Cell. Mol. Biol. 57 (supp): OL1500-OL1504
Published on May 30, 2011; DOI 10.1170/172

LEVRAD SOFTWARE AS A TOOL TO LEARN HOW TO PROCEED WITH AN EVALUATION OF BARRIERS

C. C. FERREIRA[1] ✍ AND S. O. SOUZA[2]

1 Núcleo de Física, Campus Prof. Alberto Carvalho, Universidade Federal de Sergipe, 49.500-000, Itabaiana-SE, Brazil
2 Departamento de Física, Universidade Federal de Sergipe, 49.100-000, São Cristóvão-SE, Brazil

Abstract

We developed the software LevRad with the objective of teaching how to proceed in an analysis of barriers shielding against x-rays to minimize the contact of the professional or the student with x-rays and also to prevent wearing out of the x-ray equipment. Some tests of the software were made, and preliminary results indicate that LevRad is efficient as a complementary tool for the development of professionals related to diagnostic radiology. In the case of education, an advantage is gained when the beginner uses the software before his or her first contact with x-ray equipment in locu. The software introduces a basic knowledge about evaluation of barriers, prevents wearing out of the x-ray tube, reinforces teaching of evaluation of barriers, and reduces the collective effective dose by avoiding unnecessary exposures when possible.

Key words: Shielding adequacy, radiation protection, collective effective dose.

Article information's

Received on February 25, 2011
Accepted on May 12, 2011

Corresponding author
C. C. FERREIRA
Núcleo de Física, Campus Prof. Alberto Carvalho, Universidade Federal de Sergipe, 49.500-000, Itabaiana-SE, Brazil
E-mail: cassio.c.ferreira@gmail.com

INTRODUCTION

Since the discovery of x-rays by Roentgen in 1895, several recommendations about the hazards from this radiation source have been published. About 14% of the total annual worldwide collective effective dose originates from diagnostic x-ray examinations (13), representing about 90% of the total population dose from all artificial sources in the UK (6). Diverse strategies have been realized in an attempt to reduce the worldwide collective effective dose (4,10,7).

A shielding barrier interposed between an x-ray source and the individual to be protected must attenuate the radiation intensity up to the shielding design goal, defined as the maximum equivalent ambient dose that a particular barrier is designed to transmit (11). In order to protect the staff and population, various countries have instituted federal laws that oblige institutions to apply evaluation of barriers for the protection against x-rays.

In Brazil, the Ministry of Health established a set of directives for radiology services in order to reach acceptable standards of security and quality as reported in “Portaria MS-453/98” (8). One of the most important aspects of this regulation is the practice of an evaluation of barriers for the protection against x-rays which establishes a maximal equivalent ambient dose allowed for controlled and uncontrolled areas. The guidelines published in 2005 by the Brazilian Hygienic Protection Agency (National Health Surveillance Agency – ANVISA) (9), similar to the technical manuals published by the American College of Radiology (2) and by the American Association of Physicists in Medicine (1), assist in elaboration of the regulation of evaluation of barriers for the protection against x-rays. In Brazil, an evaluation of barriers for the protection against x-rays must be performed every four years by a specialist in radiation protection.

This advance caused the appearance of some institutions in Brazil which are responsible for the teaching of professionals in Diagnostic Radiology (medical physicists, work security engineers, radiology technicians). Among these institutions are the federal and private universities as well as centres for the teaching of radiology technicians, which teach students to measure the equivalent ambient dose. Since an x-ray tube is an expensive device, it is usually not available in educational institutions, but only in hospitals. This is especially true for less developed regions, such as the State of Sergipe in Brazil. This increases the importance of education of the professionals who are expected to evaluate barriers for the protection against x-rays in x-ray facilities.

We created the LevRad software application with the objective of providing a tool to teach students how to estimate the equivalent ambient doses before they access the x-ray tube, and in this way to minimize their exposition to radiation, contributing to a reduction in the collective effective dose as well as preventing wearing out of the actual x-ray tube.

MATERIALS AND METHODS

With the aid of the Flash Macromedia package from Microsoft®, a computational program was designed to provide visual and numerical information regarding a standard general radiographic room (12). Using this information, the user should be able to calculate the equivalent ambient dose received by the occupied area of interest in order to ensure an acceptable level of protection according to Brazilian laws.

Croquis

Figure 1 shows the croquis (scheme) of the standard general radiographic room drawn with Flash Macromedia. The typical radiographic room contains one x-ray tube, one chest bucky (image receptor), one command panel, and one x-ray table with image receptor. In the design or evaluation of barriers, the equivalent ambient dose in the area to be protected is weighted by the occupancy factor and by the use factor (for the primary barrier only).

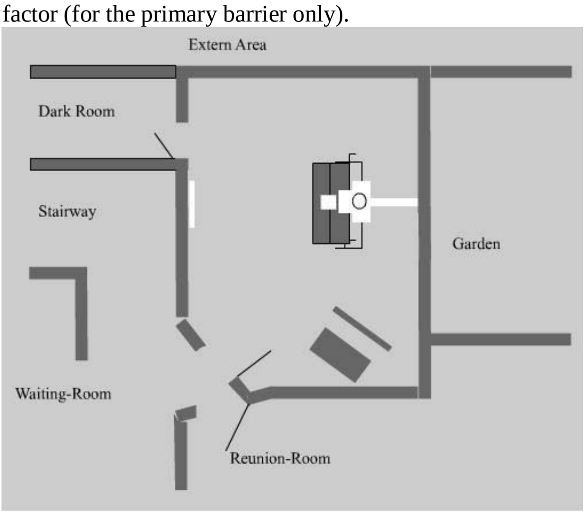

Figure 1. Croquis of a standard x-ray tube room designed with Flash Macromedia.

In the case of evaluation of barriers, in order to calculate this dose it is also necessary to measure exposure with an ionization chamber.

The technical Brazilian guide from ANVISA (9) describes the basic procedures used to test the shielding by the primary and secondary barriers. It is necessary for the user to follow this guide and to know at least the following information: the workload of each type of radiological installation, equipment characteristics, and the technical parameters of each test.

Random unknowns

The program randomly supplies the exposure rate through each radiation protection barrier, average workload per patient, average number of patients per week, equipment characteristics, and exposure factors in the test of primary or secondary barrier. With these data, the user can calculate and return to the program his or her results referring to the equivalent ambient dose rate for each analysed barrier. Finally, the program indicates whether or not the value is correct.

RESULTS

With the aid of the mouse cursor, the user can explore several resources offered by the program. With a click on the x-ray equipment he or she is able to observe the equipment characteristics and its average workload per patient, as shown in Figure 2. The rows (bars) scattered in all directions simulate the secondary radiation. With a click on the command panel, the user can observe the corresponding exposure factors of each examination, as shown in Figure 3. Figures 2 and 3 also display the mouse cursor in the ionizing chamber format and the phantom on the x-ray table (both marked by black circles).

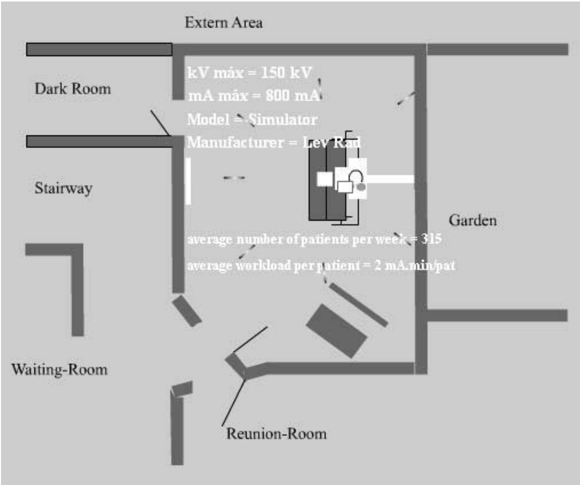

Figure 2. The x-ray tube's characteristics, its average workload per patient, and the number of patients imaged per week.

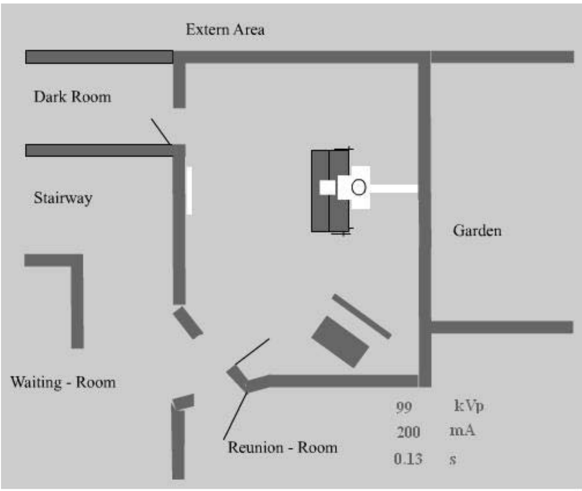

Figure 3. The exposure factors generated by the program LevRad for a given test.

Figure 4 shows the results of an exposure rate measurement through the door of the darkroom acquired by the user.

Using the language Action Script 2.0 integrated in the Macromedia Flash package, random values for all the unknowns are generated. The unknowns are: exposure rate through each radiation protection barrier, average number of patients per week, average workload per patient, equipment characteristics, and exposure factors.

The range of the average workload per patient generated by the program was based on the studies performed by Simpkin (12), whereas the exposure factors were based on Azevedo et al. (3) and Freitas and Yoshimura (5).

The equivalent ambient dose rate is estimated by Equation 1:

$$E = (R \times 0{,}0087 \times f \times U \times w_p \times N_p) \div (60 \times mA) \quad (1)$$

where E is the equivalent ambient dose rate, R is the exposure rate in milliröntgen per hour (generated randomly), f is the occupation factor, U is the use factor, wp is the workload per patient (generated randomly), Np is the number of patients per week (generated randomly), and mA is the x-ray tube current value (generated randomly).

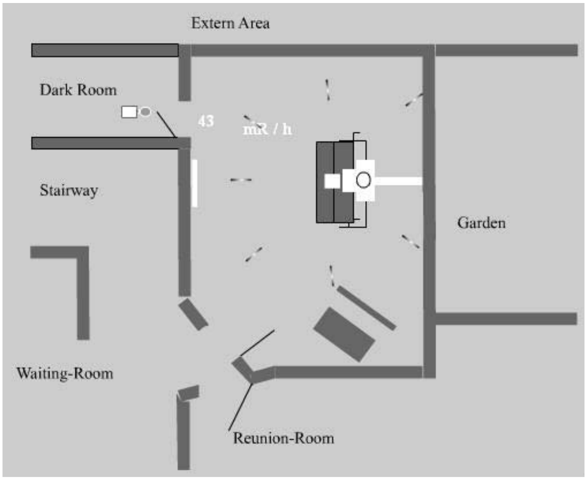

Figure 4. Demonstration of a measure acquired through the door of a darkroom with an ionization chamber for the test of the secondary barrier.

Application

On the basis of the random data offered by the program, the user should calculate for him- or herself the equivalent ambient dose through each barrier in a given croquis. Figure 5 shows the panel where the user should type his or her results. LevRad then calculates the equivalent ambient doses and compares them with the user's data. In this way, the user is able to verify whether or not his or her calculated data for the equivalent ambient dose rate corresponding to each barrier are correct. The program validates the user's result as correct if it lies within some interval of values defined by the program via an algorithm that is implemented.

Figures 4 and 5 are related to the case of the secondary barriers test, but the program also calls the user's attention to the accomplishment of the primary barrier test. Figure 6 illustrates the program asking the user which test he or she will carry out first, before using the exposure data.

Depending on the user's choice, the program scene will be adjusted to this choice.

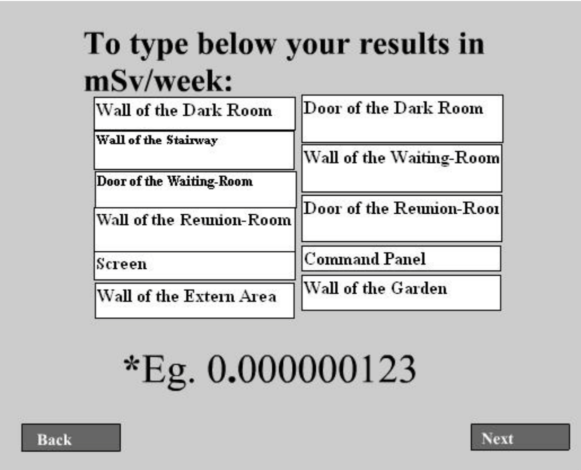

Figure 5. Screen to verify the results. The user types his or her calculated results into each corresponding panel.

Figure 7 shows a typical scene for examining the only existing primary barrier in this standard room drawn for the program. At the end of the primary (or secondary) barriers test the program asks the user whether he or she has already performed the other, lacking test, as shown in Figure 8.

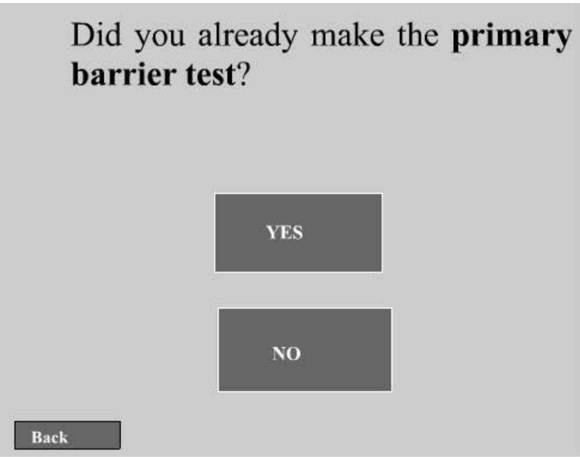

Figure 6. Choice of the test of shielding barriers.

Finally the user should report to the instructor the correct results and his or her conclusions concerning the standard general radiographic room, as well as structural shielding recommendations that will have to be adopted to guarantee the radiological security of the place.

CONCLUSIONS AND PERSPECTIVES

The program was initially tested by 30 students of Radiology at the Physics Department of the Federal University of Sergipe, Brazil, as a complementary part of the curricular programme of the Medical Physics course, and by some professionals who have worked in the area for about three years. The items evaluated were: [1] the efficiency of the program as a complementary tool in education and professional improvement, and [2] the user's satisfaction with the interface of the program.

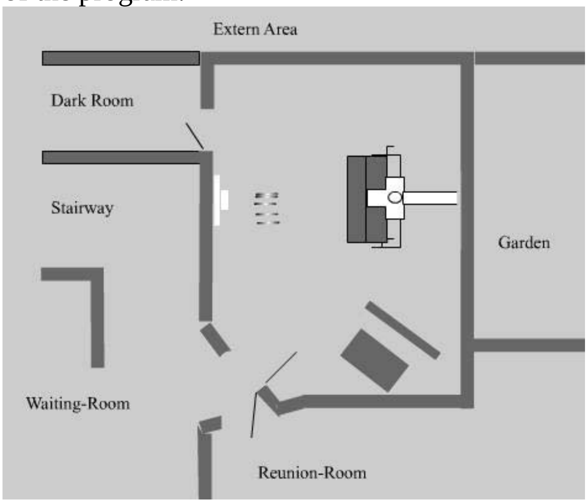

Figure 7. Screenshot of the test of the primary barrier.

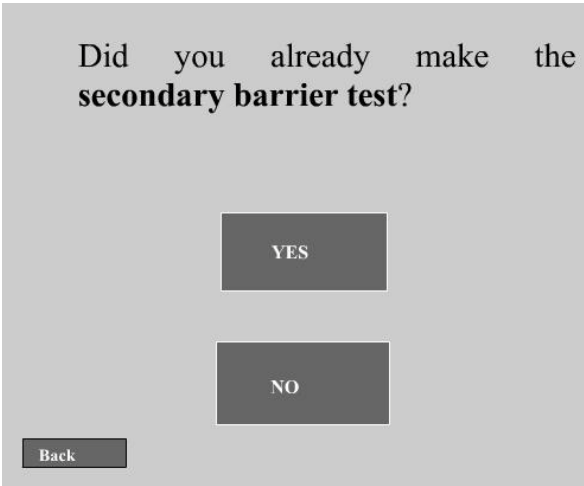

Figure 8. Question to the user about the realization of the tests of barriers.

The preliminary results showed that all users were satisfied with the program and characterized it as easy to use. Although the number of users who tested the program was small, the results indicate that the program LevRad is efficient as a complementary tool in the education and improvement of professionals related to diagnostic radiology. In the case of education, an advantage is gained from use of the program before the beginner's first contact with x-ray equipment. In this way, wearing out of the x-ray tube and possible unnecessary exposure to the radiation are prevented, reducing the collective effective dose.

In the future, it is planned to expand the program possibilities by simulating new kinds of rooms. Tomography, fluoroscopy, mammography, and other kinds of rooms will be included, together with the diverse occupation factors. Moreover, the random data base will create distinct situations that will stimulate the use of the program. Thus, the user will be able to test different kinds of rooms instead of only one. In this way he or she will gain more knowledge about the calculations and regulations concerning the evaluation of barriers before using a real x-ray tube.

In this work we presented a new software application, LevRad, created with the objective of teaching and (or) training professionals in the field of Medical Physics to estimate equivalent ambient doses for distinct areas as well as to protect people from excessive radiation and equipment from excessive workload. The program is demonstrated to be efficient as a complementary tool in education and professional improvement related to diagnostic radiology, but it does not substitute for the contact of the beginner or professional with the clinical or hospital reality. This software can be requested by emailing the corresponding author.

REFERENCES

1. American Association of Physicists in Medicine, *Essentials and Guidelines for Hospital Based Medical Physics Residency Training Programs*, AAPM Report No. 36, American Institute of Physics, 64 Depot Road Colchester, Vermont 05446, (1992).

2. American College of Radiology, CR ACR technical standard for diagnostic medical physics performance monitoring of radiographic and fluoroscopic equipment. In: *Standards*, Reston, Va: American College of Radiology, 2001.

3. Azevedo, A.C.P., Mohamadain, K.E.M., Osibote, O.A., Cunha, A.L.L., and Filho, A.P., Estudo comparativo das técnicas radiográficas e doses entre Brasil e Austrália. *Radiol. Bras.* 2005, **38**: 343–346.

4. Baumann, E. and Terry, I.R., The EPR: A clear step forward in dose reduction and radiation protection. *Nucl. Eng. Des.* 2006, **236**: 1720–1727.

5. Freitas, M.B. and Yoshimura, A.E.M., Dose measurements in chest diagnostic x rays: adult and paediatric patients. *Radiat. Prot. Dosim.* 2004, **111**: 73–76.

6. Hart, D. and Wall, B.F., UK population dose from medical x-ray examinations. *Eur. J. Radiol.* 2004, **50**: 285–291.

7. Kalra, M.K., Maher, M.M., Toth, T.L., Hamberg, L.M., Blake, M.A., Shepard, J.A., and Saini, S., Strategies for CT radiation dose optimization, *Radiology* 2004, **230**: 619–628.

8. Ministério da Saúde, Diretrizes de proteção radiológica em radiodiagnóstico médico e odontológica, Portaria No. 453, Brazil, Anvisa, 1998.

9. Ministério da Saúde, Radiodiagnóstico Médico: Segurança e Desempenho de Equipamentos, RE 1016, Brazil, Anvisa, 2005.

10. Mohamadain, K.E.M., Da Rosa, L.A.R., Azevedo, A.C.P., Guebel, M.R.N., Boechat, M.C.B., and Habani, F., Dose evaluation for paediatric chest x-ray examinations in Brazil and Sudan: low doses and reliable examinations can be achieved in developing countries, *Phys. Med. Biol.* 2004, **49**: 1017–1031.

11. National Council on Radiation Protection and Measurements, *Structural Shielding Design for Medical X-Ray Imaging Facilities*, NCRP Report No. 147, 7910 Woodmont Avenue, Suite 400, Bethesda, MD 20814, 2005.

12. Simpkin, D.J., Evaluation of NCRP Report No. 49 assumptions on workloads and use factors in diagnostic radiology facilities. *Med. Phys*. 1996, **23**: 577–584.

13. United Nations Scientific Committee on the Effects of Atomic Radiation, *Sources and Effects of Ionizing Radiation*, New York, United Nations, 2000.

