BULLETIN OF NATIONAL ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
ISSN 1991-3494
Volume 3, Number 385 (2020), 29 – 35 **https://doi.org/10.32014/2020.2518-1467.66**

UDC 578.7
IRSTI 34.25.39

N. G. Klivleyeva[1], G. V. Lukmanova[1], N. T. Saktaganov[1], M. Kh. Sayatov[1], T. I. Glebova[1], N. S. Ongarbayeva[1], A. M. Baimukhametova[1], M. G. Shamenova[1], V. E. Berezin[1], G. E. Nusupbaeva[2], A. M. Aykimbaev[2], A. B. Sagymbay[2], E. I. Isaeva[3]

[1]LLP Scientific Production Center for Microbiology and Virology, Almaty, Kazakhstan;
[2]Scientific and Practical Center for Sanitary and Epidemiological Expertise and Monitoring, a Branch of the RSE on REM National Center for Public Healthcare of the Ministry of Health of the Republic of Kazakhstan, Almaty, Kazakhstan;
[3]FSBI Federal Research Center for Epidemiology and Microbiology named after Honorary Academician N.F. Gamaleya of the Ministry of Health of the Russian Federation, Moscow, Russia.
E-mail: i_nailya@list.ru, biochem_vir@mail.ru, gal_l@bk.ru, nsaktaganov1984@mail.ru, taty1962@mail.ru, nuray.syrlybay@gmail.com, a_baimukhametova@mail.ru, mira.shamenova@bk.ru, vberezin359@gmail.com, gnusupbaeva@mail.ru, alim.aikimbayev@mail.ru, altinai_S@mail.r, immunol.lab@mail.ru

ACUTE RESPIRATORY VIRAL INFECTIONS IN KAZAKHSTAN IN 2017-2019

Abstract. During the 2017-2019 period, 4,391 clinical samples were collected from patients diagnosed with ARVI, ARI, bronchitis, and pneumonia in polyclinics and healthcare facilities located in various regions of Kazakhstan.

Laboratory diagnosis of 4,391 nasopharyngeal swabs in the real-time polymerase chain reaction revealed the genetic material of pathogens causing ARVI in 24.41 % of cases, including adenovirus in 1.78 %, rhinovirus in 4.34 %, coronavirus in 0.82 %, parainfluenza virus type I/III in 0.87 %, metapneumovirus in 1.04 %, bokavirus in 0.30 % of examined samples. The number of samples tested positive for respiratory syncytial virus was the highest (15.25 %).

The data obtained from screening of nasopharyngeal swabs in the real-time polymerase chain reaction suggested the circulation of ARVI of mixed etiology in the examined areas of the RK.

The results of the primary screening of clinical samples collected from various regions of Kazakhstan during the epidemic seasons 2017-2019 in the polymerase chain reaction correlate with the data obtained over the 2016-2017 epidemic season according to the spectrum of influenza and ARVI causative agents. Co-circulation of adenovirus, rhinovirus, coronavirus, type I/III parainfluenza virus, metapneumovirus, bocavirus is continuing with the predominant prevalence of the respiratory syncytial infection pathogen, the proportion of which was 15.25 % of the total number of samples.

Differential diagnosis of ARVI contributes to the timely identification of infectious agents in humans and more effective implementation of sanitary and preventive measures.

Key words: PCR diagnostics, surveillance, influenza, ARVI.

Introduction. Acute respiratory viral infection (ARVI) is the most common disease group characterized by damage to the human respiratory tract regardless of age, place of residence, and social status. Despite certain successes achieved in the fight against infectious diseases, the importance of ARVI pathogens not only does not decrease, but also shows an increasing tendency. It has been established that infectious diseases currently account for at least 50-60 % of the entire human pathology, up to 20 % of the population can suffer from a respiratory infection during the epidemic period [1-6].

ARVI is a heterogeneous group of infections that has similar development mechanisms, epidemiological and clinical characteristics. ARVI causative agents include respiratory syncytial virus (RSV), parainfluenza and influenza viruses, adenoviruses, rhinoviruses, reoviruses, etc., and more than 300 of their subtypes.

The natural susceptibility to ARVI is high. Unstable immune response, lack of cross-immunity, and a large number of pathogen serotypes contribute to the development of the disease in the same person several times a year, which leads to a decrease in the overall resistance of the body [7].

The danger of ARVI lies in the complications and exacerbations of chronic diseases. In connection with the characteristics of virus structure and life activity, almost all types of acute respiratory viral infections in the early stages of the disease have similar clinical manifestations. Different laboratory methods are used to confirm the clinical diagnosis, differentiate a respiratory virus, and carry out epidemiological studies. The real-time polymerase chain reaction (RT-PCR), based on the detection of viral DNA/RNA is one of the most modern, highly sensitive, and specific methods.

The purpose of this study was to identify the causative agents of ARVI among the population of Kazakhstan during the epidemic seasons 2017-2019 in RT-PCR.

Materials and methods. In 2017-2019, clinical samples (nasopharyngeal swabs) were collected from patients during the period in polyclinics and infectious diseases hospitals located in five regions of Kazakhstan, including 13 regions and Nur-Sultan and Ust-Kamenogorsk cities.

Human nasopharyngeal swabs were collected in sterile tubes with 2 ml of Medium 199 containing 0.5 % bovine serum albumin and a complex of antibiotics (50,000 units/ml of penicillin, 50 μg/ml of streptomycin, 3,000 μg/ml of gentamicin, and 5,000 units/ml of nystatin). Samples were kept for 24 hours at 4 °C and stored in a low-temperature freezer at -80 °C.

To isolate RNA from the samples under study and carry out the reverse transcription reaction, the Ribo-prep and Reverta-L reagent kits were used. Primary screening was carried out in RT-PCR assay using fluorescent hybridization detection with AmpliSens®ARVI-screen-FL reagent kits for detection of ARVI RNA (FBIS Central Research Institute for Epidemiology of Rospotrebnadzor) on the Rotor-Gene Q6plex instrument (QIAGEN, Germany).

Results and discussion. To study the circulation of ARVI among the population during the epidemic seasons 2017-2019, biomaterials were obtained from patients diagnosed with ARVI, ARI, bronchitis, and pneumonia from patients with diagnoses of acute respiratory viral infections, acute respiratory infections, bronchitis and pneumonia, the collection of biological materials. Clinical samples (nasopharyngeal swabs) were collected together with medical personnel from polyclinics and infectious disease hospitals located in five regions of Kazakhstan (the northern region – Akmola, North Kazakhstan, Kostanai, Pavlodar oblasts, and Nur-Sultan city; the southern region – Almaty, Kyzylorda, and Turkestan oblasts; the western region – Atyrau, Aktobe, West Kazakhstan, and Mangystau oblasts; the eastern region – East Kazakhstan oblast, Ust-Kamenogorsk city, and the central region - Karaganda oblast). A total of 4,391 swabs were obtained.

The largest number of samples was obtained from patients living in the Northern and Southern Kazakhstan – 1,466 samples (33.38 % of the total number of samples) and 1,002 biosamples (22.81 %), respectively. 806 (18.35%), 723 (16.46 %), and 394 (8.97 %) nasopharyngeal swabs were collected from the Western, Eastern, and Central Kazakhstan, respectively.

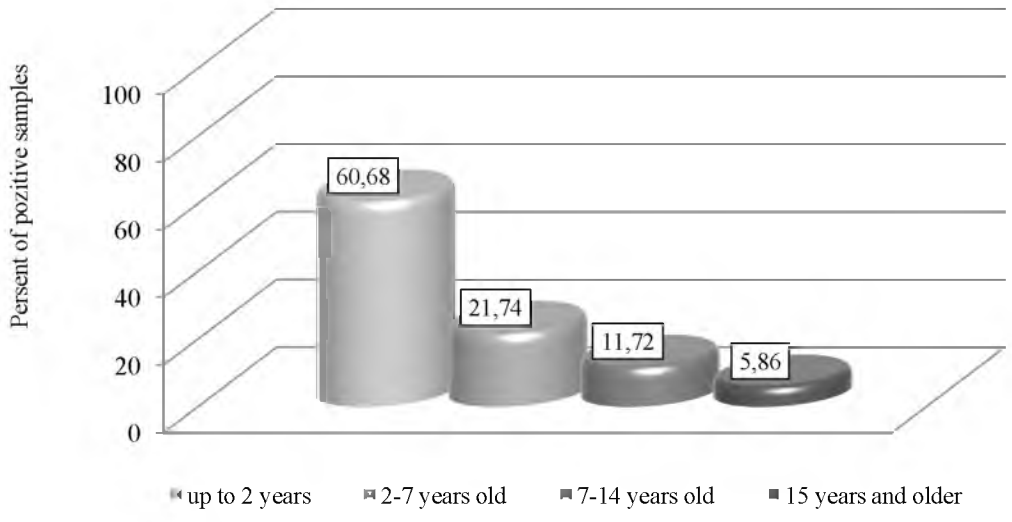

Figure 1 – Age structure of patients examined during the epidemic seasons 2017-2019 (%)

As can be seen from figure 1, 94.30 % of the samples were collected from children (4,141 samples), of which the number of examined children under two years old was 61.50 % (2,700 samples), aged 2-7 years old – 17.30 % (760 samples), 7-14 years old – 15.50 % (681 samples). The number of samples collected from the adult population was 5.70 % (250 swabs) of the total number of samples.

Figure 2 shows the ratio between clinical samples depending on the diagnosis of the examined patients.

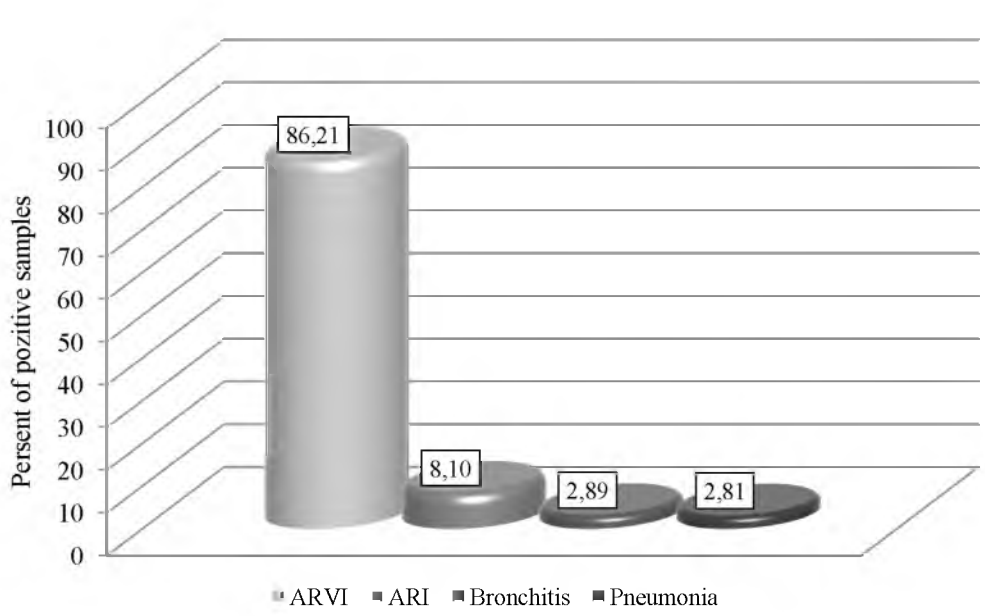

Figure 2 – Primary diagnosis of the examined patients (%)

The percentage of collected samples, depending on the diagnosis, was as follows: ARVI – 87.30 % (3,833 samples), ARI – 8.33 % (366 samples), bronchitis – 2.77 % (122 samples), and pneumonia – 1.60 % (70 samples).

A molecular genetic study of 4,391 nasopharyngeal swabs for the presence of ARVI was carried out. The table demonstrates the results of the primary screening of nasopharyngeal swabs in RT-PCR.

Screening of clinical samples collected during 2017-2019 in RT-PCR for the presence of ARVI causative agents

Region	Total number of samples	Number of positive samples	Number of PCR positive samples for							
			human respiratory syncytial virus hRSv	adeno virus hAdv	rhino virus hRv	parainfluenza virus hPiv 2/4	corona virus hCov	parainfluenza virus hPiv 1/3	human metapneumovirus hMpv	boka virus hBov
Southern Kazakhstan:	1002	440	301	18	75	0	10	17	11	8
Northern Kazakhstan:	1466	127	76	3	16	0	7	5	16	4
Western Kazakhstan:	806	249	175	13	32	0	8	9	11	1
Eastern Kazakhstan:	723	130	71	5	40	0	3	4	7	0
Central Kazakhstan:	394	126	47	39	28	0	8	3	1	0
Total:	4391	1072	670	78	191	0	36	38	46	13

As can be seen from the table, the genetic material of ARVI pathogens was detected in 1,072 samples (24.41 % of the total number of examined samples). Adenovirus was found in 78 (1.78 %), rhinovirus in 191 (4.34 %), coronavirus in 36 (0.82 %), parainfluenza virus type I/III in 38 (0.87 %), metapneumovirus in 46 (1.04 %), bocavirus in 13 (0.30 %) samples. The number of samples tested positive for respiratory syncytial virus was the highest (670 samples – 15.25 %).

Data obtained from the primary screening of nasopharyngeal swabs in RT-PCR thereby suggested the circulation of ARVI of mixed etiology in the examined areas of RK.

Conclusion. The incidence of ARVI continues to remain at a high level, increasing annually in the autumn-winter season. According to the WHO, 4 million children under five years of age annually die from acute respiratory viral infections and their complications, and the proportion of children under one year of age among the dead ones is more than 66 %. Acute pneumonia is the cause of infant deaths from ARVI in 75 % of cases [8].

The results of the studies indicate that RSV pathogens, rhino- and adenoviruses, and parainfluenza viruses I/III are most common among the acute respiratory viral infections. The constant variability of viruses and emergence of new causative agents of ARVI, which make up 80-90 % of all cases of infectious pathology, constitute a serious threat.

During the 2017-2019 period, 4,391 biosamples were collected from patients diagnosed with ARVI, ARI, bronchitis, and pneumonia in polyclinics and healthcare facilities located in five regions of Kazakhstan including 13 oblasts and Nur-Sultan and Ust-Kamenogorsk cities. While studying samples in RT-PCR, the genetic material of ARVI pathogens was detected in 22.41 % of cases: adenovirus in 1.78 %, rhinovirus in 4.34 %, coronavirus in 0.82 %, type I/III parainfluenza virus in 0.87 %, metapneumovirusin in 1.04 %, and bokavirus in 0.30 % of samples. The number of samples tested positive for respiratory syncytial virus was the highest (15.25 %).

Laboratory diagnosis of clinical samples obtained from patients during the 2016-2017 epidemic season showed the prevalence of parainfluenza viruses, RSV, adenoviruses, metapneumoviruses, and rhinoviruses. Bocaviruses and coronaviruses were detected only in isolated cases [6, 9].

The results of the primary screening in RT-PCR of clinical samples collected from various regions of Kazakhstan during the epidemic seasons 2017-2019 for the presence of ARVI causative agents correlate with the data obtained over the 2016-2017 epidemic season [9]. Circulation of the same causative agents of ARVI is continuing with the predominant prevalence of respiratory syncytial infection, the proportion of which was 15.25 % (670 samples).

At present, unfortunately, capabilities in the diagnosis of respiratory viral infections provided by modern methods of virology and molecular biology do not always coincide with the level of realization of these capabilities in practical laboratories. Due to the limitation in the arsenal of drugs active against respiratory viruses, the etiotropic therapy of ARVI also remains an open issue.

The study was carried out as part of the scientific and technical program BR05226330 “Development of new diagnostic, preventive and medicinal preparations for combating influenza and acute respiratory viral infections in humans, development of technologies for their production”.

The work was carried out as part of the scientific and technical programme: BR05226330 “Creation of new diagnostic, preventive and medicinal products for combating influenza and acute respiratory viral infections of a person, development of technologies for their production”.

Н. Г. Кливлеева[1], Г. В. Лукманова[1], Н. Т. Сактаганов[1], М. Х. Саятов[1], Т. И. Глебова[1], Н. С. Онгарбаева[1], А. М. Баймухаметова[1], М. Г. Шаменова[1], В. Э. Березин[1], Г. Е. Нусупбаева[2], А. М. Айкимбаев[2], А. Б. Сагымбай[2], Е. И. Исаева[3]

[1]«Микробиология және вирусология ғылыми-өндірістік орталығы» ЖШС, Алматы, Қазақстан;
[2]Қазақстан Республикасы Денсаулық сақтау министрлігінің «Қоғамдық денсаулық сақтау Ұлттық Орталығы» ШЖҚ РМК «Санитариялық-эпидемиологиялық сараптама және мониторинг ғылыми-практикалық орталығы» филиалы, Алматы, Қазақстан;
[3]Құрметті академик Н.Ф. Гамалеи атындағы «Эпидемиология және микробиология бойынша федералды ғылыми-зерттеу орталығы» Денсаулық сақтау министрлігі, Мәскеу, Ресей

2017-2019 ЖЫЛДАРДАГЫ ҚАЗАҚСТАНДАГЫ ЖІТІ РЕСПИРАТОРЛЫ ВИРУСТЫҚ ИНФЕКЦИЯ

Аннотация. Жұқпалы аурулардан келтірілген экономикалық залал тұрғысынан жедел респираторлық вирустық инфекциялар әлемде және біздің елімізде бірінші орында тұр. Әлеуметтік мәртебесіне, тұрғылықты жеріне, жасына қарамастан, адамдардың тыныс алу жолдарын зақымдау және клиникасы ұқсас респираторлы вирустық инфекцияларға әртүрлі аурулар тобы жатады.

Тұмаудың клиникалық-эпидемиологиялық маңыздылығына қарамастан, адамдар үшін бірінші орынды этиологиясы тұмау емес ЖРВИ алады. Этиологиясы тұмау емес респираторлы инфекциялардың мәселесі олардың кең таралуы, полиэтиологиялық және нақты алдын алудың болмауына байланысты. Сонымен қатар осы инфекция ошақтарында эпидемияға қарсы іс-шараларды ұйымдастыруға жеткілікті көңіл бөлінбейді.

Осыған байланысты, инфекцияның таралуын бақылау, оның ішінде қоздырғышты дер кезінде диагностикалау, респираторлық вирустық инфекциялармен күресуде өте маңызды.

Жұмыстың мақсаты 2017-2019 жылдардағы эпидемиялық маусымдарда Қазақстан Республикасының тұргындары арасында жедел респираторлы вирустық инфекциялар қоздырғыштарын РТ-ПТР-да анықтау.

2017-2019 ж. Қазақстанның әртүрлі аймақтарындағы емханалар мен медициналық мекемелердегі жедел респираторлы вирустық инфекция, бронхит және пневмония диагнозы бар науқастардан 4391 клиникалық сынама алынды.

4391 назофарингальді үлгілерді полимеразды тізбектік реакциясында зертханалық балауда нәтижесінде 24,41 %-дық жағдайда ЖРВИ қоздырғыштарының генетикалық материалы анықталды. Солардың ішінде аденовирус 1,78 % сынамада, риновирус 4,34 %, коронавирус 0,82 % анықталды, I/III парагрипп вирусы – 0,87 %, метапневмовирус – 1,04 %, бокавирус – 0,30 %. Оң нәтиже көп берген сынамалар респираторлық синцитиальды вирус үшін 15,25 %-ды құрады.

Назофарингальды сынамаларды полимеразды тізбектік реакциясында скрининг жүргізу нәтижесі, ҚР зерттелген облыстарында ЖРВИ аралас этиологиясын көрсетті.

2017-2019 ж. эпидемиялық маусымында Қазақстанның әртүрлі аймақтарынан жиналған клиникалық үлгілерді полимеразды тізбекті реакцияда тұмау қоздырғыштары және ЖРВИ спекторы бойынша алынган нәтижелерді, 2016-2017 ж. эпидемиялық маусыммен салыстырганда ұқсас болды. ЖРВИ бірдей нұсқаулары және респираторлық синцитиальды инфекция қоздырғышарының үлесі 15,25 % басымдылыгымен айналымда жалгасуда.

Жедел респираторлы вирустық инфекциялардың дифференциалды балау нәтижесі, науқас адамдардан қоздырғышты уақтылы анықтауға және санитарлық-профилактикалық шараларды тиімді жүргізуге ықпал етеді.

Түйін сөздер: ПЦР-диагностика, эпидбақылау, тұмау, ЖРВИ.

Н. Г. Кливлеева[1], Г. В. Лукманова[1], Н. Т. Сактаганов[1], М. Х. Саятов[1], Т. И. Глебова[1], Н. С. Онгарбаева[1], А. М. Баймухаметова[1], М. Г. Шаменова[1], В. Э. Березин[1], Г. Е. Нусупбаева[2], А. М. Айкимбаев[2], А. Б. Сагымбай[2], Е. И. Исаева[3]

[1]ТОО «Научно-производственный центр микробиологии и вирусологии», Алматы, Казахстан;
[2]Филиал «Научно-практический центр санитарно-эпидемиологической экспертизы и мониторинга» РГП на ПХВ «Национальный центр общественного здравоохранения» Министерства здравоохранения Республики Казахстан, Алматы, Казахстан;
[3]ФГБУ «Федеральный научно-исследовательский центр эпидемиологии и микробиологии им. Почетного академика Н. Ф. Гамалеи» Минздрава Российской Федерации, Москва, Россия

ОСТРЫЕ РЕСПИРАТОРНЫЕ ВИРУСНЫЕ ИНФЕКЦИИ В 2017-2019 ГГ. В КАЗАХСТАНЕ

Аннотация. По величине экономического ущерба, наносимого инфекционными заболеваниями, первое место как в мире, так и в нашей стране занимают острые респираторные вирусные инфекции. К респираторным вирусным инфекциям относится разнообразная группа заболеваний, объединяемых вирусной природой возбудителя, общим механизмом передачи и клиникой поражения респираторного тракта человека независимо от возраста, места проживания и социального статуса.

Несмотря на наибольшее клиническое и эпидемиологическое значение гриппа для людей, первое место стабильно принадлежит ОРВИ негриппозной этиологии. Проблема респираторной инфекции негриппозной этиологии определяется их широким распространением, полиэтиологичностью и отсутствием возможности специфической профилактики. При этом не всегда уделяется достаточного внимания вопросам организации противоэпидемических мероприятий в очагах этих инфекций.

В связи с этим крайне важными направлениями борьбы с респираторными вирусными инфекциями являются надзор за их распространением, который включает своевременную диагностику возбудителя.

Целью данной работы явилось выявление возбудителей ОРВИ среди населения РК в эпидемические сезоны 2017-2019 гг. в РТ-ПЦР.

В 2017-2019 гг. в поликлиниках и лечебных учреждениях различных регионов Казахстана от больных людей с диагнозами ОРВИ, ОРЗ, бронхит и пневмония получен 4391 клинический образец.

При лабораторной диагностике в полимеразной цепной реакции в режиме реального времени 4391 носоглоточного смыва, генетический материал возбудителей ОРВИ обнаружен в 24,41% случаев: аденовирус выявлен в 1,78% проб, риновирус – в 4,34%, коронавирус – в 0,82%, вирус парагриппа I/III типов – в 0,87%, метапневмовирус – в 1,04%, бокавирус – в 0,30% проб. Наибольшее количество положительных образцов выявлено к респираторно-синцитиальному вирусу – 15,25%.

Результаты, полученные при скрининге носоглоточных смывов в полимеразной цепной реакции, указывают на циркуляцию в исследованных областях РК ОРВИ смешанной этиологии.

Первичный скрининг в полимеразной цепной реакции клинических образцов, собранных в различных регионах Казахстана в эпидемические сезоны 2017-2019 гг., по спектру возбудителей гриппа и ОРВИ, коре-лируют с результатами эпидсезона 2016-2017 гг. Продолжается социркуляция аденовируса, риновируса, коронавируса, вируса парагриппа I/III типов, метапневмовируса, бокавируса с преимущественным преобладанием возбудителя респираторно-синцитиальной инфекции, доля которой составляла 15,25% от общего числа проб.

Дифференциальная диагностика ОРВИ способствует своевременному выявлению возбудителей инфекции у людей и более эффективному проведению санитарно-профилактических мероприятий.

Ключевые слова: ПЦР-диагностика, эпиднадзор, грипп, ОРВИ.

Information about the authors:

Klivleyeva N.G., PhD, Head of the Laboratory of Viral Biochemistry of LLP Scientific Production Center for Microbiology and Virology, Almaty, Kazakhstan; i_nailya@list.ru; https://orcid.org/0000-0002-4094-137X

Lukmanova G.V., Master of Natural Sciences, Research Officer of the Laboratory of Viral Biochemistry of LLP Scientific Production Center for Microbiology and Virology, Almaty, Kazakhstan; gal_l@bk.ru; https://orcid.org/0000-0002-9809-6674

Saktaganov N.T., Master of Veterinary Science, Junior Research Officer of the Laboratory of Viral Biochemistry of LLP Scientific Production Center for Microbiology and Virology, Almaty, Kazakhstan; nsaktaganov1984@mail.ru; https://orcid.org/0000-0001-6526-956X

Sayatov M.H., PhD, professor, academician of NAS RK, Chief Researcher of the Laboratory of Viral Ecology of LLP Scientific Production Center for Microbiology and Virology, Almaty, Kazakhstan; https://orcid.org/0000-0003-4740-9156

Glebova T.I., PhD, Leading Research Officer of the Laboratory of Viral Biochemistry of LLP Scientific Production Center for Microbiology and Virology, Almaty, Kazakhstan; taty1962@mail.ru; https://orcid.org/0000-0002-1139-9868

Ongarbayeva N.S., Master of Natural Sciences, Junior Research Officer of the Laboratory of Viral Biochemistry of LLP Scientific Production Center for Microbiology and Virology, Almaty, Kazakhstan; nuray.syrlybay@gmail.com; https://orcid.org/0000-0001-9022-331X

Baimukhametova A.M., Bachelor of Public Health, Junior Research Officer of the Laboratory of Viral Biochemistry of LLP Scientific Production Center for Microbiology and Virology, Almaty, Kazakhstan; a_baimukhametova@mail.ru; https://orcid.org/0000-0002-8959-126X

Shamenova M.G., PhD, Senior Research Officer of the Laboratory of Viral Biochemistry of LLP Scientific Production Center for Microbiology and Virology, Almaty, Kazakhstan; mira.shamenova@bk.ru; https://orcid.org/0000-0003-2757-3469

Berezin V.E., PhD, professor, Corresponding Member of NAS RK, Head of the Department of Virology of LLP Scientific Production Center for Microbiology and Virology, Almaty, Kazakhstan; vberezin359@gmail.com; https://orcid.org/0000-0002-9197-8199

Nusupbaeva G.E., Head of the Reference Laboratory of Virology of the "Scientific and Practical Center of Sanitary-Epidemiological Examination and Monitoring", Branch of the RSE for REM "National Center of Public Health" of the Ministry of Health of the Republic of Kazakhstan, Almaty, Kazakhstan; gnusupbaeva@mail.ru

Aikimbayev A.M., Consultant of the "Scientific and Practical Center of Sanitary-Epidemiological Examination and Monitoring", Branch of the RSE on REM "National Center of Public Health" of the Ministry of Health of the Republic of Kazakhstan, Almaty, Kazakhstan; alim.aikimbayev@mail.ru; https://orcid.org/0000-0003-1020-5790

Sagymbai A.B., Specialist of the Reference Laboratory of Virology of the "Scientific and Practical Center of Sanitary-Epidemiological Examination and Monitoring", Branch of the RSE for REM "National Center of Public Health" of the Ministry of Health of the Republic of Kazakhstan, Almaty, Kazakhstan; altinai_S@mail.ru; https://orcid.org/0000-0002-2323-5043

Isaeva E.I., PhD, Head of the Laboratory of Immunology of Department of Arboviruses and Experimental Production of FSBI Federal Research Center for Epidemiology and Microbiology named after Honorary Academician N.F. Gamaleya of the Ministry of Health of the Russian Federation; Moscow, Russia; immunol.lab@mail.ru; https://orcid.org/0000-0002-2523-0692

REFERENCES

[1] Korteweg C., Gu J. (2010) Pandemic influenza A (H1N1) virus infection and avian influenza A (H5N1) virus infection: a comparative analysis, Biochem Cell Biol., 88: 575–87. DOI: 10.1139/O10-017

[2] Ignatov P.E. (2002) Immunity and infection. Vremya, Moscow. ISBN 5-94117-038-6 (in Russ.).

[3] Foll M., Poh Y.P., Renzette N., Ferrer-Admetlla A., Bank C., et al. (2014) Influenza virus drug resistance: a time-sampled population genetics perspective, PLoS Genet; 10: e1004185. https://doi.org/10.1371/journal.pgen.1004185

[4] Khaitov R.M., Pinegin B.V. (2000) Modern ideas about the protection of the body from infection, Immunology [Immunologiya] 1: 64-4 (in Russ.).

[5] Reperant L.A., Grenfell B.T., Osterhaus A.D. (2015) Quantifying the risk of pandemic influenza virus evolution by mutation and re-assortment, Vaccine, 33: 6955–66. https://doi.org/10.1016/j.vaccine.2015.10.056

[6] Smagul M.A., Nusupbaeva G.E., Aykimbaev A.M. et al. (2018) Influenza and acute respiratory infections surveillance in Kazakhstan, Medicine, 3 (194): 25-31. DOI: 10.31082/1728-452x-2018-194-8-25-31 (in Russ.).

[7] Pokrovsky V.I., Pak S.G., Briko N.I., Danilkin B.K. (2007) Infectious diseases and epidemiology [Infektsionnye bolezni i epidemiologiya]. GEOTAR-Media, Moscow. ISBN 978-5-9704-1652-5 (in Russ.).

[8] Ivannikov Yu.G., Zhukov A.O., Parsagashvili E.Z. (1994) Mortality from influenza, acute respiratory infections and acute pneumonia as one of the determinants of public health, Annals of the Russian academy of medical sciences, 9: 44-48 (in Russ.).

[9] Smagulova M.K., Nusupbaeva G.E., Amandosova D.M. et al. (2017) Information on acute respiratory viral infections and influenza following the results of the epidemiological season 2016-2017, Environment and Public Health, 2: 24-33 (in Russ.).