Database development for the automated workplace of the perinatal neurologist

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ABSTRACT: The paper describes the development of a specialized database for the automated PC workplace of the perinatal neurologist that can be implemented in perinatal centers. We defined the subject area for such database, developed the conceptual model of the database, its logical (infological) structure, created the adjacency matrix of the database entities, and designed a physical model of a database for an automated workplace of the perinatal neurologist. The structure and content of the database are customized for use in perinatal centers and hospitals and include the neurologist review database, reference database, EMG analysis database, service database. Specific database entities and their attributes are also considered.

1 INTRODUCTION

Perinatal centers in Ukraine are now well-equipped, but they are not provided with specialized medical information systems to ensure optimal mode of their activity. Design and implementation of such information systems are the important tasks of the development of perinatal medicine (Shunko 2011), as far as they will provide quick access to the data of patients, reference information, telemedicine, etc. Such systems provide systematization and generalization of clinical data, and, based on this, the selection of optimal regimens of treatment and rehabilitation. The lack of appropriate information systems forces the physicians to spend a lot of time on organizational work, less on medical care.

Solving the task of building an automated workplace (AWP) for a neurologist physician is impossible without the design, development, and implementation of an information warehouse of data arrays that arise in the process of medical research, reviews, analyzes on the one hand, as well as certain reference expert data on the other hand. Some examples of neurologist AWP are known (for example (Shakhnovich & Preobrazhenskiy 2006)), but they deal with adults or talking children. The perinatal module is included in the database (Tsaregorodtsev & Gorlov 2006), but it is quite limited. An automated workplace of the

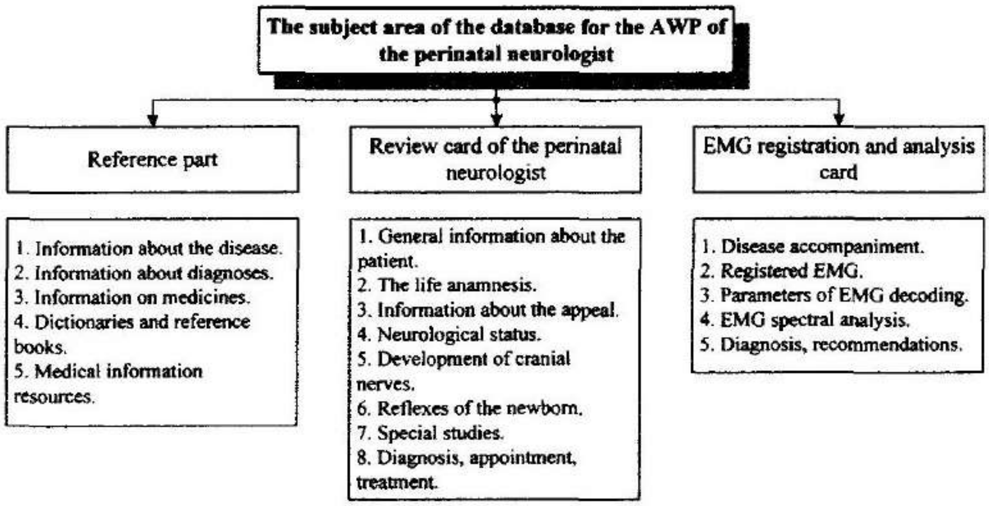

Figure 1. The subject area of the database for the AWP of the perinatal neurologist.

pediatrician-neurologist in the perinatal center is proposed in (Zlepko et al. 2016), but its database is not developed enough.

In the general case, the database can be interpreted as a named set of data that is structured somehow and interconnected with one subject area. This set has certain functioning laws and DBMS governing the operation of the database (Abiteboul et al. 1995).

Taking into account this definition, the scope of application of the developed AWP can be represented in the form of the structure depicted in Fig. 1.

As an array of data that will be stored in the database, there are sets of text, numeric and visual data that allow to form a patient's health monitoring process, to store the general information contained in their personal medical cards and to analyze their electromyogram.

Each element of the given structure represents an array of certain typed information and is expressed in the general conceptual database model; it has its content and relationships, and it is related in some way to neighboring objects (Chui et al. 2015, Kovalenko et al. 2017, Zlepko et al. 2016). Thus, each developed database is responsible for its own defined and clearly defined scope of data.

There are three main thematic constituents of the subject area: a reference part, a neurologist's review card and an EMG registration and analysis unit (Barashnev 2005). Each component is subdivided into separate sub-fields due to its content and filling.

The optimal database structure can only be provided with its prior design and strict implementation of the optimization rules. The main purpose of database design is to reduce the redundancy of stored data and ensure its integrity. It corresponds to the algorithm of decision making in neonatal neurology (Fenichel 2007). It also allows to save the memory space, reduce the cost of data operations, and eliminate the possibility of conflicts due to the storage of duplicate data. While designing a database, two problems are to be solved:

1. Converting the objects of the subject area considered into the formal objects of the selected data model using a selection of the typology and coding tables for the information fields of the database.
2. Ensuring the execution of queries to the database by placing data in a structured form in memory.

2 METHODOLOGY

Designing databases for modern information systems is carried out on two levels—logical and physical. At the logical level, a conceptual data model is being developed, and on the next level it expands into a datalogical model. The datological data model contains a description of the subject area, executed in the language of the selected database management system

(DBMS). In our case, the MySQL 5.5 DBMS was chosen, which is noted for its speed, input-output queries design simplicity, wide settings, and customer-server technology orientation.

We developed the conceptual model of database (Fig. 2) that reflects the logical connections between the data elements, regardless of their content and storage environment. It is based on a physical model that defines the location of the data, access methods and indexing techniques in accordance with the database management system used.

Since the chosen DBMS supports the relational data model, databases serving the neurologist automated workplace are also based on it. Their important feature is that in determined conditions, the relations in the subject area are presented in the form of two-dimensional tables, which is convenient for human perception.

A relational data model is a set of relations that are two-dimensional tables that contain certain data and can change over time. In addition to the relations, this model assumes the presence of other objects such as attribute (a named characteristic of the entity) and tuple (a value of all attributes of one instance of the entity in relations).

Relations between entities are implemented using keys, one of them is implemented in the developed database—the primary key, which is the minimum set of attributes, with the values of which each instance of the entity can be uniquely identified (Weber 1996, Serkova et al. 2017). The presence of this primary key in the database provides the requirement for the

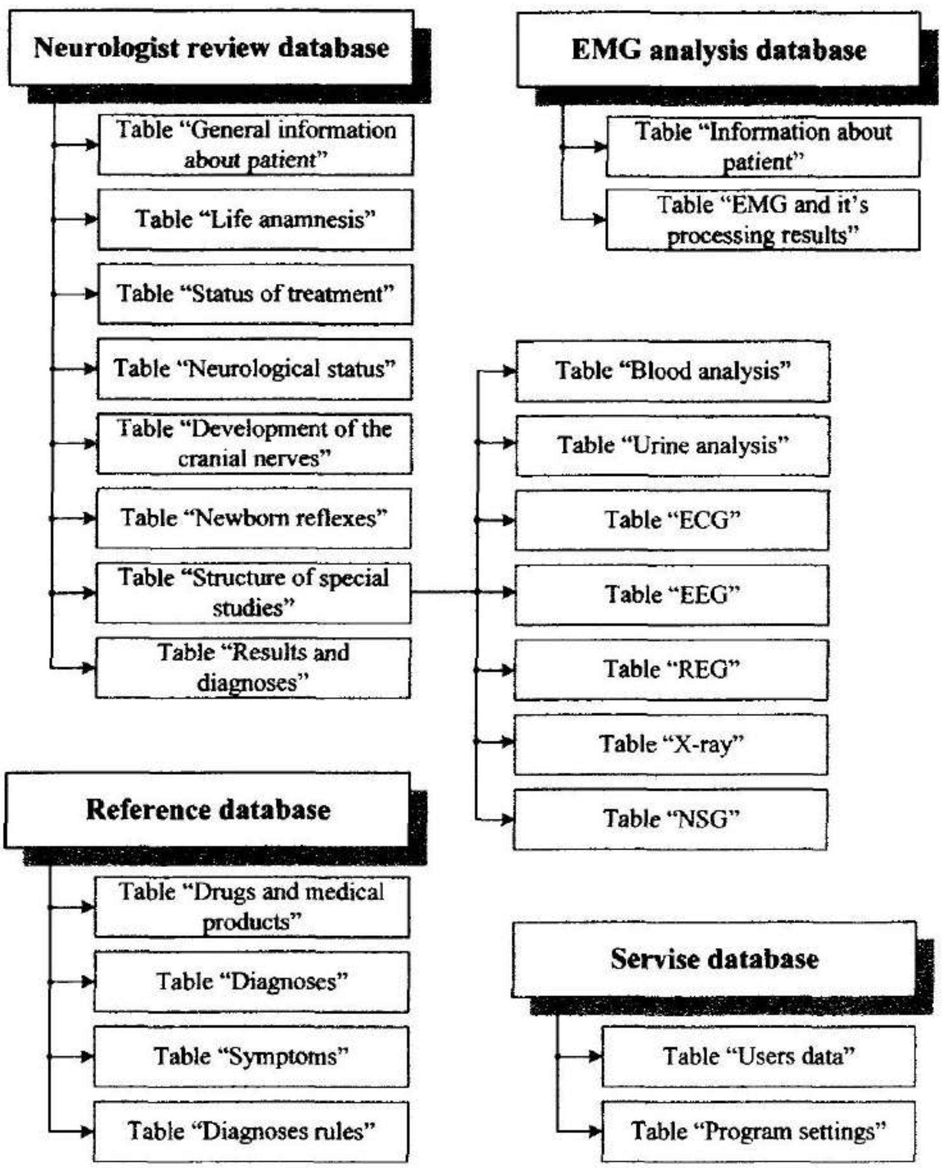

Figure 2. Conceptual model of database structure for the provision of neurologist AWP.

integrity of databases, i.e. the property of the data, which determines the completeness and accuracy of the information stored in the database (Meij et al. 2014, Wójcik & Smolarz 2017).

Since this set of databases is used to support the operation of the information provision of the developed automated workplace, so as a connection provider, we select the MyDAC components of Devart Company. Database-driven MyDAC-based applications are easy to deploy, do not require the installation of other data provider tools (such as BDE or ODBC), and therefore they can run faster than those based on standard solutions RAD Studio for environment data connectivity. In addition, MyDAC provides a supplementary opportunity to work directly with the MySQL database without involving the MySQL client library.

3 DATABASE DESIGN

The database should provide:

- storage of an array of data resulting from the AWP operation;
- optimization of data placement in physical memory;
- comprehensive search over data warehouse according to the criteria of SQL queries;
- requests for comparison of the diagnosis rules (Gardener et al. 2009).

The general structure of the DB set that functions within the AWP is presented in Fig. 2.

The main data model is a relational one, according to which the information is stored in the form of entities or tables, in which unique tuples (entities instances) are stored according to the attributes of entities.

For the accomplishment of databases operation within the developed AWP, the following principles were formulated and implemented:

1. the principle of "template" – most of the attributes of the database can accept only those values that are listed as available. This makes it easy to find information and speeds up the database operation;
2. the principle of "project typing" – defining the typology of attributes of entities at the stage of DB design;
3. the principle of "saving changes" – any changes introduced into the database are stored. This principle ensures an increase of the reliability of data storage in the database while the connection is available.
4. the principle of "changes registration" – the use of registration of any data changings in the database fixating the modifier and time of modification;
5. the principle of "connections optimizing" – reducing the number and optimizating the relations between entities and replacing them with SQL queries that have a higher operation speed. That leads to simplification of the database structure without losing the functionality of the AWP operation.

These principles relate primarily to the operation specifics of medical information systems, which involves working with data that presents vital information.

4 DATABASE OF THE NEUROLOGIST REVIEW CARD

The database of the neurologist review card is intended for provision of electronic documentation of the reviews conducted by the appropriate physician, as well as information on the medical characteristics that accumulate as a result of this activity. At the stage of conceptual design we selected the subject area of knowledge, which data should be stored in the database. This area was divided into separate entities, and the links between them were organized (Volpe 2008). The basic entities contained in this database are presented in the matrix in Table 1.

When expanding the conceptual model, the attributes of each entity were determined, and the form of the database was normalized in accordance with the appropriate rules. At the stage of physical design of this database, a data scheme physical model based on the use of

MySQL 5.5 relational BD management system was developed. This DBMS provides high-speed information system and client-server data transfer technology. The physical model of the database is depicted in Fig. 3, and further on the text there are examples of entities that are the elements of the model.

The entity "analiz_rentgen" is intended to preserve the information about the initial data and results of the patient's X-ray analysis, its description and date. It contains the following attributes:

- code – serial number on the list, Integer type;
- id – the patient's identifier, Integer type;
- nazva – the reason of the survey, the string type, 100 characters;
- date – date of the survey, date-time type;
- doctor – survey physician, string type, 100 characters;
- harakt – description of the conclusion, multiline text type;
- pict – file with the result of the survey, OLE type;
- prim – notes, multistring text type.

The entity "analiz_blood" is intended to preserve information about the results of the advanced analysis of the patient's blood. It contains the following attributes:

- code – serial number on the list, Integer type;
- id – the patient's identifier, Integer type;
- pH – blood acidity, fraction type;
- eritrc – the number of erythrocytes, fraction type;
- leykoc – the number of leukocytes, fraction type;
- tromboc – the number of thrombocytes, Integer type;
- SHOE – value for the erythrocyte sedimentation, Integer type;
- nv – the amount of hemoglobin, Integer type.

The entity "analiz_EEG" is intended to preserve the information about the results and data of the electroencephalogram. It contains the following attributes:

- code – serial number on the list, Integer type;

Table 1. Adjacency matrix of the entities of the database.

Entities	General information	Life anamnesis	Physician reception	Neurological status	Cranial nerves	Newborn reflexes	Special studies	Blood test	Urine analysis	X-ray study results	ECG results	EEG results	Results of NSG	Results of REG
General information	–	1:1	1:N	1:N	1:N	1:N	1:N	–	–	–	–	–	–	–
Life anamnesis	1:1	–	–	–	–	–		–	–	–	–	–	–	–
Physician reception	N:1	–	–	–	–	–	–	–	–	–	–	–	–	–
Neurological status	N:1	–	–	–	–	–	–	–	–	–	–	–	–	–
Cranial nerves	N:1	–	–	–	–	–	–	–	–	–	–	–	–	–
Newborn reflexes	N:1	–	–	–	–	–	–	–	–	–	–	–	–	–
Special studies	N:1	–	–	–	–	–	–	1:N	1:N	1:N	1:N	1:N	1:N	1:N
Blood test	–	–	–	–	–	–	N:1	–	–	–	–	–	–	–
Urine analysis	–	–	–	–	–	–	N:1	–	–	–	–	–	–	–
X-ray study results	–	–	–	–	–	–	N:1	–	–	–	–	–	–	–
ECG results	–	–	–	–	–	–	N:1	–	–	–	–	–	–	–
EEG results	–	–	–	–	–	–	N:1	–	–	–	–	–	–	–
Results of NSG	–	–	–	–	–	–	N:1	–	–	–	–	–	–	–
Results of REG	–	–	–	–	–	–	N:1	–	–	–	–	–	–	–

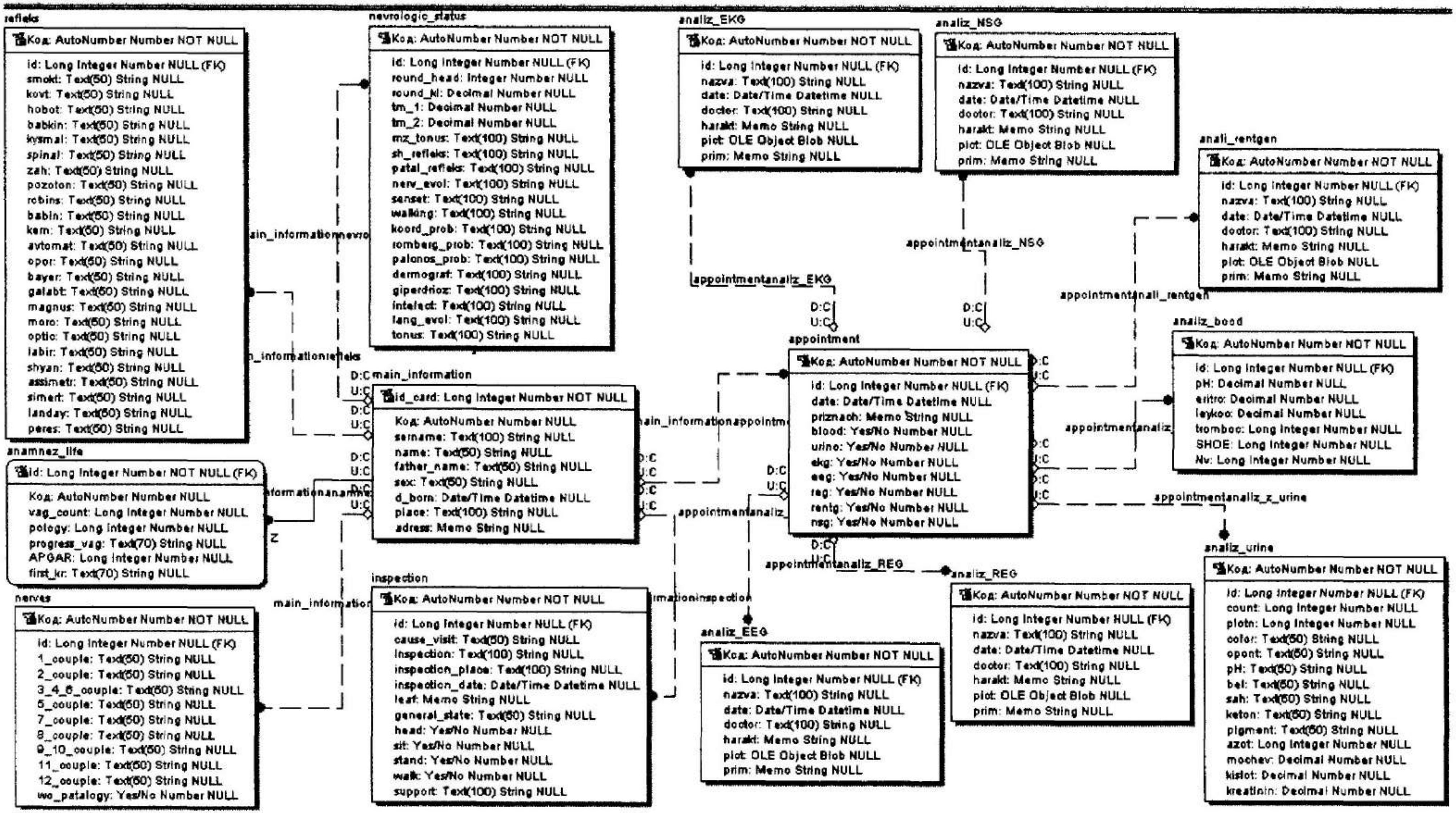

Figure 3. Physical model of the database of the neurologist review card.

– id – the patient's identifier, type Integer;
– nazva – the reason of the survey, string type, 100 characters;
– date – date of the survey, date-time type;
– doctor – survey physician, string type, 100 characters;
– harakt – description of the conclusion, multiline text type;
– pict – file with the result of the survey, OLE type;
– prim – notes, multiline text type.

The entity "analiz_NSG" is intended to store information about the results and source data of neurosonography. It contains the following attributes:

– code – serial number on the list, Integer type;
– id – the patient's identifier, Integer type;
– nazva – the reason of the survey, string type, 100 characters;
– date – date of the survey, date-time type;
– doctor – survey physician, string type, 100 characters;
– harakt – description of the conclusion, multiline text type;
– pict – file with the result of the survey, OLE type;
– prim – notes, multiline text type.

The "analiz_urine" entity is intended to store information about the results of advanced patient's urine analysis. It contains the following attributes:

– code – serial number on the list, integer type;
– id – the patient's identifier, integer type;
– count – number per day, integer type;
– plotn – density of urine, integer type;
– color – urine color, string type, 50 symbols;
– opont – transparency, string type, 50 characters;
– pH – acidity of urine, string type, 50 symbols;
– bel – proteins in urine, string type, 50 symbols;
– sah – sugar in urine, string type, 50 symbols;
– keton – ketone bodies in urine, tape type, 50 symbols;
– pigment – pigments in urine, tape type, 50 symbols;
– azot – nitrogenous bases in urine, type Integer;
– mochev – urea in urine, fraction type;
– kislot – acid residues of urine, fraction type;
– kreatinin – creatinine in urine, fraction type.

The "anamnez_life" entity is intended to preserve information on objective indicators of life anamnesis of a baby. It contains the following attributes:

– code – serial number in the list, Integer type;
– id – the patient's identifier, Integer type;
– vag_count – serial number of pregnancy, Integer type;
– pology – serial number of childbirth, Integer type;
– progress_vag – the nature of the pregnancy, string type, 70 characters;
– APGAR – the value of Apgar score, Integer type;
– first_kr – first cry character, string type, 70 characters.

The "main_information" entity is the basic entity that keeps a register of patient cards, and contains general information about them. The primary key of this entity determines the unique identifier of the patient in the AWP. This entity contains the following attributes:

– code – serial number in the list, Integer type;
– id_card – patient identifier, unique primary key, integer type;
– sername – the patient's name, string type, 100 characters;
– name – patient name, string type, 50 characters;
– father_name – patronymic of the patient, string type, 50 characters;

- sex – the patient's gender, string type, 50 characters, the substitution of "Male/Female";
- d_born – date of birth of the baby, date-time type;
- place – city of baby birth, string type, 100 characters;
- address – patient's address, multithreaded text type.

The "nevrologic_status" entity contains information on the parameters of the neurological status of the newborn and the results of their evaluation by the physician. This entity contains the following attributes:

- code – serial number in the list, Integer type;
- id – the patient's identifier, Integer type;
- round_head – head circumference, integer type;
- round_kl – chest circumference, fraction type;
- tm_1 – the length of the fontanel, fraction type;
- tm_2 – the width of the fontanel, fraction type;
- mz_tonus – muscle tone, string type, 100 characters;
- sh_refleks – tendon reflexes, string type, 100 characters;
- patal_refleks – pathological reflexes, string type, 100 characters;
- nerv_evol – neurological development, string type, 100 symbols;
- senset – sensitivity, string type, 100 characters;
- walking – pace, string type, 100 characters;
- koord_prob – coordinate test, string type, 100 characters;
- romberg_prob – Romberg's test, string type, 100 characters;
- palcnos_prob – finger-nose test, string type, 100 characters;
- dermograf – dermographism, string type, 100 symbols;
- giperdrioz – hyperdriosis, string type, 100 symbols;
- intelect – intelligence development, string type, 100 characters;
- lang_evol – language development, string type, 100 characters;
- tonus – total tone, string type, 100 characters.

The "reflex" entity stores information about the results of studies of various reflexes of the newborn. Essence contains the following attributes:

- code – serial number on the list, Integer type;
- id – the patient's identifier, Integer type;
- smokt – the state of sucking reflex, string type, 50 characters;
- kovt – the state of swallow reflex, string type, 50 characters;
- hobot – the state of oral automatism reflex, string type, 50 symbols;
- babkin – the state of Babkin reflex, string type, 50 characters;
- kysmal – the state of Kussmaul reflex, string type, 50 characters;
- spinal – the state of the spinal reflex, string type, 50 characters;
- zah – the state of the upper protective reflex, string type, 50 characters;
- pozoton – the state of the post-tonic reflexes, string type, 50 symbols;
- robins – the state of the Robinson-Yanishevsky reflex, string type, 50 characters;
- babin – the state of Babinsky reflex, string type, 50 characters;
- kern – the state of Kernig reflex, string type, 50 characters;
- avtomat – the state of the "automatic pace" reflex, string type, 50 characters;
- opor – the state of the support reflex, string type, 50 symbols;
- bayer – the state of Bauer reflex, string type, 50 characters;
- galabt – the state of Galant reflex, string type, 50 characters;
- magnus – the state of the Magnus-Klein reflex, string type, 50 symbols;
- moro – the state of Moro reflex, string type, 50 characters;
- optic – the state of the optical constitutive reflex, string type, 50 symbols;
- labir – the state of the labyrinth reflex, string type, 50 symbols;
- shyan – the state of the neck reflex, string type, 50 symbols;
- assimetr – the state of the asymmetrical tonic neck reflex, string type, 50 symbols;
- simert – the state of the symmetrical tonic neck reflex, string type, 50 symbols;

– landay – the state of Landau reflex, string type, 50 characters;
– peres – the state of Perez reflex, string type, 50 characters.

5 CONCLUSIONS

We discussed and formulated the subject area of the application of database of the medical information system for the neonatal neurologist, which includes a reference part, a perinatal neurological review card and EMG analysis unit. A common structure and conceptual model of the database was developed. An adjacency matrix that determines the relations between entities of the database was constructed. Finally, the physical model of the database for the perinatal neurologist's workplace was developed. Examples of entities and their attributes are given.

We developed the structure, physical model and software application of the database for the automated workplace of perinatal neurologist. It passes the trial period in the perinatal center.

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For many centuries, mankind has tried to learn about his health. Initially, during the pre-technological period, he could only rely on his senses. Then there were simple tools to help the senses. The breakthrough was turned out to be the discovery of X-rays, which gave insight into the human body. Contemporary medical diagnostics are increasingly supported by information technology, which for example offers a very thorough analysis of the tissue image or the pathology differentiation. It also offers possibilities for very early preventive diagnosis. Under the influence of information technology, 'traditional' diagnostic techniques and new ones are changing. More and more often the same methods can be used for both medical and technical diagnostics. In addition, methodologies are developed that are inspired by the functioning of living organisms.

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Information Technology in Medical Diagnostics II links technological to medical and biological issues, and will be valuable to academics and professionals interested in medical diagnostics and IT.

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