A DATA BASE FOR THE NATIONAL RADIATION CONTROL PROGRAMME IN MEDICAL AND DENTAL RADIOGRAPHY

por

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SUMMARY -- To support radiation control programmes in Diagnostic Radiology facilities (medical and dental) carried out by health authorities a computer data base is under development. During the surveys, we collect data for the institution, X-ray equipment, frequency of examination and many other parameters related to the exposure of the patient, the staff and the public. The whole routine work to process the input data from the surveys and to compare the assessed values of single parameters with acceptance values is done by a microcomputer IBM-PC/XT compatible equipment. Regional programmes generate input files to the national data base.

The data assessed by such a software are an important part of the system of dose limitation. Surveys at regular intervals will give the trends in population and occupational doses due to radiodiagnostics and will evaluate the efficacy of the overall programme of radiation control.

INTRODUCTION

In highly industrialized countries the irradiation of the population and of the occupationally exposed persons by medical and dental X-ray examinations is quantified and is part of the system of dose limitation (United Nations, 1988). Quality control and quality assurance of the sources and their application therefore is very common and is necessary from the viewpoint of safe use and the potential benefit to society.

Analytical models even relate the frequency of the use of radiation sources in Medicine and Dentistry to a scale of industrialization and to the level of health care in a society (United Nations, 1988). To localize Brazil in this scale by already available data is not possible due to the inhomogeneous geographic and demographic situation of the country with a large range in the status of development. Furthermore, any assessment of the quality in procedures using X-rays in a national level is also not possible due to the lack of data related to the

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performance of the overall radiographic technique Drexler et al (1990).

OBJECTIVES

To support quality control and quality assurance programmes in Diagnostic Radiology (medical and dental) carried out by regional radiation protection bodies, a computer based system was developed to supply local health authorities with uniform methodology to perform surveys and to issue survey reports to the users. At national level, health authorities will have a reliable data base to make decisions in their policies.

The described system is intended to be implemented step by step in the various regions of Brazil and it is designed to record data from a total of about 15000 medical and 40000 dental X-ray units. The first step includes data related to radiation protection features and irradiation parameters in Radiography. Subsequent steps will deal with other diagnostic radiology techniques like fluoroscopy, computer tomography and so on.

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The main applications of this data base will be:

(a) to analyse on a quantitative and a qualitative basis the radiographic procedures in the various regions of the country,
(b) to check the technical performance of X-ray generators and tubes of different factories and production lines,
(c) to support licensing activities and routine inspections in X- ray facilities (medical and dental),
(d) to assess the quality of the performance of the X-ray units,
(e) to assess the level of adequacy of the protection afforded to patients, members of the staff and members of the public in or in the vicinity of the X-ray rooms,
(f) to issue survey reports with recommendations to the users.

GENERAL REQUIREMENTS.

(a) Measuring Methods and Personal Training.

In order to get a reliable data base, it is necessary to adopt standardized methods for measurement and/or for the collection of the information of interest. In this work, standard methods were adopted or developed to get data related to X-ray tubes and generators and to radiation protection features (adequacy of protective barriers and individual monitoring).In this

paper standardization means the selection of standard measuring techniques, test tools and/or measuring instruments and acceptance limits for the measured parameters. According to this methodology, the input data are collected in a uniform way in all regional programmes.

Personal training to perform the measurements is also an important component in data acquisition. To make the training of inspectors to run the surveys easier, two user guides were prepared for each parameter measured. One guide describes step by step how the measurement is to be done.The second one explains the way to run the software through the description of the input fields, length of variables and so on.

(b) Hardware

At regional level, the computer system is designed to run on an IBM-PC/XT or "true" compatible with PC-DOS version 3.3 . Due to the amount of data to be recorded and the length of the executable module, it is necessary to have 40 Mbytes hard disk capacity and 640 Kbytes of RAM memory. Regional programmes generate input files to the national data base. At national level, the data base needs a mainframe computer in order to allow the processing of such a large amount of data.

SOFTWARE DESCRIPTION.

The software is developed in the Clipper computer language and the programmes to process the input data from measurements use a special technique of "overlays" in order to save memory space. With this technique the executable module for radiography needs only 266 Kbytes RAM memory. The whole radiography module is designed to record data from the Institution, the X-ray units, radiation protection features, frequency of examinations and 6 parameters related to the irradiation. To manage these data 103 computer programmes that generate 32 data files are used.

Figures 1 and 2 demonstrate the organization of data acquisition through hierarchical diagrams for medical and dental facilities respectively.

DATA ASSESSED

(a) Institution, X-Ray Unit and Frequency of Examinations.

The first group of data are related to the Institution (name,address, category and person responsible for radiation protection), to the X-ray unit (maker , model, number and characteristics of generator, X-ray tubes and other components like table, grids, image intensifier etc...) and to the frequency of examinations (average number of examinations per type and per week).

(b) Quality Assurance and Protection Features.

The remaining data are related to QA and protection features. In medical X-ray facilities, data are collected for thefollowing items under the viewpoint of occupational and patient exposure. These include:

- radiation output: magnitude, variation with mA, variation with kV, variation with mAs and automatic exposure,
- beam quality: beam filtration,
- kilovoltage accuracy: dial calibration and this calibration against current variation.
- focal spot size: broad and fine focus,
- field size: alignment and collimation,
- exposure time: accuracy and reproducibility,
- individual monitoring,
- lead equivalence of protective barriers,

For dental X-ray units and film processing data related to the following items are recorded:

- exposure at skin entrance,
- beam quality: beam filtration,
- radiation field size and uniformity,
- film processing: developing time, fog and developer activity
- individual monitoring.

DATA ACQUISITION.

(a) Medical Facilities

Data related to the Institution, the X-ray unit, frequency of examinations and individual monitoring do not depend essentially on measurements and therefore they may be acquired and/or updated either by previous information before the inspection or during the visits. Data related to X-ray generator and tube performance and protection features have to be acquired in the course of the inspections. They are valid for the time the survey was performed.

(b) Dental Facilities

Data related to dental X-ray units differ from the medical units with regard to essencial elements. Data for radiation protection features are acquired in the same way as that for medical facilities. The remaining data may be obtained either by "in loco" visits or by a postal survey. Exposure at skin entrance, field size and filtration for a single molar tooth

examination are measured with a postal kit containing TLD-100 dosimeters, radiographic film and aluminium filters. When used in the postal mode, the measuring system has to be exposed by the dentists and they also have to answer questions concerning technical characteristics of the X-ray unit, radiographic film and average number of examinations per month.

To assess the quality of the film processing in the dental office, a special method was developed. It consists of a paper card containing two pre-exposed dental radiographicfilms, both having the same image. The right half registers the latent image of the molar region of a mandible phantom, and the left half contains four optical densities (base+fog, 0.25, 1.00 and 2.00 above base+fog density). The four optical densities are used to determine the mean optical density (OD) of the images developed at dentists' offices Peixoto et al (1984). The exposure measuring kit can also be used in postal surveys.

DATA INTERPRETATION.

(a) Acceptance Limits for Single Parameters.

Radiation protection features (adequacy of protective barriers and individual monitoring) have to follow national or international recommendations therefore no range of acceptable values is given (ICRP, 1977). Table 1 gives an example of the acceptable limits adopted in the assessment of performance of medical X-ray generator and tubes. They follow the criteria developed by the Hospital Physicists' Association Reece (1981) taking into account recent proposals from the literature (BIR, 1989). Table 2 gives the accetable limits adopted in the assessment of performance of dental facilities Peixoto et al (1984). These ranges of values have to be selected according to local circumstances also and they are,broadly spoken, instruments for justification and optimization of the practice under consideration.

TABLE 1

Parameter	Good	Normal	Poor
1. Radiation Output			
Magnitude (10E-02 mGy/mAs)	4.5-5.5 * 8.0-10.0**	3.5-6.5 * 7.0-12.0**	<3.5 or >6.5 * <7.0 or >12.0**
Variation with mA	linear within 5 %	linear within 10 %	discontinuities, excessively non-linear
Variation with mAs	+/- 10%	+/- 20%	> 20%
Variation with kV (kV)exp(n)	1.9<n<2.3	1.6<n<2.6	n<1.7 or n>2.5
2. Filtration	>2.5 mm Al	2.2-2.5 mm Al	<2.2 mm Al
3. Focal Spot Size:	Both axes	One axis	Both axes
Broad focus	<tolerance	<tolerance	>tolerance
Fine focus	IEC limits	IEC limits	IEC limits
4. kV Accuracy with:			
Dial calibration	+/-5 kV	+/-10 kV	>10 kV
Current variation	+/-5kV	+/-10 kV	>10 kV
5. Timer Accuracy:			
Range: Tolerances:	three	two	one or less
>0.1s +/- 10%	measurements	measurements	measurement
0.01-0.1s	+/- 0.005s	< tolerance	<tolerance <tolerance
<0.01s +/- 0.002s	limits	limits	limits
6. Field Size			
Collimation	-	< 2 %	> 2 %
Alignment	-	<1.5 degrees	>1.5 degrees

* - one phase equipment ** - three phase equipment

Table 1: Tube and generator assessment: acceptance limits for medical X-ray units

TABLE 2

Parameter	Good	Normal	Poor
1. Dose at Skin Entrance (mGy)			
D Speed Group Film	2.0-5.0	1.5-6.5	<1.5 or >6.5
E Speed Group Film	1.7-2.3	1.0-5.0	<1.0 or >5.0
2. Total Filtration			
< 50 kV	>0.5 mm Al	0.5 mm Al	<0.5 mm Al
50 kV - 70 kV	>1.5 mm Al	1.2-1.5 mm Al	<1.2 mm Al
> 70 kV	>2.5 mm Al	2.2-2.5 mm Al	<2.2 mm Al
3. Field Diameter(cm)			
Source-Skin Distance:			
< 18 cm	5.5-6.5	5.0-7.0	<5.0 or >7.0
> or = 18 cm	6.5-7.5	5.0-8.0	<5.0 or >8.0
4. Film Processing			
Mean Optical Density(OD)in %	+5 to -10	+10 to -20	<-20 or > +10

Table 2: Exposure and processing assessment: acceptance limits for dental X-ray units

(b) Actions Deduced.

The data analysis will indicate the level of the actions to be implemented in local programmes. Based upon local infrastructure of health care and on the existing state of adequacy of the X-ray rooms and equipment, health authorities have to set forth which actions will be implemented in a collective sense. Furthermore, in many cases the necessary changes to be introduced are not only a matter of corrections in the X-ray rooms or equipment.In these cases the improvement in the overall radiographic technique needs actions in the field of personal training, norms and regulations and equipment design. As an example, in Brazil there is no special equipment to perform paediatric examinations. In this case children are exposed to radiation in the same way as adults (large field sizes, no gonadal shielding and high doses at skin entrance).

(c) The Survey Report.

The input data are collected in the course of the surveys. In preparing the input files, data for single parameters are compared with acceptance limits and norms and a report is issued to the medical or dental institution. The whole report is subdivided into individual reports for each X-ray unit. In the first part of the report are given informations concerning the technical characteristics of the various components of the X-ray unit (generator, tubes, table, image intensifier etc...). After that, an individual printout for each parameter with a clear indication of the measured value, its acceptance (good, normal or poor) and recommendations is given.

The survey report serves as an important instrument for the users and to local health authorities in the implementation of their quality control and quality assurance programmes.

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