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Original paper

Web-based platform for patient dose surveys in diagnostic and interventional radiology in Bulgaria: Functionality testing and optimisation

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ABSTRACT

In the period 2013–2016 the National Centre of Radiobiology and Radiation Protection (NCRPP) at the Ministry of Health of Bulgaria has developed a web based platform for performing national patient dose surveys and establishing Diagnostic Reference Levels (DRLs). It is accessible via internet browser, allowing the users to submit data remotely. Electronic questionnaires, specific for radiography, fluoroscopy, image guided interventional procedures, mammography and CT, were provided. Short and clear manuals were added to guide users and minimise human errors. The web-based data collection platform is functional and is currently being used for performing the third national dose survey in Bulgaria, launched in 2016. Data analysis is facilitated due to the standardisation of collected data and their storing. Using the platform, the participating facilities can establish their typical dose levels based on the median value, and compare them to DRLs. A disadvantage of the platform is the need to enter data manually, but it is opened for future upgrades for automatic data harvesting and analysis. Various practical approaches were used to overcome the lack of qualified human resources and insufficient understanding of the DRL and dose tracking concept and to motivate facilities to submit data.

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1. Introduction

Diagnostic Reference Levels (DRLs) are an important tool for optimisation of patient protection in diagnostic radiology [1,2]. This concept was introduced by the International Commission on Radiological Protection (ICRP) in 1996, and adopted in the International Basic Safety Standards [3]. The requirement for establishing and using DRLs was introduced in Europe first with the Medical Exposure Directive 97/43/EURATOM of the European Union [4]. This Directive was recently repealed by the European Council Directive 2013/59/EURATOM, in which requirements for patient dose recording and tracking have been further strengthened [5].

The experience in some countries demonstrated that when the concept of DRLs is appropriately used, it is possible to minimise the variation in patient radiation dose among different facilities across a country [6,7].

Most European countries employ DRLs, either established from own surveys or adopted from other countries [8]. Worldwide, only about 28 of the 135 low or middle income countries (LMICs) have some published DRL data [9]. To foster the process of establishing DRLs, some responsible authorities employ web-based data collection systems [10–13]. In addition to improving the process of regular data collection, these systems allow medical facilities to compare their dose indices to the regional or national DRLs. The national dose reporting systems are an addition to the dose monitoring at hospital level that ideally should be also automatic. Although proved to be an excellent tool for local optimisation, dose

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tracking software systems are still not widespread because of the high price of the commercial software and human resources involved but also because of the insufficient understanding of their effectiveness.

The Bulgarian legislation from 2005 requires the National Centre of Radiobiology and Radiation Protection (NCRRP) at the Ministry of Health to perform national patient dose surveys for establishing DRLs, and all medical facilities to perform dose audits for establishing their typical dose levels and comparing them to the DRLs [14]. Optimisation actions are required if typical dose levels exceed or are significantly lower than the national DRLs, taking into account the image quality.

Two national dose surveys have been completed since 2002 [15,16]. In both, data collection was performed manually by filling out for each facility standardised paper forms, collecting and digitizing them by the NCRRP for further data processing and analysis. Staff members of the NCRRP and the five regional radiation health inspectorates were involved in data collection. Due to these limited human resources, the first national DRLs from the 2002–2004 survey were based on limited number of patient data collected for radiography, and on phantom measurements for mammography and CT. The second set of national DRLs from the 2007–2009 survey was based on patient data for radiography, fluoroscopy and interventional procedures, while keeping phantom measurements for mammography and CT [15,16]. Despite the limitations of these surveys, the recently published analysis of Meyer et al. shows that Bulgaria is the only country among LMICs having established DRLs for all main X-ray modalities [9].

Planning of the third national patient dose survey started in 2013 with the development of a centralised online data collection platform to be hosted by the NCRRP [17]. The aim was to improve and foster the data collection process, to increase the response rate and to facilitate the analysis of the results. The other purpose of the platform was to provide immediate feedback to the participating medical facilities by automatically calculating their typical facility dose levels.

This article presents various phases of designing, testing and improving the functionality of the on-line platform for dose data collection. The third national survey has been officially launched in July 2016 and the data submission is still in process. The results present here are based on the data submitted only to the platform. The article does not aim to present the results of the survey that will be subject of a separate work after the completion of the survey. Some examples of selected data submissions and analyses are presented to demonstrate the usability of the on-line platform and the potential for its future improvements.

2. Material and methods

The online platform and its database were designed by the NCRRP and developed by a software company, with several iterations of testing and improving the platform, summarised in Fig. 1.

The main futures of the platform are described in our previous paper [17]. The platform is accessible via Internet browser and allows the user to send remotely data for dose indices and exposure parameters for a number of patient examinations performed

with particular X-ray equipment. Modality specific electronic questionnaires with the essential information were designed, implemented and further improved during the development and testing periods.

The software was written in PHP. The system works with a MySQL relational database where all the data about the hospitals, departments, X-ray systems (units), studies and statistics is stored. The current server characteristics are: processor Intel® Xeon® E-5-2620 0 @ 2.00 GHz (2 processors), RAM 8 GB, OS Windows Server 2012.

The users have different levels of hierarchy (listed from highest to lowest): Senior administrator; Hospital administrator; Hospital operator; and Departmental operator. The Senior administrator can manage all users from the system. Hospital administrator can manage all users of the given hospital, which have a lower level of rights. The access to the system is free of charge for all registered users.

The system includes five types of X-ray systems: Radiography, Radiography and Fluoroscopy (R/F), Fluoroscopy (C-arm or Angiography), Mammography and Computed Tomography (CT). Each type has a separate table in the database where studies are stored. The most frequently performed procedures were selected based on the national and international experience, and after consultation with radiologists. The names of the procedures were standardised. CT examinations were divided by clinical indications. Electronic tables (templates) in Excel (Microsoft Corporation, USA) format were created and implemented in the software. The user can download these templates, fill them out and transmit in the web platform through the user electronic table, as shown in Fig. 2.

In terms of data export, the system offers several different options. When exporting from a given X-ray system, the user has the functionality to export each X-ray study separately. When exporting the data at a hospital level, the system allows for exporting data in Excel format from all units for all studies that were recorded during a specified period of time.

Every time a user submits new study, the system calls specific database procedures to update the current values of the minimum, maximum, mean and median of the important parameters. An example of a module, which calculates and displays the statistical data is shown in Fig. 3.

3. Results

The phase of the development and optimisation of the platform (March 2014–December 2015) involved many meetings and continuous communication between the software developer and the NCRRP staff. In this phase, all identified technical errors were eliminated and proper work of the software was ensured. Errors that have been detected, eliminated or significantly reduced in the automatic system through its optimization and improvement are summarised in Table 1.

In order to reduce the human errors, additional standardisation of data entries was implemented during this phase, not initially foreseen in the technical specification. The first was the preparation of a predefined list of the healthcare facilities. According to the current statistics from the Ministry of Health, there are 563 registered healthcare facilities of different type in Bulgaria that perform diagnostic imaging procedures, including hospitals, outpatients medical centres and small X-ray laboratories. Their names have been included in the software, so the user needs to select from this predefined list. Only the Senior administrator can add or modify names of facilities. During registration, the users must select their hospital and department, and thus the users table is related to the table with the hospitals and the registered departments.

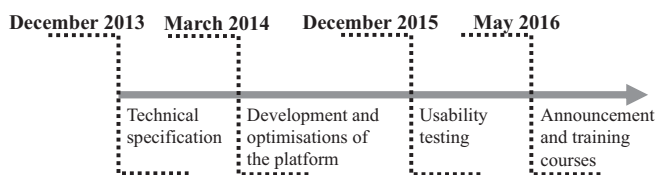


Fig. 1. Timetable of the project.

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