Knowledge Evaluation of People Working in Radiation Areas for Medical Diagnostics after Undergoing Radiation Protection Instructions

Master Thesis

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Declaration

I declare that I have developed and written the enclosed Master Thesis completely by myself, and have not used sources or means without declaration in the text. Any thoughts from others or literal quotations are clearly marked. This work was not used in the same or in a similar version to achieve an academic grading or is being published elsewhere.

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Abstract

Radiation used in diagnostic medicine must provide a careful and safe application, as it has the potential to increase health risks of the human body. To provide application of radiation in high quality, health professionals working in radiation areas, have to undergo regularly radiation protection instructions whose participation is mandatory by the Austrian legislation. However, the existing lack of how to verify the through those instuctions transferred knowledge, brings up the need for adequate tools of evaluation as there is no standardized and statutory way of how to enable assurance that all important aspects of radiation protection instructions got discerned by its participants.

For this study, a questionnaire covering all required aspects of radiation protection instructions, was created. The technical implementation presented the questionnaire's transfer into a framework for an online survey. Subsequent the online survey was conducted on the target group of radiological technologists and/or medical-technical assistants working in diagnostic radiology at two different hospitals in Vienna. The data was analysed using Microsoft Excel and parameters of descriptive statistic.

In the overall ranking of performance, subjects reached the highest score in category 2 "Applied Radiation Protection for Patients and Staff" and category 4 "Health Risks" with each 82% of correct given answers on average. The second highest score reached category 3 "Occupationally Exposed Personnel" with 67%. The lowest score with 61% reached category 1 "Dose Terms and Definitions".

The results show that overall all categories reached as adequate considered scores in overall level of knowledge after radiation protection instructions as none category reached less than 60% of correct given answers. Still there were certain aspects that were obviously less adequate perceived by the target group, where the majority of given answers were false.

An online questionnaire constructed equal as in the present study can help revealing aspects of radiation protection that would benefit from a revision of knowledge transfer. For this reason, it presents a feasible tool for evaluation of radiation protection instructions in order to enable feedback to the instructing preceptor. Further, its' easy implementation may motivate radiological institutions to integrate evaluation of radiation protection instructions via an online questionnaire into practice and thus strengthen quality assurance in diagnostic radiology

Kurzfassung

Die Anwendung von Röntgenstrahlung in der medizinischen Diagnostik muss unter sorgfältig erwogenen Sicherheitsaspekten erfolgen, da diese das Potenzial hat, das Risiko für Gesundheitsschäden des menschlichen Körpers zu erhöhen. Um die Anwendung von Röntgenstrahlung in entsprechend hoher Qualität zu gewährleisten, müssen sich GesundheitsexpertInnen, die in Strahlenbereichen tätig sind, regelmäßig Strahlenschutzunterweisungen unterziehen, deren Absolvierung durch die österreichische Gesetzgebung vorgeschrieben ist. Jedoch indiziert der bestehende Mangel an Möglichkeiten zur Evaluierung des innerhalb dieser Unterweisungen vermittelten Wissens, eine Notwendigkeit adäquater Instrumente, da keine standardisierte und gesetzlich verankerte Art und Weise existiert, um zu verifizieren, dass alle wichtigen Aspekte von Strahlenschutzunterweisungen von den Teilnehmern wahrgenommen wurden.

Für die vorliegende Studie wurde ein Fragebogen erstellt, der alle erforderlichen Aspekte einer Strahlenschutzunterweisung abdeckt. Die technische Umsetzung erfolgte anhand des Transfers des Fragebogens in ein Framework für eine Online-Befragung. Anschließend erfolgte die Online-Befragung der Zielgruppe bestehend aus RadiologietechnologInnen und / oder medizinisch-technischen AssistentInnen, mit Berufsausübung in der diagnostischen Radiologie zweier unterschiedlicher Krankenhäuser in Wien. Die generierten Daten wurden mit Microsoft Excel und Parametern der deskriptiven Statistik analysiert.

In der Gesamtreihung der Performance erreichten Kategorie 2 „Angewandter Strahlenschutz für PatientInnen und Personal“ und Kategorie 4 „Gesundheitsrisiken“ die höchste Punktezahl mit jeweils durchschnittlich 82% korrekter Antworten. Die zweithöchste Punktzahl erreichte Kategorie 3 "Beruflich strahlenexponiertes Personal" mit 67%. Die niedrigste Punktzahl mit 61% erreichte die Kategorie 1 "Dosisbegriffe und Definitionen".

Die Ergebnisse zeigen, dass insgesamt alle Kategorien ein als adäquat bewertetes Ergebnis des Gesamtwissensstandes nach erfolgter Strahlenschutzunterweisung erreichten, da keine Kategorie im Durchschnitt weniger als 60% an korrekten Antworten erzielte. Dennoch gab es Aspekte, die weniger adäquat von der Zielgruppe wahrgenommen wurden, in dessen Fällen die Mehrheit der gegebenen Antworten falsch gegeben wurden.

Ein Online-Fragebogen, konstruiert entsprechend dem der vorliegenden Studie, kann helfen, Aspekte des Strahlenschutzes aufzudecken, die von einer Revision des Wissenstransfers profitieren. Aus diesem Grund präsentiert sich dieser als ein praktikables Instrument zur Evaluierung von

Strahlenschutzunterweisungen, um der unterweisenden Person Feedback zu ermöglichen. Darüber hinaus kann auch die unkomplizierte Implementierung radiologische Institutionen motivieren, die Evaluierung von Strahlenschutzunterweisungen mittels Online-Fragebogen in die Praxis umzusetzen und damit die Qualitätssicherung in der diagnostischen Radiologie zu stärken.

Table of Content

1 Introduction

Radiation is a substantial part of human daily life as we are exposed to radiation from cosmic rays in our surroundings as well as from nutriment and drink that may contain traces of radioactivity. The number of medical examinations and procedures using ionizing radiation is increasing worldwide meaning that this adds exposure of ionizing radiation to that which is present all around us.[1]

In high doses, ionizing radiation is harmful to the human body. Although it is not certain if there is direct harm linked to the small doses of ionizing radiation that are used for medical diagnostics in controlled situations, it is important to understand that the risk of causing harm is depending upon its dose. The generation of radiation risk is cumulative which means that the more radiation exposure a person gets, the more the risk of health harm rises. In this context the medical exposure needs to be justified, so that the benefits for the patient most likely far outweight the risks.[1]

To keep the risk of ionizing radiation induced health harm for the patients and for the applying medical staff as low as possible, the knowledge and utilization of general principles of radiation protection is fundamental.

In order to assure a constantly consideration and application of these radiation protection principles in medical examinations and treatments, the Austrian legislation regulates by law (see chapter 2.7 National & International Situation) that there has to be radiation protection instructions for the applying staff on a regularly basis. These radiation protection instructions, performed by an authorized specialist, intent to consecutively keep the needed standards of radiation protection on a high level. Especially in the field of radiology where new technologies are rapidly developed, the need for continuing training of the applying staff is of great importance to ensure high quality practice of radiation protection troughout every radiological examination or intervention. The existing lack of how to verifiy the transferred knowledge through radiation protection instructions brings up the need for adequate tools to make such a verification possible.

1.1 Problem

As radiation safety in medical diagnostics is a complex field, the problem in terms of quality assurance is that the instructing person has to make sure that the delivered content surely was understood by the audience. However, there is no standardized way and no existing standardized tool to evaluate the delivered content of radiation protection principles.

1.2 Aim

For this reason, this thesis aims to create a feasible tool that allows an evaluation of the delivered knowledge of radiation protection instructions to embrace the requirements of laws and promotes radiological quality assurance. This tool aims to provide an adequate opportunity to precisely evaluate the within radiation protection instructions delivered knowledge and therefor enables the instructing preceptor feedback on how the different aspects of radiation protection are discerned by its participants.

1.3 Pivotal Question & Hypothesis

Concerning the technical aspect, the aim of this thesis is the development of an online questionnaire for the evaluation of radiation protection instructions. Trough the evaluation with this tool, conducted with the target group, the following research question will be answered:

Do the instructed persons not adequately perceive relevant aspects of radiation protection after completing a radiation protection instruction? Moreover, if so, to which specific aspects of the delivered knowledge applies that?

In order to give the instructing preceptor feedback on the knowledge transfer, the developed online questionnaire intends to cover all important aspects of radiation protection instructions in conventional and diagnostic radiography. This research question and subject matter rise up as there is no existing standardized and statutory way of how to evaluate radiation protection instructions, as they are a fundamental aspect in medical radiation areas and their included knowledge is of great importance and must be integrated into the everyday workplace of radiology.

1.4 Method

First, a research of existing literature was conducted to reveal different aspects of radiation protection and to point out the importance of executing principles and methods of the use of ionizing radiation for medical purposes. Secondly, the questions for the online questionnaire were framed, paying attention that all important aspects of radiation protection instructions in diagnostic radiography are covered. Subsequently the target group carried out the online survey. After completed participation by the target group, the results are statistically analyzed, interpreted and discussed.

1.5 Structure of the Thesis

The following chapter explains the theoretical background on ionizing radiation and presents the current state of the art. In chapter 3 “Methodology”, the procedural method of realization of this project, explaining the process of framing the content for the online questionnaire and the technical part, consisting of the testing and implementation of the online survey as well as documentation of results, are presented. Subsequent in chapter 4 the results of the online survey are shown. In a final statement in chapter 5 these results are discussed and continuative aspects of experiences and insights concerning this project are illustrated.

2 Theoretical Background & State of the Art

To get an overview about radiological principles in the context of radiation protection and understand why quality assurance in radiation protection is of great importance, the following subchapters intend to explain the theoretical background about what is ionizing radiation, the biological effects of radiation, the sources of radiation exposure, ionizing radiation in medical diagnostics and finally dosimetric principles. Afterwards the current situation and state of the art are explained.

2.1 Ionizing Radiation

Ionizing radiation is every electromagnetic radiation or energetic particles that can remove electrons from atoms or molecules and therefore leaving molecular residuals with a positive loading. This process is called ionization. The energetic particles that are produced during ionizing radiation (photons, protons, electrons, alpha particles or heavy nuclei) interact with matter. In conventional diagnostic radiology, the applied particles are photons, also named X-ray quanta. When they are emitted from sources of radiological machines to cells of the human body for medical purposes, they deposit part or all of their energy to the cells leading to varied interactions and effects on molecular levels. Responsible effects for the attenuation and scattering of photons when penetrating human tissue are three physical elementary processes. A schematic representation of these interactions of photons with matter that include the “photo effect”, the “compton effect” and “electron pair production” is shown in figure 1. Within these effects, the energy of an inclined photon is altered. Either it gets completely absorbed as during photoeffect or electron pair production, or it leaves matter with reduced energy, such as during compton effect. Besides these effects, a process where the inclined photon does not lose energy but simply gets deflected from its original path direction, known as the “conventional scattering”, occurs. Conventional scattering plays a vital role in radiation protection as it mostly occurs within the energy field that is used in conventional diagnostic radiology. The probability of occurrence of all these effects depends on varying highly dependence of several factors, such as the amount of the inclined photons’ energy and atomic composition of the absorbers’ matter [2] [3].

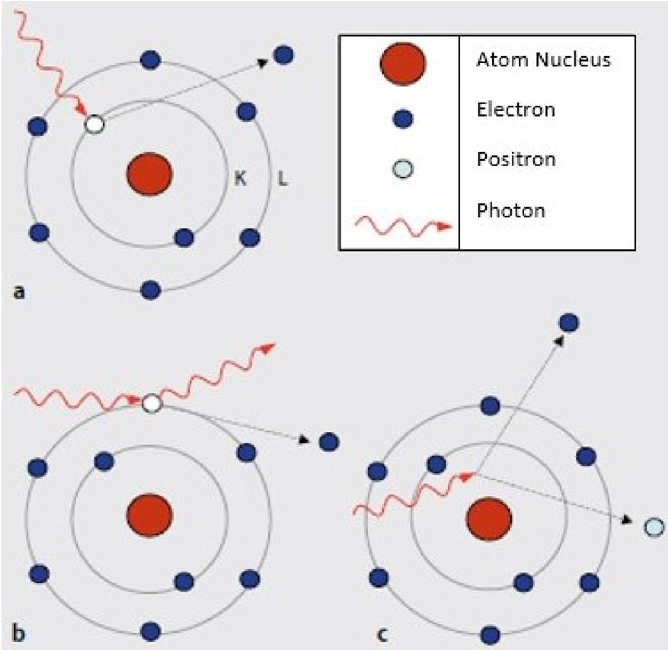


Figure 1: Schematic representation of the interactions of photons with matter. ***a*** *During photoeffect the inclined photon transmits its energy to an electron of the absorber which thereby gets released (photoelectron).* ***b*** *During compton effect the inclined photon transmits only part of its energy to a slightly bound electron of the outer shell, which therby gets dissolved of the atom and scattered.* ***c*** *Nearby an atom nucleus can spontaneously an electron pair production occur, when the energy of the inclined photon exceeds the electrons' double amount of static energy of 511 keV. The differential amount between the inclined photon and the electron-positrons' (product of the electron pair production) static energy gets transmitted as kinetic energy to the formed particles [2].*

In conventional diagnostic and interventional medicine, ionizing radiation that has photon energies between 100 electron volt (eV) and one mega electron volt (MeV) is used. A more common term for this kind of radiation, as normally used among general population, is X-ray. The technical production of X-rays takes place in the X-ray tube, where electrons get accelerated through an electrical field and impinge with high velocity on a solid target object. Therby X-ray quanta (photons) are produced that are used for radiological image acquisition [2].

The above described interactions and effects between the energetic particles when penetrating a human body may there cause changes in the tissue. Therefor, in the context of occupational environment, ionizing radiation represents one of the detrimental factors that can cause serious and irreversible damages in the body of people working in radiation areas [1] [4].

2.2 Biological Effects of Radiation

The biological effects of ionizing radiation due to the interactions and processes as described in chapter 2.1 “Ionizing Radiation” are versatile and complex. In general, radiation may damage various cellular components directly through molecule ionization, indirectly through production of reactive oxygen species, or both occurring alongside. Irradiated cells protect themselves by initiating various defense mechanisms, such as removal of oxidative stress and damaged cells and repair of genetic material. Remained cell damages may cause dysfunctions of tissue and organs and malignant diseases [5].

There are two main biological effects that may be caused by ionizing radiation:

1) Deterministic Effects
2) Stochastic Effects

1) Deterministic effects are the occurrence of tissue reactions that happen when the delivered dose of radiation exceeds a specific threshold. These effects cause an immediate and predictable change to tissue. The severity of these reactions is proportional to the dose accumulated of the tissue, more than the probability of their occurrence [1].

2) Stochastic effects describe the potential for future harm that may be caused to the body and tissue that is of random (stochastic) nature as the interaction of ionizing radiation with matter. They can be used to describe the potential of cancer occurrence and have no dose threshold for their occurrence. That means that theoretically a single mutation of desoxyribonucleic acid (DNA) can cause carcinogenic effects in the body. Although cellular repair mechanisms can reduce the possibility of cancer occurrence due to DNA mutations, the probability of stochastic effects and gaining radiation induced health damages is cumulative and proportional to the imparted dose [1].

2.3 Sources of Radiation Exposure

Radiation exposure can derive from natural sources and from artificial sources. The natural sources include radiation that is either from cosmic or terrestrial origin. Cosmic radiation consists of particles with high energies invading the planet earth at all the time. The terrestrial radiation comes from the earth itself, from radiation emitting isotopes that naturally exist in rocks and soil. The artificial sources relate to radiation exposure from dose delivered in controlled situations in diagnostic or interventional medicine, or can be dose contributions from nuclear weapons testing side effects and nuclear power plant discharges or accidents [1].

From both natural and artificial sources, doses to the human tissue can be imparted by external irradiation, inhalation (mainly radon gas inside buildings, but also small amounts of polonium from tobacco smoke) or ingestion.

2.4 Ionizing Radiation in Medical Diagnostics

When ionizing radiation is used in medical diagnostics, there are three main principles that must be followed:

Firstly, the principle of justification gets applied. Each examination where ionizing radiation is used must be orderly justified. This means that the benefits and risks of the intended examination must be weighted with consideration of alternative examinations which could be applied to answer the clinical question without using ionizing radiation [1] [6].

Secondly, the principle of optimization has to be used. Once the radiation examination is justified, it should be performed with the minimal possible radiation dose. At the same time, an adequate image quality is required. So the radiation dose can not just be minimized to a very low level, because radiation dose and image quality go along with each other and a minimization of radiation dose may result in a remarkable loss of image quality. Generally, the acquisition parameters, that account for the delivered dose and are recommended for achievement of optimal image quality, are predefined in saved settings of the X-ray machines' software, that is provided by the device manufacturer. Dependent on the phototelegraphic receiver (conventional film-foil system vs. digital detector system) that is used, adaption of acquisition parameters is more (conventional film-foil system) or less (digital detector system) of importance, as the latter system works with integrated automatic exposure control. Adaptive acquisition parameters include the applied voltage of the X-ray tube, specified in kilovolt (kV) and the applied power-time-product, specified in milliampere-second (mAs). The kV are responsible for the quality of radiation, meaning their amount determines the penetration of objects (hardness of radiation), while the mAs-product determines the quantity of radiation. These two parameters together with the distance between the X-ray tubes' focus and the detector as receptor of radiation represent the three main parameters that contribute for image quality and define the delivered dose to the patient.

Besides these three main parameters, there are several more components, that play a vital role in image quality and dose level, such as type of X-rax machines' generator, type of phototelegraphic receiver, shutters, anti-scatter grid, lens tube, additional filters and the patients' volume [6] [7].

In radiological practice it is further the applying operators' responsibility to take the parameters that contribute for image quality into consideration and adapt them where necessary. Adaption of parameters are made in order to achieve an adequate balance between delivered dose and image quality. In diagnostic radiology, the applying operators are radiological technologists or medical-technical assistants.

This means the principle of optimization can further be defined as the requirement to keep the exposure as low as reasonably achievable. This is also called the "ALARA principle" ("as low as reasonably achievable") [8].

The third principle is the principle of limitation that also represents an important tool for quality assurance in diagnostic radiology. That means that the delivered radiation doses should get compared with regional or national radiation dose reference levels [8].

In addition to these principles, unnecessary repeated examinations using ionizing radiation should be avoided. Exceptions are repeated examinations that are needed to monitor progress of disease or follow-up examinations [8].

2.5 Dosimetric Principles

Along with the use of ionizing radiation in medicine there is the need for dose control of the applying staff that is occupationally exposed to long-term levels of ionizing radiation [4].

The main tools for individual monitoring of dose assessment are physical and biological dosimetry. While biological dosimetry in form of a complete blood cells counting requires an invasive venipuncture, the physical dosimetry can easily be performed in form of wearing measuring devices in form of thermoluminescent (TLD) or air-equivalent ionization chamber dosimeters [4]. Correctly worn, they must be mounted on a representative area on the body torso. Figure 2 shows a correctly mounted TLD-dosimeter on the workwear in hip height. On the frontside, it displays the employees' name and corresponding month and year of radiation recording.

Figure 2: Correctly worn dosimeter mounted on the workwear in hip height.

All staff members working in radiation areas, in order to control their dose accumulation and monitor potential increases of health harm, must wear dosimeter. Authorized institutions, such as the Seibersdorf Laboratories in Austria, make the analysis of the absorbed doses of dosimeter. Therefor the dosimeter gets send to the congruent institution by the employer. Analysis takes place in monthly intervals in order to record the time constribution of the staff members' doses and to initiate correspondent sanctions with consideration of health protection if necessary.

2.6 Current Situation & State of the Art

As already mentioned radiation protection is an essential issue in the context of the safe and justified use of ionizing radiation for medical purposes.

Employing ionizing radiation in medicine demands for carefully balancing the benefits of improving human health and the risks related to radiation exposure of people. Therefore an appropriate level of radiation protection in radiological practice among health professionals has to be assured [9].

While the health benefits of radiation for medical purposes are widely recognized, the downsides should not be lost of sight. Radiation incidents due to radiation exposure in medicine account for more deaths and early acute health harm than any other source of radiation incident, including accidents at nuclear power plants. Health effects from radiation and cases of overexposure continue to be reported worldwide. Besides, the occupational exposure of people working in radiation areas is far greater in medicine than from any other source [9].

Vano et al [10] already reported 2006 that several of the published dose levels of occupational reported dosimetry support underestimation of delivered radiation dose in diagnostic and interventional medicine. These findings are based on the fact that many personal dosimeters are not worn according to instructions which points out the importance of carefully following the principles and rules of radiation protection instructions where personal dosimetry is part of [10].

In addition, most operators are not aware of the delivered dose level dimensions of unprotected organs during medical exposures. This leads to a constant underestimation of occupational hazard [11].

Heydarheydari et al [4] investigated the relation between radiation exposure and blood paramters of staff working in radiation areas. They found out that although the delivered radiation doses were below the permitted limits based on the ICRP, their study indicated the role of low-level chronic exposure in decreasing certain blood parameters appropriate as a biological dosimetry method of radiation workers with at least 10 years record. Their findings underline that monitoring of absorbed doses in radiology is essential for observation of potential health risks and the radiation exposure should be minimized as possible. Most important they emphasized that the exposed medical personnel should carefully follow the radiation protection instructions as this is the forming quintessence of quality assurance [5].

Congruent to that, several studies investigating outcomes of biological parameters of chronic to low-level radiation exposed personnel, broach the issue of the potential increased risk of radiation-induced health harm and risk perception in general, due to their profession [12] [13] [14]. Although physical control through dosimetry and periodic health examinations provide a control mechanism for the occupationally exposed personnels' accumulated dose, it is important to keep the radiation exposure from the beginning as low as possible through the responsible handling of ionizing radiation. This underlines the needed awareness of every health professional that it is his or her own responsibility to obey the principles of radiation protection and fully integrate them into his or her working environment.

The International Atomic Energy Agency (IAEA) accentuates that it is one of the main responsibilities as a medical-technical assistant or radiological technologist to perform the radiological procedure following an optimized protocol and ensuring radiation protection for the patient [15].

These findings and statements support the need for fully integrated and applied radiation protection principles by the responsible health professionals. As these principles are based and instructed through radiation protection instructions, the evaluation of their delivered knowledge presents a prevailing core of quality assurance in radiology.

2.7 National & International Situation

In Austria, the legislation about radiation protection in general is composed in the law of radiation protection (“Strahlenschutzgesetz”, StrSchG) [16].

Every person who is working in radiation areas, such as in hospitals or diagnostic ordinations, is bound to undergo regularly radiation protection instructions. These radiation protection instructions are obligatory referred to § 29 SchtrSchG and are further defined in § 16 (1) AllgStrSchV ("Allgemeine Strahlenschutzverordnung") [17].

The instructions must be in the required dimension, particularly before the beginning of employment and further in regular time periods as well as on special occasions such as the introduction of new technologies or after radiation incidents. At least there must be a radiation protection instruction for every person who is working in radiation areas, once a year [17]. Usually a radiation protection instruction takes place in form of a small group of employees (if hold at the place of employment), a group or a whole year of students (if hold at an university or other educational facility), or also in form of single instructions when executed in the course of radiation protection examinations of the employees’ health, that also are obligatory to undergo by every person working in radiation areas. The time consumed by a radiation protection instruction depends on the amount of content necessary to deliver to the instructed person with respect to his or her specific working environment and field of action. For example, a health professional working in diagnostic radiography gets instructed about the radiation protection instructions concerning all aspects of diagnostic radiography such as the safe use of ionizing radiation for medical purposes, but will not get instructed about radiation protection aspects of nuclear medicine, such as how to safely handle and apply radiopharmaceuticals to patients for medical purposes.

The Austrian StrSchG as mentioned above predetermines the frame conditions of radiation protection instructions’ content, but the specific contents can vary from different institutions due to different radiological equipment, machines or procedures performed.

The important contents of radiation protection must be well known by every applying operator in the medical and technological field such as radiological technologists, medical physicists, physicians or students of radiological technology or medicine. This is of great importance to provide an adequate practice of radiation whether for diagnostic or therapeutic applications.

Especially in the radiological and technical environment where new technologies and treatments are rapidly developed, the assured knowledge of radiation protection tasks is fundamental.

The World Health Organization (WHO) and the International Atomic Energy Agency (IAEA) framed a collaborative statement within the International Conference on Radiation Protection in 2012 that identifies the main actions that are fundamental for strengthening radiation protection in medicine over the next decade – the “Bonn Call for Action” [9].

They stated and confirmed existing gaps in radiation protection in medicine and presented the tools for closing those gaps [9]:

- Strengthen radiation protection of patients and staff working in radiation areas overall;
- Attain the highest benefit with the least possible risk of health harm to all patients with the safe and appropriate use of ionizing radiation in medicine;
- Aid in the full integration of radiation protection into health care systems;
- Help improve the risk-benefit dialogue with patients and the public;
- Enhance the safety and quality of radiological procedures in medicine.

This collaborative statement underlines the importance of constantly strengthening radiation protection in medicine to provide radiological procedures on a safe and qualitative high standard. For this reason a quality assurance of radiation protection instructions as evaluated within this study aims to support these requirements [9].

3 Requirements & Methodology

The complex of problems within the requirement of quality assurance in radiation protection is a prevailing and ongoing topic in radiology. As already mentioned in chapter 2 “Current Situation & State of the Art”, there is no standardized and statutory way of how to evaluate and assure oneself of the full range of delivered knowledge trough radiation protection instructions. The corollary that this thesis focuses on, in context to that problem, is to develop a feasible tool to make an evaluation of radiation protection instructions possible with respect to enable adequate quality assurance in radiological facilities.

3.1 Methodology

Radiation protection instructions intend to deliver a specific scope of knowledge to the instructed persons. The first consideration of how to evaluate this knowledge was to use a digital questionnaire covering the contents of radiation protection instructions. For an easier and straightforwardly accessibility, this questionnaire should be online available. Statistical analysis of the answered questions will provide data for evaluating the results and be the basis for interpretation of findings.

Firstly, a research in existing literature was conducted to reveal and verify different aspects of radiation protection in medical environments. The applying person and author of this survey and thesis herself is trained in radiation protection due to her educational degree of Bachelor of Science in Radiological Technology that contains the apprenticeship of executing the position as radiation protection officer. Further knowledge of this thesis’ author is featured through practical experience in radiation protection on grounds of an 18-month and ongoing employment at a radiological department in a Viennese Hospital. These facts support and ensure the correct delivery and integrated validated knowledge of radiation protection.

Secondly, the content of radiation protection instructions was compiled and structured in categories. Categorisation resulted in dependence on and about content of radiation protection instructions from different institutions (hospitals, university) as well as with respect to the Austrian legislation that provides the framework for the content of radiation protection instructions. According to these influencing factors, the following four categories were defined for the survey:

1) Dose Terms and Definitions („Dosisbegriffe und Definitionen“)
2) Applied Radiation Protection for Patients and Staff („Angewandter Strahlenschutz für PatientInnen und Personal“)
3) Occupationally Exposed Personnel („Beruflich strahlenexponiertes Personal“)
4) Health Risks („Gesundheitsrisiken“)

The first category focuses on dose terms and definitions as they build the fundament of dosimetry and need to be understood by health professionals working in radiation areas. Here the units of different dose measurements used in radiology are explained.

The second category “Applied Radiation Protection for Patients and Staff“, emphasizes how to viable apply principles of radiation protection in the radiological everyday routine, such as tasks to decrease radiation exposure and the optimal positioning of radiological machines and equipment for radiation protection.

The third category „Occupationally Exposed Personnel“ broaches the issue of personal dosimetry and how to correct wear personal dosimeters. Correct wearing of dosimeters is on the staff’s own responsibility of compliance and execution and builds the basis for monitoring of occupationally absorbed dose. Further the differentiation of categories of occupationally exposed personnel is important, as every employee in radiation areas, gets classified dependent on the possible accumulated doses within specified time ranges.

The fourth category „Health Risks“ refers to the knowledge of health harm different magnitudes dependent on the exposed organ or body part. This serves up for the essential knowledge of every person working in radiation areas of which organs are the ones at most risk of health harm trough ionizing radiation. Finally, in cases of female personnel, the importance of an early notification of pregnancy to the employer gets underlined.

While assuring that the important aspects of radiation protection instructions according to § 16 (1) AllgStrSchV with the categories mentioned above are covered, this evaluation also enables the assurance of delivered knowledge to the target group and its’ appropriate understanding. This important function comes up, as the instructing preceptor has to assure oneself that the delivered principles of radiation protection got understood by the audience [17].

Further explained in § 16 (2) AllgStrSchV is the fact that there must be recordings about time and content of the instruction, that must be signed by the instructing preceptor as well as by the person that gets instructed. These recordings must be preserved for at least 7 years and exhibited if requested by the responsible authority [17].

In daily practice of radiological facilities, the radiation protection instructions are carried out by authorised preceptors, generally the radiation protection officer or a further person that is commissioned with radiation protection in the correspondent facility. A further with radiation protection commissioned person can also be described as the replacement person for the radiation protection officer.

The records of radiation protection instructions are usually a printed form that gets signed by the two parties involved and therfor is not more than a paper of participation certificate.

The consideration of executing the evaluation of radiation protection instructions online is founded on the fact that this provides a feasible realisation and is easy accessible for the target group. For the technical realisation of the online questionnaire, the online platform "Unipark" (Questback GmbH, Köln, Germany) is used. This platform provides the framework for producing and conducting online surveys. After completion of the questionnaire by the participants and end time of the survey the generated data for analysis get provided.

3.2 Survey Implementation

3.2.1 Subject Information- and Declaration of Consent

The first step towards conducting the online survey is to consider general rules prevailing for every study that aims to investigate a specific topic or outcome of subjects. On this account, an information and agreement form for subjects was drafted to inform them about all important aspects of the survey. This enabled that they could give their informed consent to take part at the survey, without having any further questions or leaving any aspects within their participation that are not clear, open.

The subject information and declaration of consent form consists of four parts:

1. Address of welcome and introduction
2. Aim of the survey
3. Actions extending warranty of data privacy protection
4. Declaration of consent

In the first part, the title of the study is stated and the subjects get invited to take part at the survey. They get informed that participation of the survey will take place online. Further they get advised that appended to that form they find the link for participation in printed form and as an alternative a QR-Code for reading in via smartphones or other mobile end devices. Continuing information on how much time will approximately be demanded for answering the questionnaire and how much questions are overall, is given to enable the subjects estimating the time consumption of their participation. Closing the first part of this form, the fact that participation of the survey is anonymous and no personal data will be inquired or recorded, is pointed out. (For reasons of clearly arrangement the “address of welcome and introduction” is here numbered as part one of the information and agreement form although on the printed form this part is not numbered and the “aim of the study” starts as numbered part one.)

The second part explains the aim of the study. The introducing sentence here explains the importance of radiation protection instructions in context of quality assurance for the safe application of ionizing radiation. After mentioning title and responsible person, the research question is stated and why it is relevant to investigate these. In addition, it gets emphasized that the survey does not aim to reveal state of knowledge of single subjects, but rather to investigate the entity of state of knowledge of instructed persons to provide statistical analysis of radiation protection instructions. The further explanation declares that the statistical analysis serves as tool for feedback in terms of quality assurance for the instructing preceptor.

The third part of the form deals with the handling of within the survey generated and collected data and what actions for guarantee of personal data privacy are initiated. Here the subjects again get informed that filling in the online survey is anonymous and the generated data solely serve to answer the research question within this master thesis project. No passing on of generated data to third parties and no link-up by name will take place. Subsequent the subjects get informed that participation is voluntary. In case of nonparticipation the subjects will not be disadvantaged in any way. The third part is rounded up by the hint, that the subjects can cancel their participation at any time by closing the window of their browser.

The fourth and last part presents the declaration of consent. Here the subjects give their confirmation of having read and understood the information form and give their written agreement that the data investigated within the survey are recorded. This part gets signed by the subject and the person responsible for the study.

One copy of the form gets handed out to each participating subject while the original form remains in possession of the person responsible for the study.

This subject information and declaration of consent form is constructed accordingly to the “guidelines for online surveys” of the German “Arbeitskreis Deutscher Markt-und Sozialforschungsinstitute e.V.” (ADM) and is to be found in the appendix [18].

3.2.2 Technical Realization

After the questions for the survey were finalized, the technical realization of the questionnaire was executed by using the online framework provider Unipark. The following enumeration of steps explains the procedural method:

1) Creation of a project
   To start this project on Unipark, the first thing to do was creating a project and give it a for the survey appropriate title.

2) Validity Period
   Also at the very start, the validity period of the project had to be set up. Within this project, the time range was defined as starting at the first of May 2017 and ending at the 30th of June. If needed, validity periods could afterwards be extended, however that function was not necessary in the present study.

3) Project Mode
   The project immediate got switched to active, as this mode enables the pre-survey testing through the operator and testing persons.

4) Project Attributes
   Through the project attributes different settings were adjusted. The possibility of showing a back button on every page was eliminated to not allow navigation back to previous questions and change already selected answers.
   No time limit was set for answering the questions in order to not put “stress” on the participants and therfor leading them to potentially pick a random answer by being afraid of not having picked any answer at all before the time limit expires.
   Here the anonymity of participants was ensured by non-determination, respectively not saving their IP-adresses for any reasons of analysis.

Standard layout was chosen for showing the questionnaire on computer monitors, smartphones or tablets. For better readability, the layout attribute for answer options was set to be shown in alternating colours.

5) Page Creation
In terms of clear arrangement and to support adequate usability, every question of the survey appears on a single page. That allows the subjects to focus on the current question and not getting distracted by already seeing parts of following or previous questions. Overall 19 pages were created. The first page is named “Welcome Page”. After a short welcome address, the conditions of participation, as explained in the subject information and declaration of consent form, in slightly abbreviated form, are located. Further the participants get the hint, that there are single- and multiple choice questions. Wherever multiple answers are correct, it is clearly mentioned directly under the question itself.
A rational appeal to the participants to not use additive resources for answering the questions is stated here and to reinforce that, it is accentuated that the aim of this study is not to reveal the state of knowledge of a single person but to determine the overall state of knowledge of the target group after undergoing radiation protection instructions to generate data for statistical analysis. The indication to complete the online questionnaire only once is also stated here, claryfing that a repeatedly completion would lead to falsified outcomes. Concluding to that, the sentence of agreement of the survey under the conditions mentioned above by clicking the forward button was added. The full text of the welcome page can be found in the appendix.
To structure the pages according to the four categories defined in chapter 3.1. “Methodology”, each page was titled with the corresponding categorie and numbered. However, visible for the participant was solely the title and number of the current question, as this setting appears more clearly.

6) Construction of Questions
After the questions were compiled, wrote out and harmonized to the required contents of radiation protection instructions, they got assembled into the online frame for the survey. First thing to choose was the kind of question to be used, thus whether a single-, multiple choice or other kind of question should be created. Figure 3 shows the possible options for question construction on the example of

question 1 “What is the unit of the absorbed dose?” (Dt.: “Was ist die Einheit der Energiedosis?”).

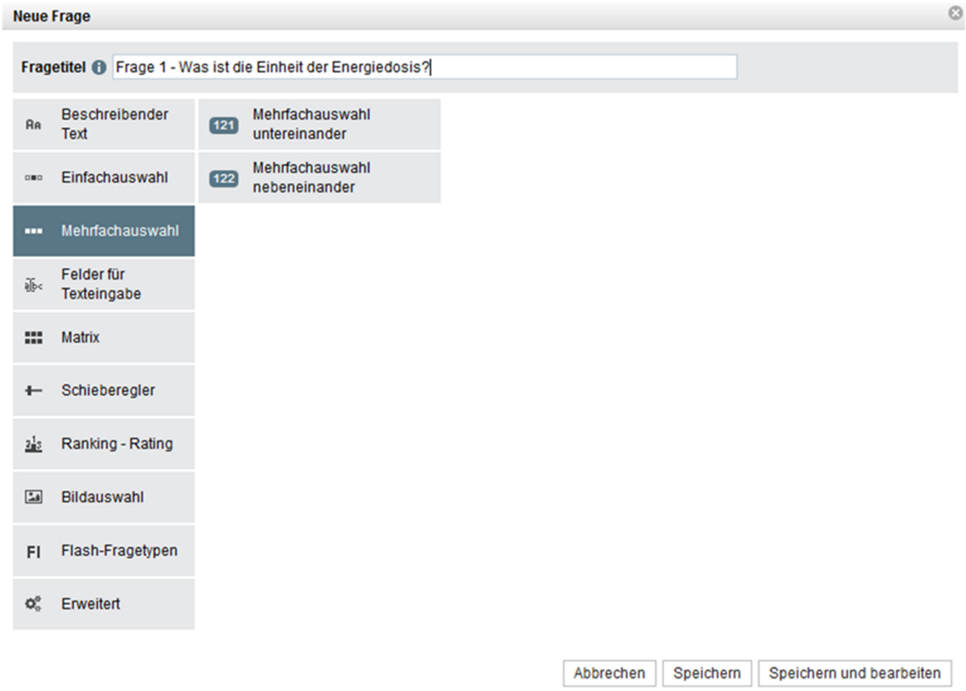
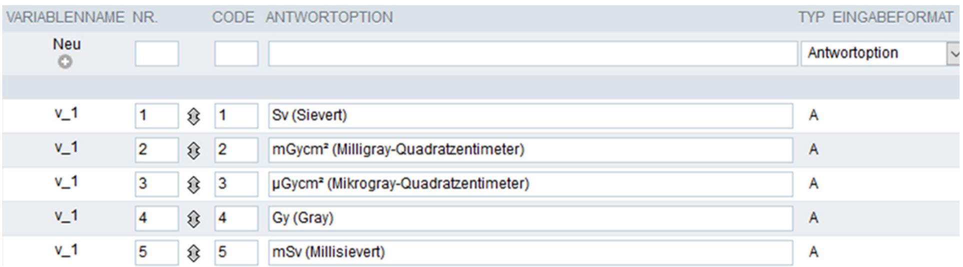


Figure 3: Construction of question on the example of question 1.

As this example of question 1 is a multiple choice question, the next step to chose was the positioning of answers, meaning whether the answers that can be chosen are located one below each other or side by side. After selection of kind of question and title creation, the question text was filled in and the different answer options were placed in the correspondent fields. Each answer option is linked to a variable and encoded for enabeling statistical analysis afterwards. Figure 4 shows the filling in of answer options on the example of question 1.



VARIABLENNAME	NR.	CODE	ANTWORTOPTION	TYP	EINGABEFORMAT
Neu					Antwortoption
v_1	1	1	Sv (Sievert)	A	
v_1	2	2	mGycm² (Milligray-Quadratzentimeter)	A	
v_1	3	3	µGycm² (Mikrogray-Quadratzentimeter)	A	
v_1	4	4	Gy (Gray)	A	
v_1	5	5	mSv (Millisievert)	A	

Figure 4: Inserted answer options of question 1.

In the course of construction and defining the kind of question, an additional fill-in instruction for the participant was made where needed. That was the case in multiple choice questions, to explicit indicate that there are more than one correct answers that can be chosen. Further in this step of construction of questions, the option of obligation to answer the question could be set. The setting for this option was switched on but with possibility to ignore the hint that is popping up when a participant clicks the forward button without having chosen an answer. The hint that pops up in that case says that the given answer is not complete followed by a polite request of answering the question by selecting an answer. This setting intended to remind the participantto pick an answer in case of that he or she may have just forgot to pick an answer. In case of the participant does not want to give an answer for reasons of not knowing the answer, not wanting to guess or other reasons, it is still possible to continue the questionnaire by simply omitting the hint and clicking the forward button which then navigates the participant to the next question.

A randomization of answer options was embedded to ensure that every participant gets presented the answer options in different order. That intended to eliminate the possibility of participants to match or discuss their given answers depending on the order of their occurrence with other participants instead of considering the content of an answer option.

7) Test and Validation
   Important part of creating a well-working and run according to plan online questionnaire is the testing cycle.
   Here the first step was a self check of the complete survey to find potential errors, whether that may be spelling mistakes within the questions, errors in the sequence or other errors. After the self check and correction of all occurring errors by the author, the second part of the testing cycle was conducted. A test data set was created that imitated completed surveys of participants. With the help of those data sets the statistical analysis of competed surveys could be pre-inspected in order to check if the used kind of questions were appropriate for evaluation of the intended purpose. Further the online questionnaire got pre-tested by 4 independent test persons that were not part of the target group, to investigate and estimate the approximate time needed to read the questions, fill-in instructions and answers. That average time was then used for giving the future participants of the online survey an idea of how much time will be

consumed for completing the survey and is therefor mentioned on the welcome page.
After completion of testing cycle all data sets were set back to primary settings, meaning that all within that testing generated data was deleted to not count for analysis of real survey results.

8) Survey Access
To take part at the online survey, the access for the participants was provided via a link and a QR-Code on a printed document, delivered in the appendix of the subject information and declaration of consent form. The option of a printed document handed out was chosen by reasons of easier reachability of participants, making the demand for relinquish personal email addresses to send out the link via online resources redundant. On the printed document firstly the link, followed by the QR-Code in adequate printed size was placed. It was pointed out to use either the link or the QR-Code to enter the online survey. A short instruction on how to use the QR-Code for access to the online survey was given in addition as shown in figure 5.

Zur Nutzung des QR-Codes benötigen Sie eine entsprechende App, die das Auslesen von QR-Codes ermöglicht. Um den QR-Code einzulesen, öffnen Sie die App auf Ihrem Smartphone oder anderem mobilen Endgerät und halten anschließend die Kamera des Geräts über den QR-Code.

Figure 5: QR-Code and short instruction of using it for access to the online survey.

The complete document for access to the online survey, as handed out to the subjects, is shown in the appendix.

3.2.3 Selection Criteria of Subjects

Inclusion criteria of subjects were predefined as being medical-technical staff (either radiological technologists or medical-technical assistants) working in diagnostic radiology and having completed a radiation protection instruction within the last six months in the course of their occupation.

Exclusion criteria were defined as not having a completed education in radiological technology (students before graduation) and different education in radiology (radiologists, staff of medical and healt care). Further exclusion criterion of subjects was the completion of a radiation protection instruction that has been longer ago as six months.

3.2.4 Survey Implementation Settings

The frame conditions for participation were given identical to all subjects: The subject information and declaration of consent form was handed out to provide all necessary information for participation. The information on how to get access to the online survey (working internet connection/ link/QR-Code) was given out on the appended form.

There was no time limit fixed for answering the questions. A fixed time limit may have put the subjects under “exam stress” and may have let to fewer participations when knowing in advance that the time is limited. Further there was a rational appeal on the first page of the online questionnaire not to use additive resources, to reinforce that the aim of this study is not to reveal the state of knowledge of a single person but to determine the overall state of knowledge of the target group to generate data for statistical analysis.

When handing out the required documents for participation to the subjects, no fixed point of time of completing the online questionnaire was given to them. This provided the possibility to independently choose when to complete it, nevertheless they got instructed to complete it inside a time range of two weeks.

3.2.5 Survey Evaluation Method

After participation at the online survey by all subjects that were eligible and invited for participation, the online survey was closed. All data of results were analysed using Microsoft Excel. The results for state of knowledge of all included subjects were subdivided according to the four categories, Dose Terms and Definitions, Applied Radiation Protection of Patients and Staff, Occupationally Exposed Personnel and Health Risks. Overall state of knowledge in percentage was also evaluated.

4 Evaluation Results

4.1 Study Group

The study group comprised totally of 23 subjects working in diagnostic radiology at two different hospitals in Vienna. The subjects either had an educational certificate of Bachelor of Science in Radiological Technology (BSc) or diploma of the academy for medical technical assistants that permits to work in the field of radiological technology and therefor were eligible for the survey. The study group consisted of 5 males (22%) and 18 females (78%). Age within the study group ranged between 22 and 54 years.

A further chararacteristic of the study group was that all subjects underwent a radiation protection instruction within the last 6 months of their employment. Overall duration of employment was not collected.

4.2 Results

The results of the conducted online survey are presented as follows:

General data concerning the completion of the survey by the subjects are mentioned (completion rates, cancelling per category, data about the time of processing). All questions of the survey with their answer options are shown in tables 2 – 18. Subsequent the tables 19 – 23 present the results of correct chosen answers per category. Afterwards the ranking of performance per category correspondent to these results is listed. Finally, the index of difficulty for each question and its' arithmetic average per category that got calculated, is presented in table 24 with the intention to evaluate the homogeneity of difficulty of the construction of questions and categories for its' intented purpose.

Of overall 23 participating subjects, 20 completed the online questionnaire, meaning the survey reached a completion rate of 87,0%. Three subjects (13,0%) cancelled the online questionnaire. One subject (4,4%) finished after interruption and 19 subjects (82,6%) completed without interruption. Rates of finished and cancelled subjects are shown in table 1. Cancelling of the online questionnaire occurred once within categorie 1 - Dose Terms and Definitions, at question 2 ("Was ist die Einheit der Energiedosis?") and once within categorie 2 - Applied Radiation Protection of Patients and Staff, at question 9 ("Welche Aussagen zum angewandten

Strahlenschutz treffen zu?”). The third cancelling occurred at the welcome page.

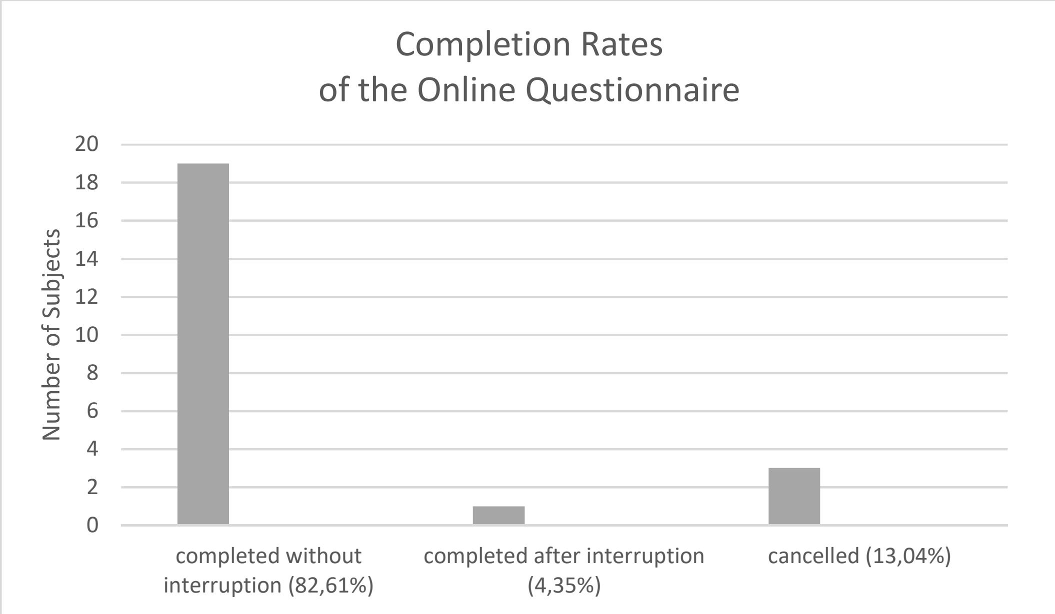


Table 1: Completion rates of the online questionnaire.

Mean processing time (arithmetic average) was 14 minutes and 47 seconds. The median value was 13 minutes and 21 seconds.

In the following, table 2 – 18 present all questions of the online survey, as well as their answer options. Further, the tables 2 - 18 show the number of chosen answers (n) for the corresponding answer option, as well as percentage of correct (% (c)) and false (% (f)) given answers. The correct answer option (respectively the multiple correct answer options in cases of multiple choice questions) is highlighted in green. Percentage of correct answers (% (c)) is further highlighted in green and percentage of false answers (% (f)) in red.

Subjects that cancelled (3), regardless at which question and did not complete the online survey are not shown in the following results. The tables 2 - 18 shown below start with question number 1 and continue in numerical order.

A detailed listing of the results summarized per category is then presented in tables 19 – 23.

Question 1:

Was ist die Einheit der Energiedosis?

	ANTWORTOPTION	n	% (c)	% (f)
A)	Sv (Sievert)	1	**95%**	**5%**
B)	mGycm² (Milligray-Quadratzentimeter)	1	**95%**	**5%**
C)	µGycm² (Mikrogray-Quadratzentimeter)	5	**75%**	**25%**
D)	Gy (Gray)	9	**45%**	**55%**
E)	mSv (Millisievert)	4	**80%**	**20%**

Table 2: Results of question 1 (single choice) in number of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 2:

Die Äquivalentdosis dient dazu...

	ANTWORTOPTION	n	% (c)	% (f)
A)	... die Wirkung auf übermäßig strahlenempfindliche Gewebe abschätzen zu können.	5	**75%**	**25%**
B)	... die Wirkung auf biologisches Gewebe zu beschreiben.	12	**60%**	**40%**
C)	... die Wirkung auf von Streustrahlung exponiertem Gewebe, das nicht im primären Strahlengang liegt, zu beschreiben.	3	**85%**	**15%**

Table 3: Results of question 2 (single choice) in number of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 3:

Die effektive Dosis...

	ANTWORTOPTION	n	% (c)	% (f)
A)	... berücksichtigt zusätzlich die zeitliche Verteilung des linearen Energietransfers (LET) in Geweben.	5	**75%**	**25%**
B)	... berücksichtigt zusätzlich die Strahlenempfindlichkeit einzelner Gewebe durch Wichtungsfaktoren.	14	**70%**	**30%**
C)	... berücksichtigt zusätzlich die Strahlenempfindlichkeit des digitalen Strahlendetektors.	2	**90%**	**10%**
D)	...ist die Summe aller Äquivalentdosen der einzelnen Organe und Gewebe.	16	**80%**	**20%**

Table 4: Results of question 3 (multiple choice) in number of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 4:

Was bedeutet das ALARA-Prinzip in Bezug zur Optimierung einer medizinisch indizierten Strahlenanwendung?

	ANTWORTOPTION	n	% (c)	% (f)
A)	Vor jeder Strahlenanwendung sind die kV- und mAs-Werte zu überprüfen und schriftlich zu dokumentieren.	3	**85%**	**15%**
B)	Die applizierte Strahlendosis ist niedriger zu halten als die Richtwerte für Röntgenuntersuchungen des jeweiligen Körperbereiches, die durch die Internationale Strahlenschutzkommission (ICRP) vorgegeben sind.	3	**85%**	**15%**
C)	Die applizierte Strahlendosis ist so niedrig zu halten, wie vernünftigerweise erreichbar.	17	**85%**	**15%**
D)	Die Exposition von einzelnen Personen sowie der Bevölkerung insgesamt, ist so gering zu halten, wie dies unter Berücksichtigung wirtschaftlicher und sozialer Faktoren möglich und vertretbar ist.	8	**40%**	**60%**
E)	Vor jeder Strahlenexposition ist zu überprüfen, welche geringst möglichen Dosiswerte für die Untersuchung am jeweiligen Röntgengerät eingespeichert sind und vernünftigerweise angewendet werden können.	10	**50%**	**50%**

Table 5: Results of question 4 (multiple choice) in numbers of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 5:

Welche Maßnahmen tragen zu einer Verringerung der Strahlenexposition bei?

	ANTWORTOPTION	n	% (c)	% (f)
A)	Die Aufenthaltsdauer im Strahlenfeld so gering wie möglich halten.	19	**95%**	**5%**
B)	Die Aufenthaltsdauer im Strahlenfeld erst reduzieren, sobald davon auszugehen ist, dass eine effektive Dosis von 0,5 Sievert im Vormonat erreicht wurde.	0	**100%**	**0%**
C)	Die Aufenthaltsdauer im Strahlenfeld bei Verwendung von Bleischutzkleidung und Bleiabschirmungen muss nicht gering gehalten werden.	1	**95%**	**5%**

Table 6: Results of question 5 (single choice) in numbers of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 6:

Welche auf den Abstand zur Strahlenquelle bezogenen Maßnahmen können getroffen werden um die Strahlenexposition zu verringern?

	ANTWORTOPTION	n	% (c)	% (f)
A)	Der Abstand zur Strahlenquelle sollte so gewählt werden, dass die vom Patienten ausgehende Streustrahlung das Personal nur in einem Winkel von 90 Grad erreichen kann.	3	**85%**	**15%**
B)	Der Abstand zur Strahlenquelle sollte immer so groß wie möglich gehalten werden.	18	**90%**	**10%**
C)	Der Abstand zur Strahlenquelle muss in jedem Fall mindestens 0,5 Meter betragen um eine hohe Dosisakkumulation durch Streustrahlung zu vermeiden.	4	**80%**	**20%**
D	Je größer der Abstand zur Strahlenquelle gehalten wird, desto besser.	17	**85%**	**15%**

Table 7: Results of question 6 (multiple choice) in numbers of schosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 7:

Welche Aussage bezogen auf die Verwendung von Abschirmungen zum Strahlenschutz trifft zu?

	ANTWORTOPTION	n	% (c)	% (f)
A)	Die Verwendung von Bleiabschirmungen hilft, ionisierende Strahlung zu verringern.	14	**70%**	**30%**
B)	Die Verwendung von Abschirmungen ist nur bei Alpha- und Beta-Strahlung sinnvoll.	2	**90%**	**10%**
C)	Die Verwendung von Bleiabschirmungen reduziert die akkumulierte Dosis des Personals, wenn sich diese zwischen der Strahlenquelle und dem anwendenden Personal befindet.	19	**95%**	**5%**

Table 8: Results of question 7 (multiple choice) in numbers of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 8:

Welche Positionierung der Röntgenröhre bzw. des Detektorsystems sollte bei durchleuchtungsgezielten Untersuchungen oder Interventionen aus Strahlenschutz-Gründen für das anwendende Personal bevorzugt werden?

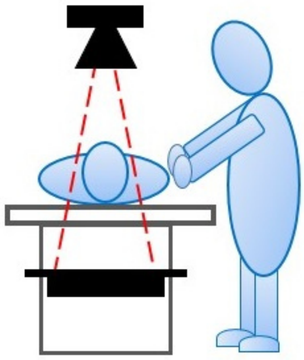
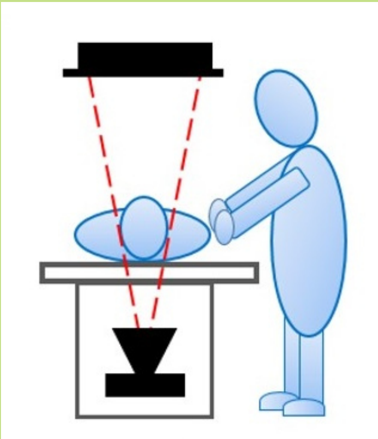
	ANTWORTOPTION	n	% (c)	% (f)
A)	 Obertischröhre	6	**30%**	**70%**
B)	 Untertischröhre	14	**70%**	**30%**

Table 9: Results of question 8 (single choice) in numbers of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 9:

Welche Aussagen zum angewandten Strahlenschutz treffen zu?

	ANTWORTOPTION	n	% (c)	% (f)
A)	Grundsätzlich sollte der Patient möglichst röhrenfern und detektornah positioniert werden.	16	**80%**	**20%**
B)	Um die Streustrahlung zu reduzieren sollte der Patient immer möglichst zentriert und röhrennahe positioniert werden.	6	**70%**	**30%**
C)	Um die Dosisleistung gering zu halten sollte stets mit eingeblendetem "field of view" (FOV) gearbeitet werden.	20	**100%**	**0%**
D)	Ein quadratisch eingeblendetes "field of view" (FOV) ist jenem mit unterschiedlichen Seitenlängen (rechteckig) zu bevorzugen.	0	**100%**	**0%**

Table 10: Results of question 9 (multiple choice) in numbers of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 10:

Wozu dienen Personendosimeter?

	ANTWORTOPTION	n	% (c)	% (f)
A)	Zur Messung der vom Patienten ausgehenden Streustrahlung.	1	**95%**	**5%**
B)	Zur Messung der Personal-Aufenthaltsdauer in Strahlenanwendungsräumen.	3	**82%**	**15%**
C)	Zur Messung der externen Strahlendosis einer Person.	13	**65%**	**35%**
D)	Zur Messung der externen Strahlendosis einer Person und Berechnung deren Aufenthaltsdauer in Strahlenanwendungsräumen.	3	**85%**	**15%**

Table 11: Results of question 10 (single choice) in numbers of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 11:

Wo soll das Personendosimeter getragen werden?

	ANTWORTOPTION	n	% (c)	% (f)
A)	An einer repräsentativen Stelle an der Körperhinterseite und bei Verwendung von Bleischutzkleidung mit mindestens 1 Meter Abstand zum Boden angebracht.	0	**100%**	**0%**
B)	An einer repräsentativen Stelle am Körperrumpf und bei Verwendung von Bleischutzkleidung oberhalb dieser.	0	**100%**	**0%**
C)	An einer repräsentativen Stelle am Körperrumpf und bei Verwendung von Bleischutzkleidung unterhalb dieser.	20	**100%**	**0%**

Table 12: Results of question 11 (single choice) in numbers of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 12:

Welche Personen zählen als beruflich strahlenexponiertes Personal?

	ANTWORTOPTION	n	% (c)	% (f)
A)	Personen, die aufgrund ihrer beruflichen Tätigkeit eine Strahlendosis erhalten können, die die Hälfte des Grenzwertes (=0,5 mSv) für 12 aufeinander folgende Monate für eine Person der Normalbevölkerung (1 mSv) übersteigt.	5	**75%**	**25%**
B)	Personen, die aufgrund ihrer beruflichen Tätigkeit eine Strahlendosis erhalten können, die den Grenzwert für 12 aufeinander folgende Monate für eine Person der Normalbevölkerung (1 mSv) um mindestens 1,8 Sv übersteigt.	0	**100%**	**0%**
C)	Personen, die aufgrund ihrer beruflichen Tätigkeit eine Strahlendosis erhalten können, die den Grenzwert für 12 aufeinander folgende Monate für eine Person der Normalbevölkerung (1 mSv) übersteigt.	15	**75%**	**25%**

Table 13: Results of question 12 (single choice) in numbers of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 13:

Zu beruflich strahlenexponiertem Personal der Kategorie A ...

	ANTWORTOPTION	n	% (c)	% (f)
A)	... zählen Personen, die in 12 aufeinander folgenden Monaten mehr als 9 mSv effektive Dosis oder höhere Äquivalentdosen als 20 mSv für Augenlinsen bzw. 80 mSv für Haut, Hände & Gliedmaßen erhalten können.	6	**70%**	**30%**
B)	... zählen Personen, die in 12 aufeinander folgenden Monaten mehr als 6 mSv effektive Dosis oder höhere Äquivalentdosen als 45 mSv für Augenlinsen bzw. 150 mSv für Haut, Hände & Gliedmaßen erhalten können.	6	**30%**	**70%**
C)	... zählen Personen, die in 12 aufeinander folgenden Monaten mehr als 12 mSv effektive Dosis oder höhere Äquivalentdosen als 0,8 mSv für die Augenlinsen bzw. 0,5 mSv für Haut, Hände & Gliedmaßen erhalten können.	8	**60%**	**40%**

Table 14: Results of question 13 (single choice) in numbers of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 14:

Zu beruflich strahlenexponiertem Personal der Kategorie B ...

	ANTWORTOPTION	n	% (c)	% (f)
A)	... zählen Personen, bei denen davon auszugehen ist, dass diese in 12 aufeinander folgenden Monaten weniger als 6 mSv effektiver Dosis erhalten.	13	**65%**	**35%**
B)	... zählen Personen, bei denen davon auszugehen ist, dass diese in 12 aufeinander folgenden Monaten weniger als 8 mSv effektiver Dosis erhalten.	2	**90%**	**10%**
C)	...zählen Personen, die ausschließlich in der Strahlentherapie tätig sind und daher davon auszugehen ist, dass eine effektive Dosis von 6 mSv nicht überschritten wird.	5	**75%**	**25%**

Table 15: Results of question 14 (single choice) in numbers of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 15:

Welche der unten genannten Gewebe sind sehr bzw. wenig strahlenempfindlich?

ANTWORTOPTION	sehr n	sehr %	wenig n	wenig %
Darmepithel	9	**45%**	11	**55%**
Knochenmark	15	**75%**	5	**25%**
Nerven	1	**5%**	19	**95%**
Augen	20	**100%**	0	**0%**
Bindegewebe	1	**5%**	19	**95%**
Gonaden	20	**100%**	0	**0%**
Muskulatur	0	**0%**	20	**100%**
Schilddrüse	20	**100%**	0	**0%**

Table 16: Results of question 15 (multiple choice) in numbers of chosen answers (n) and percentage (%) for each corresponding answer option („sehr“/ „wenig“).

Question 16:

Welches ist das am stärksten durch Röntgenstrahlung gefährdete Organ?

	ANTWORTOPTION	n	% (c)	% (f)
A)	Schilddrüse	5	**75%**	**25%**
B)	Augenlinsen	12	**40%**	**60%**
C)	Mamma	2	**10%**	**90%**
D)	Gastrointestinaltrakt	1	**95%**	**5%**

Table 17: Results of question 16 (single choice) in numbers of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

Question 17:

Im Falle weiblicher Arbeitskräfte...

	ANTWORTOPTION	n	% (c)	% (f)
A)	...ist eine Schwangerschaft ab Bekanntwerden dieser, unverzüglich an den Arbeitgeber zu melden.	20	**100%**	**0%**
B)	...ist eine Schwangerschaft ab Bekanntwerden dieser, unverzüglich an das städtische Arbeitsinspektorat zu melden.	0	**100%**	**0%**
C)	...ist eine Schwangerschaft an den Strahlenschutzbeauftragten mit Beginn der 6. Schwangerschaftswoche zu melden.	0	**100%**	**0%**

Table 18: Results of question 17 (single choice) in numbers of chosen answers (n), percentage of correct answers (%(c)) and percentage of false answers (%(f)).

The results of correct chosen answers per category in number of correct (green highlighted) and false (red highlighted) given answers (n) and percentage (%) per question are presented in tables 19 -23. In cases of multiple choice questions (question 3, 4, 6, 7 and 9) the arithmetic average of correct and false given answers (n_a) and corresponding percentage (%) is presented.

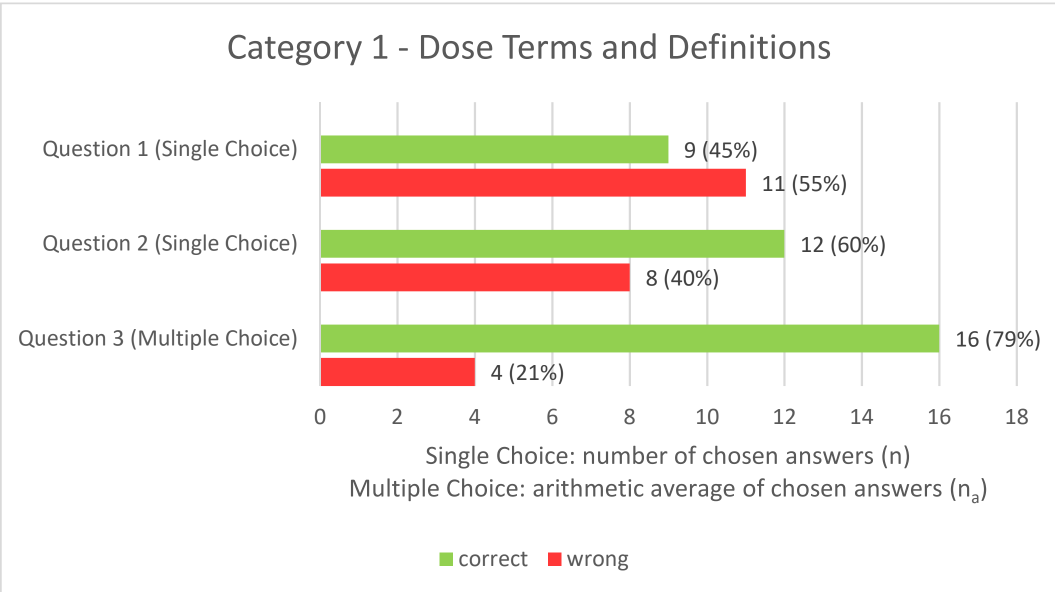


Table 19: Results of category 1 in number of correct and false given answers (n) and percentage (%) per single choice question and arithmetic average (n_a) of correct and false given answers and corresponding percentage (%) per multiple choice question.

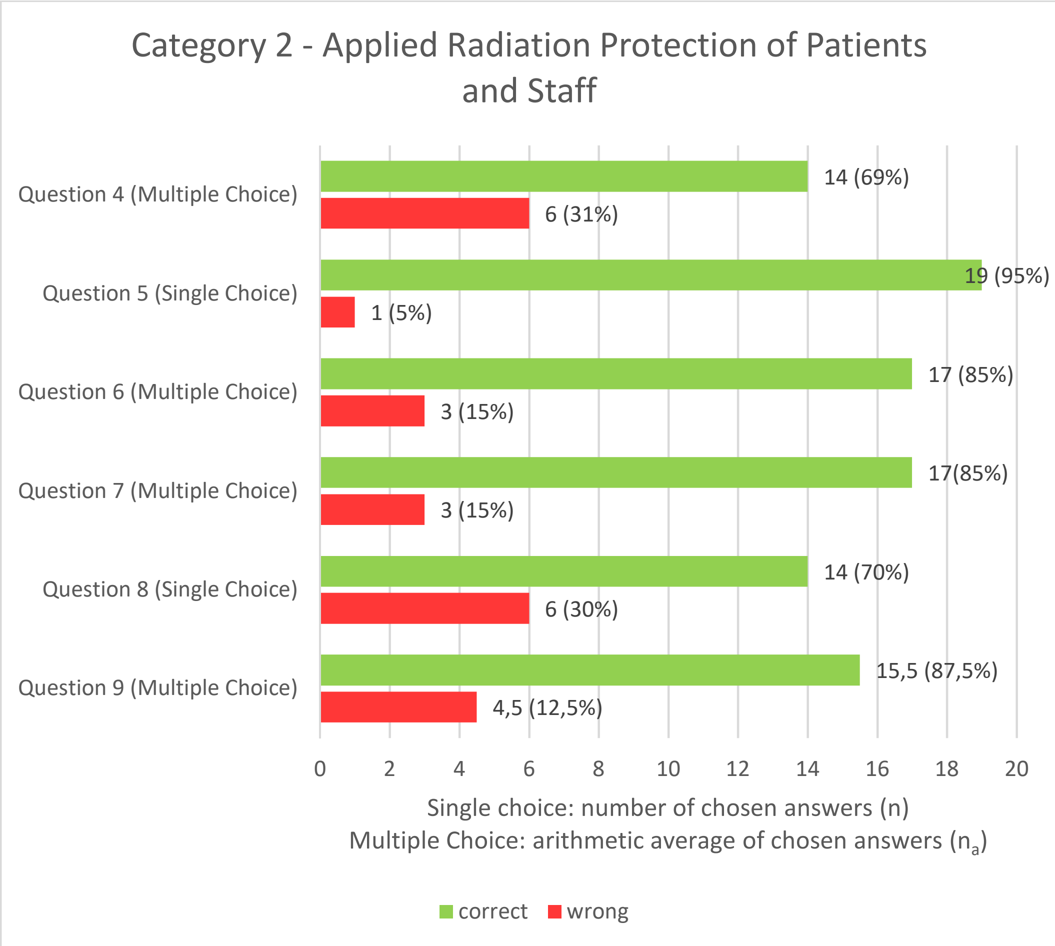


Table 20: Results of category 2 in number of correct and false given answers (n) and percentage (%) per single choice question and arithmetic average (n_a) of correct and false given answers and corresponding percentage (%) per multiple choice question.

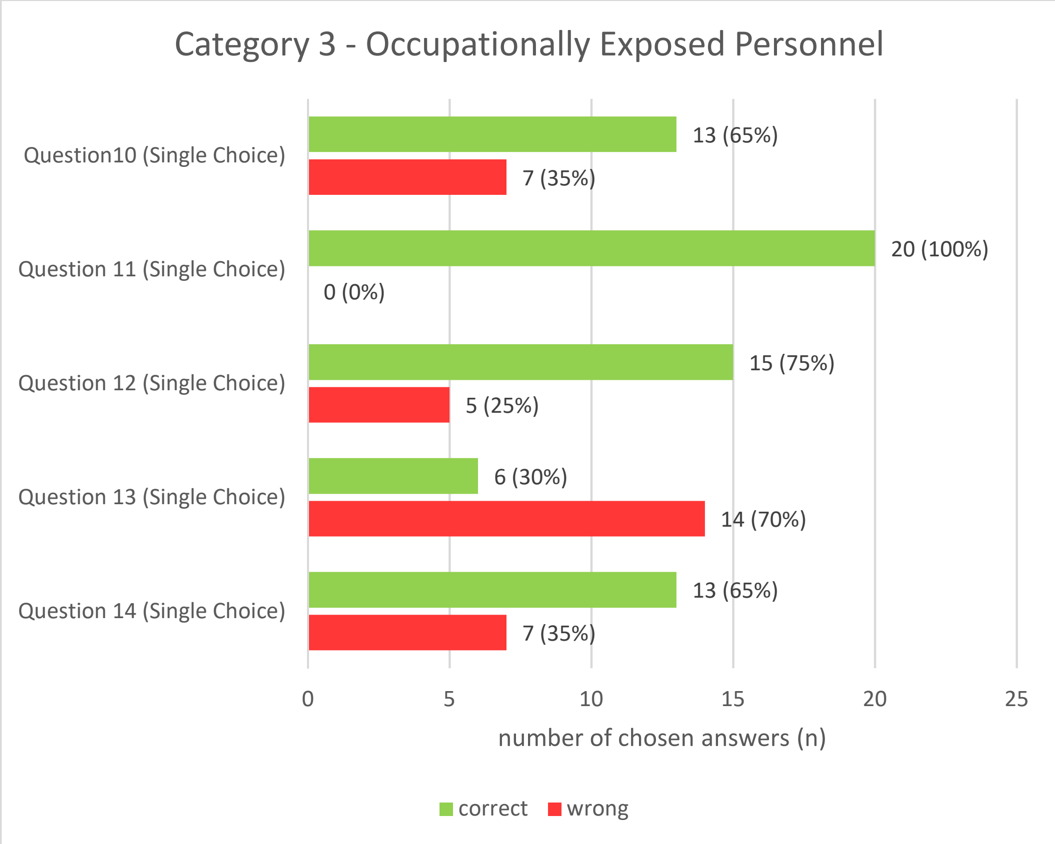


Table 21: Results of category 3 in number of correct and false given answers (n) and percentage (%) per question.

Continuing with the results of category 4 – Health Risks, the following table (table 22) shows the results of question 15 separately for reasons of clear arrangement. Question 15 had overall 8 columns including different types of human organs or tissue that had to be chosen either as being „very“ or „little“ sensitive to exposure of ionizing radiaton. Results are presented in number of correct and false chosen answers (n) and percentage (%) for the corresponding answer option („very“/“little“). Results of questions 16 and 17 are then shown in table 23.

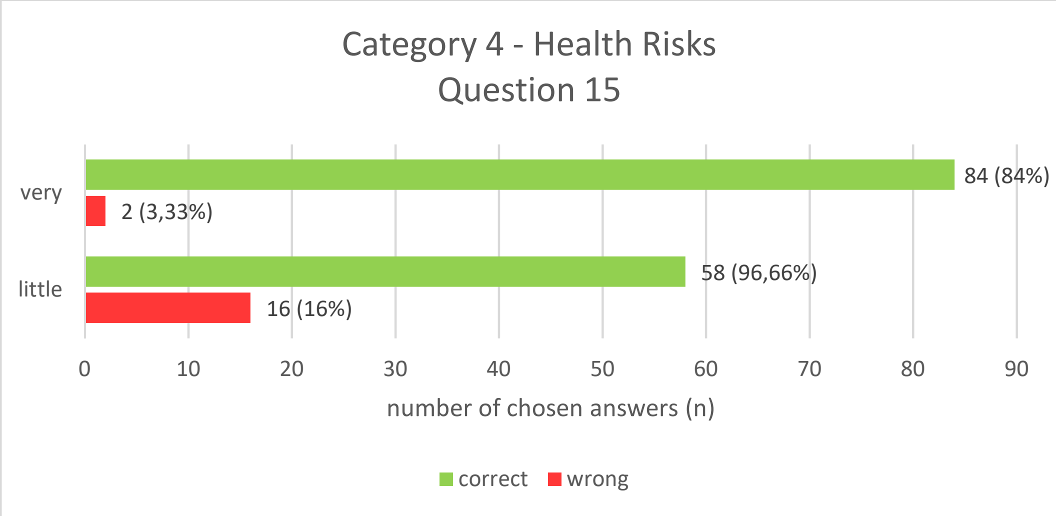


Table 22: Results of question 15, category 4, in number of correct and false given answers (n) and percentage (%) per answer option („very“ vs. „little“) of each question column.

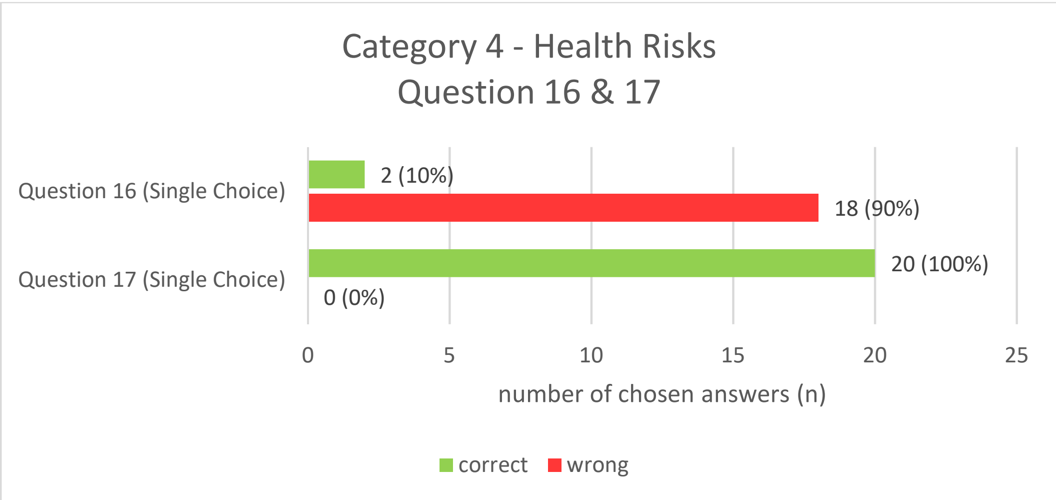


Table 23: Results of questions 16 and 17 of category 4 in number of correct and false given answers (n) and percentage (%) per question.

In the following, the comparison of the results between categories 1 – 4 in percentage of overall correct given answers per category, is presented (in cases of single choice questions the percentage of correct given answers is counted in and in cases of multiple choice questions the arithmetic average of correct given answers in percentage is counted in):

In category 1 (Dose Terms and Definitions) the arithmetic average of correct given answers in percentage is 61%. Category 2 (Applied Radiation Protection for Patients and Staff) reached 82%, category 3 (Occupationally

Exposed Personnel) and category 4 (Health Risks) reached 67%, respectively 82% on average of correct given answers.

That gives the different categories the following ranking of performance by percentage of on average correct given answers:

1. Category 2 – Applied Radiation Protection of Patients and Staff and Category 4 – Health Risks (each 82%)
2. Category 3 – Occupationally Exposed Personnel (67%)
3. Category 1 – Dose Terms and Definitions (61%)

For evaluation of the survey's questionnaire, an item analysis with the calculation of level of difficulty was conducted. In particular, for each item (one item equates to one question) the index of difficulty was calculated. The index of difficulty for each question and for better comparison, its' arithmetic average per category is presented in table 24.

The aim of calculating the index of difficulty is to differentiate between subjects with high caracteristic value and low caracteristic value. In the present study the focus on differentiating the state of knowledge between each subject in order to reveal subjects with high level of knowledge and those with poor level of knowledge was not intended. Rather the evaluation of overall level of knowledge of subjects was proposed. The present calculation of level of difficulty refers to the level of knowledge per category to enable comparison of each categories‘ entirety of level of knowledge. For interpretation of the index of difficulty, it gets assessed where its‘ value inside the range of 0 and 1 is located. Difficult items have a lower index of difficulty that is closer to the value of 0, while easy items have a higher index of difficulty that is closer to the value of 1. An index of difficulty with the value of 0,5 is considered as optimal [19] [20] [21].

	Index of Difficulty per Item	Index of Difficulty – Arithmetic Average
Category 1		0,6
Question 1	0,45	
Question 2	0,6	
Question 3	0,75	
Category 2		0,8125
Question 4	0,625	
Question 5	0,95	
Question 6	0,875	
Question 7	0,825	
Question 8	0,7	
Question 9	0,9	
Category 3		0,67
Question 10	0,65	
Question 11	1	
Question 12	0,75	
Question 13	0,3	
Question 14	0,65	
Category 4		0,64
Question 15	0,82	
Question 16	0,1	
Question 17	1	

Table 24: Index of difficulty per question and category.

5 Discussion

The present study had a sample size of overall 23 subjects. Of that sample size, 20 subjects completed the online survey, presenting a completion rate of 87,0%. For evaluation and discussion of results only the results of the completed data sets of the 20 subjects were analysed, not completed data sets of the remaining three subjects were filtered out to eliminate falsified interpretations.

The results show that by ranking of performance, category 2 (Applied Radiation Protection of Patients and Staff) and category 4 (Health Risks) reached the highest score of correct given answers on average (each 82%).

The high score of category 2 (82%) is presumably due to the fact that the applied radiation protection of patients and staff presents the key components of radiation protection that is applicable during the daily routine of health professionals working in diagnostic radiology. Further those applicable components may get more emphasized during radiation protection instructions than less applicable ones. For example, question 4 (multiple choice) that asked the meaning of the “ALARA-Principle” pertaining to the optimization of a medical indicated radiation exposure, reached on average 14 correct answers (69%). Concomitant with an index of difficulty of 0,625 the difficulty of question 4 was within an adequate scope (near 0,5). Also question 9 (multiple choice) that asked to pick correct statements reffering to the applied radiation protection and were presented in the answer options below, reached a majority of on average correct given answers (15,5; 87,5%). Answer options included methods of patient positioning and methods of adjustment of the “field-of-view” (FOV) that is used as visual support of patient positioning and important for dose contribution. Regarding the questions’ index of difficulty of 0,9 it could be implicated that the question was constructed relatively easy (index value near 1,0). Yet the answer options sounded quite similar and subjects had to read attentively to choose the correct answers. For that reason, results of question 9 are considered as good performance of delivered knowledge and not conditional upon easy construction of the question.

The consistent high score in ranking of performance of category 4 (82%) could get interpreted that subjects are most aware of the risks that involve being exposed to ionizing radiation for patients and for themselves in terms of their occupation. However, the results of question 16 (single choice) of category 4 that asked which is the most of ionizing radiation endangered organ of the human body, got answered wrong by the majority of subjects (90%). Only 2 subjects (10%) chose the correct answer (“mamma”). This result may also be due to the relative difficulty of the questions’ construction with an index of difficulty of 0,1 (value located nearby 0, thus being valid as rather difficult). This result may be consequence of the fact that besides the correct answer ("mamma"), two of the other answer options listed organs that are also very sensitive to ionizing radiation ("eye lenses", "gastrointestinal tract") and therefor likely also get emphasized for protection during radiation protection instructions. For this reason, it may have been difficult for the subjects to distinguish which organ is the *most* endangered one.

The second highest score in ranking of performance reached category 3 (Occupationally Exposed Personnel) with 67% of on average correct given answers. The result of 67% in this study is interpreted as adequate performance, though it shows that the delivered knowledge of radiation protection instructions within this category is 15% lower as the category with the highest score in ranking of performance (82%). That may be due to the content of category 3 that broached the issue of occupationally exposed personnels' dosimetry (question 10 and 11), definition of occupationally exposed personnel (question 12) and categories of occupationally exposed personnel (question 13 and 14). Particularly answer options of questions 12, 13 and 14 contained dose values that refer to categorization of occupationally exposed personnel, so that answer options mostly only differed in amount of those values. Index of difficulty of these questions varied from 0,3 (minimum) and 0,75 (maximum). The value of 0,3 of index of difficulty for question 13 (single choice) would implicate that this question got constructed as being relatively difficult to answer correct which also gets confirmed by the results of only 30% of correct given answers. Question 13 deals with categorization through threshold values allowed gaining for occupationally exposed personnel and the relative low score of correct given answers may be due to the fact, that this categorization is not an emerging topic in the daily routine of diagnostic radiology. Categorization of personnel is carried out at the beginning of employment or university studies and usually not further discussed or changed during employment or educational path.

The third and lowest score in ranking of performance reached category 1 (Dose Terms and Definitions) with 61% of on average correct given answers. Within this category the knowledge about three basic dose terms was asked: unity of energy absorbed dose (question 1) that describes the middle on a specific absorber transmitted energy relating to the mass of that volume element (Gray [Gy]); equivalent dose (question 2) that is used to describe the effect on human tissue; effective dose (question 3) that considers additionally the sensitivity of different tissue through weighting factors and is the sum of all equivalent doses of all relevant organs and tissues. The relative good level of on average correct given answers in the multiple choice question 3 (79%) may be resulted from the more common usage of the effective dose at the workplace as it can be used as collective dose for medical diagnostic exposure for comparative purposes in similar patient populations [22]. Coeval the index of difficulty for question 3 with the value of 0,75, showing that level of difficulty resides in a still adequate scope. In contrast to that, results of question 1 (single choice) showed, that the majority of given answers were wrong (55%). Still the index of difficulty for this question is in an adequate scope (0,45). Possible explanation of that result is the less common usage of the energy absorbed dose in the daily workplace routine compared to the effective dose which is asked at question 3. This categories' results may be based on the fact, that the field of radiation doses with its' variety of unities and their definitions is very complex and usage of that definitions is not commonly deeply integrated in the daily workplace routine of medical-technical assistants or radiological technologists. Nonetheless a vital knowledge of basic dose terms and their definitions should be present on health professionals working in diagnostic radiology to ensure knowledge on radiation doses.

Overall the findings of the present study show that some aspects of radiation protection instructions got better perceived than others. More accurately defined, the level of knowledge within the four categories differed within the range of 21% as the highest score category reached 82% and the lowest score category 61% of correct given answers on average. Level of knowledge of the individual questions differed in the range of 34% in category 1 (Dose Terms and Definitions), as question 1 (single choice) reached 45% and question 3 (multiple choice) reached 79% of correct answers. In category 2 (Applied Radiation Protection of Patients and Staff) the range adds up to 26%, as question 5 (single choice) reached the highest score of correct answers with 95% and question 4 (multiple choice) the lowest score with 69% within that category. Difference within the range of 70% occurred in category 3 (Occupationally Exposed Personnel), as question 11 (single choice) reached 100% presenting the highest score of correct answers and question 13 (single choice) the lowest score with 30% of correct answers. Difference in category 4 (Health Risks) between the highest and lowest score of correct answers differed within the range of 90%, as question 17 (single choice) reached 100% and question 16 (single choice) reached only 10% of correct answers.

Simultaneously for each question the index of difficulty as well as its' arithmetic average per category (see table 24) was calculated to enable additionally assessment of the questions' construction in view of level of difficulty which can also effect a questions' outcome.

The fact that some questions got higher percentage of wrong given answers (question 1, question 13 and question 16) as correct given ones, shows that though overall results of correct given answers which refer to an adequate level of knowledge transfer, some individual aspects can benefit of a revision of knowledge transfer. However less knowledge in form of wrong given answers could also be due to the fact, that some subjects may have longer duration of employment in diagnostic radiology and thus having completed correspondent numerous radiation protection instructions, that may account for more consolidated knowledge within that field.

Concluding, to answer this studies' hypothesis, it can be said that overall no relevant aspects of radiation protection instructions got inadequately perceived by the study group. Consideration as "adequate" perceived knowledge counts for overall all categories since none category scored less than 60% of correct given answers. This percentage of results can be put into context with most universities' grading keys for adequately passing an exam. Still the online questionnaire is suitable for detecting if certain aspects or individual questions would not be adequately perceived by the target group.

Regarding the applicability of the present studies' online questionnaire, it can be said, that it presents an easy to handle and practicable tool for evaluation of radiation protections instructions' knowledge transfer. For this reason, it could immediately get implemented at medical or educational institutions and support the intra-institutional quality management through providing feedback for the radiation protection instructions' preceptor.

6 Conclusion

Summing up the results of the presents study, the findings show that overall all categories reached as adequate considered scores of level of knowledge after radiation protection instructions, as none category reached less than 60% of correct given answers. Still there were certain aspects that were obviously less adequate perceived by the target group, as the majority of given answers were wrong in these cases (question 1, question 13 and question 16). On these grounds, an online evaluation of radiation protection instructions as constructed within this study, can help revealing aspects that would benefit from a revision of knowledge transfer. Since there is no existing standardized and statutory way of how to evaluate radiation protection instructions, but their assured knowledge is fundamental in providing and practising high quality radiation protection, an online questionnaire constructed equal as in the present study, is considered being a feasible tool for that purpose. Further a qick and easy realization is possible when the needed requirements, consisting of internet access and access to an online survey framework provider (e.g. Unipark in the present survey), are available. Evaluation of radiation protection instructions through this tool enables statistical analysis of generated data that can be used to provide feedback for the instructing preceptor and can be integrated in the institutions' quality assurance of radiation protection. This conclusion may motivate corresponding medical and educational institutions to integrate online evaluation of radiation protection instructions into practice and thereby embracing the collaborative statement phrased 2012 by the WHO and IAEA to strengthen radiation protection in medicine over the next decade and taking quality assurance in diagnostic radiology to a higher level [9].

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Appendix

A) Subject Information and Declaration of Consent Form

ProbandInneninformation und Einwilligungserklärung zur Teilnahme an der Online-Befragung

Evaluierung des Wissensstandes nach erfolgter Strahlenschutzunterweisung von in Strahlenbereichen zur medizinischen Diagnostik tätigen Personen

Sehr geehrte Teilnehmerin, sehr geehrter Teilnehmer!

Sie sind herzlich eingeladen, an der Online-Befragung zum oben genannten Projekt teilzunehmen.

Die Befragung erfolgt über einen Online-Fragebogen. Den Link zur Teilnahme erhalten Sie in ausgedruckter Form im Anhang dieses Dokuments, sowie auch als QR-Code zum einfachen einlesen über Ihr Smartphone oder ein anderes mobiles Endgerät.

Zur Beantwortung der insgesamt 17 Fragen sind nicht mehr als 10 Minuten vorgesehen.

Die Befragung erfolgt anonym. Es werden keine persönlichen Daten zu Ihrer Person erfragt oder aufgezeichnet.

1. Was ist der Zweck der Studie?

Zur sicheren Anwendung ionisierender Strahlung in der medizinischen Diagnostik sind Strahlenschutzunterweisungen für das Personal ein wichtiger Bestandteil der Qualitätssicherung medizinisch indizierter Expositionen.

Der Zweck dieser Studie im Rahmen der Masterarbeit *„Knowledge Evaluation of People Working in Radiation Areas for Medical Diagnostics after Undergoing Radiation Protection Instruction" von Karoline Kurka ist daher*, folgende Fragestellung zu beantworten:

Werden relevante Aspekte einer Strahlenschutzunterweisung von den unterwiesenen Personen nicht ausreichend wahrgenommen? In weiterer Folge soll erforscht werden, welche Aspekte der Strahlenschutzunterweisung dies betrifft und daher von einer Revision der Wissensvermittlung dieser Inhalte profitieren.

Da keine allgemein gültigen Vorgaben zur Evaluierung der im Strahlenschutzgesetz und nach § 16 (1) der Allgemeinen Strahlenschutzverordnung gesetzlich verpflichtenden Strahlenschutzunterweisung existieren, soll diese Studie erforschen, ob die Evaluierung mittels Online-Fragebogen zu diesem Zwecke geeignet ist.

Seite 1 von *3*

Es geht dabei *nicht* darum, den Wissensstand einzelner Personen aufzudecken oder zu bewerten, sondern die Gesamtheit des Wissensstandes der unterwiesenen Personen statistisch zu erfassen. Diese statistische Auswertung dient dem Feedback des Unterweisenden im Sinne einer Qualitätssicherung zur Übermittlung strahlenschutz-relevanter Informationen.

2. In welcher Weise werden die im Rahmen dieser Befragung gesammelten Daten verwendet und welche Maßnahmen zur Gewährleistung des Datenschutzes werden ergriffen?

Das Ausfüllen des Online Fragebogens erfolgt anonym.
Die Ergebnisse der Auswertungen der Online-Fragebögen dienen ausschließlich der Analyse der in dieser Masterthese behandelten Fragestellung und werden nicht an Dritte weitergegeben. Es erfolgt keine namentliche Verknüpfung oder Nennung mit Ergebnissen der Befragung.

Die Teilnahme erfolgt auf freiwilliger Basis. Bei Nichtteilnahme an dieser Studie entstehen Ihnen keinerlei Nachteile.

Sie können Ihre Teilnahme an der Befragung jederzeit abbrechen indem Sie das Fenster Ihres Browsers schließen.

3. Einwilligungserklärung

Name in Druckbuchstaben: ....

Ich erkläre mich bereit, an der Online-Befragung zur Studie *„Evaluierung des Wissensstandes nach erfolgter Strahlenschutzunterweisung von in Strahlenbereichen zur medizinischen Diagnostik tätigen Personen"* teilzunehmen.

Ich habe den Text dieser ProbandInneninformation und Einwilligungserklärung, die insgesamt 3 Seiten umfasst gelesen und verstanden.

Ich bin damit einverstanden, dass meine im Rahmen dieser Befragung ermittelten Angaben aufgezeichnet werden. Die Bestimmungen des Datenschutzgesetzes in der geltenden Fassung werden eingehalten.

Eine Kopie dieser Probandeninformation und Einwilligungserklärung habe ich erhalten. Das Original verbleibt bei der Studienverantwortlichen.

....

(Datum und Unterschrift des/der ProbandIn)

....

(Datum, Name und Unterschrift der Studienverantwortlichen)

(Der/die ProbandIn erhält eine unterschriebene Kopie der ProbandInneninformation und Einwilligungserklärung, das Original verbleibt bei der Studienverantwortlichen.)

Seite 3 von 3

B) Document for Survey Access

Master Thesis Project, Karoline Kurka BSc., Digital Healthcare, St. Pölten University of Applied Sciences

Link zur Online-Befragung:

https://ww3.unipark.de/uc/DHC/9538/

oder benutzen Sie
alternativ den QR-Code:

Zur Nutzung des QR-Codes benötigen Sie eine entsprechende App, die das Auslesen von QR-Codes ermöglicht. Um den QR-Code einzulesen, öffnen Sie die App auf Ihrem Smartphone oder anderem mobilen Endgerät und halten anschließend die Kamera des Geräts über den QR-Code.

C) Full Text of the Welcome Page

Willkommen zur Online-Befragung "Evaluation of Radiation Protection Instructions"!

Bitte nehmen Sie sich einige Minuten Zeit, die insgesamt 17 Fragen zu beantworten. Hierfür sind nicht mehr als 10 Minuten vorgesehen.

Es gibt sowohl Fragen mit nur nur einer richtigen Lösung als auch Fragen, bei denen mehr als eine Antwortmöglichkeit richtig sind. Sofern bei einer Frage mehr als eine Antwortmöglichkeit richtig ist, so ist dies mit "Mehrfachantworten möglich" gekennzeichnet.

Das Ausfüllen des Online Fragebogens erfolgt anonym.

Die durch Ihre Teilnahme generierten Daten und deren Verarbeitung erfolgt anonym. Es findet keine namentliche Verknüpfung oder Nennung mit Ergebnissen der Befragung statt. Die Ergebnisse der Auswertungen dienen ausschließlich der Analyse der in dieser Masterthese behandelten Fragestellung und werden nicht an Dritte weitergegeben.

Füllen Sie die Fragen bitte ehrlich und ohne zusätzliche Hilfsmittel aus. Es geht in dieser Studie nicht darum, Ihren persönlichen Wissensstand aufzudecken, sondern die Gesamtheit des Wissenstransfers von Strahlenschutzunterweisungen statistisch auszuwerten.

Bitte füllen Sie den Fragebogen nur einmalig aus. Ein wiederholtes Ausfüllen der Befragung verfälscht die Ergebnisse.

Die Ergebnisse der Auswertungen der Online-Fragebögen dienen ausschließlich der Analyse der in dieser Masterthese behandelten Fragestellung und werden nicht an Dritte weitergegeben. Es erfolgt keine namentliche Verknüpfung oder Nennung mit Ergebnissen der Befragung.

Ihre Teilnahme erfolgt auf freiwilliger Basis. Sie können die Teilnahme an der Befragung jederzeit abbrechen indem Sie das Fenster Ihres Browsers schließen.

Mit Klicken des "Weiter" Buttons erklären Sie sich mit den oben genannten Bedingungen einverstanden und die Befragung wird gestartet.

Vielen Dank für Ihre Mithilfe!