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Depression among chronic arsenic exposure patients in Shampur Upazila, Rajshahi, Bangladesh

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Abstract

Multiple studies suggest that as a toxicant arsenic can adversely affect the growth of human brain and neural functions even when it is present with a permissible limit. This study suggests a hypothesis that four to eight weeks of sub-chronic arsenic exposure (10 mg/L arsenic in drinking water) can cause or increase anxiety and depression-like behaviours. This cross-sectional comparative study was carried out among the 54 participants of Shampur Upazila, Rajshahi, Bangladesh. The study was conducted between 2019 to 2022. The depression levels were assessed using Zung depression scale. The researcher himself collected primary data from the patients of chronic arsenic exposure at Shampur village, Rajshahi, who were using arsenic-containing tube-well water as the source of drinking water, through an in-person interview in a partly structured questionnaire. It was found that the relationship between depression and drinking water source, consumption of arsenic-contaminated water, and level of depression was statistically significant. Chronic arsenic exposure can cause depressive illness. Depression is common in chronic arsenic exposure patients. So attempts should be made to ensure arsenic-free water.

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Introduction

Arsenic (chemical symbol 'As' and atomic number 33) is an extremely poisonous and culprit white powder. This natural substance is one of the most familiar ecological detriments in groundwater. Prolonged arsenic-related health impacts are widespread among populations vulnerable to tainted water (Vahidnia *et al.,* 2007). A high level of chronic arsenic causes poisoning or arsenicosis as it occurs because of the presence of traces of arsenic in the human body. Arsenicosis has been found as a factor to augment the danger of neurological disorders in a number of epidemiological studies (WHO, 2001; IARC, 2004; BGS, 2001). Long-term experience with inorganic arsenic is closely linked with neurotoxicity that occurs when exposed to natural or manmade toxic substances and it is typically more harmful than organic arsenic components in humans and rodents (Khan et al., 2003). Multiple studies suggest that as a toxicant arsenic can adversely affect the growth of the human brain and neural functions even when it is present with a permissible limit of 0.05 mg/L (milligram per litre) arsenic content in drinking water (Chowdhury 2004). Anxiety and depression are presently the widely prevalent and well-calculated temper tantrums in humans and they are commonly coexistent (Safiullah 2006). It was suggested that anxiety and depression may be a neuro-endocrine variety, in which anxiety occurs first in the course of life and then major depressive episodes later (Khan *et al.,* 2006).

Several hypotheses point to some mechanisms that highlight depression disorders along with monoamine, neurotrophic and neurogenic hypotheses. Another type of depression is manic depression or bipolar disorder. It is a mental issue rendering somebody to change suddenly from being extremely depressed to being extremely happy.

The deficiency or imbalance in monoamine neurotransmitters, for example serotonin, dopamine and norepinephrine, has been found to be the potential mechanisms central to the pathophysiology of depression (Spallholz *et al.,* 2004). The 5-HT_{1A} receptor is a key monitor of serotonin activity and its dysregulation is implicated in the emergence of both generalized anxiety and major depression disorders (Havenaar & van Brink, 1997). The 5-HT_{1A} receptor plays a prominent role in facilitating serotonin's post-synaptic receptor intervening with serotonin's activity on cortico-limbic regions along with the cerebral frontal cortex, amygdala, and hippocampus (Hassan *et al.,* 2005). The therapeutic functions and mechanisms of 5-HT_{1A} agents in relieving anxiety and depressive disorders have been recorded perfectly (Bhuiyan 2002). Neurotrophic factors are crucial signaling molecules for the growth of the nervous system, and the survival of adaptive pliability of neurons in the adult brain.

In addition, information is scanty about the mechanisms through which arsenic can induce behaviors of mood swings. This study suggests a hypothesis that four to eight weeks of sub-chronic arsenic exposure (10 mg/L arsenic in drinking water) can cause or increase anxiety and depression-like behaviours in normal mice and a vulnerable mouse model of depression, chemically induced by reserpine pretreatment. Reserpine can produce depression-like behaviours in animals by depleting catecholamine and blocking reuptake. This animal prototype has been used for probing the underlying mechanism of depression (Paul 2004; Rosado *et al.,* 2007).

Materials and methods

Methodology and criteria

The study was performed in a cross-sectional comparative design in Shampur Upazila, Rajshahi during June 2019 to June 2022. All the respondents in Shampur Upazila, Rajshahi, were consuming arsenic-containing water for more than six months during the study period. All the respondents at Shampur village were consuming arsenic-containing tube-well water for more than six months during the study period. In addition, exclusion criteria were considered for those who declined to participate in the study i.e. did not give consent to be interviewed or who did not consume arsenic-containing water for more than six months.

Sampling

In this study, we used a purposive sampling technique for all samples. The sample size was ascertained by using the following formula:

Sample size, $n = (z^2pq)/d^2$

Where,

p = Response distribution i.e., proportion of factor in the publication or the expected frequency value.

q = 1 – p

d = Margin of error is the number of errors that one would tolerate.

z = Area under normal curve corresponding to a desired confidence level (CI) and it is the extent of uncertainty that one can tolerate.

Now, for the present study,

N = Sample size.

Z = 1.96 at 95% confidence interval

p = 1.6% = 0.016 Prevalence of arsenic poisoning.[7]

q = 1-p = 1-0.016 = 0.984

d = 5% of prevalence = 5% of 0.016

= 0.0333

Formula, $n = \frac{Z^2 pq}{d^2}$

So, $n = \frac{1.96^2 \times 0.016 \times 0.984}{0.0333^2}$

= 54.1

So, the total sample size was 54.

Data collection technique

The researcher himself collected primary data from the patients with chronic arsenic exposure at Shampur village, Rajshahi, who were using arsenic-containing tube-well water as the source of drinking water, through an in-person interview in a partly structured questionnaire. Primary information on some selected socio-demographic and depression levels was assessed on the Zung scale. Every endeavor was made to collect data precisely. In open questions, the respondents were asked in such a way that they could speak spontaneously and give their opinions neutrally and without hesitation. No misleading questions were thrown. All the participants were clinically examined for different depression conditions. The following data collection tools were used: a partially structured questionnaire, tools for mental/physical examination (Zung scale to assess the level of depression), an informed written consent form in Bangla, and an informed written consent form in English.

Data processing and analysis

Statistical analysis of the survey results has been done by using Windows-based computer software devised with Statistical Packages for Social Sciences (SPSS-23). The results have been presented in tables and figures. Steps taken during data collection are as follows: (i) collected data entered into SPSS software, ii) the data was then evaluated for completeness, accuracy, and consistency before the analysis was made, iii) the analysis of the exploratory data was done to describe the study population in which categorical variables were summarised using frequency tables and continuous variables were summarised using measures of central tendency and dispersion such as mean, median, percentiles and standard deviation and (iv) to determine associations' chi-squared tests were used. Results were described as percentages with 95% confidence intervals and in each analysis, p values <0.05 were considered statistically signific

Results and discussion

As regards age distribution, most respondents (46.29%) were in the age group of 41-50 years, 27.7% were in the age group of 31-40 years, 12.96% were in the age band of 50-plus years and 7.4% were in the age group of 21-30 years among the exposure group. A majority (37.03%) were in the age group of 41-50 years, 33.3% were 31-40 years of age group, 1.6% were in the age group of 21-30 years, 9.25% were in the age group of 50-plus years and 1.85% were before 20 years of age group among the non-exposure group (Figure 01).

Among the exposure group, most (68.51%) were male and 31.48% were female. It was revealed that 64.8% were male and 35.1% were female among the non-exposure group (Figure 02). In the exposure group, 100.0% of respondents used a duration of >6 months of arsenic-contaminated water and 100.0% in non-exposure group used <6 months (Table 04).

Table 1. Distribution of the respondents by source of drinking water.

Source of drinking water	Exposure	Non-exposure
Tube-well	51 (94.4%)	9 (16.6%)
Well/Pond/River	2 (3.7%)	41 (75.9%)
Supply/Others	1 (1.9%)	4 (7.4%)
Total	54 (100.0%)	54 (100.0%)

Regarding physical illness among the exposure group, it was found that 53.7% did not have any systemic diseases, 27.7% had diabetes, 12.9% had hypertension, 3.7% had other illnesses and 1.85% had heart disease. In the non-exposure group, 79.6% did not have any systemic diseases, 9.25% had diabetes, 7.4% had hypertension, and 1.85% had heart disease and others (Table 05).

Table 2. Distribution of the respondents by duration of consumption of arsenic-contaminated water.

Duration of consumption of arsenic-contaminated water	Exposure	Non-exposure
<6 months	0 (0.0%)	54 (100.0%)
>6 months	54 (100.0%)	0 (0.0%)
Total	54 (100.0%)	54 (100.0%)

Regarding the assessment of depression, 96.29% had depression among the exposure group and 3.7% did not have depression. Among the non-exposure group, no one had depression (Figure 03). This study found that the correlation between depression and source of drinking water, intake of arsenic-contaminated water, level of depression, marital status and occupation were statistically significant (Table 04).

Table 3. Distribution of the respondents by physical illness.

Physical illness	Exposure	Non-exposure
No systemic diseases	29 (53.7%)	43 (79.62%)
Diabetes	15 (27.7%)	5 (9.25%)
Heart disease	1 (1.85%)	1 (1.85%)
Hypertension	7 (12.9%)	4 (7.4%)
Others	2 (3.7%)	1 (1.85%)
Total	54 (100.0%)	54 (100.0%)

This cross-sectional comparative study was conducted to find out the correlation between arsenic exposure and depression. The sample size was 54 in both exposure and non-exposure groups, which were selected as respondents for the study purposively.

A semi-structured questionnaire was used to collect data from the respondents through an in-person interview. Every endeavor was made to collect data perfectly. In open questions, the respondents were asked in such a way that they could speak spontaneously and give their opinions normally and without hesitation. As regards age distribution, most respondents (46.29%) were in the 41-50 age group, 27.7% were in the 31-40 age group, 12.96% were in the age group of 50-plus years and 7.4% were in the 21-30 age group among the exposure group. A majority (37.03%) were in the 41-50 age group, 33.3% were 31-40 years of age group, 1.6% were in the 21-30 age group, 9.25% were in the age group of 50-plus years and 1.85% were under-20 respondents among the non-exposure group (Figure 01).

In another study, they picked the patients and non-patients from the same villages by matching age (±5 years) and sex (Syed *et al.,* 2012). Among the exposure group, most (68.51%) were male and 31.48% were female. It was revealed that 64.8% were

male and 35.1% were female among the non-exposure group (Figure 02). In another study, it involved 261 male participants and 260 females (Syed *et al.,* 2012). It was originated that 40.7% of the respondents had up to class V level of education, 33.3% had class VI-XII level of education, and 22.2% were illiterate among the exposure group. Among the non-exposure group, 42.5% of participants had class VI-XII levels of education, 31.48% had up to class V level of education, 11.1% were graduates and 9.25% were illiterate (Figure 03).

In terms of literacy, 17.7% of the patient participants and 10.7% of the non-patient category were illiterate while 82.3% of the patients and 89.3% of the non-patient category were literate (Syed *et al.,* 2012).

Table 4. Relationship with a source of drinking water and depression in exposure group Depression.

1. Source of drinking water

	SS	df	M	F	Sig
Between Items	12.250	1	12.250	26.978***	.000
Residual	22.250	53	.454		
Total	34.500	54	.690		

2. Duration of consumption of arsenic-contained water

	SS	df	M	F	Sig
Between Items	57.760	1	57.760	155.167***	.000
Residual	18.240	53	.372		
Total	76.000	54	1.520		

3. Level of depression

	SS	df	M	F	Sig
Between Items	9.000	1	9.000	21.000***	.000
Residual	21.000	53	.429		
Total	30.000	54	.600		

4. Marital status

	SS	df	M	F	Sig
Between Items	54.760	1	54.760	155.640***	.000
Residual	17.240	53	.352		
Total	72.000	54	1.440		

5. Occupation

	SS	df	M	F	Sig
Between Items	56.250	1	56.250	159.783***	.000
Residual	17.250	53	.352		
Total	73.500	54	1.470		

As regards occupation among the exposure group, it was found that 37.3% were farmers, 27.7% were housewives, 20.3% were in business, 7.4% were day laborers, 3.7% were in service and 3.1% were in other professions. Among the non-exposure group, it was found that 24.0% were in business, 24.0% were housewives, 22.2% were in service, 12.9% were farmers, 9.2% were day laborers and 7.4% were in other professions (Table 01). It was exposed that 79.6% of the respondents in the exposure group had 10001-20000 BDT as monthly family income, 11.5% had 20001-30000 BDT, 7.4% had > 30000 BDT and 1.85% had <10000 BDT. The mean monthly family income among the same group was 15400±4025.43. On the other hand, 53.7% had 10001-20000 BDT as monthly family income among the non-exposure group, 22.2% had 20001-30000 BDT, 7.4% had >30000 and 3.7% had <10000 BDT. The mean monthly family income among the same group was 17020±6374.34 (Table 02). The mean annual cash income of the patients was US$ 761 (SD±$ 388). On the other hand, the mean annual cash income of the non-patients was US$ 915 (SD±$ 466), with a significant difference ($p<0.01$) (Syed *et al.,* 2012). Among the exposure group, 44.4% were married and 55.5% were unmarried. It was revealed that 64.8% were unmarried and 35.1% were married among the non-exposed group.

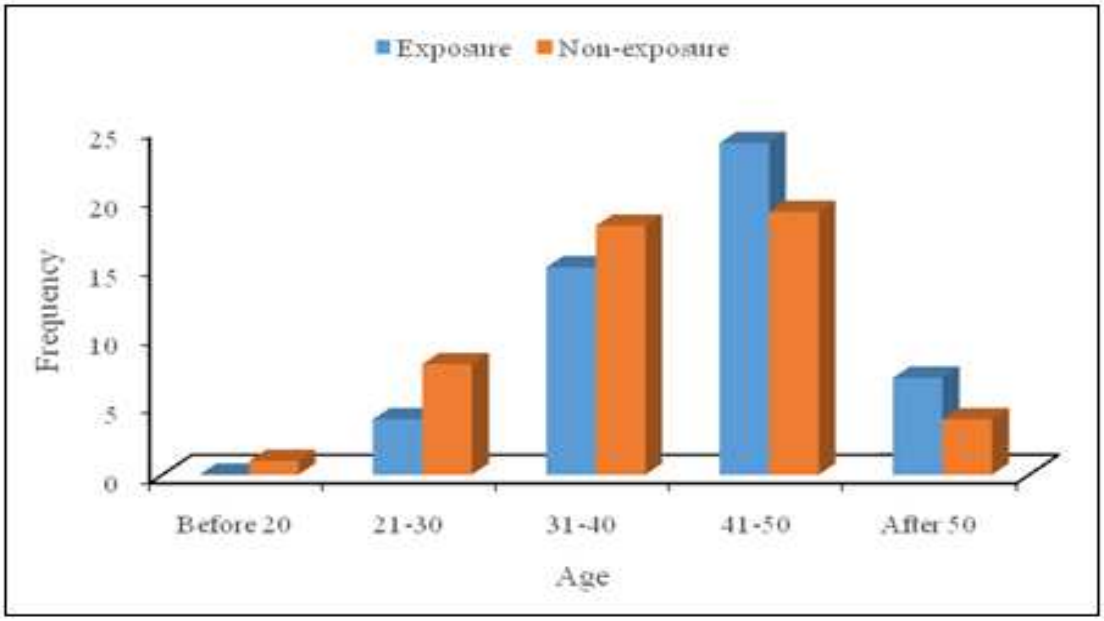

Fig. 1. Distribution of the respondents by age.

Regarding the source of drinking water, it was found that 94.4% used tube-well water, 3.7% used well/pond/river water and 1.9% used to supply water among the exposed group. On the other hand, 75.9% used well/pond/river water, 16.6% used tube-well water and 7.4% used to supply water in the non-exposed group (Table 03). In the exposure group, 100.0% used >6 months' duration of arsenic-contaminated water and 100.0% in the non-exposure group used <6 months. Regarding physical illness among the exposure group, it was found that 53.7% did not have any systemic diseases, 27.7% had diabetes, 12.9% had hypertension, 3.7% had other illnesses and 1.85% had heart disease. In the non-exposure group, 79.6% did not have any systemic diseases, 9.25% had diabetes, 7.4% had hypertension, and 1.85% had heart disease and others. The participants with arsenic levels of 2 µg/L or greater were statistically more likely to report a history of depression, high blood pressure, circulatory problems, and bypass surgery than the respondents with arsenic concentrations less than 2 µg/L (Zierold *et al.,* 2004). As regards the assessment of depression, 96.29% had depression among the exposure group and 3.7% did not have depression.

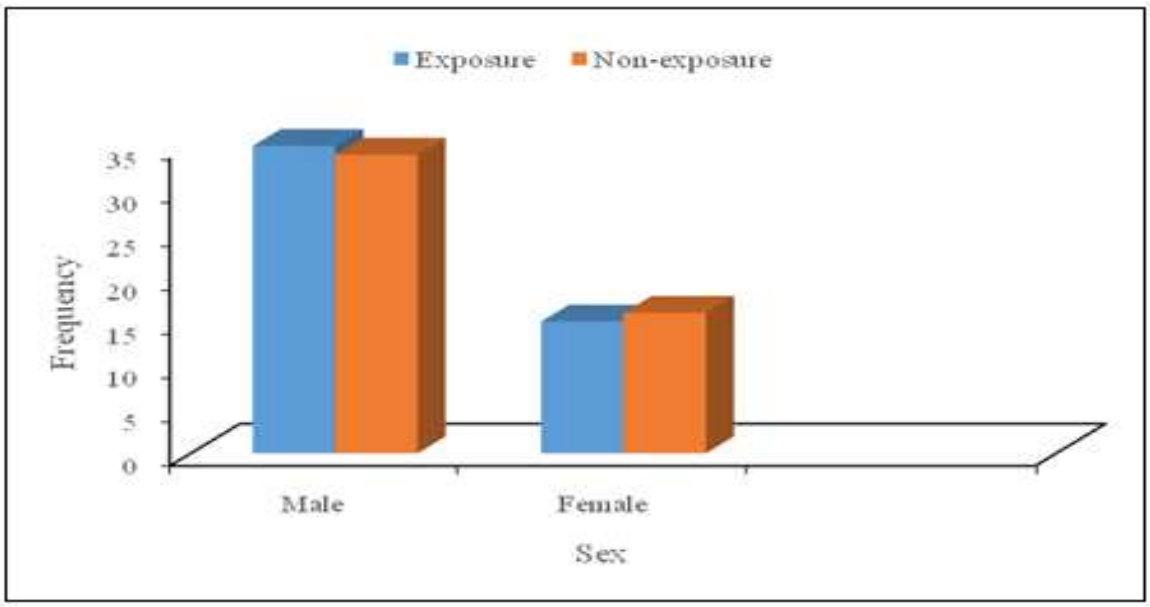

Fig. 2. Distribution of the respondents by sex.

Among the non-exposure group, no one had depression. It was found in an arsenic-affected community in western Japan in 1998 that 36% of arsenic victims (n=63) were undergoing a complete or partial post-traumatic stress disorder after arsenic poisoning (Asuki N 2003). Arsenic may be a natural pollutant in some deep water wells. Low level of arsenic exposure continues to occur in common people through the commercial use of inorganic arsenic components. Some of the organic arsenic is relatively non-toxic, but inorganic arsenic accumulates in the gastrointestinal tract, kidneys, liver, lungs and spleen. It leaves a residue in keratin-rich tissues like hair, nails and skin. Although sensory and motor polyneuritis has been recorded, the central nervous system's involvement has still not been described. Regarding the level of depression among the exposure group, 87.7% had severe depression, 11.25% had mild-to-moderate depression and 1.05% did not have any depression.

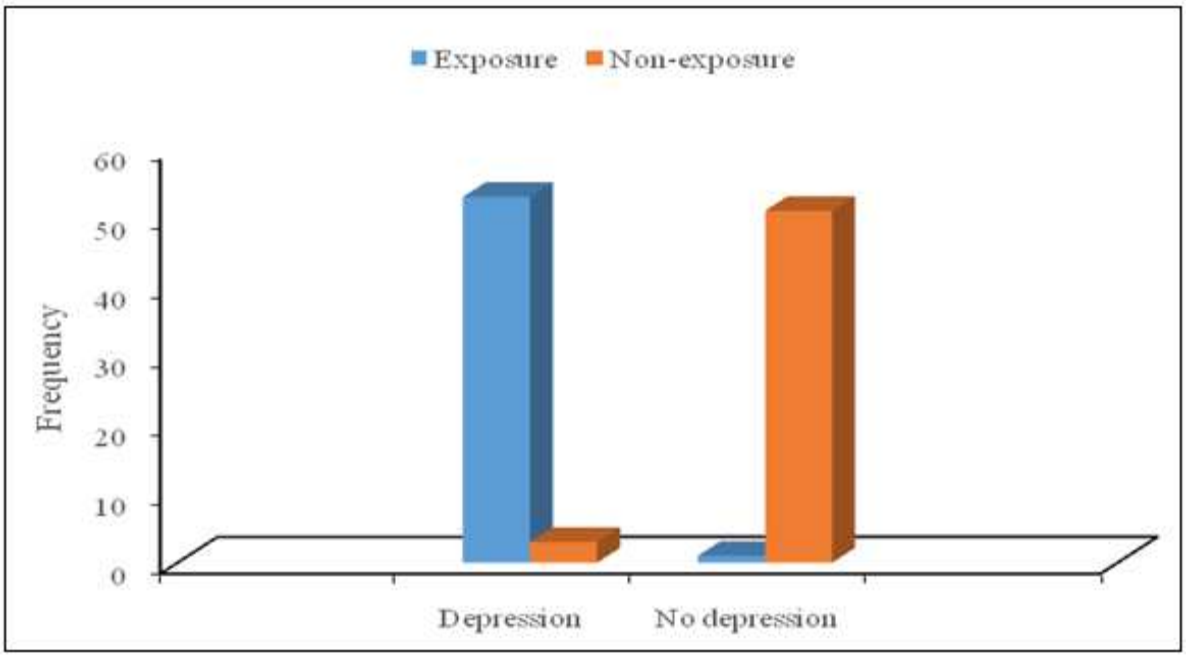

Fig. 3. Distribution of the respondents by depression.

In the non-exposure group, 94.4% did not have any depression, 3.7% suffered mild-to-moderate depression and 1.9% had severe depression. In another study, 19% of arsenicosis cases developed some other psychiatric manifestations. Out of that, 8.47% of arsenicosis patients had depression, 4.61% mixed anxiety and depressive disorder, 2.22% adjustment disorder, 0.77% SUD and 0.26% GAD (Sen & Biswas 2012). The prevalence rate for anxiety neurosis (combining anxiety and depression) witnessed 18.5 per thousand common people in India (Murali MS 2011). It was found that the relationship between depression and drinking water source, consumption of arsenic-contaminated water, level of depression, marital status and occupation were statistically significant. This result is reflected in a similar study in Inner Mongolia, China, that showed a considerably higher burden of mental health problems among people from arsenic-affected villages compared to those in arsenic-free villages (Fujino *et al.,* 2004).

Conclusion

This study will provide an outline of mental health problems and social concerns among a sizeable arsenic-exposed population. The all-pervasive impact of arsenic on physical and mental health makes it a most important public health issue of great concern, especially in Bangladesh. According to the World Health Organisation, health is not only the absence of disease, but it is also the state of complete physical, mental and social well-being. Both the physical and social conditions of arsenic victims can, therefore, have a corrosive impact on their mental health. Although dozens of many studies have already been carried out regarding physical health outcomes, the correlation between arsenic and mental health still gets a raw deal with insufficient studies on it. Hence, the pernicious effects of arsenic on mental health demand further investigations to protect the victims' mental health and also enhance their psychological well-being. This is crucially important because arsenic victims are living with and undergoing social uncertainty, injustice, isolation, and problematic family issues. Arsenic can also cause neurotoxicological problems, which often lead to behavioural changes. Sensitizing community members and law enforcement authorities to prevent separation and ostracism may help to improve the mental health of arsenic victims. Again, socio-economic rehabilitation programs for arsenicosis cases, especially for women, are badly needed. To address this socio-economic crisis, it is necessary to ensure psychosocial support and employment opportunities for them. Arsenic victims need accurate health information as well as supportive counseling in order to improve their stressful situation. Last but not least, the burden of mental health in arsenic-prone areas should be assessed by larger studies and considered in the wider context of public and community health to understand the underlying mechanism of poor mental health because of the curse of arsenic and the resultant arsenicosis.

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