In the analyzed period, the range of NSs belonging to the list II, in the republic is 66.6% of the nomenclature of registered drugs under the international non-proprietary name.

In the regions of the republic, classified as a cluster with a low level of the accessibility index of the National Assembly and the Parliament, the range of NSs for the international non-proprietary name was 55.5%, for trade names 31.6% of the nomenclature of registered drugs.

The smallest assortment of ND is represented in regions with a very low level of accessibility index of ND and PS -55.5% of the nomenclature of registered medicines in the international non-proprietary name and 26.3% in the trade name.

Analysis of the completeness of the assortment of ND and PS in medical and pharmacy organizations of the Republic of Sakha (Yakutia) showed that there are significant differences in the range of ND and PS present in the municipal districts of the republic. A number of indicators characterizing the state of the assortment of ND and PS, despite the existence of a regulatory framework in the organization of activities related to the provision of ND and PS, has a pronounced range of differences in the municipal regions of the republic. The lowest value of the indicators in the analysis of the assortment of ND and PS was noted in the municipal districts of the republic with a very low level of accessibility index narcotic drugs and psychotropic substances.

The indicators of primary morbidity and mortality from malignant neoplasms for 2014-2016 in municipal areas classified as a group with a very low availability of narcotic drugs and psychotropic substances suggest that the current need for ND and PS is significantly higher than the actual consumption of ND and PS for the last three years.

Thus, a complex of state regulation measures is needed to equalize the availability of analgesic therapy for the population and medical organizations. The ranking of municipal districts by drug provision groups for analgesic therapy creates the conditions for the development of conceptual documents with a set of measures to increase the availability of ND and PS at the level of the subject of the Russian Federation.

REFERENCES

1. Tarabukina S.M. Metodicheskie podkhody k formirovaniyu regional'noj strategii lekarstvennogo obespecheniya naseleniya na primere Respubliki Sakha (Yakutiya) [Methodical approaches to the formation of the regional strategy of medicinal provision of the population on the example of the Republic of Sakha (Yakutia): avtoreferat [the PhD author's abstract]. Moscow, 2011.
2. O narkoticheskikh sredstvakh i psikhotropnykh veshhestvakh [On narcotic drugs and psychotropic substances]: Feder. zakon ot 8 yanvarya 1998 g. № 3 [Federal law, January 8, № 3].
3. Plan meropriyatij («dorozhnaya karta») «Povyshenie dostupnosti narkoticheskikh sredstv i psikhotropnykh veshhestv dlya ispol'zovaniya v meditsinskikh tselyakh [Action plan (road map) «Increasing the availability of narcotic drugs and psychotropic substances for medical use]: Rasporyazhenie Pravitel'stva RF ot 1 iyulya 2016 g. №1403-r. [Order of the Government of the Russian Federation, July 1, 2016, No. 1403-r.].

The authors:

Tarabukina Sardana Makarovna - Candidate of Pharmaceutical Sciences, Associate Professor of the Department of Pharmacology and Pharmacy of the M.K. Ammosov MI NEFU, tcmx@mail.ru, Yakutsk, Republic Sakha (Yakutia), Russia;

Afanasyeva Elena Borisovna - assistant of the Department of Pharmacology and Pharmacy of the M.K. Ammosov MI NEFU, E.Cassi@yandex.ru, Yakutsk, Republic Sakha (Yakutia), Russia;

Lopatina Sargy Vladimirovna - Post-graduate student of MI NEFU, Department of Differential Equations, lopatinasv_1208@mail.ru, Yakutsk, Republic Sakha (Yakutia), Russia.

HYGIENE, SANITATION, EPIDEMIOLOGY AND MEDICAL ECOLOGY

L.P. Shadrina, A.A. Strekalovskaya, P.G. Petrova, T.A. Androsova, D.V. Bosikov

THE INFLUENCE OF GEOMAGNETIC STORMS ON THE DEVELOPMENT OF HYPERTENSIVE CRISES (AT THE EXAMPLE OF YAKUTSK RESIDENTS)

ABSTRACT

The data of appeal to the ambulance station with hypertensive crises of residents of Yakutsk with a geomagnetic field at the maximum (2013) and a minimum (2017) of the XXIV solar cycle was compared. It is shown that in the years of high solar activity, the effects of geomagnetic storms are manifested in the increase in the number of calls for emergency medical care with a preliminary diagnosis of the hypertensive crisis. At the same time, the majority are elderly and senile people, who, are believed, to have a cardiovascular system more susceptible to the influence of geophysical perturbations. An increase in the number of patients with hypertensive crisis is observed not only on the day of the maximum decrease of the Dst-index (the 0th day of the storm), but also in the interval from the -2th to the 2nd day of the storm. Differences in the reaction time are revealed depending on the type of geomagnetic storm: during sporadic storms, the maximum of calls is most often on the – 1st day, and for recurrent ones – on the 0th day.

Keywords: hypertensive crisis, cardiovascular diseases, geomagnetic storms, geophysical activity.

INTRODUCTION

Cardiovascular disease (hereinafter CVD) is the leading cause of the death all over the world: each year there is not another reason of death for many people but the CVD. One sort of cardiovascular complications and decrease in the working capacity of the population is the hypertensive crisis (hereinafter HC) – inadequate and biologically inexpedient (non-adaptive) response of the organism to the action of various factors, including environmental factors [5]. The main cause of this sort of disease, in the first place, is the state of the human body. In the modern world one can see exorbitant growth of the neuropsychological stresses, which cause a certain reaction

in the body, connected with changes in the blood supply of organs. Each such, albeit insignificant, change in blood circulation is reflected in the cardiovascular system.

In human pathology, hypertensive or hypertensive states play an important role, which is associated, on the one hand, with their high prevalence, and on the other hand, with their participation in pathogenetic mechanisms of CVD and their complications, often leading to a decrease in the working capacity of the population.

Hypertensive crisis (HC) is a patho_ logical reaction, characterized by a sudden increase in systolic and diastolic blood pressure in patients suffering from hypertension or symptomatic (secondary) arterial hypertension. Like any other pathological reaction, HC is the result of disturbances of the organism's reactivity in general or the reactive properties of tissues, organs and their systems, accompanied by a violation of the coronary or cerebral circulation. Sharp sudden increases in blood pressure can pose a threat to the life of the patient and require immediate intervention.

Factors associated with an increased risk of CVD can be divided into two groups: those that a person cannot change, and those that are amenable to change. The first group includes heredity, the aging process and other exogenous factors (psycho-emotional overload, excessive consumption of table salt and water, sudden cancellation of antihypertensive drugs, excessive physical activity). The second group includes such indicators as increased blood lipids (cholesterol and triglycerides), hypertension, smoking, lack of physical activity, excessive body weight, diabetes, stress and other endogenous factors [5].

In recent years, scientists increasingly pay attention to such objective factors as meteorological and geocosmophysical. The first factor includes weather conditions – temperature, wind, atmospheric pressure, precipitation. The geocosmophysical one– changes in the Earth's magnetic field, the level of solar activity, X-ray and other types of radiation caused by active processes on the Sun. By the magnitude of the impact on CVD, these factors are much inferior to those listed above, but their accounting can significantly improve the quality of life. This is especially true for residents of the high-latitude, Arctic zone, where the variations in geophysical activity are much stronger than in the middle- and low-latitude zones, and, consequently, the person is under the influence of more intense fields. It is noted that magnetic storms are dangerous in the first place for those who suffer from arterial hypertension and hypotension or heart disease. In the days of geomagnetic disturbances, the number of heart attacks, strokes and hypertensive crises increases by an average of 15 % [1, 3, 8].

The **purpose** of this work is to study the role of geomagnetic storms in the development of HC for the Yakutsk inhabitants, the determination of specific parameters of geomagnetic disturbances and possible mechanisms for their impact on CVD.

Materials and Methods of the research

The statistical processing of the data of the electronic database of calls to the ambulance because of HCs for 2013 and for the first half (6 months) of 2017 was performed. Medical data are compared with the Dst index of the geomagnetic field. During the geomagnetic storms Dst index has a characteristic variation: first it increases by 5-10 nT within 2-5 hours (the initial phase of the storm), then sharply, during 7-16 hours, falls by tens to hundreds of nT (main phase), and then slowly, within 3-6 days, returns to a calm level (recovery phase). The convenience of using this index is due to the fact that its online values are freely available on the website of the Center for Geomagnetism and Cosmic Magnetism of Kyoto University (Japan) [12]. The day of the main phase of the storm (maximum decrease of the Dst index) is taken as a 0-day of the storm.

Results and discussion

For a detailed study we selected geophysical data in 2013 and the first half of 2017. These years fall respectively on the maximum and minimum of the XXIV solar cycle. Compared with the previous ones, this 11-year cycle proved to be much weaker (Figure 1). If in the XXI (1976-1986) and XXII (1986-1996) cycles the number of sunspots (Wolf numbers, W) reached at the maximum the values W = 155 and W = 157 (respectively, in 1979 and 1989), and in (1996-2009) of the XXIII cycle W = 120 (2000), but in the XXIV cycle the maximum in February 2014 was only W = 71. The average annual number of sunspots in 2014 was W = 75, in 2013 it was slightly less W = 61. In the first half of 2017, the average Wolf number was only W = 15, which is typical for a minimum of solar activity.

In Figure 1, along with solar activity (W), the average annual values of the geomagnetic Dst-index module are shown by dashed lines. As you can see, geomagnetic activity also changes during the solar cycle but usually there are several maxima – one at the growth phase of the solar cycle and one or two at the decline phase. In the XXIV solar cycle, geomagnetic activity was also smaller than in previous cycles. The first maximum was observed during the growth phase of solar activity in 2012-2013 – the module of the average annual | Dst | = 8.0 nT in 2012 and 7.9 nT in 2013. The second maximum was at the decline phase in 2015 – the module of the average annual Dst = 15.5 nT. The first the maximum was much weaker than the second one. Thus, studied 2013 year falls at the growth phase of solar activity and on the first maximum of geomagnetic activity, but in 2017 geomagnetic activity was on decline phase after the second maximum in 2015.

The number of geomagnetic storms: in 2013 there were 43 storms, including 3 large, 19 moderate and 21 weak. According to the accepted classification, we consider storms as a weak if the main phase Dst decrease is 30 nT <| Dst | <50 nT, moderate storm with 51 nT <| Dst | <99 nT, and large storm with | Dst | > 100 nT. In the first half of 2017 there were 25 storms, 1 large, 7 moderate and 17 weak ones were recorded. For comparison – for the same time interval of 2013 there were 24 storms – 3 large, 8 moderate and 13 weak. So, although in the first half of 2013 and 2017 there were roughly equal total number of geomagnetic storms there were more intensive storms in 2013.

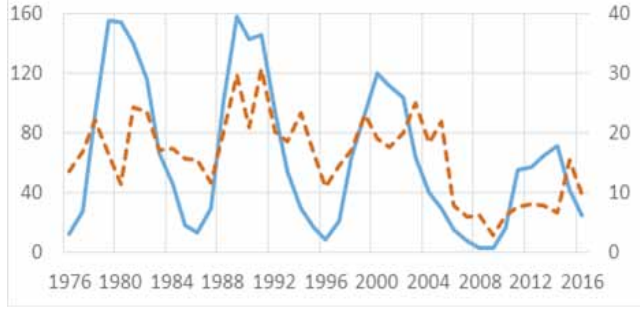

Fig. 1. The mean annual number of sunspots (Wolf numbers W) (solid curve, left scale) and the geomagnetic Dst index (dotted line, right scale) in the XXI-XXIV solar cycles.

In total, during the analyzed period of 2013 and the first half of 2017 there were 3103 ambulance calls for HC (Nhc), 2,267 in 2013 and 456 in 2017 (Table 1). Note that in the first half of 2017 Nhc = 456, which is 2.2 times less than in the same period of 2013 (1006).

In the majority of cases of the HC (2749 out of 3103, or 88.6%) was observed for people older than 50 years, which is quite logical, since pathogenetic factors contributing to the development of HC in elderly and senile people are the high content of angiotensin II circulating in the blood, the deficiency of kininogen, prostacyclin, damage to the vascular endothelium and a decrease in the release of vasodilating substances. At the same time in the vessels there are circulatory disorders of the type of ischemia, stasis or thrombosis, edema of the tissue, diapedesis bleeding. Stability of this indicator testifies its objectiveness: the percentage is almost unchanged both for the 2013 data, and for the first half of 2013 and 2017, and for all registered cases in total (see the third column). The percentage of young people (age younger than 50) is quite low, only 11.4%.

In addition to the age-related criteria in the development of HC and other cardiovascular complications, the sex of patients is an important determining factor too [7]. According to our data, out of 2 647 ambulance calls for HC women make up 78.3% (2 073) in 2013. In 2017, the indicator decreases slightly, to 74.3% (339 out of 456). It should be noted that men predominate among young patients (in 2013, 124 out of 574 or 21.6%, in 2017, 26 out of 117 or 22.2%). For women, this indicator is also stable and amounts to 177 out of 2 073 or 8.5% in 2013 and 27 from 339 or 8.0% in 2017. The frequency of HC for women aged 50 years and older, on the contrary, is several times higher than for men: 1896 against 450 in 2013 (4.2 times) and 312 against 91 in 2017 (in 3.4 times). This fact can be explained by a decrease in adaptive mechanisms in women during menopause, which is accompanied by a deficiency of estrogens due to natural extinction of ovarian function and, apparently, increases their sensitivity to geophysical factors [2, 6, 7].

Figure 2 shows the average daily values of the Dst index and the number of HC in the first half of 2013 and 2017. One can see the number of ambulance calls for HC (Nhc) in 2013 is significantly greater than for the same time interval in 2017 (in numerical terms, respectively, 1005 and 455).

As is known, geomagnetic storms are divided into two types – sporadic and recurrent. On Earth, this is reflected in the morphological characteristics of storms – sporadic storms more often shows a sharp start, more intense mail phase; recurrent storms starts more smoothly,

Table 1

Distribution of ambulance calls for HA by age and sex

Year	Nhc, all	age over 50 / %	woman			men		
			Nhc / %	age over 50 / %	Young / %	Nhc / %	age over 50 / %	Young / %
2013	2647	2346/88,6	2073/78,3	1896/91,5	177/8,5	574/21,9	450/78,4	124/21,6
2013-1	1006	887/88,2	786/78,1	721/91,7	65/8,3	220/21,9	166/75,5	54/24,5
2017-1	456	403/88,4	339/74,3	312/92,0	27/8,0	117/25,6	91/77,8	26/22,2
2013 and 2017	3103	2749/88,6	2749/77,7	2208/91,5	204/8,5	691/22,3	541/78,3	150/21,7

Note: all columns except the first one show the number of calls Nhc / percentage.

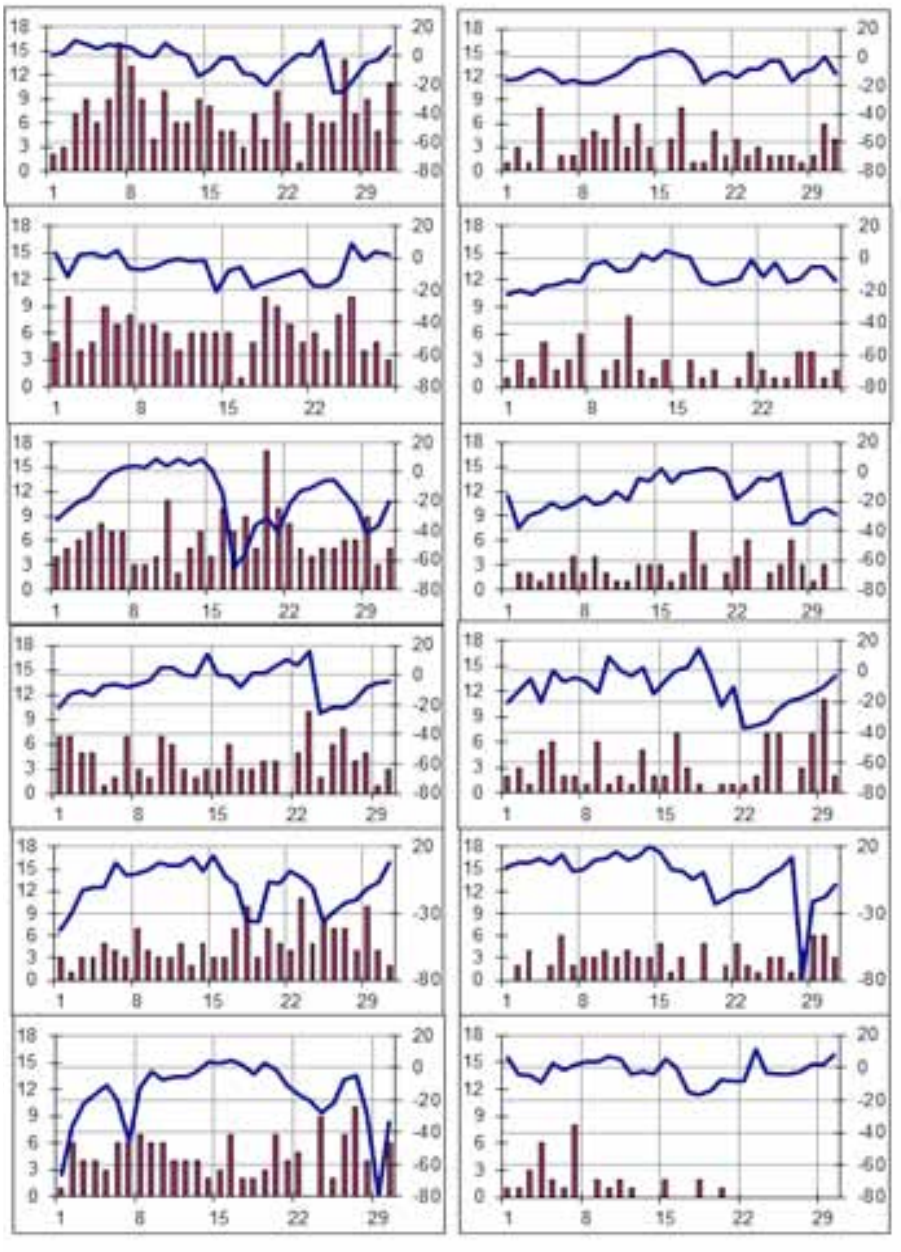

Fig. 2. Average daily values of the Dst-index (curve, right scale) and the number of patients with hypertensive crisis (histograms, left scale) from January to June (top to bottom) 2013 (left) and 2017 (right)

Fig. 3. Dst- index during large geomagnetic storms - recurrent (upper row) and sporadic (lower row) and number of patients with hypertensive crisis (columns, right scale).

several intensifications are observed during the main phase, and their duration considerably exceeds the duration of sporadic storms. The differences between these two types of geomagnetic storms are due to the difference in their solar sources – in the first case they are solar flares and associated coronal mass ejections (CME), in the second – long-lived coronal holes and corona high-speed flows (CIR) [4].

It was noted in [9, 10] that there are differences in the response of the cardiovascular system to these two types of storm. The type of storm we determined according to the method [11]. Figure 3 shows data during four large storms: two recurrent on March 17, 2013 (-132 nT) and on June 28, 2013 (-97 nT), and two sporadic on June 1, 2013 (-119 nT) and May 28, 2017 (-125 nT). One can see that during recurrent storms (upper row) Nhc increased 24 hours before the beginning of the storm (on the -1-th day). The increase in Nhc on the 3rd day after the onset of the storm on March 21, 2013 is most likely not related to geomagnetic activity and may be due to the age or individual reactivity of patients to external stimulus, or meteorological factors. During sporadic storms (lower row), Nhc increases on + 1 day after the onset of the storm.

It was shown in [3, 7, 9, 10] that changes in the cardiovascular system are observed not only on the day of the maximum decrease of the Dst- index (0 day of the storm), but also in the interval from -2 to +2 days of the storm. To test how this manifests itself in our study in the HC, we calculated Nhc (the number of ambulance calls for HC) in a 5-day storm interval (Table 2). There was calculated the number of storms for which the maximum of Nhc was observed, respectively on the -2-nd, -1-st, 0-th, 1-st or 2-nd day of the storm In 2013, at the solar cycle maximum, the number of sporadic storms was almost twice less than number of recurrent storms (15 and 28), and in 2017 (10 and 15).

Table 2 shows that an increase of Nhc is observed during most of geomagnetic storms: in 2013 this is true for 42 of 43 storms, and in 2017 there was no noticeable increase of Nhc in 7 cases out of 25, during weak storms. Of course, not all cases of Nhc increase are associated with a decreasing of the geomagnetic field (see Figure 2), but there is no well amplitude correspondence: during large storms, the Nhc increase may be less than during moderate storms, and sometimes even during weak storms there is a significant increase in Nhc. Hence, the increase in the number of applications for emergency medical care for HC is often associated with storms, but does not directly depend on the intensity of the storm.

As can be seen from the table, the growth of Nhc c during sporadic storms in 2013 more often occur on minus 2-nd and 1-st days (red color), but in 2017 this did not manifests. For recurrent storms, growth of Nhc more frequently occur on the day of the storm begins (0-day) – this is clearly visible in 2013, and in 2017 it is less pronounced. In total, for 25 sporadic and 43 recurrent storm events in 2013 and 2017 (the last 3 rows in the table), the growth of Nhc expressed fairly confidently on one day before the start of sporadic storms and on 0-day for recurrent. Accordingly, for all 68 storms, the maximum number of Nhc occurs on two days – the day before the storm begins (-1-day) and on the day of the maximum decrease of the Dst index (0- day). That is, there is a tendency of a time-differentiated reaction to sporadic and recurrent geomagnetic storms in the increase of the number of requests for medical care for HC (Nhc) in a five-day storm interval. These conclusions agree with results obtained earlier on other data [6-10].

Table 2

The number of storms with a maximum Nhc in the 5-day bore interval (from -2 days before the storm to 2 days after the storm began)

Type of storm	Number of storms	-2	-1	0	1	2	No
2013							
Sporadic	15	4	4	3	3	1	0
Recurrent	28	6	6	8	5	2	1
All	43	10	10	11	8	3	0
2017							
Sporadic	10	1	2	1	2	0	4
Recurrent	15	0	3	3	2	4	3
All	25	1	5	4	4	4	7
2013 and 2017							
Sporadic	25	5	6	4	5	1	4
Recurrent	43	6	9	11	7	6	4
All	68	11	15	15	12	7	8

Note. “No” column shows the number of storms, when there was no increase in Nhc during storm period.

Conclusion

The analysis of the data presented in the study shows the presence of a complicated, ambiguous connection of the number of requests for medical care for HC (Nhc) with geomagnetic activity. Nevertheless, the data studied agree with the previous results [9, 10] and allow

us to state that such a relationship exists.

1. The effects of geomagnetic activity are manifested in an increase in the number of requests for emergency medical care for the HC (Nhc) in years of high solar activity compared to the low.

2. 88.6% of all requests for emergency medical care are elderly and senile people, that is, people whose cardiovascular system reacts more strongly to more weak compared other factor – effect of geophysical activity.

3. The increase of Nhc does not directly depend on the intensity of the storm, but there has been a tendency for a different reaction on the number of calls for HC during sporadic and recurrent storms.

Acknowledgements

This work was made in the frame of project of the Program of Complex Scientific Researches in Republic Sakha (Yakutia) 2016- 2020, Russia and partly supported by RFBR grants № 15-45-05090-p_east_a, and № 15-42-05085-p_east_a.

REFERENCES

1. Gadzhiev G.D. Rakhmatullin R.A. Dorokhova A.N. Ekologicheskie aspekty vozdeystviya solnechnoy i geomagnitnoy activnosti na sostoyanie zdorovia sotrudnicov INC SO RAN [Ecological aspects of the effect of solar and geomagnetic activity on the health of employees of the INC SB RAS] Bulleten Vostochno- Sibirskogo nauchnogo centra [Bulletin of the East Siberian Scientific Center]. Irkutsk: 2010, No 6 (76) Part 1, pp.132-138.
2. Strekalovskaya A.A. Petrova P.G. Samsonov S.N. [et al.] Geomagnytnye vozmushenya i osloshneniya serdechno-sosudisty zabolevanyi [Geomagnetic disturbances and complications of cardiovascular diseases] Nauchno-teorenicheskyi zhurnal «Uspexi sovremennogo estestvoznanya» [Scientific and theoretical journal «Successes of modern natural science»]. 2004, pp.73-74.
3. Gurfinkel Yu.I. Ischemicheskaya bolezn serdsa i solnechnaia activnost [Ischemic heart disease and solar activity]. Moscow: Izd-vo Elf-3, 2004, 168 p.
4. Ermolaev Yu.I. Ermolaev M.Yu. Solnechnie i mezhplanetnye istochnyki geomagnitny buri: aspekty kosmicheskoy pogodyi [Solar and interplanetary sources of geomagnetic storms: aspects of space weather] Geophyzicheskie prosessy i biosfera [Geophysical processes and the biosphere], 2009, T. 8, No 1, pp. 5-35.
5. Zadionchenko V.S. Gorbacheva E.V. Gipertonycheskie krizy [Hypertensive crises] BC, 2001, № 15, pp. 628-633.
6. Petrova P.G. ,Strekalovskaya A.A., Komzin K.V. Reaksiya organyzma cheloveka na vneshnye vozmushenya. Glava 2 [The reaction of the human body to external disturbances. Chapter 2] V knyge «Biopropnoe vozdeystvie kosmicheskoy pogodyi» [In the book «Biotropic impact of space weather»] Ed. M.V. Ragulskaya. Moscow: IZMIRAN, 2010, P. 312.
7. Samsonov S.N. Sokolov V.D. Strekalovskaya A.A. Petrova P.G. O svyazy serdechno-sosudisty zabolevanyi s geofizycheskoy vozmushennostiy [On the connection between exacerbation of cardiovascular diseases and geophysical indignation] Zhurnal nevrologii i psyzianrii im. SS Korsakova [Journal of Neurology and Psychiatry. S.S. Korsakov] Stroke number 14, Moscow, 2005, pp.18-22.
8. Stoilova I. Dimitrova S. Breus T. Zenchenko T. Yanev T. Solnechno-zemnye svyazy i zdorovye cheloveka [Solar-terrestrial connections and human health] Solnechno-zemnya fysica [Solar-terrestrial physics]. 2008, No. 12, T.2, pp. 336-339.
9. Shadrina L.P. Petrova P.G. Samsonov S.N. Manykina V.I. Sravnenye izmenenyi v cardiogramme cheloveka vo vremya sporadycheski i rekurrentny bury (na primere shiteley Jakutska) [Comparison of changes in a human cardiogram during sporadic and recurrent storms (by the example of residents of Yakutsk)] Jakutskij medicinskij zhurnal [Yakutsk Medical Journal]. 2013, No 3, pp. 108-111.
10. Shadrina L.P. Vozdeistvye kosmicheskoy pogodyi na zdorovye shiteley Jakutska [The effect of space weather on the health of residents of Yakutsk] Prykladnya ecologya goroda Jakutska [Applied ecology of the city of Yakutsk]. Sat. works. Novosibirsk: Science, 2017, pp.177-187.
11. Shadrina L.P. Vasilyeva V.G. Chyslennyi parameter dlya opredelenya klassa geomagnytny bury [Numerical parameter for determining the class of geomagnetic storms] Issled. po geomagnetyzmu, aeronomii i fysike Solntsa [Issled. on geomagnetism, aeronomy and physics of the Sun]. Issue. 112, ed. SB RAS, 2001, pp. 163-167.
12. http://wdc.kugi.kyoto-u.ac.jp/dst_realtime/presentmonth/index. html

The authors:

Academy of Sciences of Sakha (Yakutia) Republic, Yakutsk, Russia:

Shadrina Lyudmila Pankratyevna - leading researcher;

Medical Institute of M.K. Ammosov North-Eastern Federal University, Yakutsk, Russia: Strekalovskaya Alena Anatolievna - Candidate of Medical Science, Associate Professor, a_strekalovskaya@mail.ru, Petrova Palmira Georgievna - MD, Professor, Head of Department;

State budgetary institution of the Sakha (Yakutia) Republic, Emergency medical station, Yakutsk, Russia: Androsova Tatyana Antonovna - Chief Physician, Dmitry Borisikov - Deputy Ch. doctor.