

Acceptability of a future phantoms bank for quality control in nuclear medicine*

Aceitabilidade de um futuro banco de objetos simuladores para controle de qualidade em medicina nuclear

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Abstract Objective: The present study was aimed at determining the acceptability of a national or regional phantoms bank to be deployed in Brazil for shared use in quality control activities by nuclear medicine centers. **Materials and Methods:** The authors analyzed the answers to a questionnaire applied to medical physicists and radioprotection supervisors in Brazilian nuclear medicine centers. Initially, the questionnaire was validated by professionals in the city of Aracaju, SE, which is located in the Northeast region. The present study sample was geographically distributed as follows: the Northeast region, with answers from 13 professionals of nuclear medicine centers; the North region, with 2 professionals; the South region, with 7 professionals; the Southeast region, with 43 professionals; and the Midwest region, with 2 professionals. **Results:** According to the data analyzed, 82% of the respondents consider that the implementation of a phantoms bank would be a suitable alternative for improving nuclear medicine quality control. The interest in sharing the bank was reported by 87% of the respondents. **Conclusion:** The present study demonstrated the motivation for a shared use of a future phantoms bank.

Keywords: Nuclear medicine; Quality control; Phantom.

Resumo Objetivo: O objetivo deste trabalho foi verificar a aceitabilidade para a implantação no Brasil de um banco de objetos simuladores nacional, ou bancos regionais, para uso compartilhado desses objetos em atividades de controle de qualidade nos serviços de medicina nuclear. **Materiais e Métodos:** Foram analisadas as respostas dadas em um questionário que foi enviado a supervisores de radioproteção e físicos médicos de serviços de medicina nuclear do Brasil. Inicialmente, o questionário foi validado por profissionais da cidade de Aracaju, SE, que está localizada no Nordeste. De acordo com as regiões geográficas brasileiras, fizeram parte da amostra investigada: o Nordeste, com respostas de profissionais de 13 serviços de medicina nuclear; o Norte, com 2 profissionais; o Sul, com 7 profissionais; o Sudeste, com 43 profissionais; e o Centro-Oeste, com 2 profissionais. **Resultados:** Segundo os dados analisados, 82% dos entrevistados consideram que a implantação de um banco de simuladores seria uma alternativa apropriada para o aprimoramento do controle de qualidade em medicina nuclear. O interesse em compartilhar com o banco foi de 87%. **Conclusão:** Os resultados mostraram que há motivação para o compartilhamento de objetos simuladores, ou seja, para o uso desses objetos de forma socializada.

Unitermos: Medicina nuclear; Controle de qualidade; Objeto simulador.

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INTRODUCTION

Simulators, also known as phantoms, are utilized in nuclear medicine for evaluating the performance of collimation sys-

tems in scintillation chambers, in the calibration of such devices, in the analysis of parameters for images reconstruction and capacity of lesions detection, and in the definition of the sensitive volume and other properties or characteristics of such systems. In this field, the following types of phantoms are most frequently utilized: quadrant bar phantoms; homogeneity phantoms, such as the Jaszczak type, with artifacts of different dimensions for the simulation of radio-pharmaceuticals uptake, allowing a sepa-

rate evaluation of several tomographic conditions of nuclear medicine imaging systems^(1,2); the Rollo phantom, utilized for evaluating contrast and spatial resolution; brain phantoms, such as the Hoffman 3-D Brain Phantom; cardiac phantoms and thyroid phantoms⁽³⁾. Certain phantoms may also function as dosimeters, whenever they contain materials such as thermoluminescent detectors or special polymer gels⁽⁴⁻⁹⁾. Some of these objects, such as the Jaszczak type, are efficient for use in quality control of single photon emission computed tomography (SPECT) and positron emission tomography (PET) systems^(2,6).

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Although several types of phantoms are already commercially available, new models are being developed to meet specific requirements or to improve nuclear medicine devices quality control processes⁽¹⁰⁻¹³⁾. For example, in 2008, based on the perception that the protocols for the study of the thyroid function would change as a result of the availability of iodine-123, an isotope that allows improved image quality and greater agility in results of thyroid scintigraphy, Andrade et al.⁽¹⁰⁾ developed a thyroid phantom for validating the use of iodine-123 in the determination of the capacity of iodine uptake by the thyroid gland. In such a study, the authors focused on eliminating possible errors caused by the adaptation of the iodine-131 usage protocols for the use of the iodine-123 radioisotope.

Debrun et al.⁽¹⁴⁾ and Lee et al.⁽¹⁵⁾ have also developed studies with phantoms for quality control in nuclear medicine. Debrun et al.⁽¹⁴⁾ have utilized a dynamic cardiac phantom as a reference in the comparison and validation of volume measurements in gated-SPECT and 4D echocardiography. Lee et al.⁽¹⁵⁾, utilizing a Korean adult voxel phantom, developed a study to calculate the specific absorbed fraction for estimating internal organ dose, and compared their results with data obtained with an adult phantom (Oak Ridge National Laboratory (ORNL), Oak Ridge, USA).

Most of the phantoms utilized in Brazil are imported, with a relatively high financial cost. Although these devices can be considered as efficient for use in quality control, their high cost and related bureaucratic import procedures probably represent limiting factors for the acquisition of such devices by nuclear medicine centers.

Difficulties in the acquisition of such devices are also observed in Cuba. For example, Varela et al.⁽¹⁶⁾ have observed that the main difficulty at the Cuban nuclear medicine centers was the lack of phantoms for quality control tests. Because of the high cost of such devices in that country, nuclear medicine centers are not required to have their own phantoms. Thus, the Cuban State Center for Medical Equipment (CCEEM) has decided to create a national phantoms bank. The creation of such bank has allowed the quantification of the phantoms utilized at nuclear medicine services

in Cuba. Any interested specialist can access the bank's electronic portal and find out the types and quantities of available phantoms and also information on the users and institutions that own such phantoms⁽¹⁶⁾. It is important to highlight that, according to the data reported on the study developed by Varela et al.⁽¹⁶⁾, in 2004 Cuba had 18 nuclear medicine centers. Just for comparison purposes, in 2009 Brazil had more than 300 operational nuclear medicine centers.

In Brazil, nuclear medicine services must comply with the Standard CNEN-NE-3.05⁽¹⁷⁾ and with the Resolution MS-Anvisa-RDC No. 38⁽¹⁸⁾. According to such regulations, every nuclear medicine center must have at least one quadrant bar phantom set, also known as orthogonal bar phantom. This type of phantom must be readily available at the nuclear medicine services for mandatory quality control tests, according to such regulations. Thus, phantoms banks would allow the sharing of less usual, more complex and expensive phantoms.

The possibility of sharing other phantoms could play an important role in the improvement of the services provided by such institutions, increasing the availability of technical resources for quality control and for professional education.

Based on the need to study the possibility of making phantoms that are less frequently found at nuclear medicine centers more accessible, and based on the observation of the increase in technological incentives in Brazil, a questionnaire was prepared in order to assess the acceptability of the deployment of a national phantoms bank or regional phantoms banks for shared use of such devices in quality control activities by nuclear medicine centers. The questionnaire served the purpose of evaluating the opinions of radioprotection supervisors and medical physicists on the possibility of the creation of such banks. The results are presented below.

MATERIALS AND METHODS

A questionnaire to evaluate the acceptability of the creation of a phantoms bank for nuclear medicine in Brazil was answered by medical physicists and/or radioprotection supervisors working at medical

clinics and hospitals providing services of nuclear medicine diagnosis and therapy. The present study was developed in the period from January to April of 2009, based on the assumption that the organization of such phantoms bank would allow, besides the improvement in the quality control of nuclear medicine images, a greater exchange of data amongst professionals involved in the radioprotection of such centers. Additionally, the deployment of a phantoms bank would help to increment the cooperation among such centers, making a set of data on clinical cases and quality control tests available for a wide number of professionals.

The questionnaire was initially applied in the city of Aracaju, SE, in the Northeast region of Brazil. After the definition of the questionnaire's contents, format, evaluation scale and the planning of the qualitative and quantitative analyses of the questions, two radioprotection supervisors in nuclear medicine centers were interviewed for evaluation and validation of the questionnaire. Subsequently, the questionnaire was applied to other radioprotection supervisors in nuclear medicine centers and hospitals in the five Brazilian geographic regions. In the North region, the questionnaires were answered by professionals in the states of Pará, Amapá and Tocantins; in the Northeast region, by professionals in the states of Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, Piauí and Maranhão; in the South region, by professionals from the states of Paraná, Santa Catarina and Rio Grande de Sul; in the southeastern region, by professionals in the states of Minas Gerais, Espírito Santo, São Paulo and Rio de Janeiro; and in the Midwest region, by professionals in the state of Goiás and Brasília. It is important to highlight that the states with the highest number of nuclear medicine centers are Rio de Janeiro and São Paulo.

The questionnaire comprised nine questions on quantitative and qualitative matters, allowing the respondents to express the advantages and disadvantages of a future phantoms bank and also their interest in acquiring such devices. The questionnaires were sent to 188 nuclear medicine institutions, although, at the time, the Comissão Nacional de Energia Nuclear

(CNEN) (National Committee for Nuclear Energy) had approximately 320 institutions on its records⁽¹⁹⁾.

The application of the questionnaires was done by means of interviews with radioprotection supervisors and medical physicists at the centers, through email or phone. Table 1 presents the Brazilian regions and number of professionals participating in the sample.

Table 1 Brazilian regions participating in the survey.

Região	Participants (%)
Northeast	13
North	2
South	7
Southeast	43
Midwest	2
Total	67

RESULTS

As expected, some of the radioprotection supervisors responded that high cost and complex bureaucratic import procedures discouraged the adoption of more complex quality control procedures in nuclear medicine centers. Additionally, on some of the answers, the respondents mentioned the fact that some center administrators do not understand the actual need for the acquisition of phantoms.

Figure 1 presents the degree of interest by the professionals in acquiring phantoms for quality control and training. In the Northeast region, of all 13 participants, 10 (77%) declared their interest in the acquisition of phantoms for quality control in nuclear medicine; in the Midwest region, such interest was declared by one of the two respondents. In the South region, five (72%) of seven respondents intended to acquire additional phantoms; in the Southeast region, interest was demonstrated by 36 (84%) of 43 respondents; and in the North region, a result similar to the Midwest region was observed, with one of two respondents declaring interest in the acquisition of phantoms.

Those professionals who reported no interest in acquiring new phantoms said that the devices available at their nuclear medicine centers were appropriate for their

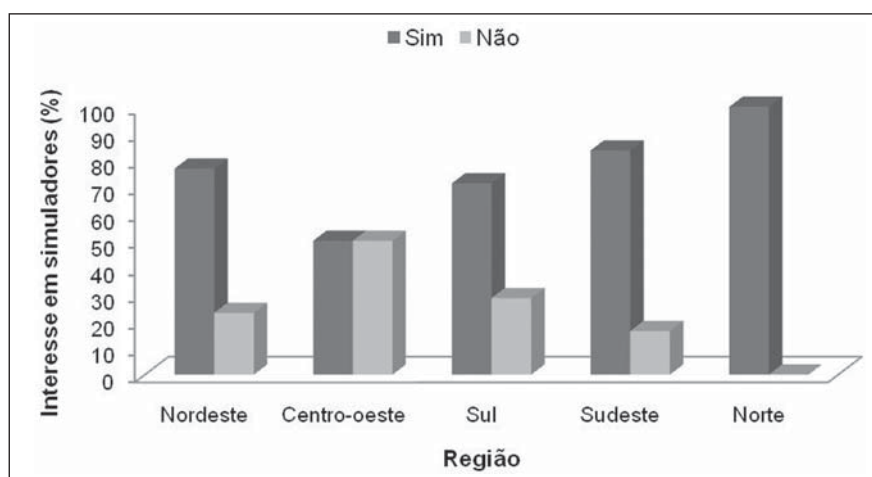


Figure 1. Degree of interest in acquiring some phantoms.

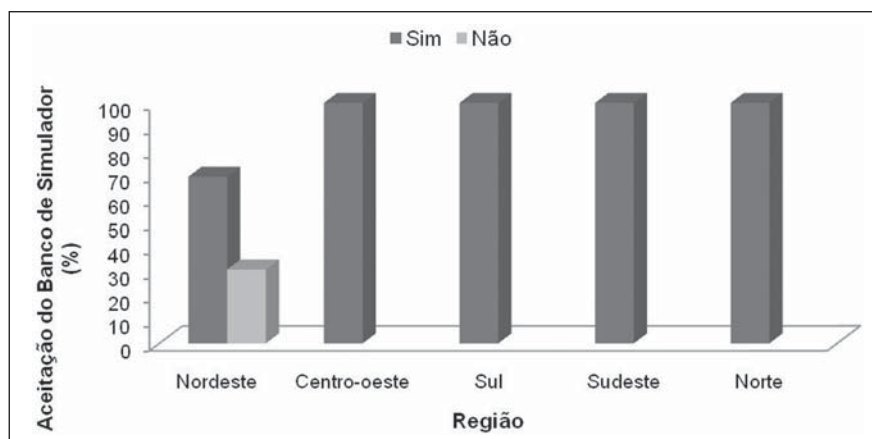


Figure 2. Index of professional acceptability of the creation of a phantoms bank.

needs with respect to the quality control test requirements set by the CNEN Standards⁽¹⁷⁾. Such professionals declared that their services owned quadrant bar type phantoms.

Based on the results of the questionnaire, it was also possible to evaluate the acceptance of the proposal to set up a future phantoms bank in Brazil, as demonstrated by Figure 2.

Only in the Northeast region the respondents were not unanimous in relation to the creation of such bank. Only nine (70%) of 13 respondents in the region supported the creation of such bank. In the other regions, the acceptability achieved 100%.

Figure 3 presents the degree of interest of the supervisors in sharing the phantoms bank. In such a sharing process, each institution would make their phantoms available to other institutions.

In general, the majority of the respondents demonstrated interest in sharing the phantoms bank. In the Northeast region, such interest was demonstrated by nine (70%) of the respondents, in the Midwest region, by two (100%), in the South region, by six (86%), in the Southeast region, by 39 (91%), and in the North region, by two (100%) of the respondents.

DISCUSSION

According to the respondents, the most relevant phantoms for quality control that should be included in the bank would be those utilized for evaluating image homogeneity, which would be utilized for heart, kidneys, lungs and liver simulations, provided that such phantoms allowed the evaluation of scintigraphic images of organs with different degrees of abnormali-

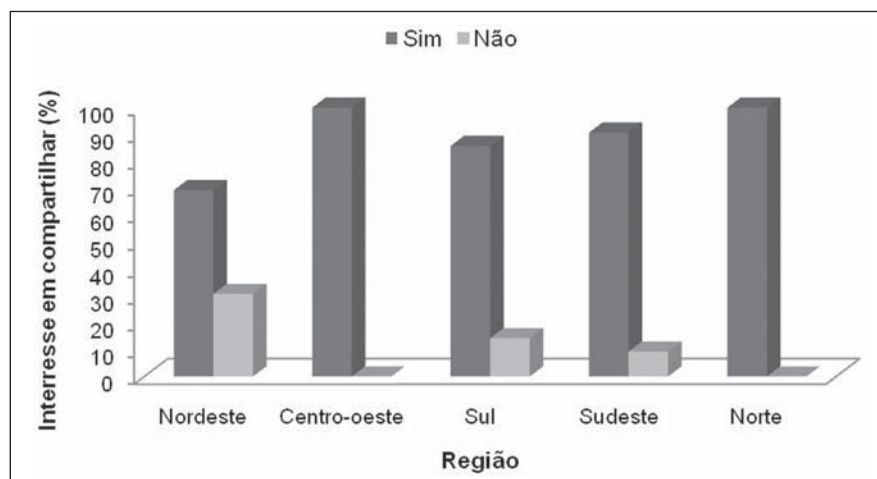


Figure 3. Level of interest of nuclear medicine professionals in sharing the phantoms by means of a phantoms bank in Brazil.

ties. Examples of phantoms that could be utilized for such purposes would be the Jaszczak-type, Rollo and Hoffman 3-D Brain phantoms.

Some professionals also mentioned that it would be important to have the phantoms locally produced. In their answers, such professionals demonstrated preoccupation with the phantoms that have been utilized for sensitivity tests, because of the way such tests are normally performed, subjecting the professionals and equipment to contamination. Such preoccupation is justifiable, as one of the ways to perform this test is by means of the deposition of the radioactive sample over a Petri dish⁽⁶⁾. However, as the sample does not always remain concealed, in the manipulation of the sample or at the moment of the homogenization of the radioactive material, it may contaminate the hands of the professional that is performing the test, or even parts of the scintillation chamber. Although other quality control tests may lead to contamination, the sensitivity test presents greater possibility of such an event.

The Northeast region professionals who did not accept the proposed phantom bank pointed out that administrative problems might be a hindrance to the proper functioning of the bank. Even believing in such hindrances, such professionals would accept being users of such bank. In general, the respondents mentioned that the deployment of the bank would be a good alternative for the improvement of quality control

in nuclear medicine, as it would lead to costs reduction, allowing improvements in the required procedures, besides encouraging the exchange of technical and organizational data among the professionals of Brazilian nuclear medicine services. After all, the availability of access to different types of phantoms would simplify the testing procedures and would allow the sharing of methods and problems solving solutions amongst medical physicists and supervisors, besides the early detection of avoidable problems such as those that are normally observed in linearity, field uniformity and spatial resolution tests in image acquisition systems.

Considering the fact that all Brazilian nuclear medicine services have a quadrant bar type phantom, the institutions would only borrow other types of phantoms useful for quality control improvements. In addition, the bank would provide data on the types of tests and scintillation chambers in which the registered phantoms could be utilized.

CONCLUSION

The present study demonstrates that there is significant interest in the possibility of the deployment of a phantoms bank for nuclear medicine.

The responses to the phone interviews and by e-mail also included suggestions given by the radioprotection supervisors for improvement in quality control and on the

method for implementing the phantoms bank. Among those suggestions, the most frequent one was the initial deployment of the bank on a regional basis, with the justification that this would optimize the access to the bank, considering the reduced transportation costs and smaller number of users as compared with a national centralized phantoms bank.

In order to set the bank up, it is necessary to survey the types, models and quantities of the phantoms that may be available at the institutions. With the results of such survey, a system for identifying the centers, the possible users as well as the availability and borrowing or exchange procedures, with the definition of usage rules, utilization scheduling and transportation of the phantoms. Additionally, even before such survey is carried out, it would be necessary to define which institution would be responsible for the management of the phantoms bank. Possibly, the Agência Nacional de Vigilância Sanitária (National Health Surveillance Agency) might assist in the indication of the managing agents for the national or regional phantoms banks.

It is likely that the demand for the phantoms and transportation difficulties may cause initial hindrances to the efficiency in availability of phantoms; however, these shall not be taken as an obstacle, but as a stage to be overtaken towards the success and advances in quality control at nuclear medicine centers in Brazil. After all, the bank would allow a greater exchange of information amongst nuclear medicine professionals at regional or even at national levels.

The present study demonstrates that a motivation to share existing phantoms in Brazil does exist. If such sharing comes to fruition, it will allow an effective improvement in quality control of nuclear medicine equipment, in the images acquisition in this medical specialty and in the continued education of professionals in this field.

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