

# DIARRHEAL INFECTIONS IN UKRAINE: CURRENT EPIDEMIOLOGICAL SITUATION

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## ABSTRACT

Purpose of the study on the background of the analytical study of the incidence of diarrheal infections in Ukraine under the current conditions, to determine the factors influencing epidemic situation. The processes of globalization, fundamental changes in nutrition and water consumption contributed to the fact that the significance of individual infection sources, ways of invader transmission, etiological structure of diarrheal infections changed. Epidemiological and statistical research methods are applied. Statistical processing of the study outcome is carried out using software application Microsoft Office Excel 2010, Statistica 6. The epidemic situation with diarrheal infections in Ukraine is characterized by a low incidence of typhoid fever, shigellosis, stable incidence rates without the downward trend, salmonellosis, high incidence of diarrheal infections of specified etiology and diarrheal infections of unspecified etiology. The most complicated epidemic situation is observed in economically most developed regions of the country. Most diarrheal infections outbreaks are connected with catering establishments 36.5 % and with children educational establishments 26.1 %. In the region with the highest shigellosis and salmonellosis incidence direct strong correlation relationships are established between the incidence and population, density, natural population movement. The oblasts with the highest diarrheal infections of specified etiology, rotaviral enteritis, diarrheal infections of unspecified etiology incidence are at least provided with water resources and have problems with provision of high-quality drinking water.



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## 1. Introduction

Diarrheal infections (DI) remain relevant for many countries of the world [1], [2]. The incidence is high enough both in developing countries and economically developed countries [3], [4].

The processes of globalization, increase in migratory movements, development of international tourism, fundamental changes in nutrition and water consumption contributed to the fact that the significance of

individual infection sources, ways of invader transmission, etiological structure of DI changed [5], [6]. On the background of general environmental degradation and decrease in the immune status of population, the role of opportunistic pathogens (OP) and viruses has increased [7], [8].

Objective of the paper: on the background of the analytical study of the incidence, etiological structure of DI in Ukraine under the current conditions, to determine the factors influencing epidemic situation (ES).

## 2. MATERIALS AND METHODS

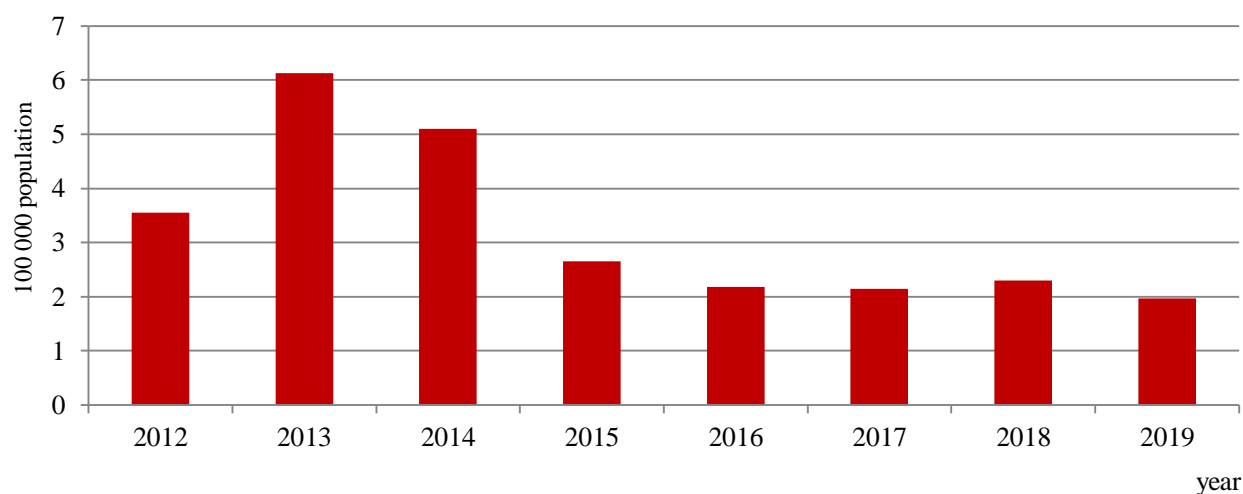
The reports of the Ministry of Health of Ukraine, Main Administrations of Statistics in Kharkiv, Odesa, Zaporizhia oblasts for 2012–2019 are used in the paper.

Epidemiological and statistical research methods are applied. Statistical processing of the study outcome is carried out using software application Microsoft Office Excel 2010, Statistica 6.

## 3. RESULTS

It has been established that in Ukraine in 2012–2019 typhoid fever incidence varied from 0.012 to 0.14 per 100 thousand people. Herewith, typhoid fever cases were registered only in separate regions of Ukraine: Dnipropetrovsk, Donetsk, Zakarpattia, Ivano-Frankivsk, Mykolaiv, Odesa, Ternopil, Kharkiv, Khmelnytskyi oblasts and in the city of Kyiv.

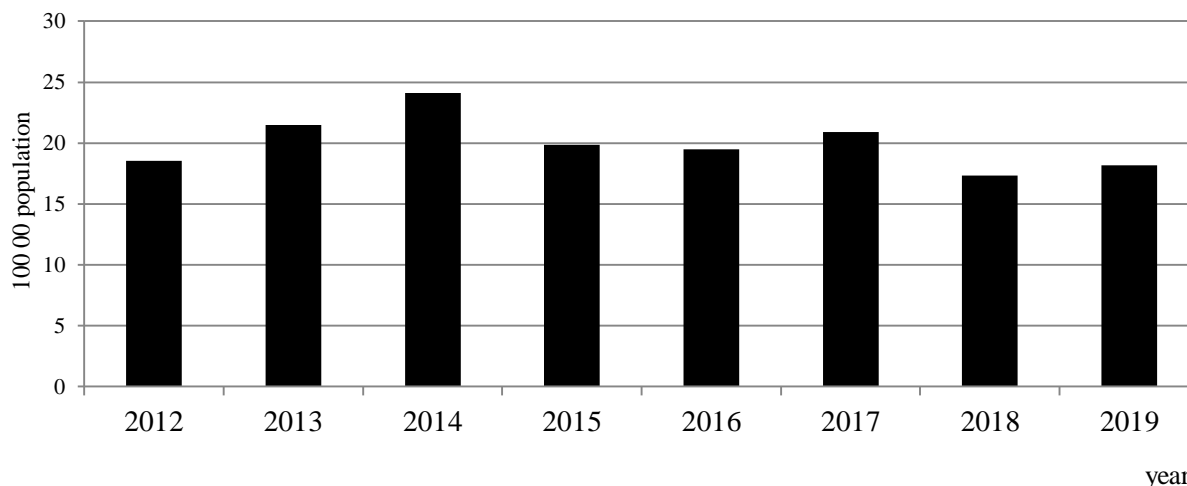
Shigellosis incidence ranged from 1.97 per 100 thousand people to 6.13 (Figure 1).



**Figure 1.** Incidence of shigellosis in Ukraine (2012–2019)

The highest median (Me) shigellosis incidence is defined in Kharkiv (18.9 per 100 thousand people), Zakarpattia (5.9 per 100 thousand people), Odesa (4.7 per 100 thousand people), Mykolaiv (3.8 per 100 thousand people) and Khmelnytskyi (2.8 per 100 thousand people) oblasts.

Salmonellosis incidence ranged 17.35–24.1 per 100 thousand people (Figure 2). Me salmonellosis incidence was the highest in Kharkiv oblast (52.97 per 100 thousand people). Besides, in Khmelnytskyi, Cherkasy, Odesa, Zaporizhia, Zhytomyr, Rivne and Dnipropetrovsk oblasts the incidence was higher than the average one in Ukraine (Me – 19.7 per 100 thousand people).



**Figure 2.** Incidence of salmonellosis in Ukraine (2012–2019)

The incidence of the DIs caused by OP, viruses, coliform bacteria, Campylobacter and Yersinia (DISE – diarrheal infections of specified etiology) in 2012–2019 ranged from 115.5 per 100 thousand people to 141.94 (Rate of incidence average:  $R_{inc.}^{av.} = 0.75\%$ ).

Me DISE incidence was the highest in Zaporizhia oblast (exceeded the average one in Ukraine by 2.6) and was 317.9 per 100 thousand people. The unfavourable ES with DISE was also observed in Vinnytsia, Dnipropetrovsk, Donetsk, Kyiv, Mykolaiv, Odesa, Poltava, Kharkiv, Kherson and Khmelnytskyi oblasts.

Rotaviral enteritis (RE) incidence varied from 18.97 per 100 thousand people to 42.5 ( $R_{inc.}^{av.} = 4.2\%$ ). Me RE incidence was 28.6 per 100 thousand people. The most favourable ES was in Zaporizhia, Vinnytsia, Dnipropetrovsk, Mykolaiv, Odesa, Poltava, Kherson, Khmelnytskyi, Cherkasy and Chernihiv oblasts.

Campylobacter enteritis incidence ranged from 0.19 to 0.37 per 100 thousand people. The highest levels were registered in Zaporizhia oblast (from 2.69 to 6.25 per 100 thousand people). At the same time, campylobacter enteritis was not detected at all in most of the regions of Ukraine.

The incidence of enteritis caused by Yersinia enterocolitica ranged within 0.15–0.3 per 100 thousand people. The highest Me was determined in Zaporizhia, Kharkiv, Mykolaiv oblasts.

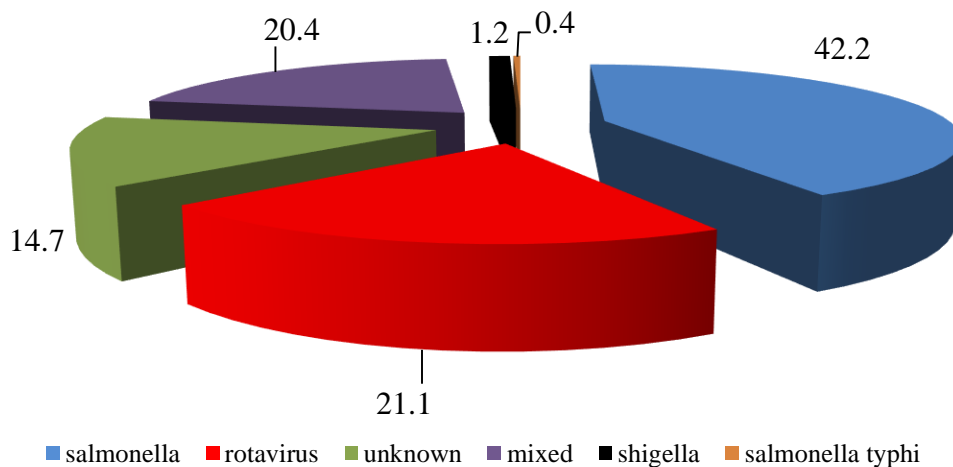
DI agent has not been identified in considerable part of the patients (DIUE – diarrheal infections of unspecified etiology). In the research period DIUE incidence varied from 69.76 till 107.02 per 100 thousand people. ( $R_{inc.}^{av.} = 3.7\%$ ). Me incidence was 89.86 per 100 thousand people. In Odesa oblast DIUE incidence was the highest and exceeded the average one in Ukraine by 4.6 times (Figure 3).



**Figure 3.** DISE and DIUE incidence in Ukraine (2012–2019)

Thus, the most complicated ES with DI is observed in Odesa oblast, where Me incidence exceeds the average shigellosis, salmonellosis, DISE, RE, DIUE incidence. Except for Odesa, the epidemic situations in Zaporizhia, Mykolaiv, Khmelnytskyi, Dnipropetrovsk, Kyiv, Kharkiv and Vinnytsia oblasts are difficult enough.

Salmonellosis share is the highest in the DI outbreak structure in Ukraine ((42.2 ± 2.1) %). Every fifth outbreak was caused either by rotaviruses ((21.1±1.7) %) or other specified agents ((20.4 ± 1.7) %) (Figure 4).



**Figure 4.** DI outbreak structure in Ukraine in 2014–2019 (%)

DI outbreak frequency is increasing year by year: DIUE – by 85.7 %, RE – by 63.6 %, DISE – by 60.9 %.

Most DI outbreaks are connected with catering establishments ((36.5 ±4.1) %) and children educational establishments ((26.1±3.4) %). Nidus index was the highest at home foci and was 22.2 (Table 1).

**Table 1** – Outbreak distribution by place of occurrence

Place of occurrence	Specific gravity of outbreaks	Specific gravity of injured	Nidus index
Children's pre-school institutions	26.1 ± 3.4	14.7 ± 0.4	8.4
Secondary schools	7.4 ± 1.1	5.2 ± 0.2	10.5
Recreation institutions for children	4.1 ± 0.8	4.0 ± 0.2	14.6
Catering establishments	36.5 ± 4.1*	41.2 ± 0.5*	16.9
Home foci	20.9 ± 1.7	31.2 ± 0.5	22.2
Other foci	5.0 ± 0.8	3.7 ± 0.2	11.3
Total	567	8481	14.9

\*p < 0.001, regarding other foci, except for children's pre-school institution

Outbreaks of salmonellosis happened most of all in Kyiv and Lviv oblasts, RE – in Zaporizhia, Donetsk and Cherkasy oblasts, DISE – in Odesa, Kyiv, Zaporizhia and Kharkiv oblasts, DIUE – in Kyiv and Lviv oblasts.

It should be noted that the ES with DI nowadays was determined by sporadic morbidity, as the part of people involved in outbreaks was miserly only 1.6 %.

In order to determine the factors, which could influence DI incidence, the demographic situation in the regions of Ukraine with the highest DI incidence was studied.

Kharkiv oblast, where the highest shigellosis and salmonellosis incidence was registered, situated on the east of the country, is one of the leading industrial, agricultural, scientific and cultural regions of Ukraine, is the fourth by population in Ukraine. In 2012–2019 population of the oblast decreased from 2755.1 thousand people to 2694.0, density from 87.7 per 1 km<sup>2</sup> in 2012 to 85.8 in 2019, vital rate - from (-5.0) in 2012 to (-8.6) in 2019, migratory movement from 0.3 per 1000 people in 2012 to 1.7. In the oblast 69.0 % of the housing stock is provided by water supply system, drainage system – 68.1 %, hot water supply – 62.2 %. According to the results of the correlation analysis conducted, direct strong connections between the indexes of population, density, vital rate in Kharkiv oblast and shigellosis and salmonellosis incidence were established (r = from 0.779 to 0.908) (p < 0.05).

Zaporizhia oblast, where the highest DISE, RE incidence, situated on the south-east of Ukraine, occupies predominantly the left-bank part of the basin of the lower reaches of the Dnipro, on the south its banks are washed by the Azov Sea; it is the tenth by population in Ukraine. In 2012–2019 population of the oblast decreased from 1801.3 thousand people to 1723.2, density from 66.3 per 1 km<sup>2</sup> in 2012 to 63.4 in 2019, vital rate - from (-4.9) in 2012 to (-8.9) in 2019, migratory movement from (-0,5) per 1000 people in 2012 to (-1.3) in 2019. In the oblast 68.2 % of the housing stock is provided by water supply system, drainage system – 66.3 %, hot water supply – 60.4 %. True correlation relationship was not statistically established between DISE, RE incidence and basic demographic rates (p < 0.05).

Odesa oblast with the highest registered DISE incidence is situated on the south-west of Ukraine, washed by waters of the Black Sea, is the sixth by population in Ukraine. In 2011–2018 population of the oblast changed from 2388.7 thousand people to 2383.1, density from 71.7 per 1 km<sup>2</sup> in 2012 to 71.5 in 2019, vital rate – from (-1.9) in 2012 to (-4.4) in 2019, migratory movement from (0.002) per 1000 people in 2012 to (0.003) in 2019. In the oblast 70.8 % of the housing stock is provided by water supply system, drainage

system – 63.4 %, hot water supply – 81.7 %. True correlation relationship was not statistically established between DIUE incidence and demographic rates ( $p < 0.05$ ).

#### 4. DISCUSSION

The ES with DI in Ukraine under the current conditions is characterized by low levels of the typhoid fever incidence. In 2012–2019 the incidence didn't exceed 0.14 per 100 thousand people. The typhoid fever cases were seldom registered only in separate regions of Ukraine. Despite the decrease in incidence, the disease remains a pressing problem for public health service in Ukraine, as the possibilities of bringing this infection by migrants and tourists preserve.

Shigellosis is popular all over the world, however, 1-4 years old children, living in the countries with low and medium income level, are mostly affected by this infection [9]. Salmonella enteric subsp. on the global scale belongs to the most common etiological factor of foodborne infections in people [10]. In Ukraine under the current conditions shigellosis incidence does not exceed 6.13 per 100 thousand people ( $R_{inc}^{av} = -7.5$  %). Salmonellosis incidence reached the rate of 24.1 per 100 thousand people ( $R_{inc}^{av} = -0.95$  %). The highest shigellosis and salmonellosis incidence rates were registered in one of the biggest industrial and scientific regions – Kharkiv oblast. The above mentioned is indicative of increase in the role of animals in the DI epidemic process and decrease in human role.

OP and rotaviruses caused DI most typically in Ukraine. The most difficult ES with DISE in general and RE, namely, was in the southern oblasts of Ukraine: Zaporizhia, Mykolaiv, Odesa and Kherson.

*Campylobacter* bacteria according to the report of the European Food Safety Authority and the European Centre for Disease Prevention and Control for 2017, are one of the most common reasons of the zoonotic diseases of food origin [11]. Incidence of the infections caused by *Y. Enterocolitica* is carefully controlled in the developed countries. In Africa and in the Middle East, due to the problems of diagnostics, the actual ES with intestinal yersiniosis is unknown [12]. In Ukraine the cases of campylobacter enteritis and intestinal yersiniosis were registered only in separate cases in its separate regions.

Most DI remains etiologically unverified. Under the current conditions, DIUE incidence rates reach 107.02 per 100 thousand people. The most unfavourable ES with DE is in Odesa oblast, where Me incidence exceeds the average one in Ukraine by several times.

Thus, considering the above mentioned, it can be assumed that the geographical position of the region influences DI incidence of the population. The ES with DI is the most unfavourable in the southern, maritime oblasts of Ukraine. This is probably due to the climatic conditions, the large number of recreational facilities, architectural monuments that attract holidaymakers and tourists.

According to data of the World Health Organization, over 80 % of all human diseases is connected with usage of low-quality water. Besides, if water resources of the country are less than 1.5 thous. m<sup>3</sup> per inhabitant, then according to the definition of the European Economic Commission of UN, this country belongs to poorly provided with water supplies available for use.

Ukraine does not only has problems in provision with water resources but the situation is complicated also with the fact that their territorial distribution is uneven and does not comply with placement of water-containing economic complexes [13- 15]. The highest level of water supply of the inhabitants is in the western and eastern oblasts of Ukraine. The fewest number of water resources is in the southern oblasts of

Ukraine, in Donbas, Kryvorizhia.

On the background of insufficient water supply, serious problems have accumulated in Ukraine connected with industrial and public utility pollution of the water bodies, great worn-out state of water-supply and sewerage networks, low productivity of treatment facilities.

Researchers have proven that under the conditions of chronic man-made pollution of drinking water with harmful physical and chemical substances, the effect of DI agent influence can be enhanced both due to strengthening of its pathogenic peculiarities and significant decrease in resistance of susceptible persons [16], [17].

As it has been already noted, the most unfavorable situation with DISE, RE is observed in Zaporizhia oblast. The water supply of this region is characterized by the lack of drinking water. 96.2 % of the water withdrawal is carried out from surface sources of the drinking water supply – the Dnipro, Berda river and Kakhovskiy main canal, which due to man-man pollution, washout of chemical fertilizers and chemical pesticides, are in unsatisfactory condition. Population of the majority of inhabited areas drinks water that does not correspond to the sanitary-hygienic standards by organoleptic properties and sanitary-chemical indices. At the same time, according to the data of sanitary-and-epidemiological surveillance conducted in Zaporizhia oblast, only 1.7% of the water samples taken do not meet the normative microbiological parameters. It is believed that the population is supplied with drinking water with a minimum degree of potential epidemic risk. This statement is in contradiction with the DI incidence in Zaporizhia oblast and indirectly proves inefficiency of the existing system of microbiological monitoring of drinking water quality.

In Odesa oblast, where DIUE incidence exceeds the average one in Ukraine by several times, the water supply for population is also mainly carried out from the surface sources of drinking water supply (the Dunai river and Danube lakes). The situation with water supply is complicated with the fact that the part of rural population uses imported water as the drinking one.

The water-supply system of Kharkiv oblast, where the highest shigellosis and salmonellosis incidence is registered, differs from the southern oblasts of Ukraine. The population is provided with water from the underground artesian springs and rivers – the Siverskyi Donets, Dnipro.

Taking into consideration the above mentioned, we consider the environmental state of the surface water bodies and water quality in them to be the important factors determining DI incidence, their etiological structure. Under the conditions of anthropogenic pressure, significant changes in the structure of microbiocinoses of aquatic ecosystems happen, the levels of viral contamination increase, the frequency of gram-negative and opportunistic pathogens increases, which is non-standardized by the documents of water-sanitary legislation.

During microbiological study of the municipal drinking water, total bacterial count, total coliforms, coliform bacterium, enterococci, coliphages are determined in its samples. If coliphages are found out in the samples of drinking water, virus studies are conducted. Considering the situation with DISE and DIUE incidence, it can be assumed that the current control system for drinking water based on the State Sanitary Rules and Regulations “Hygienic requirements for drinking water intended for human consumption” (DSanPin 2.2.4–171-10) does not ensure its real epidemic safety. We believe that there is a need to revise the microbiological attributes that are the indicators of drinking water safety. Determining total bacterial

count, total coliforms, coliform bacterium, enterococci, coliphages does not reflect the extent of potential epidemic risk of drinking water. Water quality control in different regions of Ukraine should be differentiated, if necessary, additional studies should be carried out depending on the territorial features of the region.

DI incidence in Ukraine is complicated by outbreaks. Most outbreaks are of salmonellosis etiology and are associated with catering establishments ( $p < 0.05$ ). DI outbreaks are most commonly recorded in the regions where many educational, cultural establishments and industrial enterprises are concentrated. These territories are the areas of increased epidemic risk of outbreaks.

The indicators of demographic situation can be used to predict the ES with shigellosis and salmonellosis. In Kharkiv oblast, direct strong correlation relationships are established between shigellosis and salmonellosis incidence and indicators of population, density, natural population movement.

## 5. Conclusions

1. The ES with DI in Ukraine is characterized by a low incidence of typhoid fever (from 0.012 to 0.14 per 100 thousand people), shigellosis (from 1.97–6.13 per 100 thousand people), stable incidence rates without the downward trend, salmonellosis (from 17.35 till 24.1 per 100 thousand people), high incidence of DISE (from 115.5 to 141.9 per 100 thousand people) and DIUE (from 69.76 to 107.02 per 100 thousand people).
2. DI outbreaks are mostly registered in the touristic and recreational regions of Ukraine: Kyiv, Lviv and Odesa oblasts. Most DI outbreaks are connected with catering establishments 36.5 % and with children educational establishments 26.1 %. Salmonella dominates in the etiological structure of outbreak influence (42.2 %).
3. The epidemic process of DI is indirectly influenced by social factors. In the region with the highest shigellosis and salmonellosis incidence (Kharkiv oblast) direct strong correlation relationships are established between the incidence and population, density, natural population movement ( $r =$  from 0.779 to 0.908) ( $p < 0.05$ ). The oblasts with the highest DISE, RE, DIUE incidence (Zaporizhia and Odesa oblasts) are at least provided with water resources and have problems with provision of high-quality drinking water.
4. There is a need to improve the system of epidemiological surveillance over DI by extension of the indicators of microbiological study of drinking water quality in the regions of Ukraine, where high DISE, RE, DIUE incidence is registered; by increasing frequency of food item inspections in the oblasts, where Me shigellosis and salmonellosis incidence exceeds the average one in Ukraine.

## List of abbreviations

DI: Diarrheal infections

OP: Opportunistic pathogens

ES: Epidemic situation

Me: Median

DISE: Diarrheal infections of specified etiology

RE: Rotaviral enteritis

DIUE: Diarrheal infections of unspecified etiology

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## Conflict of interest

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Conception and design: MN

Analysis and interpretation of the data: DS

Drafting of the article: MN

Critical revision of the article for important intellectual content: MN, DS

Final approval of the article: MN

Provision of study materials or patients: RR

Statistical expertise: CM

Administrative, technical, or logistic support: MN, RR

Collection and assembly of data: CM

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