Oak Ridge

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MEDICAL PHYSICS IN THE UNITED STATES

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At the present time there are about 800 individuals in the United States who are considered to be medical physicists by virtue of membership in the American Association of Physicists in Medicine. Unlike the medical profession where the holder of the M.D. degree is a physician and the lack of the M.D. degree indicates that the individual is not a physician, there is no clear distinction between one who is a medical physicist and one who is not, partly because the profession has not so far been adequately defined. Thus, the number of medical physicists would probably be less than 800 if the definition was restricted.

A survey published last year which was based on information from 400 respondents⁽¹⁾ to a questionnaire, indicates that 74% of medical physicists work in the field of medical radiation physics, which includes radiation therapy, diagnostic radiology, nuclear medicine and radiation protection. A breakdown of the work carried out by medical physicists in the categories of service, teaching and research is as follows:

1) Medical Physics Services

A. Physics of Radiation Therapy (See Figure 1).

1. Periodic calibration of all radiation therapy equipment.
2. Determination of the radiation dosimetry characteristics for the various types and energies of radiation used (superficial and medium energy x-ray machines, cobalt 60 teletherapy units, high energy accelerators such as linear accelerators, Van de Graaff units and betatrons).
3. Assay, calibration and leak testing of brachytherapy sources (radium needles and capsules, radioactive gold seeds, radioactive iridium and tantalum wires, cesium 137 sources, and californium-252 sources).
4. Calculations of radiation dose distributions in patients undergoing treatment, often with the aid of computerized dosimetry programs. Monitoring or measuring the dose delivered to the patient at selected sites.

5. Calibration, intercomparison, and maintenance of radiation dosimetry systems (ionization chambers, electrometers, thermoluminescent dosimetry systems, chemical dosimetry systems).
6. Design of radiation therapy installations and the calculations of shielding specifications.
7. Design and construction of special devices used in conjunction with radiation therapy.

B. Physics of Nuclear Medicine.

1. Calibration of radioisotope assaying equipment.
2. Assay of radioisotopes administered to patients.
3. Intercomparison and maintenance of radioisotope assay or counting standards.
4. Testing the reliability and monitoring the reproducibility of radioisotope counting equipment.
5. Determining the performance characteristics of patient radioisotope scanning and imaging equipment.
6. Helping to evaluate the efficacy of nuclear medicine procedures.

C. Physics of Diagnostic Radiology.

1. Calibration of x-ray equipment used for diagnostic purposes.
2. Evaluating the performance of new diagnostic equipment and the parameters that determine the diagnostic quality of the imaging system of special purpose equipment (e.g. mammography, image intensifying fluoroscopy, tomographic equipment, etc.).
3. Providing physics and engineering services in connection with newer diagnostic procedures and equipment such as isotope scanning devices for bone mineral determination, thermography equipment, and ultrasonic equipment.

4. Technical assistance in the evaluation of the efficacy of the various diagnostic procedures, and dose reduction to the patient.
5. Design of diagnostic x-ray facilities and calculation of shielding specifications.

D. Radiation Safety Services.

1. Radiation safety surveys of all radiation facilities in radiology, radiation therapy, nuclear medicine, and other departments.
2. Radiation monitoring of hospital personnel with appropriate dosimeters. Maintenance of personnel monitoring records.
3. Leak testing of all sealed radioisotope sources.
4. Maintaining records of the receipt, inventory, transfer, and disposal of all radioactive materials.
5. Establishing and monitoring radiation safety procedures and techniques to assure proper quality control.
6. Evaluating all license applications for the use of radioactive materials for the Institutional Radioisotope Committee.
7. Establishment of safe procedures and hazard control in the use of lasers, microwaves, and other potentially hazardous radiations.

2) Teaching Activities in Medical Physics - (including formal and informal lectures, review sessions, laboratory sessions).

Medical students

Nurses

Student x-ray technologists and nuclear medicine technicians
and technologists

Residents, particularly in radiology, radiation therapy and
nuclear medicine

Graduate students in the basic medical sciences

Graduate students and trainees in medical physics

3) Research and Development Activities in Medical Physics - Because of the multidisciplinary nature of medical physics, most of the research and development is a cooperative effort with medical specialists, biologists and

radiobiologists, engineers, physiologists, biochemists, and other physicists. Among the broad areas of investigation are the following:

- Development of dosimetry techniques for applications in clinical medicine, radiation biology, and radiation protection

- Development of new equipment and techniques for the early diagnosis and therapy of cancer, heart disease, etc.

- Investigations in the biological effects of radiation (ionizing, micro-waves, coherent light, ultrasound).

- Application of physical techniques (e.g. electron spin resonance and nuclear magnetic resonance) in cancer research

- Development of methods for automating diagnostic and therapeutic procedures and information retrieval

- Development of methods for dose reduction from roentgenologic and nuclear medicine procedures

This survey shows that the principal effort is devoted to therapeutic radiology, the remainder being divided about equally between nuclear medicine and diagnostic radiology. Most of the work is related to patient service.

In therapeutic radiology the service is often the determination of dose distributions for treatment planning. The second major effort is devoted to teaching medical physics to residents, medical students, graduate students and technologists. The least amount of time is spent in research.

It is interesting to note that the ratio of research to service increases as the number of physicists employed rises to three or four persons in a department. Figure 4 shows the sharp increase in research opportunities and decrease in service needs in departments with more than two physicists, based on data accumulated on full-time equivalents in the field of radiotherapy.

The bachelor's degree of the vast majority of medical physicists is obtained with a major in physics and a minor in mathematics. Figure 6 shows other categories of majors and minors.⁽²⁾ About 78% of the physicists also hold the Master's degree and 47% hold a doctorate of philosophy or Science in addition. Here, too, the vast majority of the advanced degrees are in physics with a minor in mathematics (See Figure 7). As is also indicated in the figure, about 20% of medical physicists who hold a graduate degree have obtained it in a program having courses in medical physics.

1. L. H. Lanzl, E. L. Saenger, M. A. Greenfield, J. R. Cameron, D. S. Childs, E. E. Christensen, E. W. Webster, R. O. Gorson, and J. G. Kereiakes. Status and Future Manpower Needs in Physicists in Medicine in the United States. Report available from the American College of Radiology, 20 North Wacker Drive, Chicago, Illinois 60606, USA.

2. L. H. Lanzl, Medical Physics Training. Quarterly Bulletin of the American Association of Physicists in Medicine, Vol. 5, No. 1, p. 47, March, 1971.

FIG. 1. Radiation therapy.

FIG. 2. Nuclear medicine.

FIG. 3. Diagnostic radiology.

FIG. 4. Radiation safety.

FIGURE 5

PERCENT TIME SPENT ON
RESEARCH, TEACHING AND
SERVICE VS NUMBER OF
PHYSICISTS

RADIOTHERAPY PHYSICISTS
FULL TIME EQUIVALENT

FIGURE 6

MAJOR AND MINOR STUDIES FOR THE BACHELOR'S DEGREE

FIGURE 7

MAJOR AND MINOR STUDIES FOR THE HIGHEST DEGREE EARNED BEYOND THE BACHELOR'S DEGREE