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Научно-методическая модель электронного паспорта здоровья для мониторинга физического, психического здоровья и физической подготовленности учащихся общеобразовательных учреждений

В современной школе в процессе обучения важным элементом достижения успеха является состояние здоровья учащихся. Являясь многогранным понятием, состояние здоровья характеризуется множеством показателей, которые требуют от коллектива образовательного учреждения значительных временных затрат для систематизации и анализа полученных данных, выработки практических рекомендаций по устранению негативных проявлений. Ускорить и повысить качество процесса мониторинга здоровья школьников возможно в современных условиях с помощью информационно-компьютерных технологий путем создания электронного паспорта здоровья учащихся.

В основу исследования положены методы теоретического анализа, синтеза, обобщения, аналитического моделирования организации и содержанию мониторинга здоровья детей, основанные на применении современных информационно-компьютерных технологий. Авторы предприняли попытку разработать научно-методическую модель электронного паспорта здоровья, в основе которого находятся научные подходы к оценке показателей физического, психического здоровья и физической подготовленности школьников.

Спроектированная концептуальная модель базы данных для компьютерной программы «Паспорт здоровья», позволяет не только получать общую и дифференцированную оценку уровня физического, психического здоровья и физической подготовленности, но и индивидуальные практические рекомендации на основе полученных результатов, отслеживать индивидуальные и групповые статистические показатели, проводить на основе методов математической статистики сравнительный анализ индивидуальных и групповых показателей участников образовательного процесса общеобразовательного учреждения.

Ключевые слова: физическое здоровье, психическое здоровье, физическая подготовленность, мониторинг, электронный паспорт здоровья

Ссылка для цитирования:

Воробьев Г. А., Чеботарев А. В., Панова И. П. Научно-методическая модель электронного паспорта здоровья для мониторинга физического, психического здоровья и физической подготовленности учащихся общеобразовательных учреждений // Перспективы науки и образования. 2021. № 6 (54). С. 521-535. doi: 10.32744/pse.2021.6.35

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The new scientific and methodological model of creating a digital health passport for monitoring physical and mental state and physical preparedness of comprehensive school students

School nowadays is focused on students' health as a prerequisite for a successful performance. The health status is a multifaceted concept which is gauged by various indicators. Determining the health status of children takes a lot of time resources on the part of educational staff engaged in systemizing and analysing the data and making practical recommendations for optimising students' health. Boosting the quality of health monitoring can be achieved via modern IT systems by creating a digital health passport for school students.

This research is based on the methods of theoretical analysis, synthesis, data generalisation, analytical modelling of the content and organisational process of health monitoring via modern information technology. An attempt was made to create a scientific and methodological model for collating and evaluating data on school children's physical health, mental health and physical preparedness. The data are presented in the form of a digital health passport.

The data were used as a basis for the computer programme The Health Passport which allows the user to obtain information on the general health status and differentiated aspects of health, such as physical or mental health and physical preparedness. The programme can also give individualised practical recommendations by analysing the test results; store statistically relevant information on individual and group performance; conduct comparative analysis of individual and group performance of comprehensive school students on the methodological basis of mathematical statistics.

Keywords: physical health, mental health, physical preparedness, monitoring, digital health passport

For Reference:

Vorobyov, G. A., Chebotarev, A. V., & Panova, I. P. (2021). The new scientific and methodological model of creating a digital health passport for monitoring physical and mental state and physical preparedness of comprehensive school students. *Perspektivy nauki i obrazovania – Perspectives of Science and Education*, 54 (6), 521-535. doi: 10.32744/pse.2021.6.35

Introduction

Health is an integral part of life. World Health Organization defines health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity [5]. This definition of health reveals two important elements – the physical and mental aspect. Physical health is a natural state of the organism in which all the organs and systems function normally [30]. Mental health is characterised by the general state of well-being which enables a person to utilise their potential, handle stress, be productive and make contributions to society [24]. Those two elements are closely intertwined and influence each other in such a way that the deterioration of one aspect will lead to the worsening of the other.

At present school children are being diagnosed with psychophysiological disorders and motor impairments at an alarming rate both in Russia [27], and abroad [29; 17]. Statistics shows that absolutely healthy children comprise just 16% of the child population in Russia (health group 1), 50% of children possess some functional impairment (health group 2), 35-40% have chronic illnesses [2]. It is worth noting that there is no statistically relevant difference between the health status of children living in the city and in the countryside [25].

The reason for the decline in health is not only in the sedentary lifestyle, but also the absence of an impactful health monitoring system that would be based on modern information technology and implemented into the education process. This dire issue warrants a better response and mobilisation of scientific, methodological and technological resources. There is a gap between the need for improving and sustaining health in the population of school students and the absence of any systemic technology-based solutions that would offer objective and well-rounded evaluation of the dynamics of physical health, mental health and physical preparedness of students in today's schools.

The aforementioned gap enabled us to formulate the goal of this research as follows: to design a scientific and methodological model of the digital health passport for monitoring physical health, mental health and physical preparedness of school students.

To reach the goal that has been set it is necessary to compile theoretical works and practical research in the field of health monitoring of school students' physical health, mental health and fitness levels; to pick the most methodologically relevant tests that would help determine students' health status; to create an algorithm of data collection, storage and analysis.

Materials and methods

This paper presents theoretical research which collates and systemises the existing approaches and information technology that are used for the monitoring of human health.

The following scientific data bases were consulted: Scopus, Web of Science, Google Scholar, RSCI. The key words used in obtaining all the necessary information were formulated as follows: physical health, mental health, physical preparedness, monitoring, digital health passport, etc. Within the framework of the theoretical research the authors analysed scientific papers published in peer-reviewed magazines and scientific conference materials.

Resource analysis

The developing organism of a school child is susceptible to negative environmental impact. Children need systematic pedagogical and psychological monitoring that would help notice the first signs of developmental disorders [1; 14]. Each of the aforementioned types of monitoring is used separately in educational practice of comprehensive schools. The process of data collection, storage and collation is fragmented and carried out by narrow specialists (healthcare staff, psychologists, PE teachers) who don't work as a team. This often leads to inability to map out the bigger picture in a timely manner and see the dynamics of a student's health status in a certain time period. More than that, it is impossible to do a comparison of individual (student vs student) and group (class vs class) dynamics. Therefore, it would be an effective solution if schools had access to a systemised source containing health profiles of children in order to facilitate efforts of the team responsible for the well-being of children. The Health Passport has the potential to become that source.

The concept of the health passport is not new. The monitoring of health status in the form of a digital passport has been attempted by many Russian scholars.

T. I. Klokova researched into the problem of monitoring medical health and presented the results in the form of a digital health passport created for school children. The digital passport system was intended as a tool for pediatricians to systemise and process health-related information [9].

The scientific works of P. P. Kuznetsov are devoted to the problem of medical health monitoring by introducing the Digital Health Passport for Children programme. He offers two systems of health passports: a subscription model with a medical insurance option included, and a data-based model that would allow users to access health-related information via the helpdesk of the Hospital Analytical and Information Centre or via a dedicated Internet resource [15].

V. V. Budyonov stresses the importance of an "open digitised system for health monitoring in schools" and the need to put more emphasis on maintaining good health throughout all the levels of education. He believes that the Digital Health Passport for Children programme could be a major component of a health-centric educational system - provided that this system follows all the up-to-day standards of health monitoring [3].

N. G. Preferansky and T. L. Guskina note that the ever improving data storage and data exchange systems are a key factor in making health-related information more transparent and available for every citizen. This approach, as the authors state, can aid in integration of medical information, digitally stored in different medical establishments; it can also boost medical literacy by giving the general population an opportunity to monitor their health levels, to subsequently improve their health and to have more awareness in terms of the medical help available to them [23].

The importance of monitoring the health of people working in high-risk environments via the health passport system is stressed in Y. A. Shavrin's work. He proposes that a unified system of monitoring health dynamics throughout an entire professional career should be instated [28].

The system of health passport is also supported by many researchers who study the health of university students.

O. A. Naumenko, S. V. Notova, I. E. Alidjanova and P. A. Boldyrev devised an approach integrating different health indicators measured in the university student population. This digital system was implemented to register personal data, physical health levels, and the levels of physical and functional preparedness. The programme is intended for automating the process of health evaluation with the help of the available data based on a student's biological sex, individual health characteristics; for storing the users' information, making prognoses and giving lifestyle advice to improve physical health levels; for gathering and collating personal data on physical health and physical preparedness in the form of graphs to provide students with recommendations in a visual format [20].

While attempting to gauge physical health and physical preparedness of students in the Kursk State University, S. M. Yatsun, D. V. Bepalov and A. S. Gorbunova created the platform Digital Health Passport of Students to evaluate the dynamics of first-year students' health levels. The data stored in Digital Health Passport of Students are intended to be used not only for evaluating health dynamics, but also for devising individualised action plans to prevent diseases and improve health in a student population with health pathologies [32].

The key factor of a successful implementation of digital health passports is the programme's usability.

According to I. I. Yeremin, the LMS MOODLE platform (open-source learning management system) is optimal for implementing the digital health passport for school students [10].

A. A. Kuznetsova and S. N. Shirobokova created a digital system called the Digital Health Map using the 1C Enterprise 8.3. Their system is intended for personal use of one's health information collected from different medical care organisations. The programme has various functions: data import, the import of visual medical data, evaluating daily calorie requirements, storing data on individual health indicators, monitoring health status and medical history, storing medical checkup and prescription data, storing and collating medical test data. The programme also has several side functions: capturing and graphically representing health indicator dynamics: body temperature, blood pressure, body mass index, lipid and glucose levels [16].

At present, the software of many mobile and PC devices allows the user to monitor their health.

The non-profit organisation Asthma UK has developed an application called Digital Health Passport, which is designed to help young people with asthma manage their symptoms, monitor their health and create actions plans for managing asthma [8].

OneLedger Innovation Tech Inc. created a mobile application Health Passport, which makes use of a unique distributed ledger technology that helps improve data safety and data verification to authenticate medical information on vaccination status of people crossing country borders. This technology solves problems related to COVID-19, but its potential is far-reaching as it provides improved data safety and information availability [12].

1C, a company specialising in the development, sharing, releasing and implementing computer programmes for the home and business, created Digital Health Passport of a Child which is designed in the form of an organiser for medical information for the personal use of school children and their parents. This digital product offers the following features [7]:

- storing visual medical information in the form of graphs;
- storing scanned test results, radiographs, discharge summaries;
- self-monitoring body mass index, blood pressure, etc.;
- keeping a health diary for children with chronic diseases;
- creating graphs demonstrating dynamics of a certain health index;

- structure and data base developed in accordance with personalised health monitoring standards and regulations of Europe, North America and the Asia-Pacific region.

The 1C:Health Monitoring in Education programme was created for more efficient application performance management in the field of school education and healthcare (i. e. healthcare provided for children in kindergartens, schools, orphanages or technical schools). This product acts as a tool for collecting and analysing data on individual and group health of school children, their physical preparedness, results of monitoring their eyesight, posture, results of multisystemic sangeretic monitoring, academic performance and other indexes of their medical, psychological and academic status [4].

Despite the growing number of programmes designed for implementing the digital health passport, most educational institutions don't use them for several reasons:

1. An overwhelming number of tests for monitoring the health status of children requires time resources on the part of healthcare workers.
2. The tests require performing physical tasks that are not part of the school syllabus for Physical Education.
3. Psychological tests require an extensive amount of documentation and time for analysing the documents.
4. Poor usability of the programmes.
5. Limited opportunity for comparative data analysis since the tests differ for each developmental stage.

While developing our own Health Passport system we took into account the experience of the scientific community and set out to solve the common issues that healthcare workers face when implementing digital health passports in schools.

Results

The health passport we have designed includes three entries:

- Physical health.
- Mental health.
- Physical Preparedness.

The **Physical Health** entry includes measuring the adaptive capacity indicator via P. M. Bayevsky's method. This method is designed to determine systemic health status and break it down into several health indicators [19]. The adaptive capacity (AC) characterises the work of all the body systems and their adaptability. AC is measured via the following formula:

$$AC = (0,011*HR) + (0,014*RSBP) + (0,008*RDBP) + (0,014*age) + \\ + (0,009*body\ mass) - (0,009*height) - 0,27$$

Note:

RSBP – resting systolic blood pressure

RDBP – resting diastolic blood pressure

The advantage of the adaptive capability test is in the fact that it requires no physical performance tasks and serves as a baseline indicator of the subject's health levels (Table 1).

Table 1**Adaptive capacity potential in a point system**

Adaptive capacity (points)	Level of adaptation	Level of the functional state of the body	Score
< 2,60	Satisfactory adaptation	The body performs its functions on a high or satisfactory level	4
2,60 - 3,09	Alert adaptation mechanisms	The body performs its functions on a satisfactory level due to sufficient body reserves	3
3,10 – 3,49	Unsatisfactory adaptation	Low level of functional adaptation	2
> 3,50	Critical lack of adaptation	Sleep decline in functional adaptation	1

The **Mental Health** entry is designed for the studying of psychological health of school children, which is characterized by adequate reaction to internal and external stimuli, peace of mind, adequate behaviour, the ability to regulate one's emotional state and handle stress, the need for self-improvement and self-discovery [22].

The wealth of psychological methods created for studying the mental state of school children allowed us to choose those which are widely used by practicing school psychologists:

For primary school students (grades 1-4):

- The Ladder test (by V. G. Schur).
- The Evaluation Test for Motivation and Academic Involvement (by N. G. Luskavona).

For secondary and high school students (grades 5-11):

- The Self-esteem test (by T.V. Dembo and S.Y. Rubinstein).
- The Diagnostic Evaluation of Academic Motivation and Emotional Involvement in the Educational Process (modified by A. D. Andrejeva).

Self-esteem is a personal characteristic that serves as a baseline for healthy interpersonal and intrapersonal relationships. V. G. Schur's method called The Ladder is designed for identifying the ways in which a school child evaluated his or her own self, relates to other people's evaluation of him- or herself and how those evaluations interact [11]. For evaluating self-esteem in older school children we suggest using T. V. Dembo and S. Y. Rubinstein's Self-esteem test. The methodology behind this test is based on a system of grading several personal qualities of children: health, abilities, character, peer relationships, self-confidence, handiness. The subject is asked to measure his or her personal qualities on a scale and to contrast it with the desired level of those qualities [33].

Academic involvement, mid to high range motivation and intellectual curiosity are important indicators of a well-rounded person. N. G. Luskanova's methodology The Evaluation Test for Motivation and Academic Involvement allows a mental health professional to make necessary corrections to the academic process in order for it to better suit the child's needs and boost academic productivity [26]. The Diagnostic Evaluation of Academic Motivation and Emotional Involvement in the Educational Process methodology modified by A. D. Andrejeva helps diagnose the level of intellectual curiosity, motivation, anxiety and anger in older school children [18].

The selected methods are easy to implement and useful in obtaining objective evaluations of children's mental health.

The **Physical Preparedness** entry includes some indicators of physical fitness: speed, physical strength, stamina, flexibility and agility – all the physical qualities that a child should possess after taking PE classes for a certain period of time [13]. The set of fitness tests

includes tasks that are part of the Russian Sports and Physical Training Programme 'Civil Defense', which was implemented by the power of Presidential Decree №172, March 24th, 2014 [5]. From the numerous tests offered by the Russian Sports and Physical Training Programme 'Civil Defense' [21] we have selected those which can be implemented on all the levels of child development and which are easy to perform from the organisational standpoint. Those tests are the following:

- 30 meter run;
- 3x10 meter shuttle run;
- double-leg long jump;
- hang pull up on a horizontal bar;
- arm bending and straightening while lying on the floor;
- torso lifting while lying on the back (times per minute);
- 1000 (1500, 2000, 3000) meter run;
- Forward bend while standing on a gymnastic bench.

Individual and group test results are contrasted with the Russian Sports and Physical Training Programme 'Civil Defense' average score points considered developmentally appropriate (Tables 2-6).

Table 2

Physical preparedness score norm for children aged 6-8

Activity (tests)	Boys				Girls			
	SCORE							
	0	1	2	3	0	1	2	3
30 m run, (per sec)	> 6,9	6,9	6,7	6,0	> 7,1	7,1	6,8	6,2
3x10 m shuttle run (per second)	> 10,3	10,3	10,0	9,2	> 10,6	10,6	10,4	9,5
double-leg long jump (cm)	< 110	110	120	140	< 105	105	115	135
hang pull up on a horizontal bar (times per minute)	< 2	2	3	4	-	-	-	-
arm bending and straightening while lying on the floor (total number of times)	-	-	-	-	< 4	4	6	11
torso lifting while lying on the back (times per minute), (total number of times)	< 21	21	24	35	< 18	18	21	30
1000 m run (min, sec)	> 7.10	7.10	6.40	5.20	> 7,35	7,35	7,05	6,00
forward bend while standing on a gymnastic bench (cm)	< 1	1	3	7	< 3	3	5	9

Table 3

Physical preparedness score norm for children aged 9-10

Activity (tests)	Boys				Girls			
	SCORE							
	0	1	2	3	0	1	2	3
30 m run, (per sec)	> 6,2	6,2	6,0	5,4	> 6,4	6,4	6,2	5,6
3x10 m shuttle run (per second)	> 9,6	9,6	9,3	8,5	> 9,9	9,9	9,5	8,7
double-leg long jump (cm)	< 130	130	140	160	< 120	120	130	150

hang pull up on a horizontal bar (times per minute)	< 2	2	3	5	-	-	-	-
arm bending and straightening while lying on the floor (total number of times)	-	-	-	-	< 5	5	7	13
torso lifting while lying on the back (times per minute), (total number of times)	< 27	27	32	42	< 24	24	27	36
1000 m run (min, sec)	> 6,10	6,10	5,50	4,50	> 6,30	6,30	6,20	5,10
forward bend while standing on a gymnastic bench (cm)	< 2	2	4	8	< 3	3	5	11

Table 4

Physical preparedness score norm for children aged 11-12

Activity (tests)	Boys				Girls			
	SCORE							
	0	1	2	3	0	1	2	3
30 m run, (per sec)	> 5,7	5,7	5,5	5,1	> 6,0	6,0	5,8	5,3
3x10 m shuttle run (per second)	> 9,0	9,0	8,7	7,9	> 9,4	9,4	9,1	8,2
double-leg long jump (cm)	< 150	150	160	180	< 135	135	145	165
hang pull up on a horizontal bar (times per minute)	< 3	3	4	7	-	-	-	-
arm bending and straightening while lying on the floor (total number of times)	-	-	-	-	< 7	7	9	14
torso lifting while lying on the back (times per minute), (total number of times)	< 32	32	36	46	< 28	28	30	40
1500 m run (min, sec)	> 8,20	8,20	8,05	6,50	> 8,55	8,55	8,29	7,14
forward bend while standing on a gymnastic bench (cm)	< 3	3	5	9	< 4	4	6	13

Table 5

Physical preparedness score norm for children aged 13-15

Activity (tests)	Boys				Girls			
	SCORE							
	0	1	2	3	0	1	2	3
30 m run, (per sec)	> 5,3	5,3	5,1	4,7	> 5,6	5,6	5,4	5,0
3x10 m shuttle run (per second)	> 8,1	8,1	7,8	7,2	> 9,0	9,0	8,8	8,0
double-leg long jump (cm)	< 170	170	190	215	< 150	150	160	180
hang pull up on a horizontal bar (times per minute)	< 6	6	8	12	-	-	-	-
arm bending and straightening while lying on the floor (total number of times)	-	-	-	-	< 8	8	10	15
torso lifting while lying on the back (times per minute), (total number of times)	< 35	35	39	49	< 31	31	34	43
2000 m run (min, sec)	> 10,00	10,00	9,40	8,10	> 12,10	12,10	11,40	10,00
forward bend while standing on a gymnastic bench (cm)	< 4	4	6	11	< 5	5	8	15

Table 6

Physical preparedness score norm for children aged 16-17

Activity (tests)	Boys				Girls			
	SCORE							
	0	1	2	3	0	1	2	3
30 m run, (per sec)	> 4,9	4,9	4,7	4,4	> 5,7	5,7	5,5	5,0
3x10 m shuttle run (per second)	> 7,9	7,9	7,6	6,9	> 8,9	8,9	8,7	7,9
double-leg long jump (cm)	< 195	195	210	230	< 160	160	170	185
hang pull up on a horizontal bar (times per minute)	< 9	9	11	14	-	-	-	-
arm bending and straightening while lying on the floor (total number of times)	-	-	-	-	< 9	9	11	16
torso lifting while lying on the back (times per minute), (total number of times)	< 36	36	40	50	< 33	33	36	44
2000 m run (min, sec)					> 12,00	12,00	11,20	9,50
3000 m run (min, sec)	> 15,00	15,00	14,30	12,40				
forward bend while standing on a gymnastic bench (cm)	< 6	6	8	13	< 7	7	9	16

In the process of analyzing the subject area under consideration, its conceptual model has been developed. In this case, the conceptual model contains the entity of the analyzed subject area and the relationship between them. It determines the semantic structure of the subject area under consideration, in a fairly generalized form. In other words, the conceptual model is an entity-relationship diagram (ER diagram, Entity, Relation). Without specifying attribute types, the generated diagram is shown in Figure 1.

Figure 1 Conceptual subject area model (ER-diagram)

The entity in the considered diagram is understood as an object of any nature (not necessarily physical) information about which will be stored in the generated database. For the considered entities their attributes are pointed in the diagram. An attribute is a property characterizing a corresponding entity.

Let's carry out a brief generalized description of the model created not going into detail about its realization in the database (DB) and the final computer application.

The formed database provides an opportunity to choose a region, municipality, educational institution, form (group in the additional education system, student group), to fill in the information necessary for the health passport formation of each pupil (listener, student). To simplify the work with the database of the end-user the entities "Region", "Municipality", "Organization" contain attributes Current of logical type. The "Yes" value corresponds to the notes connected with the educational institution where the DB is currently used.

The entities "Physical preparedness" and "Physical Health" include data on the subject's physical preparedness and physical health respectively in relation to the testing period. The information about the class or the students' age, month (September or May) is in the entity "Class_test". The entity "Points_ Physical Preparedness" is used for storing the data on the criteria of turning the students' results into points.

The entities "Test_Ladder" and "Test_3" contain data on psychological tests "Ladder" and the test on studying self-esteem according to the method of Dembo-Rubinstein in the modification of A.M. Prikhodzhan. The students' results of these tests in the corresponding period are fixed in the entities "Student_Test_Ladder" and "Student_Test_3".

The entities "Test_2_Questions" and "Test_4-Questions" contain respectively test results on assessing school motivation and academic involvement (N. Luskanov test) and diagnosing Academic Motivation and Emotional Involvement in the Educational Process in middle and high school (method of L. Tikhomirova, in the modification of A. D. Andrejeva).

The relations between the entities are shown by means of two different types of lines. The dashed lines correspond to the relations of the type "One to many" (1:M), solid lines are relations of the type "One to Many" (M:M). In 1:M relationships one instance of the first entity may correspond to a few instances of the second entity, and the reverse is not true. In M:M relations one instance of the first entity may correspond to a few instances of the second entity, and the reverse is also true. M:M relations are transformed in the process of study; the final variant of the diagram is shown in Figure 2.

Discussion of results

We agree with the authors of the studies that monitoring physical, mental health and physical preparedness is an essential part of educational process of comprehensive school students [23], and a digital health passport should be its key integral component [9; 3].

The digital health passport model designed by us for monitoring physical, mental health and physical preparedness of comprehensive school students, unlike other authors [20; 16], gives an opportunity to trace changes in the state of health of both an individual child and school students as a whole, to take prompt measures to improve it.

The automated system of the digital health passport allows us to optimize and systemize large amounts of information on various parameters characterizing human health.

As a result of the use of the digital health passport on the basis of the developed model there appears a possibility of creating a balance between the learning process and the state of health of the participants in the educational process.

Figure 2 ER diagram after M:M relations transformations

Findings

The developed scientific and methodological model of the digital health passport for monitoring physical, mental health and physical preparedness of the educational process participants in modern educational environment is based on unified scientific approaches to assessing the indicators of physical, mental health and schoolchildren's physical preparedness. The tests offered to educational process participants are widely used both in scientific research and in practical work of general educational institutions.

At this stage of the study the conceptual model of the database "Health Passport" has been designed which involves the development and testing the computer program "Health passport" which allows:

- to enter into the database the test results characterizing physical, mental health and physical preparedness of the participants of the educational process in a general educational institution;
- to get the general and differentiated assessment of the level of physical, mental health and physical preparedness of the participants of the educational process in a general educational institution;
- to get individual practical recommendations on the basis of the received results of physical, mental health and physical preparedness of the participants of the educational process in a general educational institution;
- to monitor individual and group statistical indicators of physical, mental health and physical preparedness of the participants of the educational process in a general educational institution;
- to carry out on the basis of mathematical statistics methods a comparative analysis of individual and group indicators of physical, mental health and physical preparedness of the participants of the educational process in a general educational institution.

Further the scientific and practical activity will require:

- the development of scientific and methodological manual on the organization of monitoring for healthcare workers of a general education institution;
- conducting training seminars/webinars on the topic "Health Passport" for healthcare workers of a general education institution;
- the development of draft regulatory and legal documents which will contribute to the organization and implementation of "Health Passport" in the practice of a general educational institution.

Thus, the carried-out research activities will allow us not only to improve the process of healthcare work in the conditions of a modern educational institution, but also to increase the level of health of the younger generation.

Gratitude

The research has been conducted under the project "Development and implementation of digital health passports for monitoring physical, mental health and physical preparedness of the participants in the educational process in modern learning environment" which is being implemented with the financial support of the Ministry of Education of the Russian Federation, within the framework of the state task (agreement No. 073-03-2021-017/2 of 21.07.2021)

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