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ORIGINAL PAPER

THE CONTENT OF CHOSEN ELEMENTS IN DRINKING WATER AND PREVALENCE OF CARIES AND HYGIENIC HABITS OF 15-YEAR-OLD YOUTH LIVING IN LVIV (UKRAINE) AND LUBLIN (POLAND)*

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Abstract

The aim of the study was to evaluate prevalence of caries as well as hygienic habits of 15-year -old adolescents living in Ukraine and Poland in connection with the content of chosen elements in drinking water. The study was conducted on the youth populations in Lviv and Lublin. The dental condition was assessed by checking the prevalence of caries, mean D3MFT number and SIC index of caries. Socio-medical examination followed and consisted of checking hygienic habits such as frequency of tooth brushing. Chemical composition of tn the tap water sampled in the areas inhabited by the patients was determined. The prevalence of caries in the Lviv inhabitants was 92.45%, being higher than in Lublin (88.00%). Statistical analysis of the content of chosen elements in the drinking water samples revealed statistically significant differences in the content of phosphorus, potassium and iron. Despite differences in the content of selected elements in the water from both cities, no significant differences emerged between the mean values of D3MFT of the two examined populations, except for the SIC values. Moreover, the frequency of tooth brushing had no impact on values of the mean D3MFT number in either Lviv or Lublin patients.

Keywords: D3MFT, mineralized tooth tissues, chemical composition of tap water.

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INTRODUCTION

The WHO reports indicate that caries in adolescents is a social and medical problem affecting people who live in both developing and developed countries. Incidence of caries, which is considered a social disease, depends on multiple factors, mostly connected with the environment and lifestyle. Creating pro-health behaviours such as oral hygiene positively influences the condition of teeth. Dental tissue resistance to caries is related to the quantitative ratio between organic and non-organic compounds, thus providing the body with building blocks like calcium, phosphorus, trace elements and fluoride is vital for proper odontogenesis (Selwitz et al. 2007, Costa et al. 2008).

The aim of the study was to evaluate the prevalence of caries and hygienic habits of 15-year-old adolescents living in Lviv (Ukrainian territory) and Lublin (Polish territory), and the content of selected elements in drinking water.

MATERIAL AND METHODS

The study was conducted on randomly chosen adolescents from Lviv and Lublin (large cities with over 200 000 inhabitants) and comprised the total of 101 subjects: 51 from Lviv and 50 from Lublin.

Clinical examinations were carried out by doctors with prior practical training in epidemiological research, and the calibration protocol as well as the range of error were determined for each participating doctor. The compatibility coefficient of clinical examinations kappa according to Cohen was 0.970. Standardised methods and evaluation criteria in compliance with the WHO procedures (Oral Health Surveys: Basic Methods, 5th edition, 2013) were applied to assess oral health.

Clinical examination of the mineralized tooth tissue was carried out under standard conditions, with the use of a probe and a mirror in the light of a dental lamp. Disposable dental kits were used and sterility and noninvasiveness rules were observed. The data concerning the condition of teeth were entered into tailor-prepared, anonymous survey sheets/examination files with code numbers. The total number of teeth in the oral cavity was recorded for each 15-year-old patient together with the number of teeth with caries (D3T), teeth removed because of caries (MT) and the number of teeth filled (FT). The condition of teeth was assessed by the prevalence of caries, mean D3MFT number with its components and also the SIC index of caries.

Socio-medical examination followed. The survey questions were age-appropriate, put in forms with the same code numbers as on the examination files. They dealt with hygienic habits such as frequency of tooth brushing, the use of basic and additional oral hygiene products.

Water for the tests was collected from 4 water intakes in Lublin and Lviv, where the patients lived. It was drawn into 1dm^3 plastic containers, which were filled up 3 to 4 min after opening the valve until water overflowed so as to minimize the risk of creating air bubbles. Nitrate nitrogen was determined with the Bremner's microdistillation method modified by Starck, phosphorus was measured colorimetrically with ammonium vanadomolybdate, while potassium, calcium, magnesium, manganese, iron, zinc and copper were assessed with the ASA method (Perkin-Elmer, Analyst 300).

The results were analysed statistically. Values of the analysed measurable parameters were presented as means of an average median value, minimal and maximal values, lower and upper quartile and standard deviation, while for non-measurable ones were shown as mean values of number and percentage.

A Chi^2 test was applied to quality features to detect relationships between the analysed variables. The *U* Mann-Whitney test was applied to determine differences between the two groups. The significance level of $p < 0.05$ indicated statistically significant differences or dependencies. The datasets and statistical analyses were supported by the computer software program Statistica 9.1.

RESULTS

101 people aged 15 years, inhabitants of Lviv or Lublin, were recruited for the examination. Among the Lviv inhabitants there were 66.67% of women and 33.33% of men. The female to male ration for the Lublin subjects was 72.00% to 28.00%. Table 1 contains the specification of the patients with regard to their place of residence and sex. The prevalence of caries among the Lviv inhabitants was 92.45%, thus being higher than in Lublin (88.00%). 100% frequency of having caries was observed in the male populations from Lviv and Lublin, which the results were slightly lower for females from both cities: 88.24% in Lviv and 83.33% in Lublin. Table 2 presents the frequency of having caries depending on the place of residence and sex.

Table 1

Distribution of the examined persons in groups by gender and place of residence

Gender		Lviv	Lublin
Female	*n*	34	36
	(%)	66.67	72.00
Male	*n*	17	14
	(%)	33.33	28.00
Total		51	50

Table 2

Caries prevalence with regard to the place of residence and gender in the examined population of 15-year-olds

Gender	Lviv	Lublin	Chi^2, p
Total	49	44	$Chi^2 = 0.185$
	92.45%	88.00%	$p = 0.667$
Female	30	30	$Chi^2 = 0.060$
	88.24%	83.33%	$p = 0.807$
Male	17	14	–
	100.00%	100.00%	

The prevalence of caries expressed by the mean D3MFT number in the examined population of 15-year-olds from Lviv was 5.580, compared to 4.300while in the Lublin population. The difference was not statistically significant ($p = 0.068$). However, the group from Lviv had a higher mean value of the D3T component (3.640) and lower mean value of the FT component (1.910). In Lublin, the numbers were: D3T = 1.220, FT = 3.080. The differences were statistically significant ($p < 0.001$and $p = 0.035$).The mean values of D3MFT and its components D3T, MT, FT for the 15-year-old patients are presented in Table 3.

Table 3

The average value of D3MFT number and its components D3T, MT, FT for 15-year-old patients from Lviv and Lublin

Specification	City	Mean	SD	Min	Max	Q1	Me	Q3	Difference at p level
D3T	Lviv	3.640	3.000	0	12	1.000	6.000	3.170	$Z = 4.068$
	Lublin	1.220	1.000	0	7	0.000	2.000	1.580	$p < 0.001$
MT	Lviv	0.040	0.000	0	1	0.000	0.000	0.190	$Z = 1.367$
	Lublin	0.000	0.000	0	0	0.000	0.000	0.000	$p = 0.172$
FT	Lviv	1.910	1.000	0	7	0.000	3.000	1.910	$Z = -2.112$
	Lublin	3.080	2.500	0	13	1.000	5.000	2.930	$p = 0.035$
D3MFT	Lviv	5.580	5.000	0	15	3.000	8.000	3.740	$Z = 1.823$
	Lublin	4.300	4.000	0	13	2.000	6.000	3.200	$p = 0.068$

M – mean, Me – median, Min – minimum value, Max – maximum value, Q1 – bottom quartile, Q3 – upper quartile, SD – standard deviation, p – statistical significane

There were no statistically significant differences between the mean values of D3MFT numbers concerning sex and the place of living. Statistically significant differences between D3T and FT were observed between women from Lviv (D3T = 3.790; FT = 1.710) and Lublin (D3T = 1.250; FT = 3.170), ($p = 0.004$ and $p = 0.035$ respectively). The data are shown in Table 4. In the male group, statistically significant differences were noted only for the mean values of D3T ($p = 0.002$). The obtained data are shown in Table 5.

Table 4

Mean values of D3MFT and its components D3T, MT, FT for 15-year-old female patients

Specification	City	Mean	SD	Min	Max	Q 1	Me	Q3	Difference at p level
D3T	Lviv	3.790	4.000	0	12	0.000	7.000	3.640	$Z = 2.872$
	Lublin	1.250	0.500	0	7	0.000	2.000	1.760	$p = 0.004$
MT	Lviv	0.030	0.000	0	1	0.000	0.000	0.170	$Z = 1.000$
	Lublin	0.000	0.000	0	0	0.000	0.000	0.00	$p = 0.317$
FT	Lviv	1.710	1.000	0	6	0.000	3.000	1.770	$Z = -2.104$
	Lublin	3.170	2.000	0	13	1.000	5.000	3.210	$p = 0.035$
D3MFT	Lviv	5.530	4.500	0	15	2.000	9.000	4.210	$Z = 0.995$
	Lublin	4.420	4.000	0	13	2.000	5.500	3.600	$p = 0.320$

Explanations under Table 3

Table 5

Mean values of D3MFT and its components D3T, MT, FT for the 15-year-old male patients

Specification	City	Mean	SD	Min	Max	Q 1	Me	Q3	Difference at p level
D3T	Lviv	3.350	3.000	0	7	2.000	5.000	2.120	$U = 44.0$
	Lublin	1.140	1.000	0	3	0.000	2.000	1.030	$p = 0.002$
MT	Lviv	0.060	0.000	0	1	0.000	0.000	0.240	$U = 112.0$
	Lublin	0.000	0.000	0	0	0.000	0.000	0.000	$p = 0.799$
FT	Lviv	2.410	2.000	0	7	1.000	3.000	2.240	$U = 99.0$
	Lublin	2.860	3.000	1	7	1.000	4.000	2.110	$p = 0.444$
D3MFT	Lviv	5.820	6.000	2	12	3.000	8.000	2.810	$U = 72.0$
	Lublin	4.000	4.000	2	7	2.000	6.000	1.840	$p = 0.064$

Explanations under Table 3

Statistical analysis carried out between mean values of D3MFT number and its components in the group of 15 year-old adolescents from Lviv did not reveal statistically significant differences (for females: D3MFT – 5.530, D3T – 3.790, MT – 0.030, FT = 1.710; for males: D3MFT – 5.820, D3T – 3.350, MT – 0.060, FT – 2.410). The data are shown in Table 6.

Table 7. presents mean values of number D3MFT and its components D3T, MT, FT obtained for the group of 15 year-old adolescents from Lublin. Analysis of the data did not reveal statistically significant differences in caries severity with regard to sex (for females: D3MFT – 4.420, D3T – 1.250, MT – 0.000, FT = 3.170; for males: D3MFT – 4.000, D3T – 1.140, MT – 0.000, FT – 2.860).

Significant Index of Caries (SIC) was 10.13 for Lviv and 7.320 for Lublin and the difference was statistically significant; $p = 0.001$ (Table 8).

Hygienic habits were surveyed by socio-medical examination. The results of the hygienic habit survey showed a higher percentage of adolescents from

Table 6

Mean values of D3MFT number and its components in the group of 15-year-old female and male patients from Lviv

Specification	Gender	Mean	SD	Min	Max	Q 1	Me	Q3	Difference at p level
D3T	famale male	3.790 3.350	4.000 3.000	0 0	12 7	0.000 2.000	7.000 5.000	3.640 2.120	Z = 0.000 p = 1.000
MT	famale male	0.030 0.060	0.000 0.000	0 0	1 1	0.000 0.000	0.000 0.000	0.170 0.240	Z = -0.475 p = 0.635
FT	famale male	1.710 2.410	1.000 2.000	0 0	6 7	0.000 1.000	3.000 3.000	1.770 2.240	Z = -1.084 p = 0.278
D3MFT	famale male	5.530 5.820	4.500 6.000	0 2	15 12	2.000 3.000	9.000 8.000	4.210 2.810	Z = -0.531 p = 0.595

Explanations under Table 3

Table 7

Mean values of D3MFT number and its components in the group of 15-year-old female and male patients from Lublin

Specification	Gender	Mean	SD	Min	Max	Q 1	Me	Q3	Difference at p level
D3T	famale male	1.250 1.140	0.500 1.000	0 0	7 3	0.000 0.000	2.000 2.000	1.760 1.030	Z = -0.491 p = 0.623
MT	famale male	0.000 0.000	0.000 0.000	0 0	0 0	0.000 0.000	0.000 0.000	0.000 0.000	-
FT	famale male	3.170 2.860	2.000 3.000	0 1	13 7	1.000 1.000	5.000 4.000	3.210 2.110	Z = -0.055 p = 0.956
D3MFT	famale male	4.420 4.000	4.000 4.000	0 2	13 7	2.000 2.000	5.500 6.000	3.600 1.840	Z = 0.099 p = 0.921

Explanations under Table 3

Table 8

Significant Index of Caries in the 15-year-old female and male patients from Lviv and Lublin

Index	City	Number	Mean	SD	Min	Max	Q1	Me	Q3	Difference at p level
SIC	Lviv	16	10.13	9.500	8	15	8.000	11.50	2.330	Z = 3.253 p = 0.001
	Lublin	19	7.320	6.000	5	13	5.000	7.000	2.870	

Explanations under Table 3

Lublin than from Lviv who brushed teeth 2-3 times a day (76.00% vs 52.94%). The difference is statistically significant (p = 0.014). Statistically significant differences (p < 0.001) between the youths from Lviv (56.86%) and Lublin (96.00%) were also noted with respect to the use of additional oral hygiene products, like tooth picks, dental floss, rinses (Table 9). More inha-

Table 9

Hygienic habits of 15-year-old adolescents living in Lviv and Lublin

Analyzed variable			Lviv	Lublin	Difference at p level
The frequency of brushing teeth	once a day	N	24	12	$Chi^2 = 6.000$ $df = 1$ $p = 0.014$
		(%)	47.06	24.00	
	2-3 times a day	N	27	38	
		(%)	52.94	76.00	
Brushing habits	toothbrush and water	N	1	4	$Chi^2 = 0.969$ $df = 1$ $p = 0.325$
		(%)	1.96	8.000	
	toothbrush and toothpaste	N	50	46	
		(%)	98.04	92.00	
Use of others oral hygiene products		N	29	48	$Chi^2 = 22.298$ $df = 1$ $p < 0.001$
		(%)	56.86	96.00	
Use of toothpaste with fluoride		N	16	46	$Chi^2 = 34.291$ $df = 1$ $p < 0.001$
		(%)	31.37	92.00	

N – number, p – statistical significance

bitants from Lublin admitted to using toothpaste with fluoride (92.00%) in comparison to Lviv inhabitants (31.37%, $p < 0.001$). One person from Lviv and four persons from Lublin confessed to cleaning their teeth with a toothbrush and water only.

Statistical analysis of the content of chosen elements in the samples of drinking water drawn from Lviv and Lublin revealed statistically significant differences ($p = 0.029$) in the content of phosphorus, potassium and iron. The median for the phosphorus concentration in Lviv was: 27.750 mg $P\text{-}PO_4$ dm^{-3}, compared to 4.850 mg $P\text{-}PO_4$ dm^{-3} in water from Lublin; the potassium content was 4.500 mg K dm^{-3} and 1.850 mg K dm^{-3}, respectively. Interesting results were obtained for the iron content in water. The iron concentration was found to be four times higher in the water in Lublin (0.200 mg Fe dm^{-3}) than Lviv (0.050 mg Fe dm^{-3}). The differences in the nitrogen, calcium and magnesium ion content in water from both cities were not statistically significant. The median value of the concentration of nitrates in water was 11.00 mg $N\text{-}NO_3$ dm^{-3} in Lviv and 7.450 mg $N\text{-}NO_3$ dm^{-3} in Lublin; for calcium, the medians were 67.20 mg Ca dm^{-3} and 117.5 mg Ca dm^{-3}, while for magnesium they reached 16.05 mg Mg dm^{-3} and 14.00 mg Mg dm^{-3}, respectively. The content of manganese, zinc and copper in water from both cities was similar, and small differences were not statistically significant. Table 10 shows comparisons of the differences.

Table 10

The chemical compositions (mg dm^{-3}) in drinking water from Lviv and Lublin

Elements (mg dm^{-3})	City	Median	Min	Max	p – statistical significance
$N\text{-}NO_3$	Lviv Lublin	11.00 7.450	5.000 5.000	28.50 9.000	0.200
P	Lviv Lublin	27.75 4.850	14.60 4.600	32.40 5.100	0.029
K	Lviv Lublin	4.500 1.850	3.200 1.700	4.800 2.100	0.029
Ca	Lviv Lublin	67.200 117.50	34.80 89.00	320.6 134.0	0.343
Mg	Lviv Lublin	16.05 14.95	11.90 11.20	45.80 19.00	0.686
Fe	Lviv Lublin	0.050 0.200	0.030 0.100	0.060 0.340	0.029
Zn	Lviv Lublin	0.030 0.050	0.010 0.020	0.060 0.070	0.343
Cu	Lviv Lublin	0.020 0.010	0.010 0.010	0.050 0.030	0.686
Mn	Lviv Lublin	0.030 0.040	0.010 0.030	0.060 0.050	0.343

DISCUSSION

Our research demonstrates that the prevalence of caries among 15-year-old adolescents living in Lviv and Lublin was high: 92.45% in Lviv, 88.00% in Lublin.

Examination of the same age group carried out in 2011 in Łodz revealed caries in 89.70% of patients (Hilt et al. 2014). Mielnik-Błaszczak et al. (2013) noted 100% prevalence of caries among young people in another Polish town, Rzeszów.

Studies carried out among 15-year-old inhabitants of cities in Malawi recorded a much lower prevalence of caries: 21.90% (Msyamboza et al. 2016). Higher prevalence was observed in Mexico: 48.60% (Pondingo et al. 2007).

The WHO research conducted by Indian doctors showed high caries prevalence amongst 15-year-olds: 62.02% (Kundu et al. 2015). Surprisingly, the prevalence of caries among adolescents in the cities Shimla and Himachal Pradesh was only 42.20% (Shailee et al. 2013), whereas in Valencia, where 15-year-olds were examined, it reached 55.90% (Almerich-Silla, Montiel-Company 2006). High caries prevalence was also observed in a simi-

lar age population from the United Arab Emirates: 65.00% (El-Nadeef et al. 2009), Falkland Islands: 66.70% (Jones, Walters 2015) and Iran: 75.50% (Hamissi et al. 2008).

High prevalence of caries, comparable to our results, was noted among school children in Veles, Macedonia: 90.55% (Ambrakova et al. 2014), in towns of north-western Russia: 91.80% (Gorbatova et al. 2011) and in Lithuania: 92.90% (Milciuviene et al. 2009).

The intensity of caries was assessed with values of the mean D3MFT number. Our research shows that the mean D3MFT number value and values of its components was high, reaching 5.580 for the Lviv subjects and 4.300 for the adolescent inhabitants of Lublin. The 2011 campaign 'Monitoring oral cavity health', which was conducted in Poland among 15-year-old adolescents, revealed that the mean D3MFT value was 6.120, and 5.660 for urban inhabitants, while in 2015 the number was 5.750 (Ministry of Health 2011, 2015). Examinations conducted in Lviv in 2012 achieved a lower D3MFT value: 5.180 (Smolar et al. 2012).

In the literature, the mean D3MFT number values vary, for example 5.600 in Lithuania (Milciuviene et al. 2009). Low values were recorded in Malawi: 0.710 (Msyamboza et al. 2016), Trinidad and Tobago: 1.060 (Naidu et al. 2006), the Falkland Islands: 1.780 (Jones, Walters 2015), Turkey: 2.300 (Gökalp et al. 2010), Iran: 2.660 (Hamissi et al. 2008), and in Iceland: 2.780 (Agustsdottir et al. 2010). Australian authors published mean values of the D3MFT number ranging from 0.5 to 3.0, depending on the place of living of the examined population (Skinner et al. 2013). Mean values of D3MFT>3 were also noted among 15-year-olds from Greece: 3.190 (Oulis et al. 2012), Georgia: 3.510 (Sagan-Cohen et al. 2014), India: 3.820 (Goyal et al. 2007), Russia: 4.920 (Gorbatova et al. 2011) and Macedonia: 4.980 (Ambrakova et al. 2014).

The results of epidemiological research concerning the condition of mineralized teeth tissue are based on the analysis of the D3MFT number, however, they should be considered in close correlation with the results of particular components of the number: D3T, MT and FT.

The examinations conducted in Poland in 2011 revealed that nationwide the components of the mean number D3MFT were: D3T – 2.670, MT – 0.160, and FT – 3.290, respectively, while for urban dwellers they were: D3T – 2.360, MT – 0.10, and FT – 3.290 (Ministry of Health 2011). A study conducted in Lviv in 2012 determined the following values of particular components of the D3MFT: D3T – 2.520, MT – 0.050, FT – 2.610 (Smolar et al. 2012). A more complete picture of the spread of caries among the young population can be obtained by analyzing the D_3T component, which also indicates the need for medical treatment. The D3T value in 15-year-olds from Macedonia was 0.560, while in Russia it equalled 2.610 (Ambrakova et al. 2014). The differences in D3T values, especially the D3T to MT and FT ratio, suggest inadequate dental care in the examined population and their poor health-related habits.

Significant Index of Caries (SIC) was applied to reveal the group of patients with high intensity of caries. Our research showed a high value of this index. Based on the findings from the survey "Monitoring oral cavity health", carried out in Poland in 2011, this value was estimated at 10.80 among 15-year-olds (Ministry of Health 2011). Hilt et al. (2014) found a lower value of this index, i.e. 8.200. Similarly high values were recorded for Macedonian minors, i.e. 8.930 (Ambrakova et al. 2014), but lower in Greece: 7.070 (Oulis et al. 2012) and Iceland: 6.700 (Jones, Walters 2015). The research conducted by Pontigo-Loyola et al. (2007) provided a much lower SIC value: 3.46. Significant Index of Caries (SIC) introduced by Bratthalla allows identification of high risk groups in order to provide them with particularly intensive preventive measures. Hygienic habits play an extremely important role in caries prophylaxis.

Our results show that most of the examined 15-year-olds brush their teeth 2 to 3 times a day. Dutch researchers noticed a link between the frequency of tooth brushing and intensity of caries (Dusseldorp et al. 2015). Prevalence of caries is lower in Kenyans who brush teeth at least twice a day (Masiga, Machoki 2012). The study by Msyamboza et al. (2016) shows that 35.20% of the examined 15 year-olds in Malawi brush teeth twice a day. Similar observations were made by Gupta et al. (2012), who examined an adolescent population from the south of India. They found that 61.90% of the respondents brush teeth twice a day or more often, and that over 90.00% of the examined population uses toothbrushes and toothpaste, although 63.30% of them were unaware whether their toothpaste contained fluorid. Other studies from India observe a correlation between the high prevalence of caries (80.00%) and the lack of fluoride in the toothpaste used (Goyal et al. 2007). Korean authors did not prove a statistically significant relationship between the prevalence of caries and the frequency of tooth brushing (p = 0.725) (Tarvonen et al. 2016). Surprisingly, although 84.10% of Katmandu inhabitants brush teeth only once a day, using a toothbrush and toothpaste, the prevalence of caries in this population is 58.30% and the mean value of D3MFT is low as well: 1.200 ± 1.790 (Khanal, Acharya 2014). Most probably it results from either their dietary habits or genetic predisposition. Nowadays, human bodies are increasingly more often deprived of the minerals which mainly come from water and food. The data from our research proved that the magnesium, copper and nitrogen concentrations in drinking were within the acceptable range and in compliance with the Regulation of the Minister of Health, 13 November 2015 on the quality of drinking water. The content of iron in the water drawn from two water intakes in Lublin was outside the normal range. However, it should be noted that in order to achieve positive ontogenetic and prophylactic effects with regard to caries disease, the water calcium content should exceed 150 mg dm^3, magnesium 50 mg dm^3 and iron 1 mg dm^3. (Minister of Health regulation of 31 March 2011 on natural mineral waters, spring waters and table waters).

CONCLUSION

The analysis of our research data revealed the high prevalence and intensity of caries in the groups of 15-year-olds living in Lviv and Lublin. Although there were differences in the content of the selected elements in the drinking water from both cities, no significant differences between the mean values of D3MFT scored by the two examined populations were noted. There were, however, statistically significant differences between the values of SIC. Moreover, it was reported that the frequency of brushing teeth, use of additional oral hygiene products and toothpaste containing fluoride had no impact on the values of the mean D3MFT number among the Lviv and Lublin patients. The data obtained from our survey sheets and concerning the above factors differed considerably between these two groups.

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