IONIZING RADIATION IN PEDIATRIC RADIOLOGY Do Medical Staff and Parents Know Enough – A Regional Study in Serbia

by

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Determine the level of knowledge and awareness of health professionals, medical students and parents concerning possible risks associated with ionizing radiation in pediatric population. A cross-sectional study has been conducted in two healthcare institutions and Faculty of Medicine, by filling out two anonymous questionnaires (questionnaire 1 – medical staff and medical students, questionnaire 2 – parents of the children). It included 254 respondents. The majority of examinees assessed their knowledge about ionizing radiation as moderate. Less than half clinicians, both specialists and residents, were informed about *Image gently* campaign. Over 60 % of doctors assessed that diagnostic radiology procedures are often performed unnecessarily in children. Even though 60-80 % of clinicians claimed they do inform parents in everyday clinical practice, however over 70 % of parents affirmed that they had never been informed about effects of ionizing radiation before diagnostic procedures. Between 50 % and 85 % of pediatricians and pediatric surgeons greatly underestimated the effective doses in computed tomography and fluoroscopy procedures. There were 58-100 % of clinicians who were aware that computed tomography increases the risk of carcinoma development. General knowledge of medical staff, medical students, and parents about ionizing radiation and potential risks in pediatric population is poor. Therefore, organized education is required.

Key words: ionizing radiation, pediatrics, questionnaire, medical staff, parent, Serbia

INTRODUCTION

Radiation originates from natural sources (cosmic radiation, ultraviolet radiation, and natural radio isotopes) and artificial sources where radiological diagnostic procedures dominate, and represent about 15 % of total radiation [1]. In the USA the effective dose from medical exposure already exceeded the contribution from the natural background [2]. Children have a higher radiosensitivity compared to adults due to: tissues with higher mitosis rates, longer life expectancy, exposure to scattered radiation as a consequence of body proportions, and large proportions of hematopoietic bone marrow in all parts of the body, including the extremities [3]. Therefore, radiation protection in pediatric radiology is essential.

A number of studies have shown potentially harmful effects of ionizing radiation, predominantly computed tomography (CT) and fluoroscopy among pediatric population [4]. There are studies that also indicate high percentage of unjustified CT examinations among children, *i. e*., examinations without appropriate indications [5]. Latent period for oncogenic effect of radiation varies depending on the type of malignancy (5-10 years for leukemia, about 30 years for solid malignant tumors) [6]. With the same dose of ionizing radiation, a child has 10-15 times greater risk of developing carcinoma than an adult [7].

Organized effort in order to reduce exposure of patients to ionizing radiation, as well as reduction of radiation doses the patients are exposed to, is reflected in optimisation of practice outlined in the As Low As Reasonable Achievable (ALARA) concept and *Image gently* campaign [8, 9], which significantly raised con-

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science of medical staff about potentially harmful ionizing radiation effects. However, studies show that patients and referring physicians are neither aware of the amount of radiation patients receive during the examinations nor of consequences that radiation might cause [10-12]. Therefore, this topic is one of the most current in contemporary medicine in general, and especially in pediatric radiology.

The aim of this study was to determine the level of knowledge and how well the medical staff, medical students and parents in Serbian province Vojvodina are informed about use and potentially harmful ionizing radiation effects in pediatric radiology. The additional goal is to evaluate the standpoint of doctors, radiographers, nurses, medical students and parents concerning the use of diagnostic radiology procedures based on ionizing radiation in pediatric radiology.

MATERIALS AND METHODS

A cross-sectional study has been conducted at the Institute for Child and Youth Health Care of Vojvodina (Children's Hospital), Center for Radiology, Clinical Center of Vojvodina, and Faculty of Medicine Novi Sad. The research was approved by the Ethical Board (February 10, 2016, Protocol No: 646-1). It included population of N-254 respondents of both sexes, among who n-230 were medical students and medical staff, and n-24 were parents. For research purposes two questionnaires were formed in accordance with the goals of the work. By questionnaires sociodemographic characteristics of respondents have been collected (sex, level of education, years of service), and the knowledge level and respondents' standpoints have been assessed. Questionnaire Number 1 (Appendix A) consisted of 34 questions and was intended for:

– third year students of medicine (before passing radiology course) and fourth year students of medicine (after passing radiology course),
– doctors specialists: pediatric surgeons, pediatricians, anesthesiologists and radiologists,
– doctors residents in: pediatrics, pediatric surgery and radiology, and
– radiographers and nurses

Questionnaire Number 2 (Appendix B) consisted of 30 questions and was intended for parents of children who were treated at the Children's Hospital and who were exposed to some of the diagnostic procedures based on the ionizing radiation.

Respondents were filling in the questionnaires anonymously.

Statistical analysis was performed by using software package SPSS (SPSS 21.0 for Windows, Inc., Chicago, Ill., USA). Descriptive statistics methods and correlation analysis have been used in data processing.

RESULTS

Questionnaire 1 was filled in by 230 respondents, organized in 12 groups as it is shown in tab. 1. Out of the total number of respondents, n-78 (34 %) were males and n-152 (66 %) females. According to the years of service, respondents were divided into 5 groups (tab. 2)

The Questionnaire 2 was filled in by N-24 parents, n-19 (79 %) females and n-5 (21 %) males. Among the respondents in the Questionnaire 2, n-15 (62.5 %) had high education, while n-9 (37.5 %) of parents had secondary education.

How well the respondents were informed about ionizing radiation

On the basis of 17 questions we assessed the knowledge of respondents about the characteristics, effective doses (ED) and potential harmful effects of ionizing radiation in Questionnaire 1. The average number of correct answers among the groups is shown in fig. 1. There is statistically significant difference in the number of correct answers ($p < 0.01$) between medical students who passed the radiology course and those who have not attended the course yet. Statistically significant difference between different groups of specialists and residents was not determined. Radiology residents had the greatest number of correct answers. The worst scores were shown by those medical workers who had over 20 years of service.

Most respondents assessed their knowledge about ionizing radiation as moderate n-133 (58.7 %). Radiographers assessed themselves best (56.5 % of them assessed their knowledge as excellent), while only 18.2 % of radiologists had the same opinion. However, radiology residents, radiologists, pediatric surgeons and pediatric surgery residents all showed

Table 1. The number of respondents by groups in Questionnaire 1

Group	N	[%]
Pediatric surgeons	8	3
Pediatricians (Community health centre)	12	5
Pediatricians (Children's Hospital)	15	7
Anesthesiologists	5	2
Radiologists	11	5
Radiology residents	13	6
Radiographers	26	11
Pediatric residents	12	5
Pediatric surgery residents	4	2
Nurses	22	10
Students who have not attended radiology course	51	22
Students who passed radiology course	51	22
Total	230	100

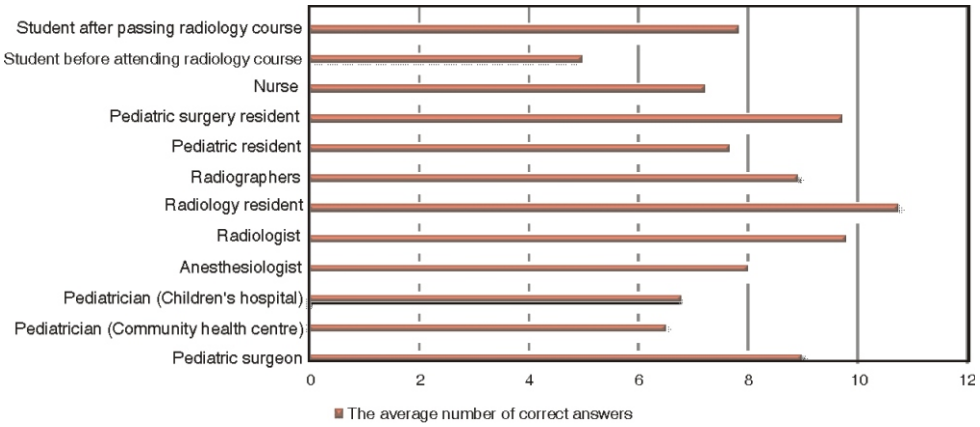


Figure 1. The average number of correct answers according to groups in questionnaire

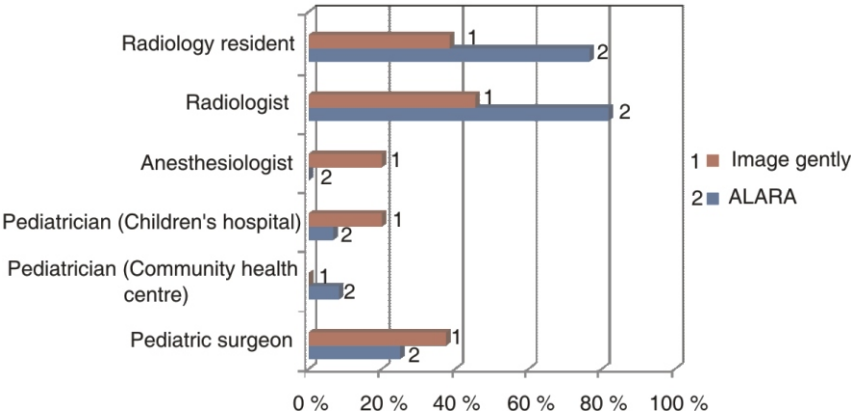


Figure 2. Clinicians' knowledge of ALARA principle and *Image gently* campaign

Table 2. The number of respondents according to the years of service in questionnaire 1

Years of service	N	[%]
With no experience (students)	102	44
Up to 5 years	29	13
From 6 to 10 years	33	14
From 11 to 20 years	21	9
Over 20 years	45	20
Total	230	100

better results than radiographers during testing. 50-80 % of clinicians assessed their knowledge as moderate.

Although two thirds of respondents in Questionnaire 1 declared that they had the chance to be informed about ionizing radiation (scientific article, lecture), statistically significant difference in the number of correct answers between this group and the group of other medical workers was not found ($r = 0.725$, $p > 0.01$).

With ALARA principle n-67 (29.1 %) of respondents who filled in questionnaire were familiar with, and only n-41 (18.7 %) of respondents were familiar with *Image gently* campaign. The percentage of students who passed radiology course and were familiar with ALARA concept significantly increased (2 % 25.5 %), as well as of those familiar with *Image gently* campaign (5.9 % 17.6 %), in comparison with students who still had not attended radiology course. In the group of parents an extremely small number of respondents were informed about these two campaigns (up to 4.2 %). Familiarity of clinicians with these principles of protection against ionizing radiation is shown in fig. 2.

Attitudes of respondents on the use of ionizing radiation

Most surveyed referring physicians and radiologists considered that radiology methods based on X-ray radiation have been excessively and unjustifiably often used in children, pediatricians from the Institute (n-9, 60 %), pediatric surgeons (n-6,75 %), anesthesiologists (n-5,100 %), radiologists (n-8, 72.7 %). Only n-3 (12.5 %) of parents share this attitude. According to the opinion of n-140 (60.4 %) Questionnaire 1 respondents, both radiologist and clinician are responsible for justification of CT examination performed on a child.

Attitudes of the doctors about the need to inform parents about potentially harmful effects of ionizing radiation, and the real situation in everyday clinical practice are shown in fig. 3.

As much as n-17, 70.8 % of questioned parents claimed that they have never been warned about potentially harmful effects of radiological examinations and risk magnitude.

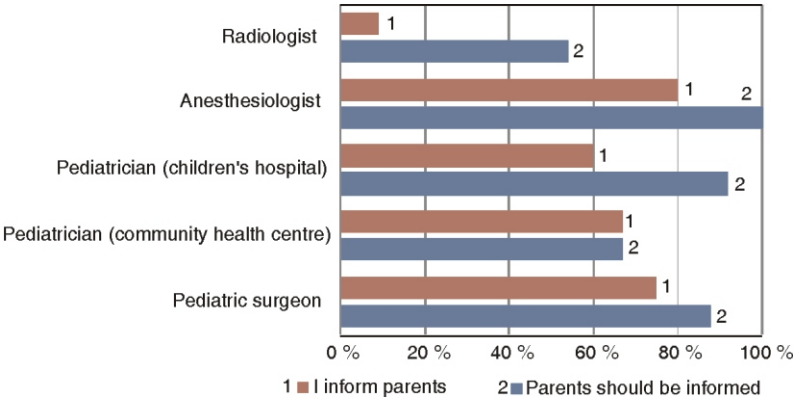


Figure 3. Attitudes of doctors on informing parents about potentially harmful effects of ionizing radiation

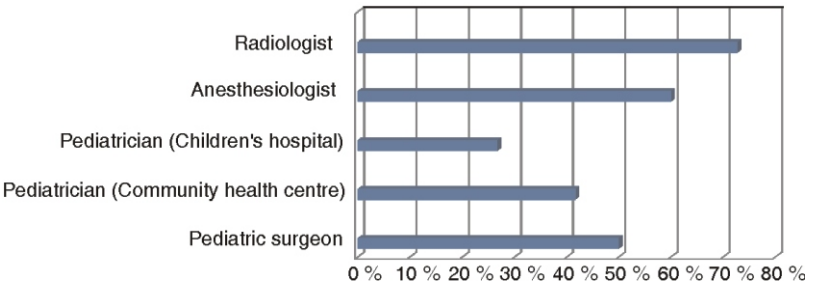


Figure 4. Percentage of doctors from different groups who consider that the effective dose of ionizing radiation derived from radiological procedures should be written on the patient records

Radiologists – 72.2 %, anesthesiologists – 60 % and up to 26 % of pediatric surgeons and pediatricians considered that detailed informing of parents might cause problems in everyday clinical work.

Great majority of parents (n-17,70.8 %) declared that there is little probability for them rejecting the examination if they knew about its potential harmful effects in advance. More than half of the parents (n-14, 58.3 %) would blame themselves if their child suffered harm because of refusing some potential harmful diagnostic procedures, while only 4.2 % would blame doctors.

The attitude of doctors about whether the effective dose of ionizing radiation (calculation based on DLP and CTDI values available on the each CT device), a child was exposed to during hospitalization, should be placed on the discharge list, is shown in the fig. 4.

The knowledge of respondents in questionnaire concerning the increasing risk of cancer development as a result of CT scan is presented in tab. 3.

That there are doses of radiation carrying no risk for children consider 37.5 % of pediatric surgeons, 41.7 % of pediatricians in Community health centre, 40 % of pediatricians at the Institute, 20 % of anesthesiologists, 18.2 % of radiologists and as much as 50 % of pediatric residents.

Table 3. Percentage of affirmative answers in different groups of respondents to the question whether CT increases the risk of cancer development

Group	N	[%]
Pediatric surgeons	8	100
Pediatricians (Community health centre)	7	58,3
Pediatricians (Children's Hospital)	11	73,3
Anesthesiologists	5	100
Radiologists	11	100
Radiology residents	12	92,3
Radiographers	24	64
Pediatric residents	11	91
Pediatric surgery residents	4	100
Nurses	14	63,3
Students who have not attended radiology course	25	49
Students who passed radiology course	35	68,6

How well the respondents are informed about the effective doses of ionizing radiation

Doctors' attitude about the relation of magnetic resonance imaging (MRI) examination and ionizing radiation are shown in fig. 5. Respondents evaluated the equivalence of one phase of head CT examination in children, one phase of abdominal and pelvic CT examination, and barium meal examination with the equivalent number of chest X-rays (CXR). Doctors' answers are shown in figs. 6-8 (pillars 2 represent correct answers).

DISCUSSION

Everyday search for the balance between potential benefits and potential postponed adverse effects which may arise when using diagnostic procedures based on ionizing radiation, is one of the main goals of contemporary pediatric radiology. This ought to be

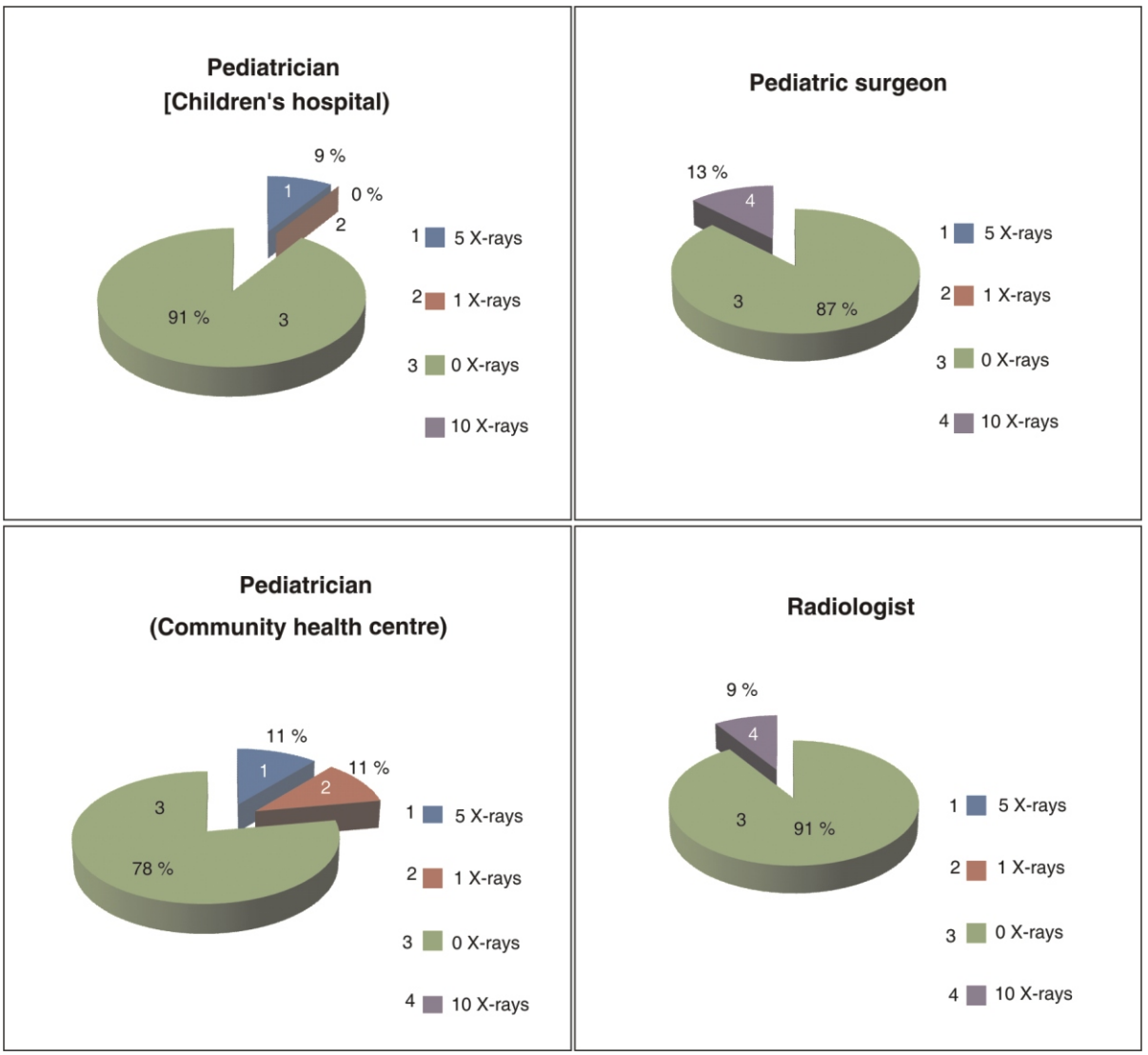


Figure 5. Percentage distribution of answers in different groups of medical doctors to the question about the equivalence of MRI examination with the number of CXR

Figure 6. Percentage distribution of answers in different groups of medical doctors to the question about the equivalence of one phase of head CT examination in children with the number of CXR (column 2 shows the correct answers)

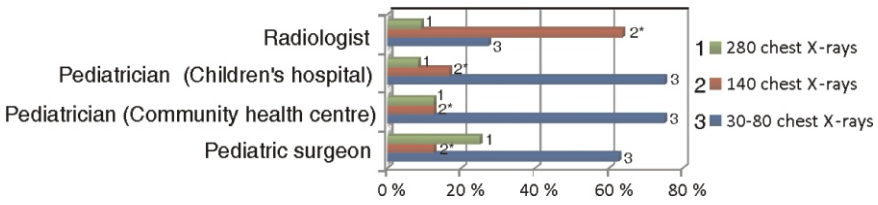
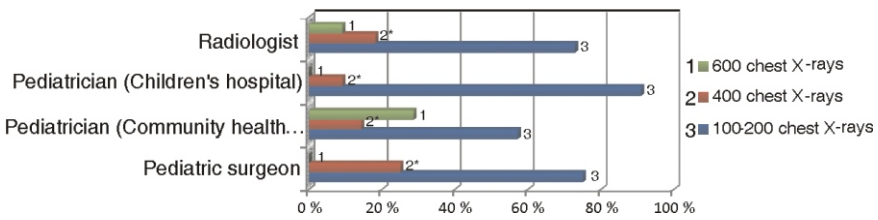


Figure 7. Percentage distribution of answers in different groups of medical doctors to the question about the equivalence of one phase of abdominal and pelvic CT examination in children with the number of CXR (column 2 shows the correct answers)



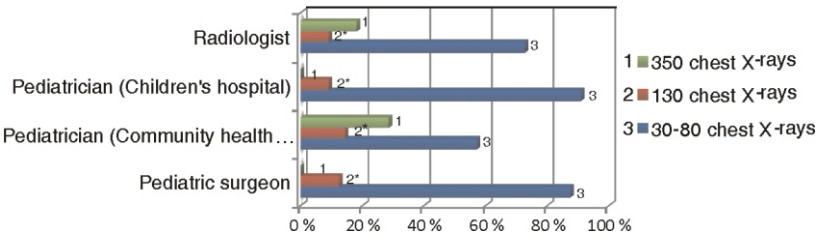


Figure 8. Percentage distribution of answers in different groups of medical doctors to the question about the equivalence of barium meal examination with the number of CXR (column 2 shows the correct answers)

one of the basic topics in mutual communication and cooperation among referring physicians, *e. g.* pediatric surgeons, pediatricians and pediatric radiologists, as well as other medical workers involved in diagnostic process and in treatment of pediatric population, but also among parents themselves who surely have the right to know about potential risks of diagnostic procedures their children are exposed to. An important question is whether consciousness about harmful effects of ionizing radiation is sufficiently present in all these groups and the goal of this study was in fact to evaluate the real situation *on the spot i. e.* to obtain more detailed access to the level of knowledge and attitudes of medical and non-medical staff (parents) on this topic. To the best of our knowledge, this is the first study of its kind not only in Serbia, but also in Southeastern Europe, dealing with this topic for pediatric population.

The greatest percentage of medical staff (50-80 %) estimated their knowledge about the ionizing radiation as moderate. An evaluation of the level of knowledge about ionizing radiation in all examined groups was based on the number of correct answers to 17 questions in Questionnaire 1. Among the doctors not one group has statistically singled out significantly, but the best results were shown by the radiology residents, which was quite expected, considering that they are probably in the situation to have to follow all up-to-date information in radiology. Medical staff with over 20 years of service had the least number of correct answers which is also expected since the interest of the doctors about contemporary up-to-date topics from their profession very often decreases with the increase of years of service. This is in accordance with the Salerno *et al.* study [13] where younger doctors also showed better knowledge than their older colleagues, but not in concordance with Dehghani *et al*., [14] study in which the level of radiation awareness was not associated with job experience. We also wanted to show the level of teaching quality on this topic, including medical students in our survey. Our study has shown statistically significant difference among groups of students before attending radiology course and after passing the same (5:8 correct answers). But, even though they passed the radiology exam, a small number of medical students (up to 25.5 %) had been informed about elementary principles and campaigns connected with protection from excessive usage of ionizing radiation in diagnostic purposes (ALARA and *Image gently*). This indicates great potential for further improvement of work with students in radiology course. Our study has shown exceptionally low knowledge about *Image gently* campaign and ALARA principle among all other groups, except radiologists and radiology residents. The campaign *Image gently* which had been initiated by pediatric radiologists in 2006 has its aim to raise awareness about the main principles of radiation protection such as medical examination justification, protection optimization and individual doses and risks limitations, while ALARA principle advocates reduction of radiation doses that patients and medical staff receive to the lowest possible level [8, 9]. Not even 20 % of pediatricians, *e. g.* referring physicians who indicate radiological diagnostic procedures almost every day, are familiar with *Image gently* campaign, while only 37.5 % of pediatric surgeons are informed about it. Up to 8.3 % of pediatricians and 25 % of pediatric surgeons have been familiar with ALARA principle. Low level of knowledge about ALARA principle has been shown in the Salerno *et al*. [13] study where only 27 % of surveyed doctors have heard of this principle, in the Heyer *et al.* [15] study, only 15 % of pediatricians, and in Hamarsheha *et al*. [16] study in which only 6.1 % of medical doctors were familiar with this principle, while we could not manage to find a survey in available literature, which dealt with *Image gently* familiarity.

Being informed about ionizing radiation from the scientific literature or lecture have reported three quarters of respondents, but no statistical significant difference in the number of correct answers in relation to the group of respondents who did not have the chance to complement their knowledge in this way was found. Significantly lower percentage of respondents (20 %) who have read scientific article about ionizing radiation is mentioned in the study by Abdullah *et al.* [17].

Extremely high percentage of surveyed medical doctors in our study considers that radiology methods based on ionizing radiation have been used excessively often in children (41-100 % respondents in groups). This is contrary to the opinion of parents among who only 12.5 % considered that radiology methods have been used excessively in children. This fact points out an outstanding trust of parents in medical decisions and assessments.

A high percentage of medical doctors in our study considered that parents should be informed about potentially harmful effects of ionizing radiation

before examining a child, but there was a smaller number of those who apply this in everyday clinical practice. Despite that, we were surprised by the high percentage of those medical doctors who claimed that they inform parents about these facts and which was over 60 % for almost all groups. It seemed to us that this was in collision with everyday clinical experience which was proved by analyzing questionnaire filled in by parents. Over 70 % of them stated that they have never been informed about potential consequences before radiological diagnostic procedures were performed in their children. It seems that on this issue radiologists have been the sincerest, admitting that they very rarely inform parents or patients, *i. e*. only 9 % of them answered this question affirmatively. In the Lee *et al*. [18] study approximately similar percentage of radiologists claimed that they inform the patients before examination itself (15 %), while that percentage among medical doctors in other fields was 22 %. We think that communication about the potential risks of X-ray based diagnostic modalities between parents or other caregivers and referring physicians/radiologist should be a standard pre-examination procedure in all children's hospitals. A proper communication seems a right way to establish the relationship of trust between parents and medical staff. However, high percentage of radiologists (72.7 %) and anesthesiologists (60 %) considered that more detailed informing of parents might cause problems in everyday work, while percentage of pediatric surgeons and pediatricians with this opinion was significantly lower (up to 27 %). It is realistic to expect that if this informing was to be introduced in everyday diagnostic protocol, it might lead to problems in terms of rejecting necessary diagnostic procedures because of parents' fear of their potential harmful effects in children, but, in our opinion this is a risk we should take because no one has more rights to get all information about one's child than the parent himself. We should, of course, think of a subtle way to present potential risks to parents, but not to cause fear among them or to attract negative media attention. Encouraging fact is that over 70 % of parents in our study would agree with indicated medical examination despite the risks mentioned before it was carried out. We consider that we have no right do disable parents' choice. If parents refused a certain diagnostic procedure to be performed on their child, and if, because of that, certain consequences occurred for their child, more than half of the parents in our research claimed that they would blame themselves for it, but only 4 % would blame the doctors. Nevertheless, this information must be taken into consideration with a caution, because cogitation and the state of consciousness is significantly different in theory (questionnaire) and in reality.

Over 70 % of radiologists considered that the total effective dose of ionizing radiation deriving from radiological diagnostic procedures performed during hospitalization should be recorded, while only up to 50 % of pediatric surgeons and pediatricians shared this opinion. This is, surely, the question which attracts numerous medico-legal aspects and would certainly open wide possibilities for lawsuits against medical doctors, but, on the other hand, it would significantly increase the responsibility and awareness of all the participants who take part in indicating diagnostic procedures, primarily of clinicians and radiologists. The risk of not performing the examination should be part of decision-making [19].

Studies have shown that CT examinations form about 13 % of all radiological procedures, but are responsible for as much as 70 % of total exposure to radiation, which makes them the *carriers* of radiation in medicine [20, 21]. As much as 30-40 % of CT examinations in pediatric population did not have appropriate indications [5]. In spite of evident harmful effects of ionizing radiation, there is an increasing number of CT examinations in children's hospitals of about 23 % [22]. This might be avoided by using imaging guidelines, such as the pediatric trauma protocol [23].

All radiologists, anesthesiologists, pediatric surgeons and pediatric surgery residents knew that CT increases the risk of carcinoma development in children, while pediatricians were aware of this fact in 58-73 %, depending on the place of employment. This can be explained by the fact that a lecture was organized on two occasions for pediatric surgeons and anesthesiologists on the topic of ionizing radiation in pediatric radiology. The study of Madrigano *et al*. [24] also showed a connection between teaching activities and superior knowledge about ionizing radiation. Yurt *et al*. [25] study has shown that 93.5 % of surveyed medical staff knew that CT examination increases the risk of carcinoma development, which showed greater awareness of medical workers comparing it with ours, primarily among the doctors specialists. A relatively large number of pediatric surgeons and pediatricians (about 40 %) are not aware that there are no doses of ionizing radiation without risk for children. The studies have however shown that three radiographs in children's age are already enough to increase the risk of acute lymphoblastic leukemia development for about three times [26].

It was surprising that in every group of doctors there was at least one who was not familiar with the fact that MRI is not based on ionizing radiation, which is, by all means, a better result than in Abdellah *et al*. [17] study in which 65 % out of 80 surveyed doctors did not know that MRI does not emit X-rays. There was also a study by Faggioni *et al.* [27] revealing a high percentage of medical students, who did not correctly, identified MRI, and even ultrasound as radiation-free procedures.

When evaluating the effective doses of radiation used for head, abdomen and pelvic CT examination, as well as for barium meal examinations, and which are

expressed in the equivalent number of CXR, the highest percentage of clinicians and radiologists underestimated ionizing radiation doses. The only exception was the question about the dose for head CT in children which was correctly answered by most radiologists. Among the doctors who mostly underestimated radiation doses in CT examinations of head, and abdomen and pelvis in children, pediatricians were in greatest number (75-90 %). Only 10-20 % of radiologists could evaluate radiation doses in CT examinations of abdomen and pelvis and in barium meal examinations accurately, which is in compliance with Lee *et al*. [18] study in which radiation doses have been underestimated by as much as 71 % of surveyed radiologists and 66 % of the rest of surveyed doctors specialists [18]. Our study is also in concordance with Salerno *et al*. [13] study which has shown that high percentage of pediatricians, as much as 78 % underestimated radiation doses in abdominal CT examinations. In our research, reference doses for CT examinations were determined on the base of an annual investigation whereby it should be emphasized that we use extremely developed and advanced pediatric CT protocols. The effective dose evaluation for barium meal fluoroscopic examination was based on literature information [28].

The major drawback of our research represents a relatively small number of respondents. We consider that similar research should be carried out on the whole territory of our country, which would enable more comprehensive insight into current knowledge of both medical staff and parents about ionizing radiation, but it would also create guidelines for further steps in education on this topic and in modernization of diagnostic algorithms, primarily in terms of more rigorous criteria for indication of CT procedures, but also for other diagnostic procedures in pediatric radiology.

CONCLUSIONS

Medical staff has not shown a satisfactory level of knowledge about ionizing radiation in pediatric radiology, which was especially illustrated by underestimation of effective doses for CT and fluoroscopy examinations by almost all clinicians, as well as by an extremely low percentage of clinicians, especially pediatricians, who have not even heard about ALARA principle and Image gently campaign. An extensive, organized education is required for medical staff, since the awareness of potential adverse effects of ionizing radiation in pediatric population might have an important influence on everyday clinical practice and indications for radiological diagnostic procedures. Our study also showed that there is still room for improvement of communication skills, in order to share information about the potential risks of X-ray based radiological procedures with parents/caregivers. Radiologists and referring physicians should be much more familiar with all potential adverse effects of ionizing radiation, the approximate effective doses of procedures they indicate, as well as with referral pediatric diagnostic guidelines. This might reduce a general medical radiation exposure of children, one of the most vulnerable populations to radiation effects.

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REFERENCES

[1] Berrington de Gonzales, A., Darby, S. L., Risk of Cancer from Diagnostic X-Rays: Estimates for the UK and 14 Other Countries, *Lancet, 363* (2004), 9406, pp. 345-351
[2] ***, NCRP Report No. 160: Ionizing Radiation Exposure of the Population of the United States National Council on Radiation Protection and Measurements, Bethesda, MD (2009). – Available at: http://www.ncrponline.org/publications/reports/ncrp-report-160-2/
[3] Alzen, G., Benz-Bohm, G., Radiation Protection in Pediatric Radiology, *Dtsch Arztebl Int, 108* (2011), 24, pp. 407-414
[4] Mettler, F. A., *et al*., CT Scanning: Patterns of Use and Dose, *J Radiol Prot, 20* (2000), 4, pp. 353-359
[5] Slovis, T. L., ed. ALARA Conference Proceedings: the ALARA Concept in Pediatric CT – Intelligent Dose Reduction, *Pediatr Radiol, 32* (2002), 4, pp. 217-313
[6] Annex, D., Medical Radiation Exposures. In: UNSCEAR 2000 Report Vol I: Sources and Effects of Ionizing Radiation. Vienna, Austria, United Nations Scientific Committee on the Effects of Atomic Radiation, 2000, pp. 295-495
[7] Hall, E. J., Lessons we Have Learned from Our Children: Cancer Risks from Diagnostic Radiology, *Pediatr Radiol, 32* (2002), 10, pp. 700-706
[8] Strauss, K. J., Kaste, S. C., The ALARA (As Low As Reasonably Achievable) Concept in Pediatric Interventional and Fluoroscopic Imaging: Striving to Keep Radiation Doses as Low as Possible during Fluoroscopy of Pediatric Patients – a white Paper Executive Summary, *Radiology, 240* (2006), 3, pp. 621-622
[9] Goske, M., *et al*., The 'Image Gently' Campaign: Increasing CT Radiation Dose Awareness Through a National Education and Awareness Program, *Pediatr Radiol, 38* (2008), 3, pp. 265-269

[10] Correia, M. J., *et al*., Lack of Radiological Awareness Among Physicians Working in a Tertiary-Care Cardiological Centre, *Int J Cardiol, 103* (2005), 3, pp. 307-311
[11] Arslanoglu, A., *et al*., Doctors' and Intern Doctors' Knowledge About Patients' Ionizing Radiation Exposure Doses During Common Radiological Examinations, *Diagn Interv Radiol, 13* (2007), 2, pp. 53-55
[12] Thomas, K. E., *et al*., Assessment of Radiation Dose Awareness Among Pediatricians, *Pediatr Radiol, 36* (2006), 8, pp. 823-832
[13] Salerno, S., *et al*., Radiation Risks Knowledge in Resident and Fellow in Paediatrics: A Questionnaire Survey, *Ital J Pediatr, 41* (2015), March, p. 21
[14] Dehghani, A., *et al*., Radiation Safety Awareness Amongst Staff and Patients in the Hospitals, *IJOH, 6* (2014), 3, pp. 114-119
[15] Heyer, C. M., *et al*., Paediatrician Awareness of Radiation Dose and Inherent Risks in Chest Imaging Studies--A Questionnaire Study, *Eur J Radiol, 76* (2010), 2, pp. 288-293
[16] Hamarsheh, A., *et al*., Assessment of Physicians' Knowledge and Awareness About the Hazards of Radiological Examinations on the Health of Their Patients, *East Mediterr Health J, 18* (2012), 8, pp. 875-881
[17] Abdellah, R. F., *et al*., Assessment of physicians' Knowledge, Attitude and Practices of Radiation Safety at Suez Canal University Hospital, Egypt, *O JRad, 5* (2015), 4, pp. 250-258
[18] Lee, C. I., *et al*., Diagnostic CT Scans: Assessment of Patient, Physician, and Radiologist Awareness of Radiation Dose and Possible Risks, *Radiology, 231* (2004), 2, pp. 393-398
[19] Madan, M. Rehani., Patient Radiation Exposure and Dose Tracking: A Perspective, *J. Med. Imag., 4* (2017), 3, 031206
[20] Dixon, A. K., Goldstone, K. E., Abdominal CT and the Euratom Directive, *Eur Radiol, 12* (2002), 6, pp.1567-1570
[21] Mettler, F. A., *et al*., CT Scanning: Patterns of Use and Dose, *J Radiol Prot., 20* (2000), 4, pp. 353-359
[22] Don, S., Radiosensitivity of Children: Potential for Overexposure in CR and DR and Magnitude of Doses in Ordinary Radiographic Examinations, *Pediatr Radiol, 34* (2004) S3, pp. 167-172
[23] ***, The Royal College of Radiologists, Paediatric Trauma Protocols, London: The Royal College of Radiologists, (2014), - Available at: https://www.rcr.ac.uk/system/files/publication/field_publication_files/BFCR%2814%298paeds_trauma.pdf
[24] Madrigano, R. R., *et al*., Evaluation of Non-Radiologist Physicians' Knowledge on Aspects Related to Ionizing Radiation in Imaging, *Radiol Bras, 47* (2014), 4, pp. 210-216
[25] Yurt, A., *et al*., Evaluation of Awareness on Radiation Protection and Knowledge About Radiological Examinations in Healthcare Professionals Who Use Ionized Radiation at Work, *Mol Imaging Radionucl Ther 23* (2014), 2, pp. 48-53
[26] Pearce, M. S., *et al*., Radiation Exposure from CT Scans in Childhood and Subsequent Risk of Leukaemia and Brain Tumours: A Retrospective Cohort Study, *Lancet, 380* (2012), 9840, pp. 499-505
[27] Faggioni, L., *et al*., Awareness of Radiation Protection and Dose Levels of Imaging Procedures Among Medical Students, Radiography Students, and Radiology Residents at An Academic Hospital: Results of a Comprehensive Study, *Eur J Radiol, 86* (2017), Jan., pp. 135-142
[28] Hart, A., Wall, B. F., Radiation Exposure of the UK Population from Medical and dental X-Ray Examinations NRPB-W4 Oxfordshire, United Kingdom: National Radiological Protection Board; 2002

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APPENDIX A Questionnaire 1

Circle just one answer to every offered question.

1) I belong to the following group of respondents:
a) pediatric surgeon
b) pediatrician (Community health centre)
c) pediatrician (Children's hospital)
d) anesthesiologist
e) radiologist
f) radiology resident
g) radiographer
h) pediatric resident
i) pediatric surgery resident
j) nurse
k) student who has not attended radiology course
l) student who passed radiology course

2) Sex:
a) male
b) female

3) Years of service:
a) up to 5
b) 6 to 10
c) 11 to 20
d) over 20

4) Degree of education:
a) secondary school
b) college
c) university
d) master's degree/ doctorate

5) How would you assess your knowledge on ionizing radiation used for most frequent radiological diagnostic procedures:
a) excellent
b) moderate
c) weak
d) it is completely irrelevant for everyday clinical work

6) Have you ever read scientific article about potentially harmful radiation effects in medicine:
a) yes
b) no

7) Have you heard of ALARA principle:
a) yes
b) no

8) Have you been acquainted with *Image gently* campaign:
a) yes
b) no

9) The largest source of man-made radiation in everyday life is the one which originates from:
a) cosmic radiation
b) inhalation of radioactive substances
c) medical diagnostic procedures
d) nuclear power plant

10) Does by moving away from the source of ionizing radiation the effective dose received by medical staff or parents change if they are not behind the lead wall:
a) yes
b) no

11) Is body mass important parameter which influences on effective dose of ionizing radiation a child will recieve:
a) yes
b) no
c) I don't know

12) Is the age important parameter that affects effective dose of ionizing radiation the child receives:
a) yes
b) no
c) I don't know

13) Do you think that radiological methods based on X-rays (*e.g*. CT or radiographs) are excessively used in children:
a) yes
b) no
c) sometimes
d) I don't know

14) Are children more sensitive to ionizing radiation than adults:

a) yes
b) no
c) I don't know

15) Are there doses of ionizing radiation that carry no risk for children:
a) yes
b) no
c) I don't know

16) If the same CT protocol is used for children as for adults, the effective dose is:
a) the same for a child and for an adult
b) slightly higher for a child
c) 2 to 3 times higher for a child
d) up to 10 times higher for a child

17) CT examination increases the risk of developing cancer:
a) yes
b) no
c) I don't know

18) Who is responsible for justification of performed CT examination in children:
a) competent clinician (pediatrician/pediatric surgeon/neurologist/physiatrist)
b) radiologist
c) responsibility is mutual

19) Do you think that parents should be informed about potentially harmful effects of ionizing radiation in children before examination:
a) yes
b) no
c) maybe
d) I don't know

20) Do you inform the parents about potentially harmful effects of ionizing radiation:
a) always
b) often
c) rarely
d) never

21) Do you consider that parent has the right in deciding about performing potentially harmful diagnostic procedure:
a) yes
b) no

22) Do you consider that detailed informing of parents could cause problems in everyday work:
a) yes
b) no
c) maybe
d) I don't know

23) Do you consider that detailed informing of parents could endanger benefit of the patient:
a) yes
b) no
c) maybe
d) I don't know

24) Who do you think should announce the diagnosis to parent concerning his child:
a) radiologist
b) doctor who treats the child
c) it doesn't matter

25) Do you think that the effective dose of ionizing radiation that the child received during hospitalization should be put on the discharge list:
a) yes
b) no
c) I don't know

26) For receiving identical dose of ionizing radiation, one year old child has greater risk of developing carcinoma than adult:
a) twice
b) 10 to 15 times
c) 50 times
d) 3 times

27) The latency period for radiation-induced leukemia is approximately:
a) 5 years
b) 15 years
c) 40 years
d) 30 years

28) The latency period for radiation-induced solid malignant tumors is at least:
a) 30 years
b) 20 years
c) 50 years
d) 10 years

29) 2-3 head CT scans in children up to 15 years of age:
a) increase the risk of developing a brain tumor 10 times
b) don't increase the risk of developing a brain tumor
c) increase the risk of developing a brain tumor 3 times

30) One phase of head CT scan in children is equivalent to up to:
a) 30 chest X-rays
b) 80 chest X-rays
c) 140 chest X-rays
d) 280 chest X-rays

31) One phase of abdomen and s pelvis CT scans in children is equivalent to up to:
a) 100 chest X-rays
b) 200 chest X-rays
c) 400 chest X-rays
d) 600 chest X-rays

32) Head MRI scan in children is equivalent to up to:
a) 5 chest X-rays
b) 1 chest X-ray
c) 0 chest X-rays
d) 10 chest X-rays

33) Voiding cystourethrography is equivalent with up to:
a) 5 chest X-rays
b) 15 chest X-rays
c) 60 chest X-rays
d) 150 chest X-rays

34) Gastroduodenal radiography is equivalent to about:
a) 30 chest X-rays
b) 80 chest X-rays
c) 130 chest X-rays
d) 350 chest X-rays

APPENDIX B Questionnaire 2

1) Sex:
a) male
b) female

2) Degree of education:
a) secondary school
b) college
c) university
d) master's degree/doctorate

3) Have you ever heard or read about potentially harmful radiation effects in medicine:
a) yes
b) no
c) I'm not sure

4) Have you ever heard of ALARA principle:
a) yes
b) no

5) Have you been acquainted with "Image gently" campaign:
a) yes
b) no

6) Does by moving away from the source of ionizing radiation, the effective dose received by medical staff or parents change if they are not behind the lead wall:
a) yes
b) no

7) Which of the following procedures your child was exposed to:

a) radiography
b) fluoroscopy
c) CT (computed tomography)
d) MRI (magnetic resonance imaging)
e) US (ultrasound)

8) CT scan increases the risk of developing carcinoma:
a) yes
b) no
c) I don't know

9) Are children more sensitive to ionizing radiation than adults:
a) yes
b) no
c) I don't know

10) Are there doses of ionizing radiation that carry no risk for children:
a) yes
b) no
c) I don't know

11) Have you asked for explanation from your doctor about why a certain radiological diagnostic procedure has to be performed on your child:
a) always
b) often
c) rarely
d) never

12) Do you think that you have the right in making decision on performing radiological diagnostics based on X-ray radiation on your child:
a) yes
b) no
c) I don't know

13) Have you ever asked your doctor if there was some other diagnostic method which was not based on radiation, but which could give similar diagnostic result on your child:
a) yes
b) no
c) I don't know

14) Had the doctor always examined the child before sending him/her to do a radiography:
a) yes
b) no
c) I don't know
d) the child has never been sent to do a radiography

15) Had the doctor always examined the child before he sending him/her to CT scan:
a) yes
b) no
c) I don't know
d) the child has never been sent to CT scan

16) Had the doctor always examined the child before sending him/her to ultrasound examination:
a) yes
b) no
c) I don't know
d) the child has never been sent to ultrasound examination

17) Have any of the doctors warned you about the potential harmful effects of diagnostic procedures based on radiation your child has been exposed to:
a) always
b) often
c) rarely
d) never

18) Would you like to be warned:
a) yes
b) no
c) I don't know

19) If someone should talk to you about potential harmful effects of radiation on your child, that would be:
a) clinician
b) radiologist
c) nurse
d) any of them

20) The probability that you would refuse the examination on your child based on X-ray radiation if someone pointed to the potential risks is:
a) high
b) low
c) it depends on urgency
d) the doctors know what they are doing and I do not question their opinion

21) Which of the offered methods are not based on potentially harmful X-ray radiation:
a) X-ray scans
b) CT scans
c) ultrasound
d) MRI scans
e) correct answers are c and d

22) If your child needed an examination which carried a high dose of radiation, would you give your consent to it:
a) yes, if that examination is really necessary and there is no alternative, less harmful examination
b) if there is examination that would give similar diagnostic results and is not harmful, but it is not available in the hospital, I would be even ready to pay for that examination somewhere else, only to avoid to expose my child to radiation
c) I wouldn't give my consent
d) I don't know

23) Are, in yur opinion, radiological methods based on X-ray radiation (*e. g.* radiography or CT) excessively and unreasonably often used in children:
a) yes
b) no
c) sometimes
d) I don't know

24) If you refused performing some potentially harmful diagnostics and if your child suffered harm due to delayed diagnostics or because of the lack of proper diagnostics, who would you blame for that:
a) myself
b) doctors
c) nobody
d) I don't know

25) Would you like to learn more about harmful effects of radiation in medicine:
a) yes
b) no

26) Who do you think should tell the parent diagnosis of his child:
a) radiologist
b) the doctor who is treating the child
c) anyone, as far as one tells me the whole thruth

27) Do you think that the dose of radiation a child received during hospitalization should be put on the discharge list:
a) yes
b) no
c) I don't know

28) One phase of head CT scan in children is equivalent with up to:
a) 30 chest X-rays
b) 80 chest X-rays
c) 140 chest X-rays
d) 280 chest X-rays

29) One phase of abdomen and pelvis CT scans in children is equivalent with up to:
a) 100 chest X-rays
b) 200 chest X-rays
c) 400 chest X-rays
d) 600 chest X-rays

30) Head MRI scan in children is equivalent with up to:
a) 5 chest X-rays
b) 1 chest X-ray
c) 0 chest X-rays
d) 10 chest X-rays

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ЈОНИЗУЈУЋЕ ЗРАЧЕЊЕ У ПЕДИЈАТРИЈСКОЈ РАДИОЛОГИЈИ
Да ли медицинско особље и родитељи знају довољно – регионална студија у Србији

Циљ истраживања био је да се утврди ниво знања и свести здравствених радника, студената медицине и родитеља о потенцијално штетном дејству јонизујућег значења. Спроведена је студија пресека у две здравствене установе и Медицинском факултету, помоћу два упитника који су конструисани за потребе овог истраживања (упитник 1 су попуњавали здравсвтвени радници и студенти медицине, а упитник 2 родитељи деце која су била изложена радиолошким дијагностичким процедурама). Обухватила је 254 испитаника. Већина испитаника проценила је своје знање о јонизујућем зрачењу као осредње. Мање од половине клиничара, специјалиста и лекара на специјализацији је упознато са кампањом "Image gently". Више од 60 % лекара сматра да се радиолошке процедуре често неоправдано користе код деце. Иако 60-80 % клиничара тврди да информишу родитеље, око 70 % родитеља је потврдило да никада нису били информисани о ефектима јонизујућег зрачења пре радиолошког дијагностичког поступка. Између 50 % и 85 % педијатара и дечјих хирурга значајно је потценило ефективну дозу код компјутерске томографије и рендгеноскопских прегледа. Од 58 % до 100 % клиничара је свесно да компјутерска томографија повећава ризик од развоја карцинома. Знање испитаника о јонизујућем зрачењу и његовим потенцијалним штетним ефектима у педијатријској популацији је недовољно, те је потребна организована едукација.

Кључне речи: јонизујуће зрачење, педијатрија, упитник, медицинско особље, родитељи, Србија