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Prospective Implementation of Telecommunication Technologies in Organization of Centralized Individual Dosimetry Monitoring of Occupational Exposure of Medical Staff

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PROSPECTIVE IMPLEMENTATION OF TELECOMMUNICATION TECHNOLOGIES IN ORGANIZATION OF CENTRALIZED INDIVIDUAL DOSIMETRY MONITORING OF OCCUPATIONAL EXPOSURE OF MEDICAL STAFF

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***Abstract*— The issues of improving the centralized individual dosimetry monitoring due to implementation the telecommunication data transmission system are considered.**

Keywords—individual dosimetric control; medical exposure; radiation protection;dose registry; data tranmission

I. INTRODUCTION

One of the most important problems of humanity is monitoring of radiation technologies use and analysis data on the global and regional levels and trends of human exposure to ionizing radiation. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) undertakes broad assessments of the sources of ionizing radiation and its effects on human health and the environment. The Scientific Committee took note of the progress report by the secretariat on the collection, analysis and dissemination of data on radiation exposures of the public, patients and workers, obtained from reviews of the scientific literature and the data submissions by Member States [1]. Governments and organizations throughout the world rely on the Committee's estimates as the scientific basis for evaluating radiation risk and for establishing protective measures.

In Ukraine about 25 500 ionizing radiation sources (IRS) are used in medicine, industry, research institutions. Also about 60 000 workers work with IRS in medicine, industry and in the Nuclear Power Plants (NPP). The Law of Ukraine *"On Human Protection against Impact of Ionizing Radiation"* define obligations on juridical and natural persons who perform particular activities related to ionizing radiation. These obligations include monitoring of radiation protection, developing standards of radiation safety, take protective measures, perform control and accounting occupational radiation exposure, perform medical inspection, provide information to Regulatory Authority, etc. [2]. The issues of radiation protection and dosimetry monitoring are concerned in the number of Regulatory documents of Ukraine:

- Radiation Safety Standards of Ukraine (NRBU-97) [3];
- Main Sanitary Rules for Radiation Safety Securing in Ukraine (OSPU-2005) [4];
- General Safety Rules for Medicine Radiation Sources [5].

According to recent available information, about 50,000 occupationally exposed workers in Ukraine are needed in individual dose monitoring: among them about 18,000 medical staff. In accordance with the requirements of Radiation Safety Standards of Ukraine and Main Sanitary Rules for Radiation Safety Securing in Ukraine, the individual dosimetry control (IDC) in specific volumes for every case is obligatory for individuals among the personnel (exposed workers of category A) overall annual effective dose of which can reach 10 mSv per year.

The problems of reliability of individual dosimetry data acquisition and huge volume of information for transfer and systemic analysis can't be solved effectively without implementation of modern telecommunication technologies [6,7].

II. THEORY PART

A. The basics of population dose calculation for systemic monitoring of individual doses for medical staff

The procedure of systemic dose monitoring is performed in the world during a particular year. The UNSCEAR Global Survey incorporates a detailed questionnaire: all available national information concerning annual numbers (*Nj*) and typical doses (*Ej*) for each type of diagnostic examination, together with a comprehensive evaluation of annual global medical practice requires information concerning every radiological additional supporting information on national medical imaging practice. For therapeutic exposure,

typical doses are requested more simply in terms of administered activity (MBq) or prescribed doses (Gy) [1].

The total number of X-ray examinations performed annually in the world is given by:

$$N = \sum_{i,j} N_{i,j} ,$$

where *Ni,j* is the annual number of examinations of type *i* carried out in country *j* and the summation includes all countries and types of examination.

Similarly, the population dose from diagnostic radiology S (man Sv) is given by:

$$S = \sum_{i,j} \left(N_{i,j} \cdot \frac{E_{i,j}}{1{,}000} \right) .$$

where *Ei,j* is the typical effective dose (mSv) for examination *i* in country *j*, and the global per caput.

Effective dose (mSv) (for world population of size P)

$$E_{per\ caput} = \left(\frac{S}{P} \cdot 1{,}000 \right).$$

B. Data registration requirements

A register of the annual effective and equivalent doses as well as the total doses during the whole period of professional activity should be kept when performing an individual radiation monitoring. According to [4] all results of individual dose monitoring should be registered and stored by the institution during 50 years.

The questionnaires used in the recent UNSCEAR Global Survey consist of four parts:

− Essential information and data on annual total numbers of examinations and procedures within each broad type of radiological discipline (such as diagnostic radiology including all X-rays, all dental examinations, all interventional radiology and all computed tomography examinations separately), together with total numbers for broad types of equipment and staffing;

− Detailed information on diagnostic and therapeutic equipment and staffing;

− Numbers of diagnostic radiological examinations, nuclear medicine procedures (both diagnostic and therapeutic) and radiation therapy treatments;

− Information of dosimetric data including estimates of effective dose per examination or procedure.

An individual dose for occupationally exposed workers of category A is registered in Database – in special electronic personal dose register card. The personal dose register card and appropriate information should be kept in DB until the worker fulfils 75 y.o. and not less than 30 years after employment termination.

All the registered records should be accessible for the Radiation Safety Department and a health department and on request for the National Regulatory Authorities in nuclear and radiation safety – Ministry of Health (MOH), State Nuclear Regulatory Inspectorate of Ukraine (SNRIU). An enterprise management should provide the worker with the full information on registration records.

Individual dosimetry control allows track the dose of external exposure to the personnel involving directly in work using ionizing radiation sources.

During 2001 - 2020 the Government by its decrees has taken a decision to develop a National Register of Individual Doses of Occupational exposure [8,9]. Ministry of Health of Ukraine and State Nuclear Regulatory Inspectorate of Ukraine are responsible for work coordination concerning development and functioning of the National Register of Individual Doses. Nevertheless Central Laboratory of Radiation Protection and Dosimetry of Medical Exposure on the base Grigoriev Institute of Medical Radiology and Oncology (Kharkiv), which operates since 1979, performs the individual dosimetry monitoring of medical staff in almost all Ukrainian Regions (except Kyiv Region) (Figure 1).

Figure 1 – IDC data acquisition in Central Laboratory of Radiation Safety and Dosimetry of Medical Exposure, Grigoriev Institute for Medical Radiology and oncology of the NAMS of Ukraine

At present Central Laboratory carries out the dose monitoring for about 6 500 occupationally exposed workers from 750 institutions/hospitals in active work [10]. The transfer and collection of dosimeters is carried out using courier service on a "from hand to hand" principle that allows provide this type of service throughout the Ukraine. However, a lot of manual procedures and written documents complicate the process of data acquisition and analysis. These problems have become particularly aggravated in the context of the COVID-19 pandemic and the war in Ukraine.

III. MATERIALS AND METHODS

Thermoluminescent determination of individual doses from external beta, gamma, X-ray radiation for the whole body; the statistical analysis of external doses in all areas of ionizing radiation sources use; dosimetry control for personnel according to requirements [1-7]. The analyzed data array contains information about doses of medical staff during last 30 years (1990-2021) for more than

19 500 persons who worked with medical sources and indicate as workers of category A [8].

IV. RESULTS OF THE RESEARCH

A. *Structure of system for centralized dose data processing for medical staff*

According to recommendations [11] the prospective scheme of data flow between Licensees (Medical Hospitals), Dosimetry Services and National Dose Register (State Nuclear Regulatory Inspectorate of Ukraine) was developed (Figure 2).

The summary annual report with data of collective and average doses and the distribution of personal doses for different type of occupational exposure in medicine are transmitted to Regulatory Bodies: Ministry of Health of Ukraine, to State Nuclear Regulatory Inspectorate of Ukraine. Finally the National Report is requested for UNSCEAR Global Survey.

B. *The structure of databse*

The developed Database IDAIS (Individual Dosimetry Automatic Information System) contains information about doses of medical staff who worked with medical sources and indicated as workers of category A. The information system IDAIS allows generate different types of forms and statistical reports. The general structure of developed Database IDAIS is shown in Figure 3.

Personal data in DB for each medical radiation worker has the unique identification and consists from: dose register code (personal number of DB); social identification number; name; data of birth; sex; occupation / profession.

Employment history registered in DB consists of data: the periods of work in different institutes (hospitals); employer data: name of institute (hospital), its address, contact person, phone/fax, e-mail; name of department and profession for each periods of work.

Employer information includes name, address, employer's ID-number given by the dosimetry service, classification of activity; name of departments and ID-number of department given by the dosimetry service; name, phone and fax of radiation protection officer.

Monitoring information means beginning and end of the monitoring intervals for all workers.

Exposure and dose data: external doses of whole body; type of radiation exposure; annual and accumulate doses.

Job characterization takes into account classification of different kinds of work with radiation sources in medicine. There are 8 categories of jobs: the brachytherapy and manual radiotherapy with sealed sources; telegammatherapy; nuclear medicine; diagnostic radiology; interventional radiology; X-ray therapy; radon-therapy; radiation protection and dosimetry.

There are 35 occupational groups of medical staff with unique DB codes for preparation of different kinds of analyses of annual dose results: 3-6 occupational groups in each types of jobs with medical radiation sources. For all employers the dosimetry service send the reports with monitored doses every quarter and then the summary reports with individual annual and cumulated doses (all years of dose monitoring period) for each workers.

The monitoring forms and annual reports with results of personal dose monitoring are sent to controllable institutions and hospitals by Center of Personal Dosimetry every quarter and annually.

There are various kinds of the statistical analysis of individual dose monitoring which are prepared using SQL software of DB:

- Annual collective and average doses for different type of work with radiation sources in medicine and occupational groups as for each hospital (institutes) and as for whole Ukraine;

- Contribution in all collective doses of various occupational groups;

- Distribution of annual personal doses depending on a kind of works carried out with sources in medicine and analysis of all cases of exceeding the dose limit for exposed worker of category A and annual reference level.

By means of the Dose Register 8 various annual statistical forms may be prepared.

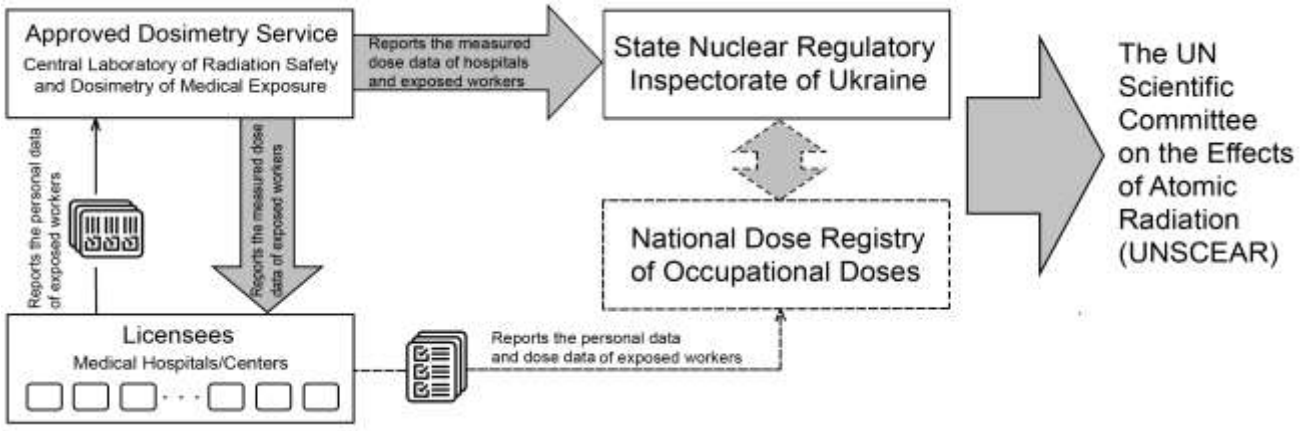

Figure 2 – Structure of system for centralized dose data processing for medical staff

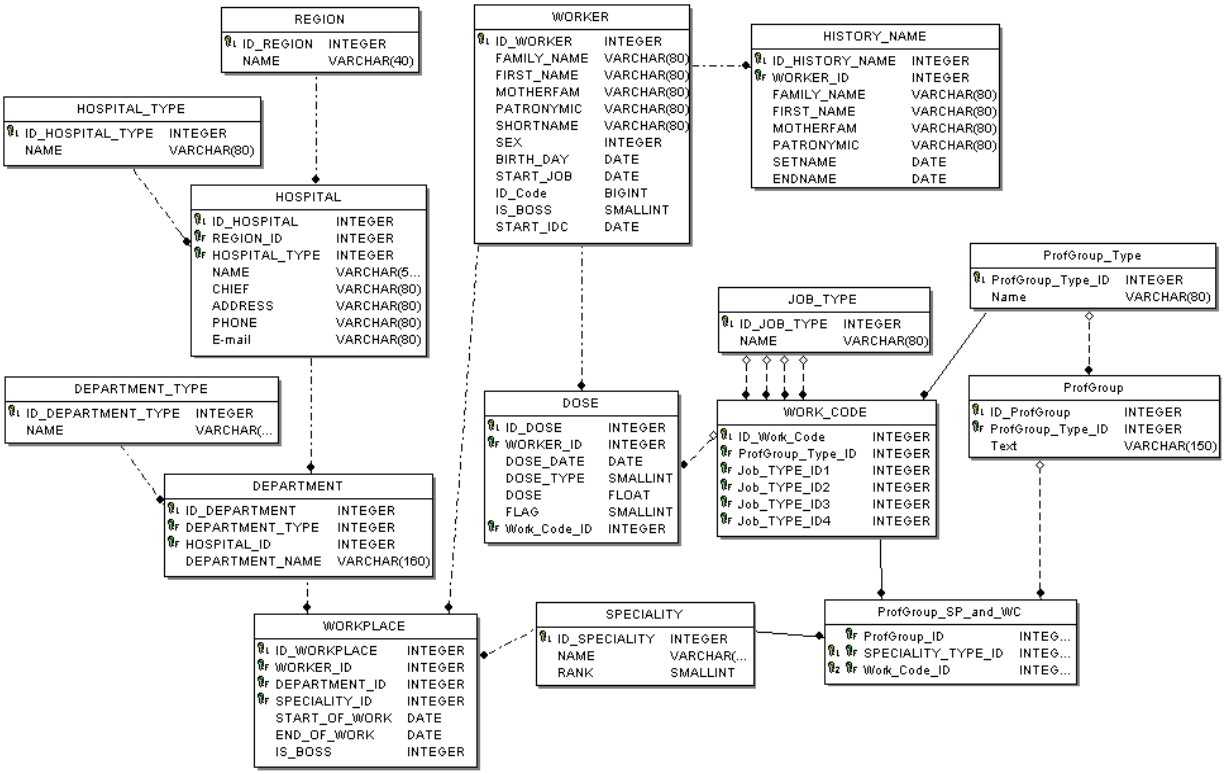

Figure 3 - Structure of Individual Dosimetry Automatic Information System

V. CONCLUSION

The main tasks of use telecommunications for data transmission from medical institutions which are supervised by the Central Laboratory of Radiation Protection and Dosimetry of Medical Exposure, to the Regulatory Authorities for Radiation Safety, to the National Dose Register for automation electronic data transfer and reports were analyzed. The structure of system for centralized dose data processing for medical staff is considered and the original Database IDAIS was developed for improvement IDC data collection, analysis and transfer.

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