Article published online: 2025-04-17

Digitalization of Nuclear Medicine in Germany – Status Quo 2024

Digitalisierung der Nuklearmedizin in Deutschland – Status Quo 2024

OPEN ACCESS

Authors

Thomas Wendler[1, 2, 3], Julian Manuel Michael Rogasch[4, 5], Moritz B. Bastian[6], Wolfgang Burchert[7], Dirk Hellwig[8, 9, 10], Lena Kaiser[11], Philipp Lohmann[12], Florian Rosar[6], Benedikt Schemmer[13], Johannes Tran-Gia[14], Isabelle Miederer[15]

Affiliations

1 Diagnostic and Interventional Radiology and Neuroradiology, University Hospital Augsburg, Augsburg, Germany
2 Digital Medicine, University Hospital Augsburg, Neusaess, Germany
3 School of Computation, Information and Technology, Technical University of Munich, Garching bei München, Germany
4 Department of Nuclear Medicine, Charité - Universitätsmedizin Berlin, Berlin, Germany
5 Berlin Institute of Health, Charité - Universitätsmedizin Berlin, Berlin, Germany
6 Department of Nuclear Medicine, Saarland University Medical Center, Homburg, Germany
7 Institute of Radiology, Nuclear Medicine and Molecular Imaging, Heart- and Diabetes-Center North-Rhine Westafalia, University Hospital of the Ruhr University Bochum, Bochum, Germany
8 Department of Nuclear Medicine, University Hospital Regensburg, Regensburg, Germany
9 Partner Site Regensburg, Bavarian Cancer Research Center, Regensburg, Germany
10 Medical Data Integration Center (MEDIZUKR), University Hospital Regensburg, Regensburg, Germany
11 Department of Nuclear Medicine, LMU University Hospital, LMU Munich, Munchen, Germany
12 Department of Nuclear Medicine, RWTH Aachen University Hospital, Aachen, Germany
13 Department of Nuclear Medicine, University Hospital Bonn, Bonn, Germany
14 Department of Nuclear Medicine, University Hospital Würzburg, Würzburg, Germany
15 Department of Nuclear Medicine, University Medical Center of the Johannes Gutenberg University Mainz, Mainz, Germany

Keywords

Nuclear Medicine, Digitalization, Healthcare Infrastructure, Healthcare Digital Transformation, Health Information Technology

received 3.10.2024
accepted 18.10.2024

Bibliography

Nuklearmedizin 2025; 64: 156–162
DOI 10.1055/a-2502-1728
ISSN 0029-5566

Georg Thieme Verlag KG, Oswald-Hesse-Straße 50, 70469 Stuttgart, Germany

Correspondence

Prof. Thomas Wendler
Diagnostic and Interventional Radiology and Neuroradiology, University Hospital Augsburg, Augsburg, Germany
thomas.wendler@med.uni-augsburg.de

Supplementary Material is available at https://doi.org/10.1055/a-2502-1728.

ABSTRACT

Aim Digitalization in the healthcare sector is becoming increasingly widespread. Yet, the degree of digitalization in nuclear medicine has not been systematically investigated. The "Digitalization and AI" working group of the German Society of Nuclear Medicine conducted a survey to assess the status quo of digitalization of the nuclear medicine health infrastructure in Germany.

Methods 100 questions were defined on eleven topics covering the main work processes in nuclear medicine. The survey primarily included single-select multiple-choice questions, yes-no questions on the availability of specific digital structures and processes, and questions assessing the degree of digitalization of certain processes and current satisfaction. The level of satisfaction was measured with an ordinal scale (1, very good to 5, poor).

Results In most subject areas, processes relied on a combination of paper-based and electronic procedures for the topics

analyzed. Differences in satisfaction regarding the different types of processes for any of the questions were not observed, and the overall level of satisfaction among responding sites was quite high.

Conclusion The survey did not reveal a clear need of the responding sites for complete digitalization of clinical processes. Yet, the participants highlighted the lack of proper Wi-Fi (60 %) and the desire for a platform for communication between hospitals, registered doctors and patients (74 %). Nevertheless, it is important to take a focused and unbiased look at the daily clinical procedures in every institution and place it in the frame of the existing tools or solutions of peer institutions to discover aspects of digitalization that can create added value in terms of time efficiency, integrity and sustainability.

Introduction

Digitalization in the healthcare sector is becoming increasingly widespread as it offers numerous opportunities in communication, administration and data availability. In Germany, it is being promoted by the Federal Ministry of Health (Bundesministerium für Gesundheit, BMG), with the focus on the development of secure networking in the healthcare system (telematics infrastructure, TI), the introduction of a general electronic health record (Elektronische Gesundheitskarte, eGK), patient file (Elektronische Patientakte, ePA) and prescription (E-Rezept), digital health (Digitale Gesundheitsanwendungen, DiGA) and care applications (Digitale Pflegeanwendungen, DiPA), the expansion of the use of video consultations and other telemedicine services [1]. The main goal of this initiatives is to provide care givers, patients and researchers with prompt access to the required data and information. The digitization of health data is also a prerequisite for making it available for cross-location analyses via the Medical Informatics Initiative (MII) data integration centers (DIC). Further details about the MII are provided in reference [2].

The transition from paper-based methods to electronic, paperless processes in the German healthcare system is considered overdue, as German hospitals were found to have a below-average level of digitalization compared to other European countries and have fallen further behind in recent years [3]. However, the degree of digitalization in nuclear medicine in Germany has not yet been systematically investigated. Imaging data is collected in digital form, archived long-term and integrated into the general infrastructure of the healthcare system and hospitals. Many other processes as well as documentation in patient and appointment management, in radiopharmacy or on the therapy wards are not necessarily digital.

The “Digitalization and AI” working group of the German Society of Nuclear Medicine (Deutsche Gesellschaft für Nuklearmedizin, DGN) has launched a survey to evaluate and discuss the status quo of digitalization in the German nuclear medicine health infrastructure. Eleven topics were defined for the survey, reflecting the data-generating processes at nuclear medicine departments. The aim of the survey was to identify the need for action in order to keep pace with the digital transformation in the healthcare sector.

Methods

A survey was conducted to assess the status quo of digitalization in the nuclear medicine health infrastructure in Germany. The reporting of this study follows, where applicable, the STROBE reporting guidelines [4] and the recommendations of [5]. The survey was designed according to [6], and the conceptual framework of the survey was developed and implemented in the “Digitalization and AI” working group of the DGN. For the survey, 100 questions on eleven subject areas were defined. The survey primarily consisted of three types of questions: 1) Single select multiple choice questions, 2) Yes-no questions regarding the availability of specific digital structures and processes, and 3) Questions assessing the degree of digitalization of certain processes and satisfaction with these processes in their current form. The level of satisfaction was measured with an ordinal scale (1: very good, 2: good, 3: satisfactory, 4: sufficient, 5: poor). The survey was implemented as an online survey. It was announced via the e-mail distribution list of the DGN in May 2023. The language of the survey was German; however, the questions and answers were translated into English for publication. From each of the 11 subject areas, one key finding was identified that was considered most relevant to the DGN, all of which are reported in the main text; all other results are given in the Supplementary Material. The survey data were analyzed using descriptive statistics to summarize the responses across the 11 subject areas.

Results

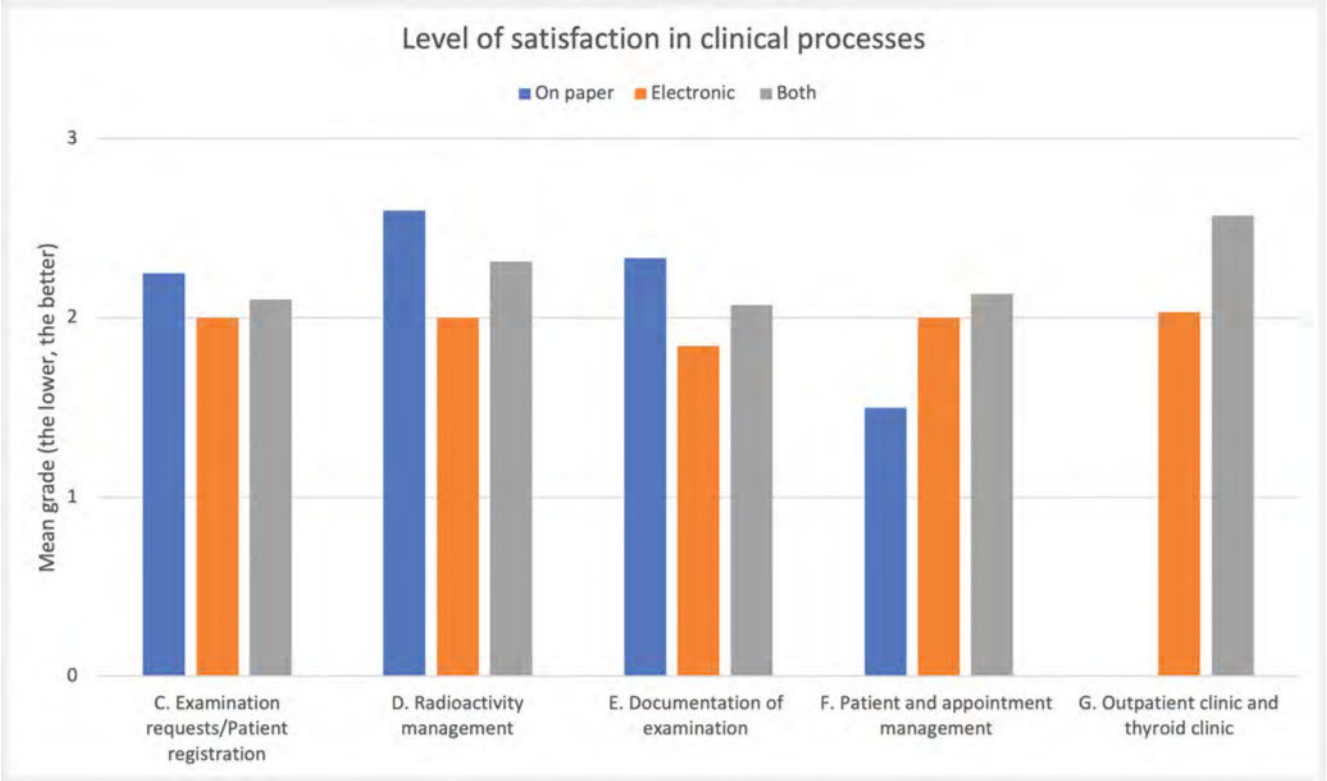
The questionnaire was completed by 100 participants, 98 of them from Germany (Baden-Wuerttemberg (17 %), Bavaria (23 %), Berlin (2 %), Brandenburg (2 %), Hamburg (3 %), Hesse (3 %), Mecklenburg-Western Pomerania (2 %), Lower Saxony (7 %), North Rhine-Westphalia (25 %), Rhineland-Palatinate (3 %), Saarland (2 %), Saxony (7 %), Schleswig-Holstein (2 %) (58 indicated their state)). Not every question was answered by every participant as it was not implemented as mandatory to answer a question to continue with the questionnaire. Multiple responses from the same institution were combined into a single response (criteria are given in the Supplementary Material), which reduced the number of responses to 70. The results of the main findings are given in ▶ **Table 1** (see the Supplementary Material for the other results). In addition, the relationship between level of satisfaction and the clinical process is given in ▶ **Fig. 1**.

▶ **Table 1** Table summarizing results of key questions of the survey.

Key questions	Answer options	Total (frequency in %)
Name of the organisation/affiliation	Medical care centres/medical practices	23 (33)
	Non-university hospital	17 (24)
	University hospital	30 (43)
	Total	*70 (100)*
Diagnostic reporting		
Is reporting formalised in your organisational unit (structured reporting)?	Yes	22 (34)
	No	13 (20)
	Both	24 (37)
	I don't know	6 (9)
	Total	*65 (100)*
Examination requirements and patient registration		
Data and information are…	On paper	4 (8)
	Electronic	9 (17)
	Both	39 (75)
	Total	*52 (100)*
Level of satisfaction (in grades)…	1	8 (15)
	2	28 (54)
	3	15 (29)
	4	1 (2)
	5	0 (0)
	Total	*52 (100)*
Management of radioactivity		
Data and information are…	On paper	5 (21)
	Electronic	3 (13)
	Both	16 (67)
	Total	*24 (100)*
Level of satisfaction (in grades)…	1	6 (25)
	2	6 (25)
	3	10 (42)
	4	2 (8)
	5	0 (0)
	Total	*24 (100)*
Documentation of imaging data		
Data and Information are…	On paper	3 (6)
	Electronic	19 (38)
	Both	28 (56)
	Total	*50 (100)*
Level of satisfaction (in grades)…	1	16 (32)
	2	21 (42)
	3	11 (22)
	4	1 (2)
	5	1 (2)
	Total	*50 (100)*

▶ **Table 1** (Continuation)

Key questions	Answer options	Total (frequency in %)
Therapy ward: Patient and appointment management		
Data and information are…	On paper	2 (7)
	Electronic	9 (33)
	Both	16 (59)
	Total	*27 (100)*
Level of satisfaction (in grades)…	1	7 (27)
	2	11 (42)
	3	8 (31)
	4	0 (0)
	5	0 (0)
	Total	*26 (100)*
Thyroid outpatient clinic or outpatient clinic: Patient and appointment management		
Data and information are…	On paper	0 (0)
	Electronic	32 (70)
	Both	14 (30)
	Total	*46 (100)*
Level of satisfaction (in grades)…	1	12 (26)
	2	21 (46)
	3	8 (17)
	4	2 (4)
	5	3 (7)
	Total	*46 (100)*
Communication with referrers		
External transmission of findings – How does communication with referrers usually take place?	By fax	14 (29)
	By post	31 (63)
	By software	4 (8)
	Total	*49 (100)*
Level of satisfaction (in grades)…	1	11 (22)
	2	24 (49)
	3	8 (16)
	4	4 (8)
	5	2 (4)
	Total	*49 (100)*
Obstacles to digitalisation and communication		
Is there sufficient Wi-Fi coverage throughout the department?	Yes	30 (60)
	No	20 (40)
	Total	*50 (100)*
Wishes with regard to digitalisation		
Is the establishment of a doctor and patient portal for the digital networking of hospitals, registered doctors and patients desired?	Yes	36 (74)
	No	9 (18)
	I don't know	4 (8)
	Total	*49 (100)*



▶ **Fig. 1** Relationship between level of satisfaction and clinical process. The level of satisfaction was assessed in relation to the implementation of the clinical processes (on paper, electronical, both) using an ordinal scale (1: very good, 2: good, 3: satisfactory, 4: sufficient, 5: poor), from which the mean value was calculated.

A. Name of the organization/affiliation

The respondents were from medical care centers or medical practices (33 %), non-university hospitals (24 %) and university hospitals (43 %) (n = 70).

B. Infrastructure and equipment

One third of the organizational units (34 %) use structured reporting for diagnostic reporting; another third (37 %) uses structured reporting to some extent. The remaining third of respondents do not use structured reporting (20 %) or do not know whether it is used (9 %) (n = 65).

C. Organization and legal affairs

Data and information for examination requests and patient registration are paper-based in less than a tenth (8 %), electronic in almost a fifth (17 %) or both paper-based and electronic in three quarters of responding sites (75 %) (n = 52). The vast majority rated the process as “good” (54 %) or “very good” (15 %) and the minority “satisfactory” (29 %) or “sufficient” (2 %).

D. Radiopharmacy

Data and information for management of radioactivity (connection to the radiology information system (RIS); activity planning and documentation) are paper-based in a fifth (21 %), electronic in more than a tenth (12 %) or both paper-based and electronic in two thirds of responding sites (67 %) (n = 24). Half of the respondents rated the process as “very good” (25 %) or “good” (25 %), while the other half rated it as “satisfactory” (42 %) or “sufficient” (8 %).

E. Imaging

Data and information for documentation of imaging data are reported to be paper-based by less than a tenth (6 %), electronic by almost two fifths (28 %), and both, paper-based and electronic, by more than half of the respondents (56 %) (n = 50). The majority rated the process as “very good” (32 %) or “good” (42 %), while fewer rated it as “satisfactory” (22 %), “sufficient” (2 %) or “poor” (2 %).

F. Therapy (ward)

Data and information for patient and appointment management (coordination with the duty rota, bed plan, camera allocation) is paper-based for less than a tenth (7 %), electronic by a third (33 %) and both, paper-based and electronic, for two thirds (59 %) (n = 27). The majority rated the process as “very good” (27 %) or “good” (42 %) and a smaller proportion as “satisfactory” (31 %).

G. Outpatient clinic and thyroid clinic

Data and information for patient and appointment management (coordination with the duty rota, bed plan, camera allocation) is

only paper-based for none of the responding sites, electronic for two thirds (70 %) and both, paper-based and electronic, for one third (30 %) (n = 46). The majority of respondents rated the process as "very good" (26 %) or "good" (46 %), while a fewer rated it as "satisfactory" (17 %), "sufficient" (4 %) or "poor" (7 %).

H. Communication with referrers

Reports are usually sent to external institutions by fax in one third of cases (29 %), by mail in two thirds of cases (63 %) and by software in less than one tenth of cases (8 %) (n = 49). The majority rated the process as "very good" (22 %) or "good" (49 %) and fewer rated it as "satisfactory" (16 %), "sufficient" (8 %) or "poor" (4 %).

I. Obstacles to digitalization and communication

Only 40 % of respondents stated that they had sufficient Wi-Fi coverage (n = 50).

J. Wishes with regard to digitalization

A doctor and patient portal for digital communication between hospitals, registered doctors and patients is desired by three quarters of respondents (74 %) (n = 49).

Discussion

There was a fairly balanced proportion of responses from medical care centers or medical practices, non-university hospitals and university hospitals, as well as the fairly representative distribution of respondents from different federal states in terms of responses per capita. We therefore assume that the survey responses are representative of the nuclear medicine community in Germany.

The survey found that one third of organizational units use structured reports for diagnostic reporting and another third use structured reports at least to some extent. For those units that use it only partially or not at all, it is desirable to move from free text to structured reporting to make results comparable within the department and between different centers. For the analysis of large datasets and the use of machine learning methods, e. g. via the German Portal for Medical Research Data (Forschungsdatenportal für Gesundheit, FDPG) or the German Radiological Cooperative Network (RACOON) [7], structured reporting facilitates the integration and retrieval of reporting data into electronic health records (EHR) and DIC databases. It may also support the time-consuming process of the manually annotating image datasets, which is required to train machine learning models. To implement structured reporting, a standardized reporting terminology is required (e. g., using report templates like TIRADS [8] and PROMISE [9]).

The results show that in most subject areas, processes rely on a combination of paper-based and electronic procedures for the subject areas analyzed: "Radiopharmacy", "Imaging", "Therapy (ward)", "Outpatient clinic and thyroid clinic" and "Communication with referring physicians". Consequently, many processes are not yet fully digitized. The reason may be that many digital procedures for an imaging department, often developed primarily for radiology, are not specific to nuclear medicine as they do not include the possibility of handling radiopharmaceuticals or administer radionuclide therapies. To our surprise, we did not observe any differences in the level of satisfaction with the different types of processes for any of the questions, and the overall level of satisfaction among respondents was quite high – despite the low to moderate level of digitalization. Thus, the survey did not reveal a clear need of the responding sites to move towards complete digitalization of the various processes. We conclude that digitalization does not necessarily imply user satisfaction.

We suspect that the lack of dissatisfaction with the status quo can be explained, among other things, by the fact that respondents have become accustomed to the way their own processes work. Notably, there is usually no choice between paper-based and digital processes. In such a situation, participants can only speculate about the potential impact or benefits of transitioning a process to a digital approach. Respondents may not be aware of how cumbersome, inefficient, or error-prone a particular process may be because there is no point of comparison. Additionally, an individual may not always be able to validly assess the entire process. For example, a physician who quickly fills out documents in paper form might not realize how time-consuming the scanning and archiving of these paper documents might be for an assistant. An independent external observer would have to objectively evaluate the entire process with respect to the availability of work forces in different qualification levels. Additionally, this may be also hindered due to fragmented software strategy of the hospitals. The PACS/RIS-system is often implemented by the hospital without the participation of the people which were expected to work with it. After installation the software is often not optimal configurable to the specific needs of the clinical application. This leads to partial digitalization. A bottom up approach with integration of different specialists can be beneficial to plan and implement future digital tools.

At this point, it should be emphasized that the benefit of digitalization lies in the ability to make data timely available where it is needed by physicians, patients and researchers. However, this is not about the complete digitalization of previously paper-based processes and procedures that have proven to be efficient, but about the implementation of supporting digital medical applications. Notably, transitioning from well-established paper-based processes to a digital approach can easily lead to more disruptions, increased time consumption, and frustration, at least during the transition phase. Such a change therefore always requires sufficient time, personnel resources, and close monitoring of the processes.

When asked about barriers to digitalization and digital communication, the lack of connectivity was the main reason given. Only 40 % of respondents reported adequate Wi-Fi coverage. For example, a reliable Wi-Fi connection ensures fast access to electronic patient records, so that medical staff always have access to up-to-date and accurate patient data, or enables the use of tablets and smartphones for in-process documentation. Building a robust, safe and reliable Wi-Fi infrastructure in hospitals is a basic requirement for various digital processes. However, this can be a particular problem in departments that use ionizing radiation, as many of the walls are specially shielded to minimize radiation ex-

posure to patients and staff – which might also weaken or completely block any Wi-Fi signal.

The need for a digital platform to facilitate communication and interaction between physicians and patients became clear as it is desired by three quarters of respondents. Yet, a physician-patient portal that meets the needs of nuclear medicine would need to allow not only access to digital patient records and laboratory results but also to the transfer and reading of multimodal imaging data from previous examinations. The development of such a portal would first require careful needs analysis and planning, including considerations of technical infrastructure, functionalities, integration, usability and interoperability.

Conclusion

The results of the questionnaire indicate that routine processes in nuclear medicine facilities in Germany are rarely fully digitalized. In some cases, respondents were able to clearly identify specific deficiencies and desires, such as incomplete Wi-Fi coverage or the need for better digital communication between nuclear medicine specialists, patients, and referring physicians. On the other hand, it seems difficult to assess to what extent a transition to digital processes would increase staff satisfaction, as familiarity with the usual practices makes it difficult to envision the potential benefits of the unknown. We therefore consider it important to closely and openly examine the everyday processes within one's own facility, with the aim of identifying the specific processes and structures where there might be a need for optimization and where digitalization could add value in terms of time efficiency, integrity, and sustainability. It is essential to involve all stakeholders in the process. Key to the future implementation is national and European standardization of data structure, file formats and communication standards. On the other hand, training of the specific tools and structure has to be organized by the clinical and scientific community. Legal and regulatory standards could be implemented by e. g. the German Standardization Institute (Deutsche Institut für Normierung, DIN) and official authorities (the Federal Ministry for the Environment, Nature conservation, Nuclear Safety and Consumer Protection, the Federal Office for Radiation Protection and the Radiation protection commission) to support the broad implementation of the digital infrastructure. The nuclear medicine community and the DGN could provide incentives and support by enabling facilities to network with each other, share information on processes, and find optimization opportunities and joint solutions. One specific aspect may be the broader implementation of structured reporting for the most frequent procedures in nuclear medicine. This would ensure that processes and data in nuclear medicine are adapted to meet future demands for connectivity, interoperability, and data integration, both in routine care and in research.

Conflict of Interest

Thomas Wendler was a consultant for Crystal Photonics GmbH until September 2023 and acts as an advisor for Magnitude Innovations Ltd since November 2024. Julian M. M. Rogasch has received speaker honoraria from GE Healthcare GmbH, Novartis Radiopharmaceuticals GmbH and Hexal AG. Lena Kaiser is simultaneously employee as medical physicist at ITM Pharmaceuticals Oncology and LMU Klinikum. Philipp Lohmann has received honoraria for lectures from Blue Earth Diagnostics Ltd and for advisory board participation from Servier Pharmaceuticals.

References

[1] Bundesministerium für Gesundheit (BMG). "Digitalisierung im Gesundheitswesen". Accessed July 05, 2024 at: https://www.bundesgesundheitsministerium.de/themen/digitalisierung/digitalisierung-im-gesundheitswesen.html

[2] Miederer I, Rogasch JMM, Fischer R et al. The Medical Informatics Initiative and the Network University Medicine – Perspectives for Nuclear Medicine. Nuklearmedizin 2023; 62 (5): 276–283. doi:10.1055/a-2067-7642

[3] Stephani V, Busse R, Geissler A. Benchmarking der Krankenhaus-IT: Deutschland im internationalen Vergleich. Krankenhaus-Report 2019 XVI: 361

[4] von Elm E, Altman DG, Egger M et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet 2007; 370 (9596): 1453–1457. doi:10.1016/j.jclinepi.2007.11.008

[5] Choi BC, Pak AW. A catalog of biases in questionnaires. Prev. Chronic Dis 2005; 2 (1): A13

[6] Jenn NC. Designing A Questionnaire. Malays Fam Physician 2006; 1 (1): 32–35

[7] Heyder R. The German Network of University Medicine: technical and organizational approaches for research data platforms. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 2023; 66 (2): 114–125. doi:10.1007/s00103-022-03649-1

[8] Schenke S, Rink T, Zimny M. TIRADS for sonographic assessment of hypofunctioning and indifferent thyroid nodules. Nuklearmedizin 2015; 54 (3): 144–150. doi:10.3413/Nukmed-0712-14-12

[9] Eiber M, Herrmann K, Calais J et al. Prostate Cancer Molecular Imaging Standardized Evaluation (PROMISE): Proposed miTNM Classification for the Interpretation of PSMA-Ligand PET/CT. J Nucl Med 2018; 59 (3): 469–478. doi:10.2967/jnumed.117.198119