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Epidemiologic Characteristics of the Novel Coronavirus Disease COVID-19 in the Armed Forces of the Republic of Kazakhstan Within the Framework of Parasitic Systems Self-Regulation Theory

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ABSTRACT

BACKGROUND: The study of infectious disease epidemiology among military personnel has long been a priority in military medicine. The COVID-19 pandemic underscored the critical role of pathogen genetic variability in shaping the patterns of the disease, serving as a demonstrative case for applying Belyakov's (1983) theory of self-regulation of parasitic systems. Although numerous studies have addressed the epidemiologic aspects of COVID-19 in various organized communities, the specific characteristics of the disease among service members of the Armed Forces of the Republic of Kazakhstan remain insufficiently studied, underscoring the importance of the present research.

AIM: to investigate the epidemiologic characteristics of novel coronavirus disease (COVID-19) in the Armed Forces of the Republic of Kazakhstan through the lens of the theory of self-regulation of parasitic systems.

MATERIALS AND METHODS: A retrospective epidemiologic analysis was conducted to assess COVID-19 incidence among military personnel and the civilian population of the Republic of Kazakhstan. Data were obtained from departmental military medical statistical reports of the Armed Forces (Form 2/med) and publicly available official statistics provided by the National Center for Public Health under the Ministry of Health of the Republic of Kazakhstan. The comparative trends in COVID-19 incidence rates among military personnel and the civilian population were examined, along with the identification of epidemiologic features across the military-administrative territories of the Armed Forces of the Republic of Kazakhstan. A combination of epidemiologic and mathematical-statistical methods was used for data analysis and interpretation.

RESULTS: The study demonstrated that the genetically determined ability of the infectious agent to alter its epidemiologically significant properties (e.g., transmissibility, pathogenicity) in response to implemented anti-epidemic measures is a key factor influencing epidemic intensity. This adaptation may manifest as an increase in the number of cases, changes in disease severity and clinical forms, shifts in distribution across population groups, and other epidemic patterns.

CONCLUSION: The genetic plasticity of pathogenic microorganisms, activated in response to changes in human population characteristics, significantly influences the regional epidemiologic features of disease spread. These patterns must be considered when designing epidemic control systems in structured military settings.

Keywords: Armed Forces of the Republic of Kazakhstan; genetic variability; civilian population; incidence; COVID-19; theory of self-regulation of parasitic systems; epidemic process.

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Эпидемиологические особенности новой коронавирусной инфекции COVID-19 в Вооруженных силах Республики Казахстан в аспекте теории саморегуляции паразитарных систем

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АННОТАЦИЯ

Актуальность. Изучение эпидемиологии инфекционных заболеваний среди военнослужащих традиционно является актуальной задачей военной медицины. Пандемия новой коронавирусной инфекции COVID-19 подчеркнула значимую роль генетической изменчивости возбудителей в формировании динамики заболеваемости, что является наглядным примером реализации теории саморегуляции паразитарных систем В.Д. Белякова (1983). Несмотря на то что имеется значительное количество научных работ по изучению аспектов эпидемиологии новой коронавирусной инфекции COVID-19 в различных организованных коллективах, эпидемиологические особенности заболеваемости данной инфекцией в Вооруженных силах Республики Казахстан остаются малоизученными, что подчеркивает актуальность данного исследования.

Цель — изучение эпидемиологических особенностей новой коронавирусной инфекции COVID-19 в Вооруженных силах Республики Казахстан с позиции теории саморегуляции паразитарных систем.

Материалы и методы. Проведен ретроспективный эпидемиологический анализ заболеваемости новой коронавирусной инфекцией COVID-19 военнослужащих и гражданского населения Республики Казахстан по данным ведомственной военно-медицинской статистической отчетности Вооруженных сил Республики Казахстан (форма 2/мед) и официальной общедоступной статистики Национального центра общественного здравоохранения Министерства здравоохранения Республики Казахстан. Изучена сравнительная динамика показателей заболеваемости военнослужащих и гражданского населения, определены их эпидемиологические особенности на военно-административных территориях Вооруженных сил Республики Казахстан. При анализе и исследовании материалов был использован комплекс эпидемиологических и математико-статистических методов исследования.

Результаты. Показано, что генетически детерминированная способность возбудителя инфекции изменять свои эпидемиологически значимые свойства (контагиозность, патогенность) в ответ на предпринимаемые противоэпидемические меры является важным фактором, влияющим на изменение степени напряженности эпидемической ситуации. Это может проявляться увеличением количества случаев инфекции заболеваний, изменением тяжести клинического течения и форм заболевания, распространенности по разным категориям населения и другими эпидемическими проявлениями.

Заключение. Генетическая пластичность патогенных микроорганизмов, реализующаяся в ответ на изменения свойств популяции человека, оказывает значимое влияние на региональные эпидемиологические особенности распространения заболеваний, что необходимо учитывать при функционировании системы противоэпидемической защиты в организованных воинских коллективах.

Ключевые слова: Вооруженные силы Республики Казахстан; генетическая изменчивость; гражданское население; заболеваемость; COVID-19; теория саморегуляции паразитарных систем; эпидемический процесс.

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ЭКО•ВЕКТОР

BACKGROUND

The COVID-19–pandemic has fundamentally transformed the global healthcare system and expanded scientific understanding of the features and mechanisms underlying the epidemic process of this infectious disease. Moreover, the pandemic spread of COVID-19 has had an impact on the combat readiness of armed forces in virtually all nations, posing a threat to the normal execution of training, routine, and operational tasks. The organization of military personnel deployment, military personnel interactions during training and combat operations, the shared use of military infrastructure facilities, and the formation of units with personnel from different geographic regions of the country collectively heighten the risk of epidemic spread of acute respiratory infections, including COVID-19 [1].

As the COVID-19 pandemic evolved, Belyakov's theory of self-regulation in parasitic systems in 1983 received renewed confirmation [2]. According to this theory, an epidemic develops through mutually determined phase changes in the biological properties of interacting populations of the pathogen and humans. These evolutionary changes are associated with genetic variability and a complex of polydeterminant characteristics of the pathogen. For instance, emerging genetic variants of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) have demonstrated reduced human pathogenicity coupled with increased contagiousness. This observation is significant for epidemiological theory and practical antiepidemic measures, offering prospects for improving epidemic situation forecasting [3–5].

Additionally, Belyakov's theory on the relative autonomy of epidemic process development, determined by demographic characteristics and local social/environmental conditions, is of particular scientific interest for organized military collectives [6]. This has warranted research into COVID-19 transmission patterns within the framework of parasitic system self-regulation theory to identify its developmental regularities in the Armed Forces of the Republic of Kazakhstan (RK AF).

Military service is a unique form of professional activity wherein personnel are exposed to multiple adverse factors. The specific nature of military service, including living conditions, duty requirements, and significant psychophysiological stressors, can affect the health status of service members, as reflected in the distinctive incidence pattern of military personnel [7, 8].

The study aimed to evaluate the epidemiological features of COVID-19 in the RK AF based on the parasitic system self-regulation theory viewpoint.

METHODS

The study used publicly available statistical data on population incidence indicators from the National Center of Public Health of the Ministry of Healthcare of the Republic of Kazakhstan (RK), departmental military medical statistical reporting of the armed forces (Form 2/Med), and annual reports from the Sanitary-Epidemiological Center of the RK AF. The observation period was 3 years (2020–2022).

Epidemiologic and mathematical-statistical methods were employed for data analysis and interpretation. A retrospective epidemiological analysis of COVID-19 incidence among armed forces personnel and the civilian population of RK was conducted using available datasets for the specified observation period.

RESULTS AND DISCUSSION

The COVID-19 pandemic underscored the role of pathogen genetic variability in shaping disease patterns, representing an example of Belyakov's theory of self-regulation of parasitic systems. Since the beginning of the COVID-19 pandemic following its first identified case in November 2019 in Wuhan, China, experts have accumulated an extensive database on the transmission features and epidemiological characteristics of the disease. Researchers comprehensively analyzed the biological and social aspects of the epidemic process. Scientific investigations established key infection parameters: the pathogen reservoir, modes of transmission, and factors contributing to its spread. Thus, a comprehensive system of preventive and anti-epidemic measures was developed, controlling infection rates, minimizing complications, and reducing mortality [9].

The pathogen emerged as a zoonotic virus, but overcame the interspecies barrier and entered the human population, primarily spreading through contact-household transmission. After the upper respiratory tract became the primary entry point for infection, the virus' epidemic potential increased. The arising potential for airborne droplet transmission enabled the virus to achieve pandemic spread. The fundamental mechanisms of population dynamics in infectious diseases are described in Belyakov et al.'s theory of self-regulation of parasitic systems [10]. This phenomenon is influenced by the interaction between heterogeneous human and pathogen populations characterized by phenotypic and genotypic polymorphism. Under specific environmental and social conditions, this interaction can lead to asymptomatic and symptomatic forms of the disease [11].

According to the self-regulation theory of parasitic systems, the characteristics of interacting parasite and host populations show dynamic interdependent variability and lead to their self-reorganization, which manifests in distinct phases of the epidemic process [12, 13]. This theory explains the wave-like pattern of the COVID-19 epidemic process observed through alternating periods of incidence growth and decline. This postulate is well-illustrated in organized communities, such as military contingents.

The spread of COVID-19 in the RK AF began in April 2020, 2 months after the first confirmed cases were registered among the civilian population.

The initial phase involved implementing an effective complex of anti-epidemic measures in military units, which stabilized the epidemiological situation until vaccination commencement between April and August 2021 (Fig. 1).

The incidence dynamics in military collectives was heterogeneous. The first recorded incidence surges across all regional commands did not correlate with civilian population incidence patterns and were detected earlier, indicating enclave-like progression of the COVID-19 epidemic process and the epidemiological vulnerability of military contingents. Furthermore, average annual incidence rates within the RK AF significantly differed across regional commands. For example, the Astana Regional Command demonstrated an average annual incidence rate during the observation period that was 10.3–13.5 times higher than other commands, despite having a smaller total personnel size (Table 1).

Epidemiological investigations of COVID-19 outbreaks showed that these differences in morbidity are associated with the massive introduction of pathogens from the civilian population of Astana and their more active spread among military personnel due to existing risk factors (e.g., public transportation, numerous crowded public spaces, and faster introduction of new genetic variants of the pathogen).

The geographic proximity of RK to the People's Republic of China led to the early implementation of preventive measures in early 2020. During this period, extensive measures were implemented, encompassing administrative, organizational, anti-epidemic, and medical–diagnostic domains. Intensifying sanitary and epidemiological surveillance in border territories, implementing public information and education programs on health literacy, temporary suspending visa services, adopting diagnostic protocols for COVID-19 detection, developing therapeutic standards and antiepidemic measures in medical facilities, creating country categorization system based on epidemiological risk levels, and establishing monitoring for individuals arriving from foreign territories were prioritized [14].

Consistent with the self-regulation theory, in response to global primary administrative and organizational antiepidemic measures, SARS-CoV-2 began modifying its biological properties to ensure its survival as a biological species [15, 16]. This resulted in emerging strains with genetically altered properties, enabling the virus' adaptation to changing population conditions [17].

However, the most significant impact on changes in SARS-CoV-2 characteristics was exerted by global vaccination [18].

In RK, the population immunization program with Gam-COVID-Vac commenced in 2021, followed by revaccination in 2022. Vaccination of RK AF personnel was a three-stage process (Fig. 2).

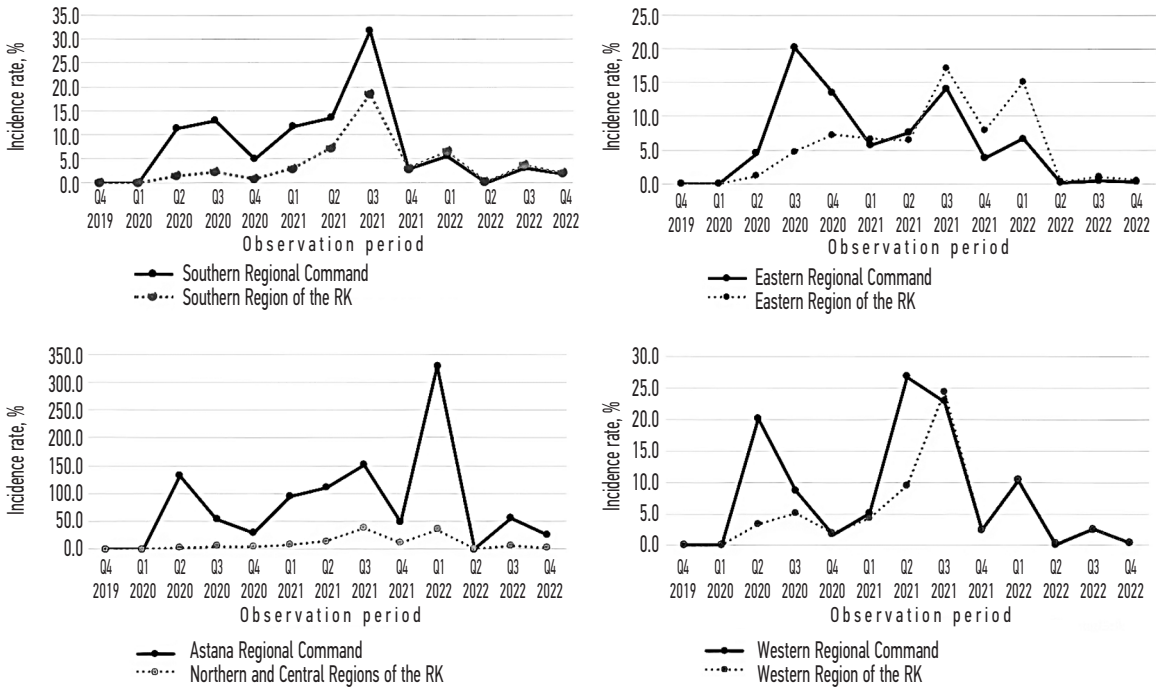

Fig. 1. Quarterly trends of COVID-19 incidence among service members of regional commands and the civilian population of corresponding administrative-territorial regions of the Republic of Kazakhstan, 2020–2022 (‰).

Рис. 1. Квартальная динамика заболеваемости COVID-19 военнослужащих региональных командований и гражданского населения соответствующих административно-территориальных регионов Республики Казахстан (РК) в 2020–2022 гг. (‰).

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Table 1. Average long-term incidence rates by regional commands of the Armed Forces of the Republic of Kazakhstan
Таблица 1. Среднемноголетние показатели заболеваемости по региональным командованиям ВС РК

Regional command name	Average annual COVID 19 incidence, P_{avg}, ‰	95% confidence interval, P_{avf}, ‰
Astana	97.3	83.2–106.9
South	9.4	5.1–13.3
East	7.2	4.2–9.9
West	9.3	6.8–12.8

Notably, the wave-like pattern of the epidemic process, with a clear upward trend in peak disease incidence, was closely linked to mass vaccination among the RK civilian population and RK AF personnel. Studies worldwide reported that the severity of clinical manifestations of COVID-19 varied significantly [19].

During the initial stage of the pandemic, the COVID-19 pathogen had relatively low transmissibility and high virulence, manifesting in a comparatively low number of cases but a high proportion of severe and moderate clinical presentations. In the civilian population, the clinical spectrum ranged from asymptomatic cases to severe viral pneumonia, often resulting in fatal outcomes, which forced regional healthcare systems to drastically expand inpatient bed capacities to provide medical care to all patients [20].

The RK AF personnel were no exception, as the ratio of COVID-19 clinical forms among military personnel demonstrated significant dynamics during sanitary and anti-epidemic (preventive) measures implementation in troops (Fig. 3).

During the initial organizational and administrative anti-epidemic measures implementation phase prior to immunization launch, the total proportion of moderate and severe cases in the incidence pattern reached maximum (70%–85%). Following two vaccination rounds, mild and asymptomatic infection forms became predominant, accounting for 50%–90% of cases.

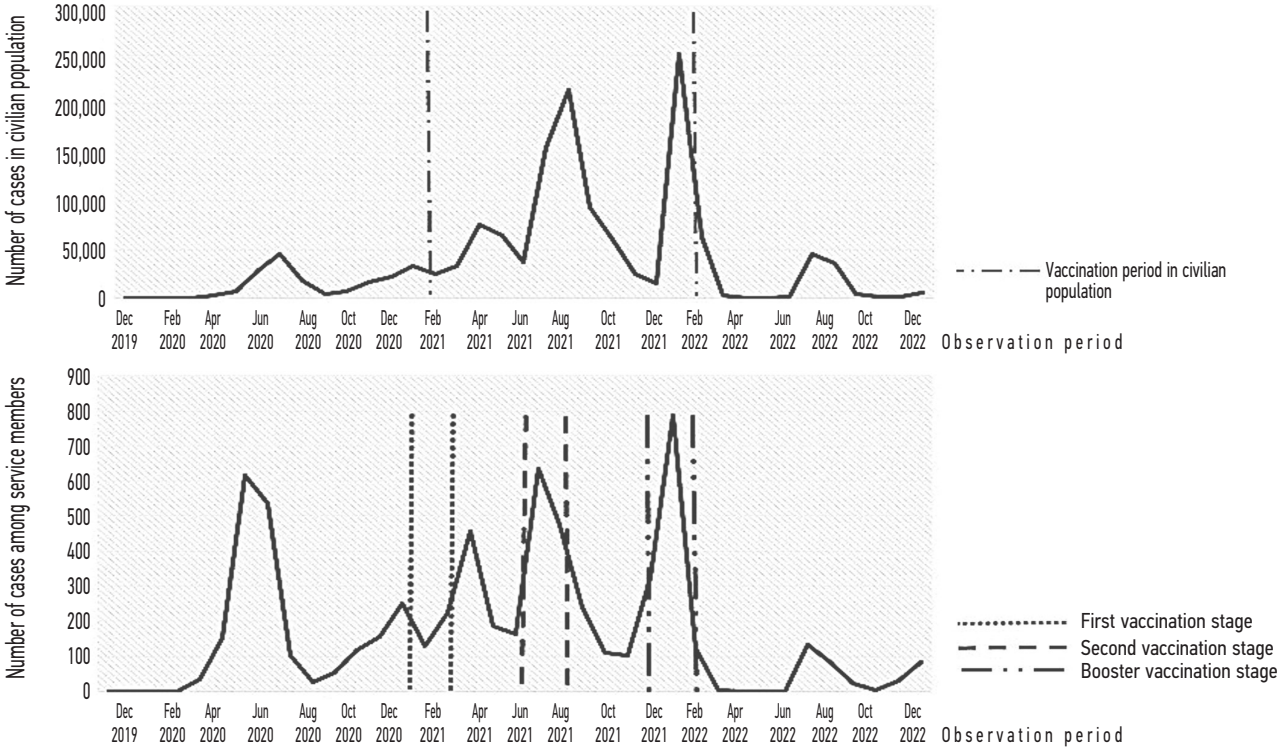

Fig. 2. Changes in the COVID-19 epidemic process among the civilian population of the Republic of Kazakhstan and military units of the Armed Forces, December 2019 to December 2022 (absolute numbers).
Рис. 2. Динамика эпидемического процесса COVID-19 среди гражданского населения Республики Казахстан и в воинских коллективах Вооруженных сил в период с 12.2019 по 12.2022 г. (абс. ч.).

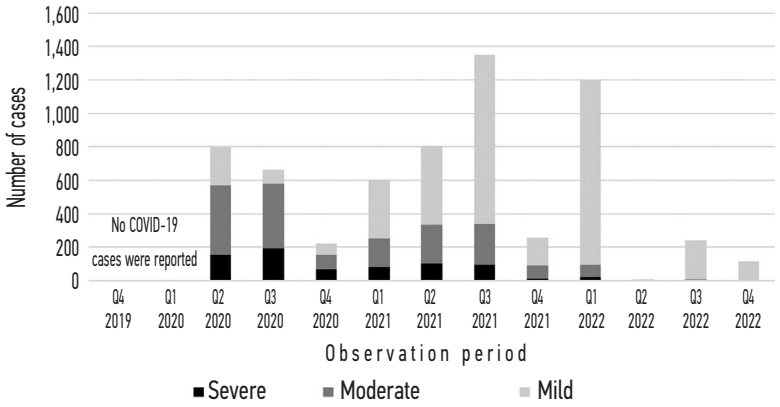

Fig. 3. Changes in the distribution of clinical severity of COVID-19 among service members of the Armed Forces of the Republic of Kazakhstan during different stages of the pandemic (absolute numbers).
Рис. 3. Динамика соотношения тяжести клинических форм COVID-19 среди военнослужащих ВС РК в разные периоды пандемии (абс. ч.).

Emerging scientific evidence during that period combined with systematic monitoring of epidemiological trends allowed prediction of incidence rate increase within a 6-month interval, correlating with expected decline in postvaccination population immunity levels. Timely booster vaccination of military personnel prevented morbidity growth and contributed to its subsequent decline during the revaccination period. This approach was adopted by most countries worldwide [21,22].

Consequently, the significant surge in COVID-19 cases since October 2020 was halted and contained within seasonal epidemic thresholds for acute respiratory infections through comprehensive immunization coverage of military personnel.

CONCLUSION

Analysis of the COVID-19 epidemic situation among the armed forces personnel and general population of RK demonstrated the wave-like pattern of the epidemic process, driven by mutually dependent transformations in the interacting populations of the parasite and host. The increased mutation density of the virus in response to global antiepidemic measures led to reduced pathogenicity of the pathogen and a manifold increase in virulence, manifesting as a pronounced wave-like surge in incidence alongside a parallel increase in the proportion of mild and asymptomatic disease forms. These results corroborate the theory of self-regulation of parasitic systems, exemplified by both model populations and a model infection.

The genetically determined ability of a potential pathogen to alter its epidemiological properties in response to implemented anti-epidemic measures is a critical factor influencing the dynamics of the epidemic situation. In addition to an increase in the number of cases, this may show through heightened clinical severity, prevalence shifts across population strata (age, occupational, etc.), and other epidemiological patterns.

ADDITIONAL INFO

Author contribution: A.M. Khissamitov, data collection, system-atisation and analysis, statistical processing of material, writing the text; A.A. Kuzin, development of the general concept, final revision; A.E. Zobov, concept and design of the study, collection and processing of materials, writing the text; V.V. Zakurdaev, collection and processing of materials, writing the text. All co-authors made a significant intellectual contribution to the study and preparation of the publication, familiarised themselves with the final version of the manuscript and expressed their agreement with its content.
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