Effects of Technician Training Levels on Quality of Diagnostic Services in the Nuclear Medicine Department

Wanda M. Hibbard

Medical College of Georgia, Augusta, Georgia

The primary objective of this pilot study was to gather information to be used in forming guidelines for the development of a nuclear medicine technology training program and continuing education programs for the working technician. Questionnaires were sent to the technicians and physicians working in nuclear medicine in the state of Georgia. Data were analyzed by computer and significance levels were determined. Results indicated that there is no significant difference between test scores and registry status or between test scores and type of nuclear medicine training program. There is, however, a trend toward higher scores as the level of education and training increases. Recommendations are offered on the basis of data compilation and technicians' responses.

The purpose of this study was to determine whether the technician who has been working in a nuclear medicine department long enough to be eligible for registry, but who is not registered, can perform as efficiently as the technician who has become registered after a period of training on the job or after completing a program of training as outlined by the Council on Education of the American Medical Association (AMA). For the purpose of this study the term "technician" was used to indicate any person performing diagnostic procedures in a nuclear medicine laboratory, whether he classifies himself as technician or technologist.

On-the-job training is defined as that period of training required by the American Registry of Radiologic Technologists (ARRT) or the American Society of Clinical Pathologists (ASCP) as a prerequisite to application for registration. The length of time required varies from one year, for persons already registered as radiologic technologists, medical technologists, or registered nurses, to six years for persons with no formal training beyond secondary school.

Approved schools are those recognized by the AMA Council on Education as meeting the requirements set forth in "Essentials of an Accredited Educational Program in Nuclear Medicine Technology," 1969 (*1*). Verification of a school's program is made through an extensive reporting process and through an initial and then periodical site visits.

The use of isotopes in the diagnostic process was begun in the late 1940s. Technicians were recruited from various allied health fields such as radiology, laboratory medicine, and nursing. They were trained to do the required procedures as outlined by their employer. A review of the literature describing the procedures done by early diagnostitians in various hospitals points to a tremendous variation in results due to an absence of standardization and a lack of quality control (*2*). As the field of nuclear medicine began to show rapid acceptance and great potential as an invaluable diagnostic tool, there was a need for technicians and technologists who could demonstrate a level of technical knowledge acceptable to the profession. During the 1960s both the ARRT and the ASCP developed an examination for certification of nuclear medicine technologists and technicians. All the first applicants applied after a period of on-the-job training. Soon thereafter, a few larger medical facilities devised training programs for nuclear medicine technicians, mostly to fill their own requirements for technicians. In 1969 the AMA published guidelines for the establishment of accredited educational programs in nuclear medicine technology. Several such programs have since been developed; however, their capacity is not sufficient to fill the projected demands for nuclear medicine technicians in the next several years. The *Allied Medical Education Directory*, 1973 (*3*), reported 33 schools offering certificate programs to a maximum of 270 students. Associate degrees were offered in 6 schools to a maximum of 97 students. One school offered a B.S. degree to a maximum of 16 students. According to available reports the present shortage of qualified technicians is a serious problem. The AMA has recently set July 1976 as a deadline for certification after on-the-job training, making the need for accredited programs extremely acute (*4*).

Is there a significant difference in the quality of diagnostic services contributed by (A) the nonregistered nuclear medicine technician, (B) the technician registered after a period of training on the job, and (C) the reg-

For reprints contact: Wanda M. Hibbard, Department of Radiologic Technologies, Medical College of Georgia, Augusta, Ga. 30902.

istered graduate of a structured program of didactic lectures and clinical practicum as set forth by the Council on Education of the AMA?

The quality of diagnostic services was measured on the basis of the definition of the diagnostic process as described by Wagner in *Principles of Nuclear Medicine* (*5*). It is that process in which diagnostic aids are properly employed, new techniques are analyzed and used or discarded according to their value, a high degree of certainty is demonstrated, and decisions are made in regard to the treatment of each patient on an individual basis.

Survey of Related Literature

A survey of the literature covering the past 5 years, since the drafting of "Essentials of an Accredited Educational Program in Nuclear Medicine Technology" (*1*), failed to reveal valid studies concerning the quality of diagnostic services contributed by technicians with varying degrees of education and training. However, proficiency levels, as compared to training levels, of some allied health professionals have been evaluated; in particular those of laboratory medicine, nursing, and physical therapy, as reported by Rausch, Brandt, and Nelson (*6–8*). Significant reports of performance studies of graduates of innovative programs in other allied health professions were not found.

Gleich (*9*) stated that there is a positive correlation between the level of education and the size of the hospital in which one is likely to be employed; there is also a correlation between the level of education and employment in a supervisory position. According to a report by the ARRT (*10*), surveys point toward a trend for smaller hospitals to employ unregistered persons to work in the nuclear medicine department, usually x-ray technicians, who may or may not attempt to become registered after a period of on-the-job performance.

Light (*11*) pointed out that education is often accepted as being synonymous with competence, and this feeling is forced upon us by educators, national professional societies, regulatory mechanisms, and employers. Credentials are more "to get the job than to do the job." It was hoped that this study would provide significant data concerning the value of formal training versus on-the-job training.

The National Regulatory Commission, which is the regulatory body for the use of radioisotopes for medical purposes, presently requires that physicians using radioisotopes as diagnostic or therapeutic agents have acceptable training and experience in the use of radioisotopes (*12*). Regulatory legislation (*13*) applicable to technicians has been proposed both on the national and state levels, and some has been passed at the time of this writing. Such legislation is an attempt to restrict the responsibility for the administration of radionuclides to certified or registered personnel. Does certification or registration as it now stands insure that a technician is capable of administering radionuclides? It was proposed that this study would positively verify the capability of the registered technician.

The Society of Nuclear Medicine is constantly attempting to upgrade the education level of technicians through annual meetings, seminars, workshops, and short training programs. A survey made by the ARRT pointed out that 61% of those attending seminars are registered nuclear medicine technicians. The unregistered technician may in fact be the one who should be urged to attend educational programs. The problem may be one of convincing the technician of the value of attending educational programs.

Hiscock (*14*) pointed out that there are approximately 4,500 nuclear medicine technicians in the United States and only 1,900 are registered through either the ARRT or the ASCP, the only registering bodies for nuclear medicine technology. Thirty-nine percent of the registered technicians hold positions as chief technicians, undoubtedly due to the small work force of two or three technicians in many departments. The failure rate for those attempting the registry on the basis of job experience with no formal training is about 60%. This indicates that a large degree of difficulty is encountered by those who attempt to go through an on-the-job training process for registration. The failure rate leads to the assumption that such technicians may be lacking in certain basic skills which are essential in the delivery of a high quality of diagnostic services.

According to Simmons (*15*), the shortage of qualified technicians is a serious problem. There is a need for additional people, and they must be highly qualified ones, capable of performing technical functions with a minimum of supervision. Their education and training must be such that they are able to provide the highest quality of diagnostic services.

Subsequent continuing education programs designed on the basis of information drawn from this study will be aimed at increasing the quality of diagnostic services contributed by the working technician.

Method of Investigation

It was hypothesized, for purposes of this study, that there is no significant difference between the quality of diagnostic services provided by the unregistered technician and one who has taken and passed a registry examination. It was also hypothesized that there is no significant difference between the quality of diagnostic services provided by the technician registered after a period of training on-the-job and one who has become registered after finishing a course of study in an approved school.

The quality of diagnostic services contributed by nuclear medicine technicians was measured through survey questionnaires. A 10-point evaluation form (Appendix A) to be answered for each technician was sent to the medical director of the nuclear medicine department in each hospital included in the survey. A 35-point survey questionnaire (Appendix B) structured to obtain general information about the responding technician as well as to measure his technical ability or performance level was sent to each technician in the participating hospitals. The questionnaire covered basic skills in all areas of nuclear medicine technology. The technicians' ability to initiate quality control procedures, knowledge of NRC regulations, technical knowledge and ability, use of new products and innovative methods, reading of current literature, and attendance at educational seminars or training sessions was evaluated.

Validity and reliability of the questionnaire were established through a review by a panel of colleagues and through administration to a sample group of practicing technicians.

The survey was made as a pilot study, including 30 of the 47 hospitals in the state of Georgia having nuclear medicine facilities. The study was not devised to serve as an indicator of the quality of diagnostic services provided by technicians on the national level. Seventy-seven questionnaires were sent out and 58 were completed and returned, giving a 75% return. Information was analyzed from all technicians who had been working as nuclear medicine technicians or had been in a training program at least 2 years but no longer than 5 years. During this time period the proficiency gained from experience should be fairly uniform. Persons desiring to become registered after a period of on-the-job training would have had sufficient time to do so. By so limiting the population, those who have been working as nuclear medicine technicians for several years without attempting or passing a registry exam were eliminated.

Data were analyzed by computer, making use of the Social Studies Statistical Package and the CD-6400 computer. The mean test score on the technicians' questionnaire was 74.8, based on percentage correct, with a standard deviation of 15. A distribution of student scores is shown in Table 1. The question missed most frequently by the examinees involved the Schilling test, a procedure which has been performed routinely in most hospitals since the beginning of a nuclear medicine department. Other questions missed by at least 35% of the examinees involved basic physics and instrumentation. Three questions were answered correctly by at least 90% of the examinees and two of those involved the choice of the proper radionuclide for a specific use. An item analysis showing the percentage of correct responses to items Nos. 11 through 35 is given in Table 2.

TABLE 1. Distribution of Technician Test Scores.

Score range	Number of respondents
100–100	0
90–99	9
80–89	18
70–79	12
60–69	14
50–59	1
40–49	2
30–39	1
20–29	1
10–19	0
0–9	0

TABLE 2. Item Analysis Showing Percent Correct Responses of Items 11–35 of Technicians' Survey Questionnaire.

Item no.	Correct responses (%)	Item no.	Correct responses (%)
11	97	24	71
12	88	25	90
13	67	26	40
14	78	27	64
15	86	28	72
16	72	29	81
17	50	30	91
18	76	31	79
19	59	32	88
20	62	33	90
21	69	34	72
22	62	35	84
23	81		

TABLE 3. Analysis of Variance for Years of Experience of Responding Technicians.

Years of experience	Mean	s.d.	No.
Less than 2	18.300	4.084	10
2 to 5	18.438	4.119	32
5 to 7	20,000	3.041	9
More than 7	18.714	2.812	7
Total	18.863	3.514	58
F = 0.4291	SIG. = 0.7330		

An analysis of variance was done to compare levels of experience (Table 3), educational level (Table 4), and method of nuclear medicine technology training (Table 5). The F values and the significance levels indicate that there is no significant difference between the type of training program or the educational level of the technicians involved in the survey. However, there is a definite trend toward higher test scores as the educational level is increased. There is also a trend toward higher test scores among those who have attended an AMA-approved training program, as compared with those working in the field as x-ray technicians or on-the-job trainees. The pilot study indicates that one does not become a more knowledgeable technician on the basis of experience, as shown in Table 3.

The registry status of the technicians included in the survey is shown in Table 6. The ratings given by the medical directors for their technicians had no correlation with registry status, experience, or education. On the categories listed, 58.4% of the technicians were

TABLE 4. Analysis of Variance for the Highest Level of Education of Responding Technicians.

Educational level	Mean	s.d.	No.
High school	16.000	6.205	5
Tech school	18.429	3.696	35
Associate	19.143	3.237	7
Bachelor	20.455	2.464	11
Total	18.6897	3.7846	58

F = 1.8010 SIG. = 0.1580

TABLE 5. Analysis of Variance for the Type of Nuclear Medicine Technology Training Program Attended by the Responding Technicians.

Type of training	Mean	s.d.	No.
X-ray school	16.400	6.731	5
On the job	17.960	3.846	25
Hospital-based school	19.571	2.878	7
AMA-approved school	19.810	2.822	21
Total	18.6897	3.7846	58

F = 1.7225 SIG. = 0.1733

TABLE 6. Registry Status of Responding Technicians.

Registry status	No. of respondents	Relative frequency (%)
Unregistered	17	29.3
Reg. after on-the-job	18	31.0
Reg. after program	23	39.7

rated good, while 30.5% were rated exceptional and only 1.7% were considered poor technicians. Technicians received their highest ratings on their ability to work with speed and efficiency, even under stress. Their lowest ratings were for a lack of initiative in finding things to be done and acting without specific direction. The reliability of the instrument can be questioned since its structure was such as to allow the rater to mark categorically without giving due consideration to each item.

Comments offered by responding technicians regarding continuing education indicate a high interest in radioassays and in the review of basic principles, both in theory and in practice. Emphasis was placed on local seminars being offered, so that technicians could attend without excessive absence from work. A mechanism for granting credit to participating technicians was mentioned repeatedly. The general consensus is that technicians feel they need an organized continuing education program offering seminars or workshops on basics as well as new procedures to enable them to maintain or enhance their ability to provide quality diagnostic services.

Conclusion

The hypothesis that there is no significant difference between the quality of diagnostic services provided by the unregistered technician and one who has taken and passed a registry exam must be accepted on the basis of a significance level set at 0.05. The hypothesis that there is no difference between the quality of diagnostic services provided by the technician registered after a period of on-the-job training and one who has become registered after finishing a course of study in an approved school must be accepted on the same basis.

One must note, however, that there is a trend toward an increased ability to deliver better diagnostic service as the level of education and training increases.

Recommendations

The following recommendations are offered as a result of this pilot study.

1. More effort should be extended to involve the working technician in an ongoing educational process. Comments offered with returned survey questionnaires indicate that technicians want to keep abreast with the field of nuclear medicine technology.
2. There should be an increase in the number of approved training programs, particularly since there will be no registration by on-the-job training after July 1, 1976.
3. Seminars and workshops should be made available to technicians at a time and place convenient to them. New techniques and procedures need to be presented to the technicians, and review sessions covering basic principles need to be scheduled periodically.

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Appendix A. Survey Questionnaire

(A) Filled by the medical director of the nuclear medicine department for each technician employed.

1. The level of training and registration is
   ______unregistered
   ______registered after on-the-job training
   ______registered after completion of a program of training in an approved school
2. The total number of years the technician has spent in nuclear medicine as an employee and as a student is
   ______less than 2
   ______2 to 5
   ______5 to 7
   ______over 7
3. The technician's technical knowledge of instrumentation and equipment used in the department is
   ______poor ______fair ______good ______exceptional
4. The technician's ability to work with speed and efficiency, even under stress is
   ______poor ______fair ______good ______exceptional
5. The technician's attitude toward changes and ability to implement new procedures is
   ______poor ______fair ______good ______exceptional
6. The technician's ability to handle patients and establish a rapport with them is
   ______poor ______fair ______good ______exceptional
7. The technician's confidence in his or her ability to work independently and produce acceptable results is
   ______poor ______fair ______good ______exceptional
8. The technician's initiative in finding things to be done and acting without specific direction is
   ______poor ______fair ______good ______exceptional
9. The technician's judgement in the evaluation of his or her work and the ability to correct mistakes without supervision is
   ______poor ______fair ______good ______exceptional
10. The technician's attention to radiation safety and proper precautionary technique when handling isotopes is
   ______poor ______fair ______good ______exceptional

(B) Filled by each participating technician.

Please place the letter of the appropriate response in the blank preceeding the question.

______ 1. How many years have you been involved in nuclear medicine technology, either as a technician or a student?
   A. less than 2   C. 5 to 7
   B. 2 to 5   D. more than 7

______ 2. What is your registration status?
   A. registry eligible   C. ARRT registered
   B. ineligible   D. ASCP registered

______ 3. What is your highest level of education or training?
   A. high school   C. associate degree
   B. technical school or vocational school   D. bachelor degree or higher

______ 4. What is your present position?
   A. technician assistant or technician in training   C. staff technician
   B. assistant chief or acting chief   D. chief

______ 5. Do you read current journals of nuclear medicine?
   A. sometimes   C. read regularly
   B. never   D. don't have access to any

______ 6. Have you attended workshops, conferences, or seminars on nuclear medicine during the past 3 years?
   A. less than twice   C. more than twice
   B. can't get time off   D. can't afford to go

______ 7. Would you be able to attend a workshop or seminar if it were conveniently located to you?
   A. yes   C. if time off from work was granted
   B. no   D. if it were on weekends

______ 8. What is your source of training in nuclear medicine technology?
   A. x-ray school with a short rotation through nuclear medicine
   B. on-the-job training after being employed
   C. a hospital-based training program
   D. an AMA-approved school of nuclear medicine technology

______ 9. How do you spend most of your working time?
   A. administration   C. radioassays
   B. imaging procedures   D. all types of procedures

______10. Do you feel you are adequately trained for the work you do?
   A. yes   C. deficient in some areas of training but acceptable in others
   B. no   D. need additional training in all areas

_______11. Potassium perchlorate should be administered to patients having a brain scan with ^{99m} Tc-pertechnetate
A. to block the thyroid and thus prevent its irradiation
B. to relax the muscles in the patients neck so positioning will be less difficult
C. to block concentration of ^{99m} Tc in the choroid plexus
D. to increase uptake of ^{99m} Tc in the sagittal sinuses

_______12. Which of the following conditions may cause "false cold areas" in ^{99m} Tc-sulfur colloid scans of the liver?
A. biliary artresia
B. splenic uptake of sulfur colloid
C. recent barium enema
D. recent radiotherapy

_______13. To properly inject radiopharmaceuticals for a lung scan
A. the patient should be in an upright position
B. the patient should be in a supine position and a bolus injection should be made
C. the injection should be done slowly
D. the patient should be in a supine position and the injection should be made over a period of seconds

_______14. The general principle for isotope determination of picogram quantities of biologic substances is
A. autoradiography
B. saturation analysis
C. radioimmunoassay
D. tagged antibodies

_______15. Eluent containing ^{99m} Tc must be assayed
A. for ^{99} Mo each time the generator is eluted
B. daily for free technetium
C. for ^{99} Mo each time a new generator is set up
D. for ^{99} Mo each time the yield of a generator is lower than usual

_______16. In adjusting a multiple system of rate meters and recorders, the proper checks to perform are to
A. set the high voltage on the rate meters and set the zero on the recorder
B. check the count rate with a long-lived standard
C. set the machines as stated in answers A and B
D. adjust zero, calibrate, and observe response to a known source on both rate meters and recorders

_______17. The first calibration check to be run on any new counting equipment should be to
A. peak the instrument to ^{131}I
B. peak the instrument to ^{137}Cs
C. run a voltage response curve
D. count a 1-μCi source at a 10-in. distance from the crystal

_______18. The "dead time" of a Geiger tube refers to the time during which
A. the instrument is warming up
B. the incoming pulses are too rapid to count, thus causing the instrument to malfunction
C. the instrument is insensitive to incoming radiation after the occurence of a pulse
D. the instrument is recording the occurence of a pulse

_______19. In a scintillation detector, the photomultiplier tubes detect
A. electrons
B. light
C. ionization
D. electrical current

_______20. If a 2.5-cm-thick shield reduces gamma rays from a specific source by one-half, 10 cm of the same shielding will reduce them to
A. 1/8   C. 1/16
B. 1/4   D. 1/12

_______21. A shipment of radioiodinated ^{131}I-serum albumin was received October 7 and assayed at 149 μCi/cc. On October 13 a solution of 5 μCi/cc was needed for a blood volume study. Approximately how many cubic centimeters of serum (RISA) should be added to 30 cc of water for this injection?
A. 5.0 cc   C. 1.6 cc
B. 0.6 cc   D. 2.6 cc

_______22. If one measured the uptake of radioiodine in a patient for five successive days and plotted this on graph paper—uptake vs. time after dose—the time in which the counts are one-half of day one would be the
A. chemical half-life   C. physical half-life
B. effective half-life   D. biologic half-life

_______23. If the red cells are first labeled with ^{51}Cr, then heated at 50° C for an hour, then re-injected intravenously in the donor, they will usually concentrate in the
A. pancreas   C. liver
B. bone marrow   D. spleen

_______24. The in vitro study of a patient's blood plasma demonstrated an elevated uptake of labeled tri-iodothyronine on the resin sponge. This result would indicate
A. Hypothyroidism. The plasma acceptor sites for tri-iodothyronine binding were unoccupied
B. Hypothyroidism. The plasma acceptor sites for tri-iodothronine binding were already occupied
C. Hyperthroidism. The plasma acceptor sites for tri-iodothyronine binding were already occupied
D. Hyperthroidism. The plasma acceptor sites for tri-iodothyronine binding were unoccupied

_______25. The material used in a red cell survival study is
A. ^{32}P   C. ^{60}Co
B. ^{24}Na   D. ^{51}Cr

_______26. The purpose of the flushing doses of B_{12} in a Schilling test is
A. to block the liver against B_{12} absorption
B. to saturate the plasma binding sites
C. to block the thyroid against radiation
D. to increase urine production

_______27. When a gamma ray collides with an orbital electron and imparts all of its kinetic energy to the electron, the event is known as
A. bremsstrahlung   C. photoelectric effect
B. Compton effect   D. annihilation radiation

_______28. A crystal detects gamma radiation because
A. the radiation causes the crystal to vibrate
B. the gamma rays produce energy pulses
C. the absorbed energy is released as light flashes
D. an avalanche is produced

_______29. Outdated stock preparations and articles contaminated by use with radioisotopes may be disposed of
A. in whatever manner is proper for the particular isotope
B. by any means that gets rid of the radioactivity
C. by the method so stated in the license
D. only in accordance with hospital regulations

_______30. Specific activity means
A. a given amount of radioactivity per unit of mass
B. the specific radioisotope used for a specific test
C. the specific quantity of a radioisotope used in a test
D. the organ of the body which specifically concentrates a given radioisotope

_______31. The purpose of the collimator in doing uptakes is
A. to cut out background
B. to eliminate backscatter
C. to shape the field of "vision" of the detector
D. to standardize the spectrum

_______32. Volume calibration of well counters must be done if
A. samples of mixed isotopes are to be counted
B. samples of different isotopes are being counted
C. samples of different volumes are being counted
D. samples of widely varying activities are being counted

______33. It is necessary to check out a spectrometer system, periodically calibrating the energy scale. A convenient source for this purpose is

A. ^{3}H C. ^{60}Co
B. ^{14}C D. ^{137}Cs

______34. The dose of whole-body radiation which is lethal to half of an exposed human population is about

A. 5000 rads C. 500 rads
B. 1000 rads D. 100 rads

______35. To show a fast change in count rate you would use a time constant that was

A. short C. medium
B. long D. any of the above since the time constant makes no difference

What type of continuing education programs would you like to have available to you?

Editor's note: Answers to questions 11–35 of the above technician test will be published in the March 1976 issue of the *JNMT* for the convenience of those technologists who may wish to take the test.