ATTENTION INDICATORS AS MARKERS OF FATIGUE IN AMBULANCE WORKERS

Bolobonkina TA ✉, Dementiev AA, Minaeva NV

Pavlov Ryazan State Medical University, Ryazan, Russia

Medical care at the pre-hospital stage requires concentration of attention from ambulance workers and induces stress on the functional systems of their bodies. The spread of COVID-19 has increased the workload on mobile ambulance teams and worsened functional state of the team members' central nervous systems. This study aimed to investigate the impact of professional activity on changes in the indicators reflecting attention capacity, allocation and switching in mobile ambulance healthcare workers in the context of the COVID-19 pandemic. We used the Number Square method to assess these indicators. The participants were divided into groups with the help of standard tens, through standardization of the number of digital symbols, correct answers, mistakes made and time spent. The clear signs of fatigue by the end of the work shift are the decreased attention capacity, registered in 40.48% ($p < 0.0001$) of participants, and deteriorating attention allocation, registered in 64.29% ($p < 0.05$). The dynamics of the indicators were revealed to be associated (negative trends) with length of service and age. The registered values did not decrease at each subsequent shift, which proves the rest period between the shifts ensures a sufficient recovery. Decreased attention capacity and allocation by the end of the shift, as objective signs of fatigue, depend on age and length of service. Lack of negative dynamics shift-to-shift shows that the functional resources of the body are restored during the prescribed rest period even in the intense conditions of mobile ambulance teams' work during the COVID-19 pandemic.

Keywords: medical worker, ambulance, fatigue, functional state, COVID-19

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✉ **Correspondence should be addressed:** Tatyana Alexandrovna Bolobonkina
8 Marta, 8, Ryazan, 390027, Russia; bolobonkina@bk.ru

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ПОКАЗАТЕЛИ ВНИМАНИЯ КАК ИНДИКАТОРЫ УТОМЛЕНИЯ МЕДИЦИНСКИХ РАБОТНИКОВ СКОРОЙ МЕДИЦИНСКОЙ ПОМОЩИ

Т. А. Болобонкина ✉, А. А. Дементьев, Н. В. Минаева

Рязанский государственный медицинский университет имени И. П. Павлова, Рязань, Россия

Оказание медицинской помощи на догоспитальном этапе требует концентрации внимания и напряжения функциональных систем организма сотрудников скорой медицинской помощи. Распространение COVID-19 увеличило нагрузку на выездные бригады и привело к негативным изменениям функционального состояния центральной нервной системы работников. Целью исследования было изучить влияние профессиональной деятельности на изменение показателей объема, распределения и переключения внимания медицинских работников выездных бригад скорой медицинской помощи в условиях пандемии COVID-19. Для оценки объема, распределения и переключения внимания использовали методику «Числовой квадрат». Разделение обследуемых на группы проводили по индексам стенов путем стандартизации показателей количества цифровых символов, правильных ответов, допущенных ошибок и затраченного времени. Снижение объема внимания у 40,48% ($p < 0,0001$) обследованных и снижение его распределения у 64,29% ($p < 0,05$) свидетельствуют об утомлении к концу рабочей смены. Выявлены негативные тенденции динамики показателей с увеличением стажа работы и возраста. Отсутствие отрицательной динамики показателей между соседними сменами свидетельствует о достаточном восстановлении за период отдыха. Уменьшение объема и распределения внимания к концу смены как объективные признаки утомления имеют зависимость от возраста и стажа. Отсутствие негативной динамики у работников между сменами является признаком восстановления функциональных ресурсов за период регламентированного отдыха в условиях напряженной работы выездных бригад скорой медицинской помощи в период пандемии COVID-19.

Ключевые слова: медицинские работники, скорая помощь, утомление, функциональное состояние, коронавирусная инфекция

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✉ **Для корреспонденции:** Татьяна Александровна Болобонкина
ул. 8-го Марта, д. 8, г. Рязань, 390027, Россия; bolobonkina@bk.ru

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The work of healthcare professionals implies extensive reliance on memory, concentration of attention, need to make complex decisions in non-standard situations, often based on insufficient information and pressed for time, with high personal responsibility for the result [1, 2]. These factors explain the high intensity associated with their work, which is especially true about medical workers providing emergency care [3]. Such conditions lead to professional burnout, which, according to the published research papers, develops more often among healthcare professionals helping patients in emergency

situations, when diagnosing and treatment become a complex tactical task that sometimes requires knowledge and skill beyond the competence of these specialists [4, 5]. The work schedule has a significant impact on the overstrain of functional systems of emergency responders. Medical personnel working in shifts or at night are especially susceptible to the negative effects of the respective factors on the functional state of the central nervous system (CNS), which directly affects the occurrence of dangerous health consequences [6]. Shift work can negatively affect awareness and performance due to lack of sleep and disruption of biological rhythms [7].

Attention is a dynamic characteristic of the psyche; it represents the orientation and concentration of consciousness. The ability to activate attention enables clear understanding of the situation [8, 9].

The levels of attention allocation and switching reflect the degree of mobility of nervous processes in the cortical parts of the CNS and determine the ability to quickly navigate a complex and changing situation. The latter quality is one of the most important components of a successful discharge of professional duty by mobile ambulance medics. The high intensity of work associated with their professional activity adversely affects the functioning of various body systems, translates into the growth of inhibition processes in the CNS and development of fatigue, the severity of which largely depends on gender, age, length of service and schedule (shift) [10].

The COVID-19 pandemic has significantly increased the load on the primary care system and further boosted the persistent fatigue processes evident among medical workers, including ambulance personnel [11]. Intensification of work at the pre-hospital stage exacerbated the negative dynamics of the professional burnout syndrome prevalence among workers. The main reasons for this were the limitedness of the healthcare system resources, the threat of viral contamination as an additional professional risk, increased time spent with a single patient because of the epidemic prevention steps made before and after contact with the patient, sleep disturbance, work-life balance, neglect of personal and family needs with increased workload in the background and lack of information about the methods of treatment and prevention of COVID-19 [12].

The above factors determined the relevance of this study, the purpose of which was to investigate the impact of professional activity on changes in the indicators reflecting attention capacity, allocation and switching among mobile ambulance healthcare workers in the context of the COVID-19 pandemic.

METHODS

City clinical ambulance station of Ryazan was the base facility for the study. Sample size sufficiency was calculated with the help of the standard resampling formula using the small population size correction technique. The inclusion criteria were: employment with Ryazan city clinical ambulance station as a member of a mobile ambulance team, shift-based: 24-hour work shift and a rest period of 72 hours; age up to 65 years (inclusive); length of service as a mobile ambulance medic — over a year; absence of medical contraindications to 24-hour shifts and hazardous working conditions.

Because of the severe epidemic situation and the pronounced ambulance staff shortage in the region, the teams of all specialties were literally devoid of breaks between calls, and the specifics of patient conditions became similar throughout the practice. Data from the Ambulance automated information system: the number of calls responded to by a single team through a shift ranged from 15 to 26 (average 19.45 ± 3.37), the total time of one call averaged at 45.46 ± 15.98 minutes. The participants were exposed to similar occupational factors and characteristics of the work process.

The sample was formed from May to October 2021. It included 42 medical workers (11 male and 31 female); 10 of them occupied positions of doctors, 32 — positions of paramedics. The mean age of the participants was 35.77 ± 3.39. NS-PsychoTest hardware and software complex (Neurosoft; Russia) was used for the study. Attention capacity (AC), attention allocation (AA) and attention switching were assessed with the help of the Number Square [13]. The examinations were done three times, during the time period from 7.00 to 8.00 AM, in accordance with the daily schedule of work shifts as follows: first examination — at the beginning of the daily work shift, second examination — 24 hours later at the end of the same shift, third examination — after 72 hours of rest (recovery period as per the applicable regulations), at the beginning of the next shift. The time allocated to the participants for the test was limited to 90 s. A single examination did not last longer than 3 minutes, including the methodology explanation and equipment set up stages.

The participants were divided into groups depending on the attention capacity and allocation levels, with the help of standard tens, which are normalized and centered assessments resulting from standardization of the number of digital symbols, correct answers, mistakes made and time spent.

The normality of the distribution of variables was checked with the help of Kolmogorov–Smirnov test. The Wilson's test (Wilson, 1927) was used to establish the confidence intervals for the stage of distribution of the examined into groups depending on the dynamics of the indicators; the significance of differences registered among the subgroups exhibiting oppositely directed trends was checked with the Pearson's chi-squared test; mean values of quantitative variables with a normal distribution are presented as $M \pm tm$ (M is the arithmetic mean of the indicator, expressed in absolute figures; m is the standard error, t is the test of validity with the given sample size).

We analyzed significant individual changes in functional indicators as registered during the work shift, when they fluctuate dynamically, and between adjacent shifts. Depending on the trend of indicator value changes, the participants were divided into three groups: group 1 — indicator value increased, group 2 — indicator value decreased, group 3 — indicator value did not change. Then we calculated the percentage of workers showing different dynamics of the studied functional changes, after that — compared groups of workers (occupation, age, length of service) by the percentage of participants exhibiting different trends of the considered indicators. The final exercise was to conduct a comparative assessment of the group means. To assess the significance of the average indicator value dynamics (mean difference between raises and falls) as registered considering the dynamics of the work shifts, we used the paired Student's t-test (the data obtained had a normal distribution). The statistical significance of the hypothesis was accepted at $p < 0.05$.

Statistical processing of the data was done with the help of Microsoft Excel 2007 (Microsoft; USA) with the Data Analysis add-on.

RESULTS

Table 1 shows the distribution of workers into groups by the nature of changes in AC through the work shift.

The physiological study revealed that by the end of the shift 40.48% of workers had the AC falling by 3.61 units on average

Table 1. Structure of workers with different individual dynamics of the attention capacity indicator against the shift-based schedule

Groups of workers	Groups with increasing AC		Groups with decreasing AC		Groups with unchanging AC
	Share, % ДИ, $p < 0,05$	Average growth of AC *t*-test	Share, % CI, $p < 0,05$	Average fall of AC *t*-test	Share, % CI, $p < 0,05$
Total *n* = 42	11,9	3,57 ± 1,04*	40,48	3,61 ± 0,98***	47,62
	[5,19; 25,0]	3,42	[27,04; 55,51]	7,33	[33,36; 62,28]
Sex distribution					
Women *n* = 31	12,9	3,16 ± 3,20	41,94	3,07 ± 1,04***	45,16
	[5,13; 28,85]	–	[26,42; 59,23]	5,87	[29,16; 62,23]
Men *n* = 11	9,09	4,66 ± 4,04	36,36	5,0 ± 1,90***	54,55
	[1,62; 37,74]	–	[15,17; 64,62]	5,27	[28,01; 78,83]
Age distribution					
Up to 30 y.o. *n* = 16	18,75	2,5 ± 1,73	50	3,00 ± 1,51*	31,25
	[6,59; 43,01]	–	[28,0; 72,0]	3,97	[14,16; 55,6]
30–39 y.o. *n* = 14	14,29	4,25 ± 3,3	14,29	6,00 ± 0,00	71,43
	[4,01; 39,94]	–	[4,01; 39,94]	–	[45,35; 88,28]
40 years and older *n* = 12	0	–	58,33	3,62 ± 1,41***	41,67
			[31,95; 80,67]	5,14	[19,33; 68,05]
Distribution by length of service					
0–5 years *n* = 13	23,08	2,50 ± 1,73	30,77	2,0 ± 1,15	46,15
	[8,18; 50,26]	–	[12,68; 57,63]	–	[23,21; 70,76]
6–10 years *n* = 12	8,33	1,00 ± 0,00	41,67	3,6 ± 2,15*	50
	[1,49; 35,39]		[19,33; 68,05]	3,34	[25,38; 74,62]
11 years and over *n* = 17	5,88	7,00 ± 0,00	47,06	4,33 ± 1,33***	47,06
	[1,05; 26,98]	–	[26,17; 69,04]	7,33	[26,17; 69,04]

Note: * — $p < 0.05$; ** — $p < 0.01$; *** — $p < 0.001$ — degree of significance using paired Student's *t*-test; CI, $p < 0.05$ — 95% confidence interval.

($p < 0.0001$). The share of participants whose AC increased was 3.4 times smaller; this indicator value did not change in the remaining participants throughout the working shift. It should be noted that the average AC decrease for men was 5.00 units ($p < 0.0001$), which is 1.6 times greater than that for women ($p > 0.05$). In 58.33% of the participants aged 40 years and older, we registered a significant mean AC decrease by 3.62 units ($p < 0.001$), and the remaining 41.77% of this age group's participants had this indicator unchanged.

We revealed an AC decrease trend associated with the length of service: from the 0-5 years mark to 11 and more years in service, the share of persons whose AC has deteriorated changed from 30.77 to 47.06%.

Table 2 shows the distribution of workers with different AA dynamics through a shift.

Most of the participants (64.29%; $p < 0.05$) had their AA decreasing by the end of the shift by an average of 3.0 units ($p < 0.0001$), with no pronounced gender differences registered in the choice behavior in the context of the work schedule's phase.

We have identified significant oppositely directed trends in the AA dynamics that depended on the age of workers ($\chi^2 = 11.407$; $p = 0.023$). In particular, half of the workers aged 30 and below exhibited a positive AA trend by an average of 2.62 units ($p = 0.0013$) and only 37.5% had the value of this indicator decreasing by an average of 3.28 units ($p = 0.0001$). On the contrary, in the age groups of 30–39 years and 40 years and older, the majority of participants (78.57 and 83.33%, respectively) had their AA value decreasing by the end of the work shift by an average of 3.60 and 3.45 units ($p < 0,0001$).

We have registered that the number of people whose AA value decreases tends to grow larger with the length of service. Thus, 82.35% of medical workers with an experience of 11 years or more have had their AA decreasing by an average of 3.71 units during the shift ($p < 0.0001$ — confidence level using Student's paired *t*-test), while those whose length of service ranged from 0–5 years to 6–10 years, lost in their AA capability 2.1 and 1.2 times less, respectively.

Physiological test have shown that, by the beginning of the next shift, 62.5% of the participants had their AA value changing to the better by an average of 2.2 units ($p < 0.0001$). This inter-shift AA improvement dynamics were registered in both men and women, the percentage of participants exhibiting the pattern — 55.56% (value increased by 2.33 on average) and 83.33% (value increased by 1.8 on average), respectively ($p < 0.0001$).

DISCUSSION

The significant deterioration of AA registered in most of the participants of the study signals of the fatigue-induced negative changes in the functional state of the CNS by the end of the work shift. A possible reason behind these processes is hard work with frequent calls and longer visit durations, as well as the need for additional anti-epidemic measures when coming in contact with infected patients. During the COVID-19 pandemic, the use of personal protection equipment contributed to the number and severity of fatigue symptoms, which resulted from the changes in the ergonomics of the work process ultimately compromising functional state and efficiency [14]. It is also known that emergency medical personnel performs better on day shifts than on night shifts [15]. The actual lack of sleep breaks with a continuous stream of calls from patients was

Table 2. Structure of workers with different individual dynamics of the attention allocation indicator against the shift-based schedule

Groups of workers	Groups with increasing AA		Groups with decreasing AA		Groups with unchanging AA
	Share, % CI, $p < 0,05$	Average growth of AA *t*-test	Share, % CI, $p < 0,05$	Average fall of AA *t*-test	Share, % CI, $p < 0,05$
Total *n* = 42	23,81*	3,98 ± 1,46***	64,29*	3,46 ± 0,78***	11,9
	[13,48; 38,53]	4,47	[49,17; 77,01]	8,81	[5,19; 25,0]
Sex distribution					
Women *n* = 31	25,81*	2,89 ± 1,51**	61,29*	2,95 ± 1,13***	12,9
	[13,7; 43,25]	3,83	[43,82; 76,27]	7,7	[5,13; 28,85]
Men *n* = 11	18,18*	5,5	72,73*	4,00 ± 3,05***	9,09
	[5,14; 42,70]	–	[43,44; 90,25]	8,1	[1,62; 37,74]
Age distribution					
Up to 30 y.o. *n* = 16	50	2,62 ± 1,41**	37,5	3,28 ± 0,84***	12,5
	[28,0; 72,0]	3,72	[18,48; 61,36]	7,81	[3,5; 36,02]
30–39 y.o. *n* = 14	14,29	5,33 ± 2,08	78,57	3,60 ± 1,37***	7,14
	[4,01; 39,94]	–	[52,41; 92,43]	5,24	[1,27; 31,47]
40 years and older *n* = 12	0	–	83,33	3,45 ± 1,56***	16,67
			[55,2; 95,3]	4,43	[4,7; 44,8]
Distribution by length of service					
0–5 years *n* = 13	46,15	2,50 ± 1,61*	38,46	3,16 ± 0,95***	15,38
	[23,21; 70,76]	3,1	[17,71; 64,48]	6,63	[4,33; 42,23]
6–10 years *n* = 12	25	4,00 ± 2,64	66,67	6,25 ± 1,29**	8,33
	[8,89; 53,23]	–	[39,06; 86,19]	4,08	[1,49; 35,39]
11 years and over *n* = 17	5,88	5,00 ± 2,82	82,35	3,71 ± 1,26***	17,65
	[1,05; 26,98]		[58,97; 93,81]	5,87	[6,19; 41,03]

Note: * — $p < 0.05$; ** — $p < 0.01$; *** — $p < 0.001$ — degree of significance using paired Student's *t*-test; CI, $p < 0.05$ — 95% confidence interval.

one of the important factors in the development of fatigue. There was also established a correlation between shift-based schedule, prevalence of drowsiness and a higher risk of workplace injury among ambulance workers [16, 17]. In this connection, monitoring attention indicators among providers of emergency medical services in order to reduce the number of occupational injuries is a task of practical importance.

The significant multidirectional trends seen in the dynamics of AA depending on the age of workers, as well as a pronounced increase of the proportion of workers with deteriorating AA in older age groups, indicate that the reserves a body has for adaptation to the specifics of work grow smaller with age, which leads to a more rapid development of fatigue [18]. The respective changes are caused by natural processes: aging disrupts the finely tuned balance of excitation and inhibition in the cerebral cortex and translates into functional disorders [8, 19].

We have found that the percentage of participants whose AC and AA tend to decrease through the shift as their length of service grows indicates its adverse effect on the development of fatigue processes in the higher parts of the CNS [20]. Long and hard work in the ambulance service leads to disruption of the processes of excitation and inhibition in the cortical parts of the CNS, which compromises attention allocation and switching.

Significant improvement of the AA indicator value registered in most workers at the beginning of their next shift (compared to the state recorded during the previous one) signals of a fairly complete restoration of the functional state of the CNS during the rest period prescribed by the applicable regulations, which is a positive factor.

Prolonged work implying continuous strain on the regulatory systems can lead to the development of various pathological conditions in a worker, as well as cause professional burnout [4, 5, 21]. Potentially, schedules without night shifts for the most maladjusted groups of workers combined with elimination of the shortage of teams (by employing reserve personnel) when the incidence is rising will help solve the problem.

CONCLUSIONS

The significant decrease of the AA indicator value registered in the majority of ambulance medics by the end of the work shift can be viewed as one of the objective signs of fatigue. The share of medical workers suffering deterioration of the functional capabilities of CNS in terms of AA tends to grow with age, which is an adverse trend. Comparison of the attention-related indicators registered at the beginning of adjacent shifts reveals no negative trends, which means the rest period, as prescribed by the applicable regulations, ensures sufficient restoration of the functional state of CNS. Tailored work schedules combined with elimination of the shortage of teams when the incidence is rising can help solve the stated problem. The next study dedicated to this subject, as planned, will rely on the similar algorithm and seek to evaluate effectiveness of the recommended preventive measures, as well as compare the attention-related indicators during the highest and lowest workload periods.

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