source for drink and domestic use, also heavy rains were precipitated in the study area during research period. Many studies reported a positive association between increased temperature or rainfall and distribution and patterns of human exposures to pathogens. Several outbreaks of water borne diseases have been reported due to groundwater contamination by pathogens as a consequence of drought that has lowered the water table, resulting in changes in groundwater flows of surface water into groundwater [54, 55].

The Present study revealed that there is no relation between educational level and knowledge of seasonal variations on drinking water quality, and no relation between educational level and washing of hands by soap before eating (P. values = 0.411 and 0.624 >0.05 (tables 9, 11), although the education plays great role in provision of knowledge and awareness, the study showed that there is lack of awareness about drinking water quality and its health risks among study population. Also the study showed that neither correlation between gender and type of water borne diseases (P. value = 0.431>0.05) (table 11). This means water borne diseases are not infecting certain age or gender but are wide spread among all ages and infected both gender (males and females no gender differentiations). In spite of the main factors of spread of water-borne diseases are: educational levels and income status, sanitation types and hygiene practices, (the primary factors are major determinants of individual or household's susceptibility to waterborne diseases, which can however be aggravated by the poor level of an individual's income and educational status [15], Poor sanitation, inadequate safe drinking water and poor hygiene practices are major attributable factors to waterborne diseases occurrence, [26, 27, 28, 29].

The study showed that seasonal variations had a great effect in prevalence of water borne diseases, where the highest prevalence rate of water borne diseases is in autumn compared with other seasons, while typhoid diseases is the more spread among populations than other water-borne diseases and then diarrhea illness (figures 2 &3). This finding agree with following statement (According to the World Health Organization, diarrheal disease accounts for an estimated 4.1% of the total daily global burden of disease and is responsible for the deaths of 1.8 million people every year. Further estimates suggest that 88% of that burden is attributable to unsafe water supply, sanitation and hygiene practicesin developing countries [17,18,19].

5. Conclusion:

Occurrence of an Indicator for pathogenic microorganisms in fresh drinking water bodies demands routine assessment and forestalling future outbreaks. However, the detection and diagnosis of water borne diseases become an evolving art which requires some sought of professionalism. Our study conclude that: bacteriological quality of drinking water varied from season to another, Indicators of bacteriological quality of water in all seasons are above guidelines of WHO and SSMO, seasonal variations had a great effect in prevalence of water borne diseases, where the highest prevalence rate of water borne diseases is in autumn compared with other seasons.

6. Recommendations:

Safe water is absolutely essential and it is a basic need for all human beings to get an adequate supply and pure drinking water. So based on the findings of this study we recommended that: Civil Water Corporation should be improving the quality of currently drinking water by treatment it to remove pollution, improvements should be include enhanced water treatment to remove impurities and disinfection to inactivate pathogenic microbes, and health authorities should be raise awareness and knowledge level about water-borne diseases and proper handling of water among community.

Conflict of Interests:
The authors have not declared any conflict of interests.

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