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THE INFLUENCE OF CLIMATIC CONDITIONS ON THE PREVALENCE OF CONGO-CRIMEAN HEMORRHAGIC FEVER IN THE WORLD

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Abstract

Introduction: Congo-Crimean hemorrhagic fever (CCHF) is a tick-borne viral zoonosis. This article reviews the literature on the influence of climatic factors on the incidence of CCHF. It was found that elevated temperature and humidity affect the number of patients hospitalized for CCHF.

Aim: to systematize and evaluate the influence of climatic conditions on the incidence of Congo-Crimean hemorrhagic fever.

Search strategy: The search for sources was carried out in the databases PubMed, The Cochrane Library, Scopus. The search depth was 22 years from 2000 to 2022. *Inclusion criteria*: reports of randomized and cohort studies, meta-analyzes and systematic reviews; articles in English. *Exclusion criteria:* materials with no evidence base, newspaper articles. During the search, 94 sources were found, of which 32 sources were selected and analyzed for a more detailed study.

Results: The analysis of the relationship between climatic conditions and the incidence of Congo-Crimean hemorrhagic fever was carried out. The effect of various factors on the incidence of Congo-Crimean hemorrhagic fever was determined.

Conclusions: We believe that the number of hospitalized patients with CCHF can be predicted, taking into account the climatic features of the places of registration of CCHF and taking the necessary measures.

Keywords: *Congo-Crimean hemorrhagic fever, climate, ticks, zoonoses.*

Резюме

ВЛИЯНИЕ КЛИМАТИЧЕСКИХ УСЛОВИЙ НА РАСПРОСТРАНЕННОСТЬ КОНГО-КРЫМСКОЙ ГЕМОРРАГИЧЕСКОЙ ЛИХОРАДКИ В МИРЕ

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Введение: Конго-Крымская геморрагическая лихорадка (ККГЛ)- клещевой вирусный зооноз. В данной статье проведен обзор литературы на предмет влияния климатических факторов на заболеваемость ККГЛ.

Цель: систематизировать и оценить влияние климатических условий на заболеваемость Конго-Крымской геморрагической лихорадкой

Стратегия поиска: Поиск источников проводился в базах PubMed, The CochraneLibrary, Scopus, elibrary. Глубина поиска составила 20 лет с 2000 по 2022 годы. *Критерии включения:* отчеты о рандомизированных и когортных исследованиях, мета-анализы и систематические обзоры; статьи на английском и русском языках. *Критерии исключения:* материалы, не имеющие доказательной базы, газетные статьи. В процессе поиска было найдено 94 источников, из которых для более подробного изучения было отобрано и проанализировано 32 источника.

Результаты: Проведен анализ взаимосвязи климатических условий и заболеваемости Конго-Крымской геморрагической лихорадкой. Было определено действие различных факторов на заболеваемость Конго-Крымской геморрагической лихорадкой.

Выводы: Мы полагаем, что количество госпитализированных больных с ККГЛ можно прогнозировать, учитывая климатические особенности мест регистрации ККГЛ и предпринимая необходимые меры.

Ключевые слова: *Конго-Крымская геморрагическая лихорадка, климат, клещи, зоонозы.*

Түйіндеме

КЛИМАТТЫҚ ЖАҒДАЙЛАРДЫҢ ӘЛЕМДЕГІ КОНГО-ҚЫРЫМ ГЕМОРРАГИЯЛЫҚ ҚЫЗБАСЫНЫҢ ТАРАЛУЫНА ӘСЕРІ

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Кіріспе: Конго-Қырым геморрагиялық қызбасы (ҚҚГҚ)- кене вирустық зоонозы. Бұл мақалада климаттық факторлардың ҚҚГҚ аурушаңдығына әсері туралы әдебиеттерге шолу жасалды.

Мақсаты: Конго-Қырым геморрагиялық қызбасының жиілігіне Климаттық жағдайлардың әсерін жүйелеу және бағалау

Ізденіс стратегиясы: дерек көздерді іздеу PubMed, The Cochrane Library, Scopus, базаларында жүргізілді. Ізденіс ұзақтығы 22 жылды құрады, 2000 жылдан 2022 жылға дейін. *Қосу критерийлері:* рандомизацияланған және когорттық зерттеулер туралы есептер, мета-талдаулар және жүйелі шолулар; ағылшын және орыс тілдеріндегі мақалалар. *Алып тастау критерийлері:* дәлелдер базасы жоқ материалдар, газет мақалалары. Іздеу барысында 94 дереккөз табылды, олардың 32-і жан-жақты зерттеу үшін таңдалып талданды.

Нәтижелері: Климаттық жағдайлар мен Конго-Қырым геморрагиялық қызбасының жиілігінің өзара байланысына талдау жасалды. Конго-Қырым геморрагиялық қызбасының жиілігіне әртүрлі факторлардың әсері анықталды.

Қорытынды: Біз ҚҚГҚ - мен ауруханаға жатқызылған науқастардың санын ҚҚГҚ тіркеу орындарының климаттық ерекшеліктерін ескере отырып және қажетті шараларды қолдана отырып болжауға болады деп санаймыз.

***Түйінді сөздер**: Конго-Қырым геморрагиялық қызбасы, климат, кенелер, зооназдар.*

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Introduction

Congo-Crimean hemorrhagic fever (CCHF) is a tick—borne viral zoonotic infectious disease characterized by fever and hemorrhagic syndrome, with a potentially fatal outcome. The infectious agent is a single-stranded RNA-containing virus with a lipid envelope belonging to the Bunyaviridae family of the genus Nairovirus. The disease occurs as a result of the virus entering the circulatory system as a result of a bite by ticks of the genus Hyalomma. In addition, transmission can occur as a result of contact with the blood or biological fluids of infected hosts [4]. CCHF is registered in 52 countries in Africa, Asia, Eastern Europe and the Middle East [15]. The prevalence CCHF includes a wide geographical range centered in Eurasia, which includes countries such as Turkey, Russia and Kazakhstan [9,27].

The present review aims is analysis of data on CCHF and climate issues in scientific articles containing the results of meta-analyses, randomized and cohort studies, systematic reviews in peer-reviewed medical journals based on MEDLINE/PubMed, Scopus, The Cochrane Library. The search interval included articles from 2001-2022. The systematic literature search resulted in 237 hits. The screening of titles and abstracts identified 94 potentially eligible articles. Finally, 32 studies were included in this review. The selection algorithm is shown in Figure 1.

Results and discussion

Currently, there is evidence in the modern literature that the incidence of zoonoses is influenced by climatic factors. There are a small number of studies concerning the study of the influence of climate on the incidence of CCHF. Thus, in a recent study conducted in Turkey, the relationship between the number of patients and the climatic features of the region in which they lived was studied [4]. The study included 548 patients with CCHF. Along with demographic and clinical characteristics of patients, temperature, humidity and precipitation were recorded in their places of residence at the time of admission to the hospital. In addition to temperature, humidity and precipitation at the time of patient admission, these indicators were evaluated one and three months before admission [4].

The relationship between the number of patients and the above values was studied. It was found that humidity during hospitalization and one month before it, as well as precipitation three months before hospitalization, affect the number of patients hospitalized for CCHF. Researchers have proven that climate affects the number of patients with CCHF [4]. In this study, it was shown that CCHF occurred in the period from March to October. It was hypothesized that the number of hospitalized patients with CCHF can be predicted, taking into account the climatic features of the places of registration of CCHF and taking the necessary measures [4]. In another study conducted in the Central Anatolia region of Turkey (Tokat, Sivas, Yozgat and the surrounding area), where summers are hot and dry, and winters are cold and moderately rainy, it was shown that this climate is suitable for optimal survival of Hyalomma mites [15].

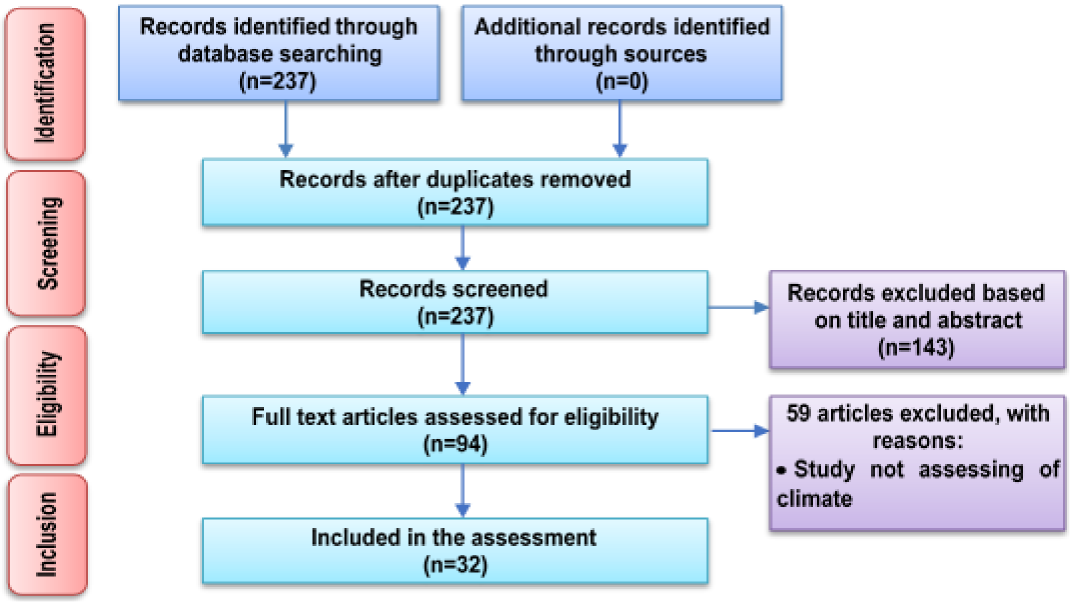

Figure 1. Flow diagram of the of the literature search.

In areas endemic to CCHF, an increase in temperature was also recorded compared to 10 years earlier; especially in April, the increase was more than 5 °C. It is known that temperature changes affect the number and life expectancy of ticks. In this regard, it was suggested that temperature may affect the recent increase in the number of patients diagnosed with CCHF [24,30]. It has been reported that climatic changes in Turkey affect the nature of bird migration and that migratory birds may play a role in the spread of CCHF [17]. Changes in the number of migratory birds and animals, as well as the structure of the land affect the tick population. Climate and environmental changes play a role in the spread of the virus in Turkey, but complex and various multifactorial causes may also be involved in the spread of the virus [17,31]. However, climate becomes the most important factor when considering all possible impacts. Many studies have been conducted on the relationship between climate change and the increase in the incidence of certain infectious diseases [11,12,31]. It is assumed that climatic conditions affect the tick population and, consequently, tick-borne diseases [11,19]. However, no studies have been conducted to study the impact of climate change on CCHF. The researchers noted that higher spring temperatures in the country for several consecutive years in the country accelerated the development cycle of the tick-borne vector H. marginatum, reduced its mortality independent of density, and increased the populations available for infection [16,32]. It was mentioned that climate is the main factor influencing the development of CCHF vector ticks and, consequently, the local circulation of the virus [16,32].

The climate can also increase the activity of searching for ticks and the parasitic load on the host, which contributes to the circulation of the virus [8]. In a deterministic model that takes into account the full development cycle of H. marginatum and each pathway of CCHF transmission between ticks and vertebrate hosts, it was shown that elevated temperature, especially in late summer, contributes to an increase in the number of oviposition cases in females before unsuitable autumn conditions, which increases the probability of survival of developing eggs [8]. However, it was found that a key factor in the transmission of CCHF in H. marginatum has a climate-independent biological parameter inherent in the vector tick, namely the rate of transovarial transmission of CCHF [8]. However, if transovarial transmission of the CCHF virus is effective, it is predicted that better egg survival due to higher temperatures will lead to an increase in the proportion of infected eggs. Consequently, it can be argued that climate change can affect both the exposure of animals to tick populations and the level of infection by ticks carrying the CCHF virus [8].

Climate change is also likely to lead to the expansion of the geographical range of H. marginatum in the north in the Mediterranean basin, since ticks have recently been discovered in southwestern Europe, and will also contribute to the concomitant geographical spread of CCHF from neighboring endemic areas [1,10]. Scientists note that H. marginatum mites prefer warm summers, relatively mild winters and less precipitation, which becomes normal with current climate changes in this region [3,10]. In southern Europe, including the south of France, certain categories of xerophilic land cover, such as shrubs, meadows and herbaceous vegetation, can expand with climate change and contribute to the spread of H. marginatum among local numerous populations of small vertebrates, such as hares and rabbits [18]. Conversely, reforestation of habitats due to the decline of agriculture may contribute to an increase in wild ungulate populations, while fragmented habitats with woodlands may increase their movement and transportation of adult ticks to a new environment [6,32]. However, France is still a CCHF -free territory, since there have never been reports of autochthonous cases of human disease, and the virus has never been detected in ticks [2]. However, antibodies to CCHF have been found in domestic ruminants on the island of Corsica, indicating local transmission of the virus, at least in this part of France. Researchers note that H. marginatum is the best candidate for this transmission, since its distribution in the south of France has been increasing for several years due to climate change [2].

Since 1850, the carbon dioxide content in the atmosphere has increased from 280 to 360 parts per million, and the average surface temperature has increased from 14.6 to 15.3 °C. In the 21st century, a further increase in temperature from 1.8 to 4.0 °C is expected [13]. Temperate and cold climate zones are mainly affected, but tropical regions are not spared either. At the same time, the global climatic consequences of the "El Nino Southern Oscillation" are intensifying. Global warming increases the growth of tropical pathogens (malaria plasmodium, leishmaniasis, yellow fever virus, dengue virus, West Nile virus, Vibrio cholera) and vectors (anopheles mosquitoes, edes, culex and phlebotomas; hard ticks). Global warming may lead to the emergence of diseases that are not currently endemic to Germany [13]. It has been reported that the high incidence of tick-borne diseases is associated with moderate winters and humid warm summers in Sweden, Slovakia and Hungary, although the incidence may also be affected by the influence of climate on recreational activities [25]. Some studies have shown that the Mediterranean basin is becoming more favorable for the spread of Congo-Crimean hemorrhagic fever [23,29]. In the Turkestan region, in particular in the city of Shymkent, there is also an increase in temperature compared to 10 years earlier [29]. Similarly to the studies conducted in the world, climate change is observed in the Turkestan region, which may probably contribute to an increase in the incidence of CCHF among the population.

In addition to climate change, which may have a significant impact on the rate of reproduction of Hyalomma vector ticks, anthropogenic factors (for example, changes in agricultural and hunting activities) may also influence the potential causes of the appearance or reappearance of CCHF [20]. In addition, vast territories of countries with sharp geoclimatic differences and uneven distribution of the population can lead to unique models of the spread of CCHF [7]. The dynamic interaction of biological, socio-cultural and environmental factors together with new aspects of the human-animal interphase create additional problems regarding the occurrence of this infectious disease [7].

Along with climate change, an additional factor of the spread of CCHF, which is associated with the migration of livestock or wild animals, should be taken into account. As a result, the virus is spreading from the Balkan region to Central Europe, and more recently to Western Europe, where various genotypes are circulating [26]. Researchers have found that climatic, environmental and economic changes, as well as the ever-growing world trade and personal mobility, open up wide opportunities for the spread of new pathogens with zoonotic potential to previously unaffected countries [22]. The level of tick infection and, consequently, the impact on humans is determined by both the biology and seasonal dynamics of ticks, as well as the dynamics and structure of the wild animal population. Which, in turn, are influenced by complex interactions between climatic variables, changes in agricultural methods, land use and wildlife density [14]. The study of the model of various climatic scenarios that may occur in the habitats of different ticks has shown that an increase in temperature and a decrease in precipitation leads to a sharp increase in their settlement in these habitats, in particular in the Mediterranean region, with a tendency to expand their range to the north [28]. The authors note that in the territory of South-Eastern Europe, the number of clinical cases of CCHF, as well as the prevalence of infected ticks, has been continuously increasing rapidly since 2000 [3].

According to various researchers, the increase in human cases reported in the Balkans, Turkey and Russia may not be so much due to the influence of climate change, but rather is the result of the impact of yet unexplored amplification mechanisms that can be supported by wild host animals [8]. An assessment of the available data suggests that epidemics in Eastern Europe are not the result of the spread of a viral wave, but are most likely associated with a combination of factors such as habitat abandonment, fragmentation of the landscape and the spread of wild host animals, which exacerbate the prevalence rates [8].

Conclusion. Thus, the increased level of humidity and air temperature, along with other factors, affect the increase in the number of patients diagnosed with CCHF. We consider it expedient to predict the number of patients with CCHF taking into account the climate in natural foci and to ensure the readiness of medical organizations to receive patients with Congo-Crimean hemorrhagic fever so that necessary measures can be taken.

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