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Assessment of the resistance of alimentary-related risk factors to the effects of chemical disinfectants

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Abstract. Currently, much attention is paid to the monitoring of new biopathogens, which are formed as a result of targeted genetic manipulations resulting from human activity, and natural variability. The sensitivity of mutated organisms to various disinfectants can differ significantly from the sensitivity of the original varieties. Thus, the assessment of alimentary-caused biological risk factors in terms of resistance to the effects of chemical disinfectants is an important area of scientific research. **The aim** of the work is to assess the nutritionally determined biological risk factors in terms of resistance to the effects of chemical disinfectants. **The research methods** were general scientific methods of cognition, as well as the analysis of alimentary-caused biological risk factors in terms of resistance to chemical disinfectants, which was carried out by us, based on the standardized methodology for the epidemiological assessment of Dubyansky-Maletskaya. The analysis covered a three-year period from 2019 to 2021, and was carried out by us on the materials of the Ryazan region provided by the Center for Hygiene and Epidemiology of the Ryazan Region and the Main Directorate of Veterinary Medicine of the Ryazan Region. **The scientific novelty** of the study lies in identifying the features of the manifestation of the sensitivity of alimentary-conditioned biological risk factors to various groups of chemical disinfectants. **Results.** Our study allowed us to draw the following conclusions: the resistance of alimentary-caused biological risk factors to chemical disinfectants is largely due to their etiological characteristics; among the group of pathogens with very low resistance to chemical disinfectants, the main share is occupied by risk factors of bacterial etiology; among the group of pathogens with medium resistance to chemical disinfectants, the main share is occupied by risk factors of viral etiology; among the group of pathogens with high resistance to chemical disinfectants, the main share is occupied by risk factors of helminthic etiology; a group of pathogens with a very high resistance to chemical disinfectants mainly consists of risk factors of helminthic etiology and spore-forming anaerobic bacteria.
Keywords: biopathogens; anthroponoses; zooanthroponoses; food quality and safety; chemical disinfection.

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Introduction

In recent years, the food safety of the population has been of increasing interest to the State System of Biological Safety of the Russian Federation.

This process can be described by qualitative and quantitative indicators of food security. Quantitative indicators include assortment diversity and economic availability of food products, while qualitative indicators include the quality and safety of food products.

The above indicators are closely intertwined, since in order to maintain the health of the nation, it is necessary to support the satisfaction of the needs of the population in a diverse, complete, high-quality and safe diet.

Diet-related biological risk factors play a key role in the spread of foodborne diseases in humans and animals.

Providing the population with safe and healthy food is a vital component of a country's food security. At present, throughout the world, chronic dietary deficiencies of a number of micronutrients (such as vitamin A, iron, iodine and zinc, B vitamins) can contribute to the development of the phenomenon of "hidden hunger", in which the consequences of a micronutrient deficiency may not be immediately visible. This type of micronutrient deficiency is one of the leading risk factors for human health worldwide and adversely affects metabolism, the immune system, cognitive development and maturation, especially in children. It is also worth noting that a healthy diet rich in micro- and macro-nutrients contributes to longevity and an increase in life expectancy, and is an important component of not only physical but also mental health of a person, positively affecting performance and mood.

Another important component is food safety. In particular, the issues of disinfection and maintaining a high sanitary and hygienic level at processing plants and public catering enterprises are acute. In recent years, the issue of mutational changes among well-known opportunistic microorganisms, and, as a result, the emergence of strains with increased resistance to physical and chemical disinfectants has become quite acute [1].

Scientists' opinions regarding the reasons for this trend are represented by two major areas of research on mutagenic factors, which include physical factors (various types of radiation), chemical factors (arbitrary use of antimicrobials and chemical disinfectants) and biological factors (mutations resulting from interaction with various genetic material, including the purposeful creation of GMOs).

A number of authors [14–16] point to the relationship between the increase in the level of the above diseases and the increase in the level of electromagnetic pollution, including the background of microwave radiation (SHF). The human body does not have a sufficiently developed sensory apparatus for recognizing electromagnetic radiation (EMR) of non-thermal intensity, and therefore people practically do not feel the negative impact on their body directly during its implementation.

Often, the consequences can be observed only after a significant period of time, while the picture of electromagnetic disorders will be non-specific in terms of a set of clinical signs and almost differentially undiagnosable from diseases of a different etiology with similar manifestations [6; 8; 12].

Also quite common is the theory of «chemical mutations» [8–10; 12; 17], which is confirmed in studies of the emergence of antibiotic-resistant strains of microorganisms, as well as the formation of L-forms of bacteria, which lead to long-term carriage and chronic forms. latent infections. As a result, human health is slowly and barely noticeably destroyed as a result of exposure to infectious agents, which ultimately can lead to death with a sharp weakening of immunity or severe stress. At the same time, the official cause of death in many cases will be diagnostically recognized as a somatic rather than an infectious disease [13].

According to official medical statistics [8; 12; 17], the root cause of 1/3 of cardiovascular diseases and 1/5 of oncological diseases are infectious and parasitic biological risk factors (including alimentary-related ones). Thus, food safety is becoming more and more of a global public health issue as people suffer from a multitude of foodborne illnesses. Many foodborne pathogens are given the opportunity to spread due to lifestyle factors, political, economic and environmental changes [18].

In industrialized countries, approximately one in three people annually suffer from mild forms of food poisoning, which can be regarded as a digestive disorder [6; 8; 12; 18].

The globalization of food markets has made the task of managing microbiological risks more difficult. Latest technologies such as genetic engineering, food irradiation, ohmic heating and modified packaging can be used to increase agricultural production, increase shelf life or improve food safety [3; 7; 12].

The manifestation of nutritional risk factors can occur at any stage of the production-consumption process, therefore, proper control is necessary throughout the entire chain of production, supply and sale of food products, and chemical disinfectants play an important role in maintaining the proper sanitary and hygienic level of the above process [1; 12; 14].

Maintaining an appropriate sanitary and hygienic level of the production-consumption process has its own characteristics associated with important changes in modern food supply and production systems, which include: increasing the complexity of networks and the dynamics of food supply chains, the intensification of classical agriculture, the emergence of alternative production niches and "green markets" of organic production, globalization world processes, accelerating the pace of life [6; 8].

These processes predetermine the secular trend to reduce the toxicity of disinfectants, on the one hand, and reduce the exposure time, on the other.

The role of chemical disinfection in food production is difficult to underestimate, and therefore regular monitoring and analysis of data on the resistance of pathogens of infectious and parasitic diseases to various groups of disinfectants is necessary.

Thus, the issues of assessing alimentary-caused biological risk factors in terms of resistance to the effects of chemical disinfectants is an important area of scientific research.

The purpose of the study was to assess nutritionally determined biological risk factors in terms of resistance to the effects of chemical disinfectants.

Research objectives:

− to conduct a qualitative and quantitative assessment of the resistance of alimentary-conditioned biological factors to chemical disinfectants.

− identify groups of resistance of pathogens to chemical disinfectants;

− identify the most dangerous biological factors-threats.

Methods

In the course of the research, we used statistical methods for analyzing and assessing the resistance of pathogens of alimentary-related diseases to chemical disinfectants.

Statistical analysis was carried out on the materials of the Ryazan region, provided by the Center for Hygiene and Epidemiology of the Ryazan region and the Main Department of Veterinary Medicine of the Ryazan region. The research period covered the data set for the period from 2019 to 2021.

The assessment of the resistance of alimentary-caused biological risk factors to chemical disinfectants was carried out by us, based on a standardized methodology [2] according to the following criteria:

1) the duration of the preservation of the pathogen when exposed to a disinfectant (exposure time);

2) the concentration of the solution;

3) type of disinfectant (groups: least toxic agents, agents with moderate toxicity, agents with high toxicity).

A quantitative assessment of alimentary-related biological risk factors in terms of resistance to chemical disinfectants was carried out by us for six groups of compounds, among which it is necessary to distinguish: alcohols, acids, alkalis, compounds that emit free active chlorine, aldehydes, phenols and related compounds.

Alcohols are the least toxic group of disinfectants. In our case, the sensitivity of biological risk factors to ethyl alcohol is considered.

A group of chemical disinfectants with moderate toxicity are acids and alkalis. According to the group of acids, resistance to the most commonly used inorganic acids in food production (including acetic acid) used in canning and pickling, as well as acids used for disinfection, was evaluated.

According to the group of alkalis, resistance to the most commonly used preparations containing NaOH, as well as to caustic soda, widely used in animal husbandry, was evaluated.

The group of chemical disinfectants with high toxicity is made up of aldehydes, compounds that release free active chlorine, phenols and related compounds.

According to the group of compounds that emit free active chlorine, resistance to the following compounds was evaluated: sodium hypochlorite (up to 95.2 % active chlorine), used for water disinfection, bleach (up to 26–36 % active chlorine), used for wastewater disinfection, chloramine (chloramine-B) and sulfochlorantin (sulfochlorantin-D) used for focal disinfection (up to 14–17 % active chlorine).

For the group of aldehydes, resistance to formaldehyde glutaraldehyde was evaluated.

For the group of phenols and related compounds, resistance to phenol, lysol and creolin was evaluated.

The evaluation was carried out according to the formula:

$$Lcr = \sum(Tex * Cs * Tds), \quad (1)$$

where Lcr – level of risk of the pathogen persisting when exposed to chemicals (chemical resistance level);

Tex – the duration of the preservation of the pathogen when exposed to a disinfectant (exposure time);

Cs – concentration of the solution,

Tds – type of disinfectant.

The level of chemical resistance is characterized by the following scale:

from 0 to 1 point – very low level;

from 1 to 3 points – low level;

from 3 to 6 points – medium level;

from 6 to 10 points – high level;

above 10 points – very high level.

Results

Quantitative assessment of alimentary-caused biological risk factors in terms of resistance to chemical disinfectants is presented in Table 1 and in Figures 1–4.

Analysis of Table 1 shows that among the presented biological risk factors, 36.11 % have very low resistance to chemical attack, 16.67 % – medium resistance, 19.44 % – high resistance, 27.78 % – very high resistance.

An analysis of the data presented in Figure 1 shows that among the group of pathogens with very low resistance to chemical disinfectants, the main share is occupied by risk factors of bacterial etiology.

Analysis of the data presented in Figure 2 shows that among the group of pathogens with medium resistance to chemical disinfectants, the main share is occupied by risk factors of viral etiology: hepatitis A virus, FMD virus (FMD virus) and rotaviruses.

Staphylococcus aureus is also of great sanitary and epidemiological importance, especially its antibiotic-resistant strains (including methicillin-resistant Staphylococcus aureus), pathogens of strongyloidiasis (Strongyloides stercoralis) and amoebic dysentery (Entamoeba histolytica), which have a borderline high level of resistance.

Analysis of the data presented in Figure 3 shows that among the group of pathogens with high resistance to chemical disinfectants, the main share is occupied by risk factors for helminthic etiology, with the exception of the Norwalk virus, which can survive in chlorinated tap water and cause norovirus infection, as well as the protozoan Cryptosporidium parvum, which produces extremely resistant, thick-walled, sporulated oocysts and causes cryptosporidiosis.

The group of pathogens with very high resistance to chemical disinfectants mainly consists of risk factors of helminthic etiology and spore-forming anaerobic bacteria.

This state of affairs is due to the high resistance of spores, cysts and eggs of parasites to adverse environmental conditions, as well as chemical and physical influences.

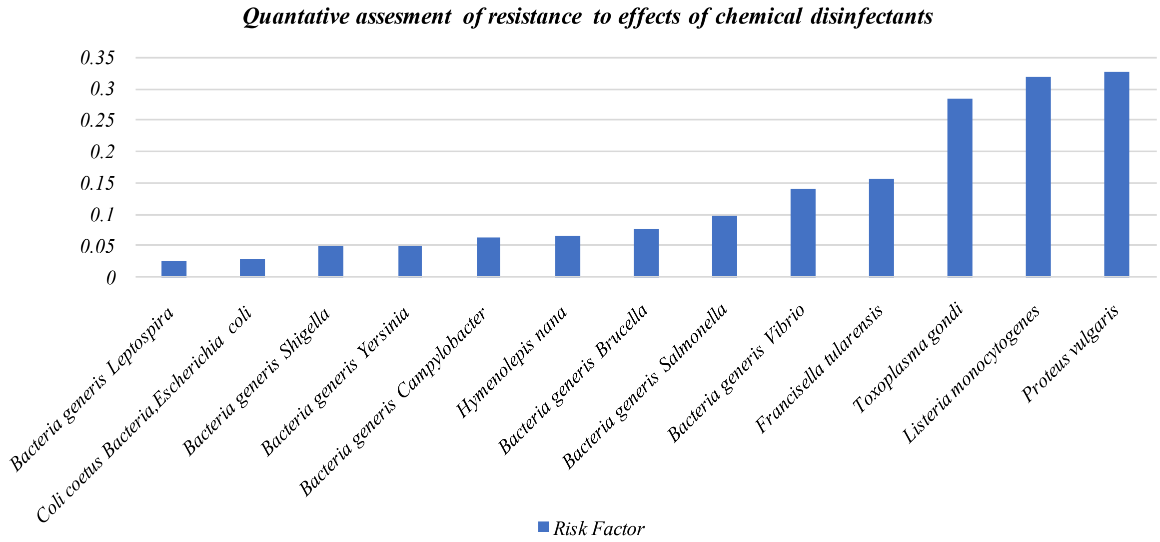

Fig. 1. Alimentary-mediated biological risk factors with very low resistance to chemical disinfectants

Discussion and Conclusion

Diseases caused by foodborne pathogens are a worldwide public health problem. Ensuring food safety to protect public health remains a major challenge for both developing and developed countries.

Effective food safety systems are vital to maintaining consumer confidence in the food system and providing a strong regulatory framework for domestic and international food trade, which contributes to economic development.

We would like to note that food safety is an important international issue, since food contamination creates a huge economic burden on society.

Governments around the world are stepping up their efforts to improve food safety so that no consumer will contract any infection or disease after eating food. Even in developing countries with low living standards, governments are forced to pursue a policy of “rapid change” in the social situation of their citizens, as the increasing level and importance of urbanization lead to the need to provide access to purified drinking water and facilities for the safe production and storage of food.

Food safety programs around the world are gradually focusing on farm-to-table methodology as a successful method of reducing foodborne risks. Among various factors, foodborne infectious and parasitic diseases account for about 20 million cases each year, and the incidence is increasing.

According to various estimates [6; 9; 11; 13–15], in developing countries, foodborne diseases annually claim the lives of 2.2 million people, of which 1.9 million are children. Food should be a source of nutrition for people, not a breeding ground for potential pathogens that can cause serious and life-threatening illness.

Alimentary-caused biological risk factors are potentially dangerous on a scale covering the entire agro-industrial production, since they have a number of features due to the specifics of living organisms, as a result of which they are the most unpredictable and difficult to manage, since when they enter the human body with food, they are able not only to survive and multiply, but also further spread from infected individuals to healthy individuals.

The globalization of food supplies creates conditions favorable for the importation into the territory of the country and the further spread of foodborne pathogens. In recent years, more and more often there are strains that are resistant not only to disinfectants, but also to antimicrobial drugs, and leading to the death of patients due to the ineffectiveness of antibiotic therapy.

The sensitivity of alimentary-related biological risk factors to chemical disinfectants is an important criterion in determining measures to reduce the risk level by disinfecting food (pickling, salting) and water (systemic chlorination at water supply facilities), chemical disinfection of equipment, livestock buildings, agricultural equipment, work surfaces and utensils in food production, as well as the skin of personnel and workers.

As the analysis of the data showed, the resistance of alimentary-caused biological risk factors to chemical disinfectants is largely due to their etiological characteristics.

Among the group of pathogens with very low resistance, the main share is occupied by risk factors of bacterial etiology, while Listeria monocytogenes (point level – 0.318) and Proteus vulgaris (0.327) have threshold values.

Listeria are able to form bacterial L-forms that can be latently present in the human body, being one of the causes of exacerbation of chronic tonsillitis, with a decrease in immune defense.

Among the group of pathogens with medium resistance to chemical disinfectants, the main share is occupied by risk factors of viral etiology: hepatitis A virus (3.189), rotaviruses (3.689) and foot-and-mouth disease virus (3.839), while the eggs of the roundworm Strongyloides stercoralis (4.150) have threshold values, causing strongyloidiasis, and cysts of Entamoeba histolytica (5,192), causing amoebic dysentery.

Of particular danger is the latent carriage of Strongyloides stercoralis, which, in a state of immunodeficiency, can cause disseminated strongyloidiasis with a mortality rate of up to 85 %.

The carriage of Entamoeba histolytica can also be latent and cause the development of the clinical picture of intestinal and extraintestinal amoebiasis with a decrease in immunity. Amebiasis ranks second in the global ranking of deaths from parasitic diseases.

Table 1

Quantitative assessment of the resistance of alimentary-caused biological risk factors to the effects of chemical disinfectants

Risk factor	Alcohols	Acids	Alkalis	Compounds that release free active Cl	Phenols	Aldehydes	Chemical resistance	
							Points	Level
Bacteria generis Leptospira	0.020	0.0005	0.0001	0.0022	0.002	0.0018	0.027	Very low level
Coli coetus Bacteria, Escherichia coli	0.004	0.006	0.0048	0.003	0.008	0.0035	0.029	
Bacteria generis Shigella	0.008	0.009	0.0048	0.0065	0.008	0.0126	0.049	
Bacteria generis Yersinia	0.016	0.005	0.012	0.0065	0.004	0.007	0.051	
Bacteria generis Campylobacter	0.010	0.015	0.0048	0.0065	0.012	0.014	0.062	
Hymenolepis nana	0.004	0.060	0.0008	0.0001	0.0008	0.0008	0.067	
Bacteria generis Brucella	0.020	0.003	0.0048	0.0017	0.0048	0.042	0.076	
Bacteria generis Salmonella	0.0082	0.030	0.012	0.003	0.016	0.028	0.097	
Bacteria generis Vibrio	0.020	0.0005	0.012	0.0165	0.036	0.056	0.141	
Francisella tularensis	0.016	0.030	0.048	0.033	0.012	0.0168	0.156	
Toxoplasma gondii	0.060	0.015	0.048	0.026	0.051	0.084	0.284	
Listeria monocytogenes	0.070	0.060	0.040	0.033	0.045	0.070	0.318	
Proteus vulgaris	0.080	0.030	0.0144	0.0225	0.096	0.084	0.327	
Hepatitis (A) virus	0.420	1.200	1.200	0.0513	0.108	0.210	3.189	Medium level
Staphylococcus aureus	1.000	1.200	1.200	0.0065	0.008	0.252	3.667	
Virus generis Rotavirus	1.000	1.200	0.456	0.0248	0.960	0.048	3.689	
FMD virus	1.000	0.002	0.016	1.500	1.300	0.021	3.839	
Strongyloides stercoralis	1.000	1.200	0.120	1.500	0.120	0.210	4.150	
Entamoeba histolytica	0.020	0.060	1.200	1.960	0.972	0.980	5.192	
Virus generis Norovirus	1.000	1.200	1.200	0.340	1.300	1.500	6.540	High level
Enterobius vermicularis	1.996	1.200	1.200	1.500	0.008	1.500	7.404	
Genus Helminths Trichinella	1.000	1.200	1.200	1.500	1.300	1.500	7.700	
Subfamily Helminths Echinococcine	1.000	1.200	1.200	1.500	1.300	1.500	7.700	
Genus Helminths Opisthorchis	1.000	1.200	1.200	1.500	1.300	1.500	7.700	
Cryptosporidium parvum	1.000	1.200	1.200	1.960	1.536	0.980	7.876	
Genus Helminths Diphyllobothrium	1.000	0.370	1.200	1.500	1.300	4.320	9.690	
M. tuberculosis, M. bovis, M. avium	1.000	1.200	1.395	0.810	5.800	0.576	10.781	Very high level
Bacillus cereus	1.000	2.700	1.200	4.810	1.300	0.210	11.220	
Lamblia (Giardia) intestinalis	0.070	0.060	1.200	9.760	0.096	1.500	12.686	
Genus Helminths Fasciola	1.000	0.060	1.200	0.0001	0.072	10.500	12.832	
Trichocephalus trichiuris	0.0095	3.168	1.200	0.660	2.700	20.160	27.898	
Ascaris lumbricoides	1.000	11.250	1.600	16.500	5.805	1.500	37.655	
Taenia solium	1.000	1.200	1.200	1.500	17.400	20.160	42.460	
Clostridium perfringens	1.000	1.200	1.200	1.500	2.880	40.600	48.380	
Taeniarhynchus saginatus	1.000	8.640	1.200	3.300	17.400	20.160	51.700	
Clostridium botulinum	2.900	0.600	1.200	1.500	5.760	40.600	52.560	

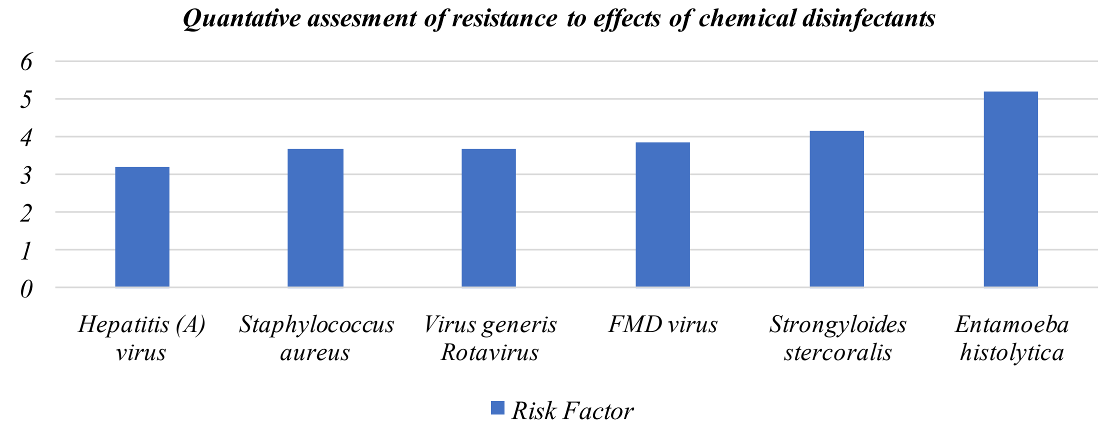

Fig. 2. Alimentary-mediated biological risk factors with medium resistance to chemical disinfectants

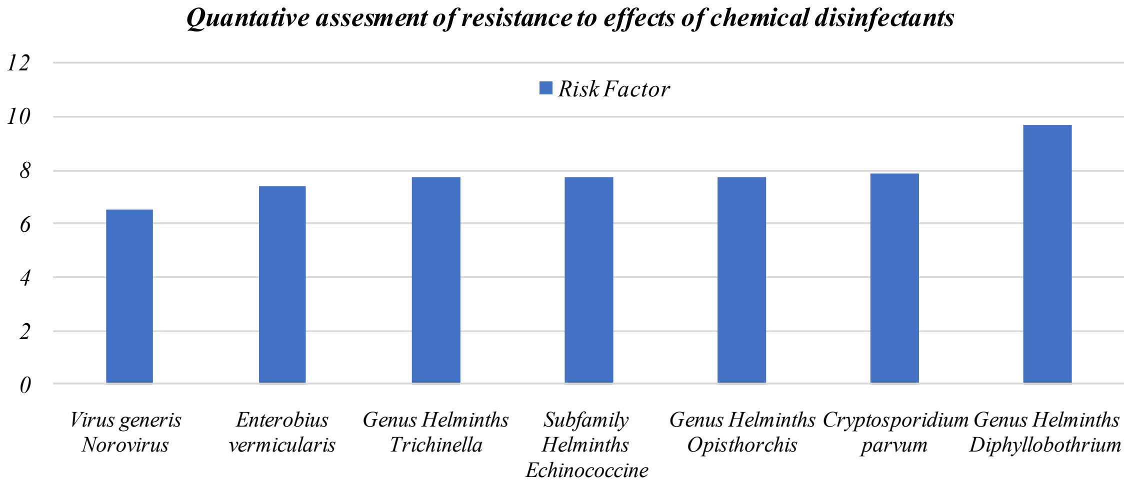

Fig. 3. Alimentary-mediated biological risk factors with high resistance to chemical disinfectants

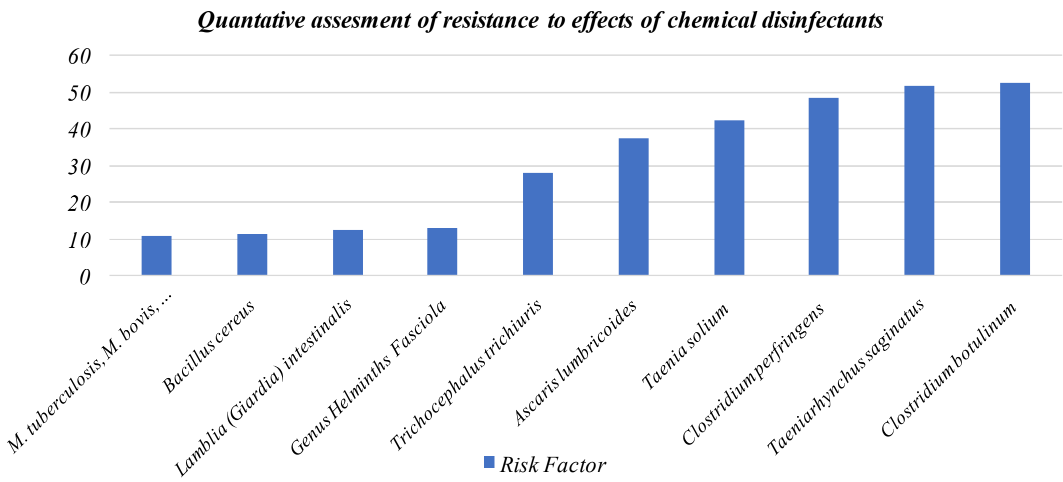

Fig. 4. Alimentary-mediated biological risk factors with very high resistance to chemical disinfectants

Among the group of pathogens with high resistance to chemical disinfectants, the main share is occupied by risk factors of helminthic etiology, with the exception of the Norwalk virus (6.540), which can survive in chlorinated tap water and cause a norovirus infection with a probability of death, as well as the protozoan Cryptosporidium parvum (7.876), which forms extremely resistant thick-walled sporulated oocysts and causes cryptosporidiosis (often fatal in people with immunodeficiency).

The group of pathogens with very high resistance to chemical disinfectants mainly consists of risk factors of helminthic etiology and spore-forming anaerobic bacteria.

This state of affairs is due to the high resistance of spores, cysts and eggs of parasites to adverse environmental conditions, as well as chemical and physical influences.

Among the risk factors of bacterial etiology, Clostridium perfringens, Clostridium botulinum and Bacillus cereus, which cause acute intoxication, represent the greatest threat of a rapid lethal outcome among the risk factors.

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