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Analysis of disinfectant use by medical organizations of the Republic of Tatarstan in the context of changes in the epidemiological situation 2019–2022

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ABSTRACT

BACKGROUND: Disinfection is an important aspect of ensuring epidemiological safety in medical organizations, particularly during the COVID-19 pandemic.

AIM: To analyze the disinfectant use in state medical organizations of the Republic of Tatarstan from 2019 to 2022, considering changes in the epidemiological situation related to COVID-19, and provide recommendations based on the analysis.

MATERIALS AND METHODS: Electronic auction data from zakupki.gov.ru were used to analyze disinfectant purchases by state medical organizations in the Republic of Tatarstan from 2019 to 2022. Data analysis involved the application of descriptive statistical methods.

RESULTS: A total of 118 electronic auctions were analyzed. A relationship between the nature of the epidemiological situation and the selection of disinfectants for purchase based on their chemical composition and intended use was identified. Before the pandemic, medical organizations preferred quaternary ammonium compound disinfectants and antibacterial soaps for hand hygiene. During the COVID-19 pandemic, their use of chlorine-based disinfectants, hydrogen peroxide, and alcohol-based hand sanitizers containing 60–69% ethanol increased. As the epidemiological situation stabilized, a discernible shift in preferences toward compound disinfectants was noted. Antiseptics with an alcohol content >70% are increasingly sought after.

CONCLUSION: Medical organizations in the Republic of Tatarstan promptly respond to changes in the epidemiological situation by implementing necessary modifications to antiepidemic measures. When developing procurement strategies, not only the requirements of sanitary legislation but also the latest scientific findings in the field of disinfectology must be considered.

Keywords: disinfection; disinfectants; hand sanitizers; COVID-19.

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Анализ применения дезинфицирующих средств медицинскими организациями Республики Татарстан в условиях изменения эпидемиологической ситуации 2019–2022 годов

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АННОТАЦИЯ

Обоснование. Дезинфекция является важным аспектом обеспечения эпидемиологической безопасности в медицинских организациях, особенно в условиях пандемии COVID-19.

Цель исследования — проанализировать применение дезинфицирующих средств в государственных медицинских организациях Республики Татарстан за период с 2019 по 2022 год с учётом изменений в эпидемиологической ситуации по COVID-19 и дать рекомендации на основе анализа.

Материалы и методы. Для анализа использовались данные электронных аукционов (zakupki.gov.ru) о закупках дезинфицирующих средств государственными медицинскими организациями Республики Татарстан за период с 2019 по 2022 год. Анализ данных включал применение методов дескриптивной статистики.

Результаты. Было проанализировано 118 электронных аукционов. Выявлена взаимосвязь между характером эпидемиологической ситуации и выбором дезинфицирующих средств по химическому составу и цели применения для закупки. В допандемийный период медицинские организации отдавали предпочтение препаратам на основе четвертично-аммониевых соединений и мылу с дезинфицирующим эффектом для гигиенической обработки рук. В период подъёма заболеваемости COVID-19 стали активнее использовать хлорсодержащие препараты, перекись водорода медицинскую и антисептические средства с массовой долей спирта 60–69%. Со стабилизацией эпидемиологической ситуации отмечается изменение приоритетов в выборе дезинфицирующих средств в пользу композиционных препаратов. Антисептики с содержанием спирта более 70% становятся всё более востребованными.

Заключение. Медицинские организации Республики Татарстан оперативно реагируют на изменения в эпидемической обстановке, корректируя противоэпидемические мероприятия. При формировании стратегии закупок учитываются не только требования санитарного законодательства, но и актуальные научные данные в области дезинфектологии.

Ключевые слова: дезинфекция; дезинфицирующие средства; кожные антисептики; COVID-19.

Как цитировать

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BACKGROUND

The prevention of healthcare-associated infections (HAI) is currently a global healthcare issue. The relevance of HAIs is determined by their widespread occurrence, serious negative consequences for the health and lives of patients and staff of healthcare institutions, which in turn leads to an increase in the healthcare costs [1]. In 2020, the Russian Federation recorded a sharp 5.1-fold increase in HAI incidence compared with 2019. In the following years, 2021 and 2022, incidence rates remained at high levels. Notably, from 2020 to 2022, the nosological structure of HAIs was dominated by cases of coronavirus disease (COVID-19) registered among healthcare professionals (HCPs) (76.58% in 2022) [2]. The main risks of infection for HCPs were provision of medical care to a COVID-19 patient, participation in aerosol-generating procedures, non-regular change of personal protective equipment, and direct contact with the environment where a COVID-19 patient was present and working as a janitor [3, 4].

Currently, coronaviruses can potentially persist on environmental surfaces for a long time and be transmitted in hospital settings by both the aerosol mechanism and the household contact route. Several studies evaluated the survival of SARS-CoV-2 and showed that the virus is quite stable on surfaces. In the presence of a high initial virus concentration and optimal environmental conditions, SARS-CoV-2 can remain viable on surfaces for up to several days. However, the duration of viability depends on the surface material, temperature, and humidity, as these factors influence the virus ability to survive [5–7]. These findings are also consistent with the studies in which the presence of SARS-CoV-2 was detected in 8.9%–18% of samples collected from various surfaces in hospitals where patients with confirmed cases of COVID-19 were treated [8, 9].

In the context of HAI prevention, the organization and implementation of disinfection measures are extremely important. During the COVID-19 pandemic, the issue of disinfectant selection became especially relevant. This was due to several factors, including the worldwide shortage of disinfectants and antiseptics, as well as the limited knowledge about the resistance of the SARS-CoV-2 virus to external environments and the most effective drugs for disinfection, particularly during the initial months of the pandemic [10]. A market research study conducted by Nielsen revealed a significant rise in hand sanitizer sales during the last week of February and the first week of March 2020. Compared with the same period of 2019, the sales increased by 300% and 470%, respectively. In Italy, the sales of hand sanitizers in supermarkets from February 24 to March 15, 2020, exhibited a 561% increase in the first three-week period of the pandemic compared with the same period of 2019 [11]. In Russia, the radiology and provisional departments of one medical clinic consumed the same amount of disinfectants in just four months that would have been needed to maintain a sufficient stock for the entire six-to-twelve-month operational period of all departments under normal circumstances. The specific disinfectants used and the premises purpose may have influenced this result [12].

In view of the above, the implementation of effective disinfection protocols at healthcare institutions can help reduce the biological burden on both staff and patients. The effectiveness of such measures depends on a reasonable choice of disinfectants and antiseptics, with due consideration given to their intended use and potential toxicological effects. The monitoring of disinfectant usage is a pivotal area of the hospital epidemiologist's responsibilities, forming an integral component in the structure of epidemiologic surveillance of HAIs.

AIM

To conduct a retrospective analysis of the use of disinfectants in public health facilities of the Republic of Tatarstan from 2019 to 2022, taking into account changes in the epidemiological situation of COVID-19, and to make guidelines based on the obtained data.

MATERIALS AND METHODS

A retrospective analysis of purchases of disinfectants by public healthcare facilities (HFs) of the Republic of Tatarstan from 2019 to 2022 was conducted using data from electronic auctions available on the official website of the Unified Procurement Information System (UPIS, zakupki.gov.ru). A total of 118 electronic auctions were analyzed. In the Republic of Tatarstan, the centralized procurement of disinfectants is performed in accordance with the requests of the HFs. These requests are formulated in September and may be subject to quarterly adjustments.

In the analysis of changes in the procurement of disinfectants by HFs, a conditional division into two groups was undertaken based on the intended use:

1. Hand hygiene products, which include skin antiseptics and antiseptic soap
2. Disinfectants intended for the treatment of surfaces and medical devices

The selected time interval for the analysis covers four years, during which changes in the epidemiological situation related to the COVID-19 pandemic were observed with the objective of better understanding the changes in the procurement of disinfectants. This, in turn, led to adjustments in the implementation of disinfection activities in the HFs. The data from 2019 were taken as a control year, characterizing the level of disinfectant consumption prior to the pandemic.

The study used epidemiological (descriptive and evaluative) and statistical methods. The data were presented as absolute and relative values (%). Common statistical methods were used to analyze the obtained data. Pearson correlation coefficient (r) was used for correlation analysis. Differences were considered significant at $p \leqslant 0.05$. The statistical data analysis was performed using the Microsoft Office 2010 software package.

RESULTS

Over the analyzed period, the second group of disinfectants, used for the disinfection of surfaces and medical devices, constituted the predominant category of disinfectants utilized by the HFs. In 2020, there was a notable exception, with 2.5 times more disinfectants of the first group purchased compared with those of the second group. The total volume of these purchases was 196,718.47 liters. Nevertheless, in subsequent years, the absolute volume of purchased antiseptic agents remained at the level of 2020, indicating an increase in the commitment of HCPs to hand hygiene (Table 1).

The skin antiseptics used by the HFs of the Republic of Tatarstan were divided into 4 groups: 1) alcohol-free antiseptics; 2) antiseptics with less than 60% alcohol by weight; 3) antiseptics with 60–69% alcohol by weight; 4) antiseptics with more than 70% alcohol by weight. The analysis showed that isopropyl alcohol-based antiseptics with a concentration of 60% to 69% are mainly used. On average, their share in the structure of purchased antiseptics was 64.5% (95% CI, 64.35–64.63).

In addition, the purchased volume of disinfectant soap was evaluated. The purchases of this item in the 2019 batches exceeded those of skin antiseptics by 34.6%. However, with the onset of the pandemic, this situation changed radically, and already in 2022, the purchases of skin antiseptics were 1.39 times greater than that of purchased soap (Fig. 1). This may be due to two reasons: changes in the HCP's attitudes to hand hygiene and changes in sanitary legislation, which requires the use of only alcohol-based antiseptics for hand hygiene since 2021.[1]

[1] Resolution of the Chief Public Health Officer of the Russian Federation No. 4 dated January 28, 2021, On Approval of Sanitary Rules and Regulations No. 3.3686-21 Sanitary and Epidemiological Requirements for the Prevention of Infectious Diseases. URL: https://base.garant.ru/400342149/.

Table 1. The structure of procured disinfectants by state medical organizations of the Republic of Tatarstan from 2019 to 2022

Year	Hand hygiene products		Disinfectants for medical devices and surfaces	Total
	Skin antiseptics	Antiseptic soap		
2019	36 366.10	50 663.00	156 678.48	243 707.58
2020	187 276.40	9442.07	79 909.01	276 627.48
2021	108 306.34	100 902.00	807 493.50	1 016 701.84
2022	106 397.10	78 232.68	253 707.84	438 337.62

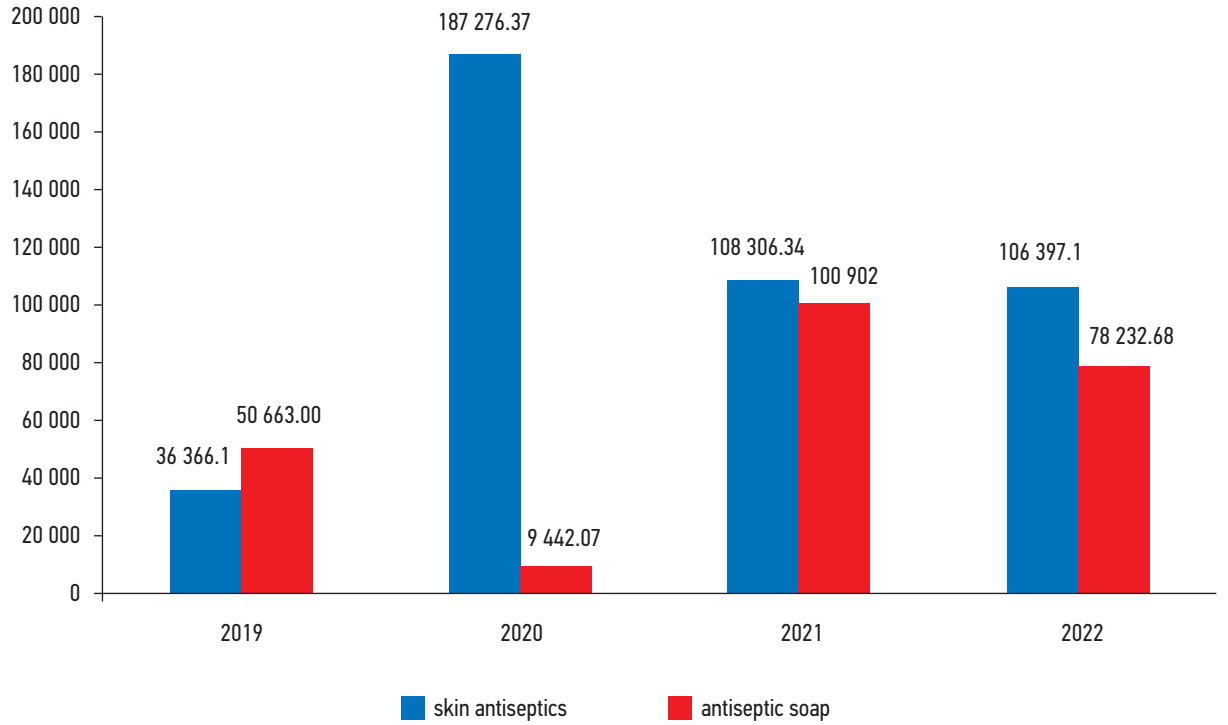

Fig. 1. The ratio of hand sanitizers and soaps by state medical organizations of the Republic of Tatarstan from 2019 to 2022.

The disinfection of surfaces, medical devices, and medical waste is another domain of sanitary and anti-epidemic regime at the HFs. All disinfectants used for these purposes were classified by chemical composition. The structure of disinfectants purchased by the HFs of the Republic of Tatarstan from 2019 to 2022 can be divided into the following main groups: chlorine-containing preparations, which accounted for an average of 30.90% (95% CI, 30.82–30.98); mono- and multi-component peroxide preparations, which accounted for 24.20% (95% CI, 24.12–24.28). Other products were classified as quaternary ammonium compound (QAC)-based products (14.60%; 95% CI, 14.54–14.66), and composite products based on QAC, amines, and polyhexamethyleneguanidine (PHMG) (8.50%; 95% CI, 8.46–8.54; Fig. 2).

DISCUSSION

The start of the COVID-19 pandemic in 2020 in the Russian Federation, including the Republic of Tatarstan, necessitated significant adjustments to the disinfectant requirements of the HFs. This was due to two factors: the opening of hospitals designated for treating patients with the novel coronavirus and the evolution of disinfection standards. In 2020, the Russian Service for Surveillance on Consumer Rights Protection and Human Wellbeing (Rospotrebnadzor) issued methodological guidelines[2] and subsequently published sanitary and epidemiological rules for prevention of [3] novel coronavirus infection. These documents delineated the fundamental principles of disinfection and provided guidance on the minimum concentrations of active ingredients in disinfectant solutions. Reasonably, the greatest number of auctions for the purchase of disinfectants (34 auctions) occurred in 2020, as observed during the analyzed period. The analysis of purchased volumes of disinfectants and antiseptics demonstrated that, with the increase in the prevalence of COVID-19, the HFs adjusted the list of purchased items, but within the available budget and at the expense of humanitarian aid from the enterprises of the Republic of Tatarstan. However, the increase in the volume of procured items as a consequence of augmented funding was observed only in 2021. The growth rate was 417.2% compared to 2019. The reduction in the incidence of the novel coronavirus, the removal of restrictive measures, and the closure of hospitals designated for patients with the virus in 2022 resulted in further adjustments to the sanitary and anti-epidemic measures of the HFs. This led to a 43.1% reduction in the volume of purchased disinfectants compared with the previous year (see Table 1).

[2] MR 3.1.0170-20. 3.1: Prevention of infectious diseases. Epidemiology and prevention of COVID-19. Methodological Guidelines. URL: https://www.consultant.ru/document/cons_doc_LAW_350140/.

[3] Resolution of the Chief Public Health Officer of the Russian Federation No. 15 dated May 22, 2020, On Approval of Sanitary and Epidemiological Rules No. 3.1.3597-20 Prevention of New Coronavirus Infection (COVID-19). URL: https://www.consultant.ru/document/cons_doc_LAW_353494/e4deaf074c290821400cfad27f87d23d667c4cfd/.

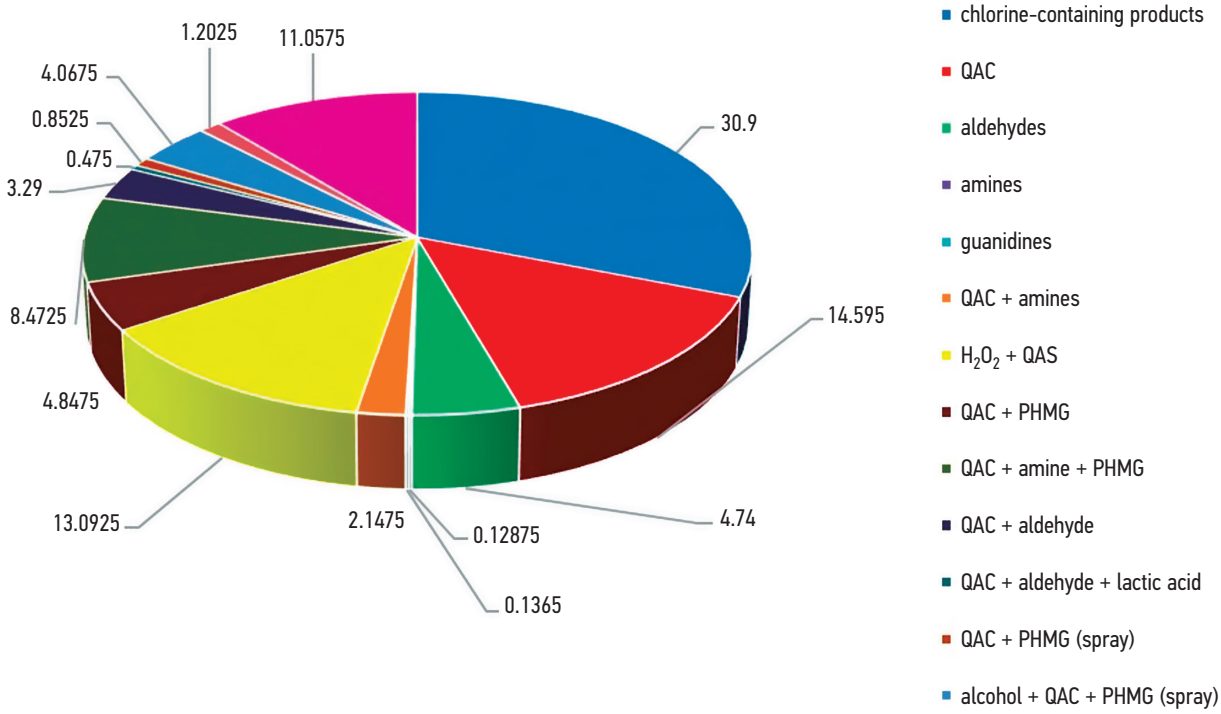

Fig. 2. Long-term average annual structure of procured disinfectants by public healthcare facilities of the Republic of Tatarstan from 2019 to 2022 by chemical composition (%).

The ability to effectively respond to changing epidemiological challenges while maintaining a balance between safety, biocompatibility, and cost-effectiveness may be achieved by introduction of adaptive procurement strategies. This includes maintaining a flexible supply chain of different types of disinfectants in response to changing needs.

In evolving epidemiological circumstances, the most significant modification to the application of measures was observed with regard to the means of treating the hands of HCPs and patients. Hand hygiene is a fundamental element of the strategy for mitigating the transmission of pathogens associated with nosocomial infections in HFs. This necessitates the use of both detergents (soap) and skin antiseptics. Alcohol-based antiseptics are the preferred agents for hand hygiene, as alcohols exhibit a broad spectrum of activity against vegetative bacteria, viruses, and fungi. In the Russian Federation[4], it is recommended that skin antiseptics with an effective alcohol concentration be used. This concentration should be at least 60% isopropyl alcohol or at least 70% ethyl alcohol [13]. However, isopropanol is believed to be more effective against SARS-CoV-2 due to its lyophilicity [14].

Notwithstanding the preference of HFs for antiseptics with an alcohol concentration of 60–69%, there was a notable upward trend in the purchase of propyl alcohol-based antiseptics with a mass fraction exceeding 70% (t = 12.47, p < 0.05) (Table 2). Thus, they constituted 4.40% (95% CI, 4.18–4.62) in 2019 and increased to 38.70% (95% CI, 38.4–39.0) by 2022. At the same time, the proportion of antiseptics purchased with an isopropyl alcohol concentration of less than 60% exhibited a decline from 2019 to 2022, with an average annual decrease of 44%. A strong inverse linear correlation was identified between the volume of other types of antiseptics and this group (r = –0.82 ± 0.28; t = 77.41; p < 0.05). Alcohol-free antiseptics are not a significant demand in the HFs of the Republic of Tatarstan. The percentage of sales accounted for by these products ranged from 2.20% (95% CI, 2.1–2.3) to 7.40% (95% CI, 7.22–7.58) over different years. However, the number of alcohol-free antiseptics purchased in 2020 was 13.4 times greater than those purchased in the previous year. This phenomenon can be attributed to a significant increase in global demand for alcohol-free antiseptics, which resulted in a scarcity of raw materials essential for their production. Consequently, the HFs were compelled to procure alcohol-free antiseptics to fulfill their requirements.

Due to increased hand hygiene requirements during the COVID-19 pandemic, prolonged work in gloves became a risk factor for contact dermatitis in HCPs [15]. To maintain skin health of the hands and reduce the risk of contact dermatitis, HCPs should be provided with sufficient hand care products (creams, lotions, and balms).[5] In this regard, the volume of hand cream purchases was analyzed. In the year 2019, the HFs of the Republic of Tatarstan purchased a total of 1,703 liters of cream. Following the pandemic onset, there was a notable decline in the volume of purchases, with a total of 110.3 liters recorded. This decline is likely attributable to the reallocation of financial resources towards the procurement of essential medical supplies, including medicines and personal protective and medical equipment. However, by 2022, the volume

[4] Letter of Rospotrebnadzor No. 02/5225-2020-24 dated March 27, 2020, On Implementation of Disinfection measures. URL: https://www.consultant.ru/document/cons_doc_LAW_349100/.

[5] Resolution of the Chief Public Health Officer of the Russian Federation No. 4 dated January 28, 2021, On Approval of Sanitary Rules and Regulations No. 3.3686-21 Sanitary and Epidemiological Requirements for the Prevention of Infectious Diseases. URL: https://base.garant.ru/400342149/.

Table 2. The structure of procured hand sanitizers by state medical organizations of the Republic of Tatarstan from 2019 to 2022

Groups of antiseptic agents	2019		2020		2021		2022	
	L	% ± m	L	% ± m	L	% ± m	L	% ± m
1. Alcohol-free skin antiseptics	827.5	2.28 ± 0.09	67 777.47	36.19 ± 0.11	2342.39	2.16 ± 0.04	7895.6	7.42 ± 0.08
2. Skin antiseptics containing less than 60% alcohol	7850.5	21.58 ± 0.22	1107.0	0.59 ± 0.02	8426.0	7.78 ± 0.08	3941.0	3.71 ± 0.06
3. Skin antiseptics containing less than 60–69% alcohol	26 099.1	71.77 ± 0.24	114 148.9	60.95 ± 0.11	89 085.95	82.25 ± 0.12	53 361.4	50.15 ± 0.15
4. Skin antiseptics containing more than 70% alcohol	1589.0	4.37 ± 0.11	4243.0	2.27 ± 0.04	8452.0	7.81 ± 0.08	41 199.1	38.72 ± 0.15
Total	36 366.1	100	187 276.4	100	108 306.34	100	106 397.1	100

of purchased cream had returned to its previous level, reaching a total of 1,760 liters.

A review of the use of antiseptics revealed that the quantity of dyed skin antiseptics procured was relatively low, averaged to only 330 liters per year. In approximately 50% of cases, this antiseptic has a mass fraction of isopropyl alcohol that is less than 60%. This suggests that the HFs are not adequately addressing the recommendations set forth in regulatory documents[6] regarding the treatment of the operating field with antiseptics that contain dyes, with the aim of visualizing the boundaries of the treated area.

In this regard, it is necessary to systematically organize training for HCPs in the correct use of various disinfectants in accordance with the governing regulatory documents and the current epidemiological situation.

The next step was to analyze disinfectants by chemical composition. Disinfectants can be classified as either mono- or multicomponent, denoting the presence of two or more active chemical groups, respectively. During the analyzed period, monocomponent preparations were used, including medical hydrogen peroxide, chlorine-containing preparations based on dichloroisocyanuric acid, QAC-based preparations, tertiary amines, and aldehydes. These preparations collectively accounted to 69% on average. A significant increase in the procurement of monocomponent drugs was observed during the peak of the COVID-19 pandemic in 2020 and 2021. Their respective shares were 70.30% (95% CI, 69.98–70.62) and 80.60% (95% CI, 79.8–81.4). Furthermore, while in the first year of the pandemic, medical hydrogen peroxide constituted the majority of procured products at the rate of 44.20% (95% CI, 43.84–44.56), in the subsequent year, chlorine-containing products emerged as the dominant category at 74.30% (95% CI, 73.3–75.3). In 2019, the largest share of total disinfectant consumption was accounted to QAS-based monocomponent disinfectants, at 27.50% (95% CI, 27.28–27.72). However, the consumption of disinfectants belonging to this group exhibited a decline year over year. By 2022, the rate of decline was 14%. This trend is primarily due to the fact that QAC have an insufficient degree of virus inactivation [16].

The use of multicomponent drugs is inversely proportional to the use of single-component drugs. In the pre-COVID-19 period (2019) and post-COVID-19 period (2022), they accounted for 45.10% (95% CI, 44.84–45.36) and 59.60% (95% CI, 59.4–59.8), respectively. Notably, composite preparations are preferred due to the enhanced antimicrobial activity resulting from the diverse mechanisms of action of the multiple active ingredients on the microbial cell [17]. Among this group of disinfectants, hydrogen peroxide-based products were the most prevalent, accounting to 13.10% (95% CI, 13.04–13.16). Three-component products (QAC + PHMG + tertiary amines) constituted the second-largest segment, with a market share of 8.50% (95% CI, 8.46–8.54). By 2022, the demand for peroxide composite formulations had increased 2.73-fold compared with the first year of observation. Such interest in this group can be attributed to the diverse range of actions and low toxicity of these drugs. The use of three-component preparations (QAC + PHMG + tertiary amines) exhibited a notable decline, with a 2.3-fold reduction in 2020 and an 11.4-fold reduction in 2021, compared with the levels observed in 2019.

For rapid surface disinfection, the HFs use ready-to-use sprays and disinfectant wipes. The volume of sprays procured in 2021 doubled compared with 2019 (19,635.9 and 9,787 liters, respectively). With the stabilization of the epidemiological situation in 2022, there was a significant increase in the procurement of wipes for surface disinfection, while the amount of procured sprays decreased by 30%.

CONCLUSIONS

The analysis of procurement of disinfectants by the HFs of the Republic of Tatarstan in the context of changes in the epidemiological situation showed the following:

1. Epidemiologists of the HFs were guided by the requirements of sanitary legislation and contemporary scientific achievements in disinfectology when preparing disinfectant applications, reacted promptly to changes in the epidemic situation, and made adjustments to the applications.
2. In the structure of purchases of skin treatment products, the volume of alcohol-based antiseptics with an alcohol concentration of more than 70% increased, whereas the volume of antiseptics with an alcohol concentration of less than 60% decreased.
3. The procurement patterns of disinfectants in HFs are closely linked to the epidemiological situation. Prior to the pandemic, there was a preference for QAC-based products. During the COVID-19 pandemic, there was an increase in demand for single-component products with chlorine and hydrogen peroxide. After the pandemic, there was a shift to composite products, reflecting the adaptability of disinfection strategies to changing conditions.

In conclusion, the changing epidemiological situation requires the establishment of a system for regular evaluation of the effectiveness of selected disinfection strategies and modification of procurement plans based on the latest scientific evidence and the specific requirements of the facility. An important aspect is the development of a comprehensive preparedness plan for sanitary and epidemiological emergencies, including a strategic reserve of essential disinfectants to facilitate a prompt response in case of epidemic outbreaks or epidemics.

[6] Ibid; Methodological Guidelines MU 3.5.1.3674-20 Decontamination of Hands of Healthcare Workers and Skin of Patients in the Provision of Healthcare. URL: https://www.garant.ru/products/ipo/prime/doc/400188098/.

ADDITIONAL INFORMATION

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Authors' contribution. All authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work. A.I. Lokotkova, I.A. Bulycheva designed the study; A.I. Lokotkova, I.A. Bulycheva, I.M. Fazulzyanova, and F.N. Sabaeva collected data; A.I. Lokotkova, I.A. Bulycheva, E.Kh. Mamkeev, L.G. Karpenko, and G.A. Toshchev analyzed data and drafted the manuscript; A.I. Lokotkova, I.A. Bulycheva, and E.Kh. Mamkeev critically revised the manuscript.

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