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ABSTRACT

A study determined elements to be included in developing a resource manual to assist radiologic technologists in completing quality management (QM) activities in diagnostic imaging. The study included these parts: a literature review; survey to assess effectiveness, content features, and improvement of six categories of resource materials (reference texts and guides, professional journals and magazines, manufacturer/vendor support, onsite support, computer software, and audiovisual resources); and a survey of 10 technologists active in QM at diagnostic imaging facilities in Anchorage (Alaska). Findings from eight returned surveys indicated traditional print-based materials were most effective. A lack of respondent knowledge about material content demonstrated a decreasing familiarity with the remaining resources. Survey results guided selection of instructional material methodology for outline development. Outline features were chosen that included elements based on techniques used in textbook design and procedural task writing integrated with job performance aids. The manual's six sections were as follows: definitions and historical perspectives; general principles of quality control (QC); elements of QC monitoring, evaluation, and maintenance; general principles of quality improvement (QI); elements of QI monitoring, evaluation, and maintenance; and documentation and forms. (Appendixes contain 46 references; survey; definitions of identified instructional resources; participant comments; and the instructional resource outline.) (YLB)

RESOURCE MANUAL DEVELOPMENT FOR QUALITY MANAGEMENT IN THE RADIOLOGIC SCIENCES

by

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Abstract

This project established guidelines for the creation of a comprehensive user's manual outline in radiologic science quality management (QM). A review of literature was accomplished and a questionnaire was developed to assess the effectiveness, content features, and possible improvement of six categorically defined resource materials. Findings indicate that traditional print-based materials, such as reference texts and guides (M=4.00) as well as professional journals and magazines (M=4.29), were most effective. Technologist's knowledge of content features was strongest with reference texts and guides and professional journals and magazines. However, decreasing familiarity with the remaining resources was demonstrated by a lack of respondent knowledge regarding material content.

Survey results were used to guide selection of instructional material methodology for outline development. The author determined that outline features should include elements based on techniques used in textbook design and procedural task writing integrated with job performance aids (JPAs), all maintaining a basis in the various concepts of instructional design and development.

INTRODUCTION

The lack of a comprehensive resource manual for quality management (QM) procedures in the radiologic sciences has minimized accurate, uniform and consistent outcomes of QM initiatives. Certainly the existence of such a manual is no guarantee that efforts in quality management would be any more accurate, uniform or consistent. However, recent developments within the profession of radiologic technology warrant such a manual. The development of an advanced level examination for certification of technologists proficient in QM activities is one indicator. A continued emphasis on producing quality in performance and product is another.

Currently, there are several excellent texts available describing various aspects of quality in radiology (Adams and Arora, 1994; National Council on Radiation Protection, Report 99, 1988; Tortorici, 1992; McKinney, 1995; Haas, 1993; Cofer, Greeley and Wrinn, 1993; Gray, Winkler, Stears and Frank, 1983). These texts provide valuable information on a variety of quality enhancing techniques. However, only the NCRP Report No. 99 provides an example of a comprehensive text. Though the report's authors indicate this text is for all health care professionals, it is "targeted primarily for practicing radiologists, other physicians and medical physicists" (NCRP Report 99, p. 1). Its use as a guide for technologists is limited primarily due to the complexity of the material. Given the limited scope of the texts noted above, this author determined that developing an outline for a user's manual in radiology QM constituted the first step in raising the awareness, comprehension, and abilities of technologists assigned QM responsibilities.

Statement of Problem

Though a variety of texts on different aspects of QM have been produced, no one resource is currently available. It is speculated that technologists, active in QM, may or may not have a variety of resources at their disposal. Furthermore, certain limitations of time, training, finances, and personnel may prohibit the effective use of QM resources throughout the radiologic profession. Therefore, the purpose of developing a manual for QM is to aid technologists in understanding and executing procedural tasks specific to QM.

The purpose of this study was to determine what elements should be included in the construction of a resource manual which would effectively assist radiologic technologists in accomplishing the activities associated with managing quality in diagnostic imaging. This study included: (1) a literature review of available guidelines for instructional design, instructional material development, and questionnaire construction; (2) a survey of local technologists active in quality management; and (3) development of a proposed outline for a resource manual. To assist in establishing guidelines in the construction, organization, format, and content determination for such a manual, it was necessary to assess the effectiveness of current resources being used by technologists.

Determining the content of each resource was necessary to evaluate the inclusion or exclusion of specific subject matter. The American Registry of Radiologic Technologists (ARRT), as a result of their national job/task analysis survey conducted in 1995-96, developed content specifications for the QM examination. The content specifications utilized here are from the 1996 ARRT

Job Analysis and Content Specifications Project for Quality Management: Final Report (p. 89-92).

A survey instrument was constructed to assess current QM resources, their effectiveness and content, and to determine how resources could be improved for technologists working in QM. This information was integrated with methodologies of instructional material design and development. Together, a proposed outline was formulated for a manual on QM in diagnostic imaging.

Definition of Terms

Radiologic technology, radiologic sciences, imaging sciences, diagnostic imaging and medical imaging are used interchangeably throughout this paper. Collectively they are defined as the practice of administering "various forms of ionizing and non ionizing radiation to human beings for the performance of diagnostic and therapeutic procedures" (American Society of Radiologic Technologists [ASRT], 1997, p. 19).

Quality management (QM) is a term that includes the subsets quality assurance, quality control, and quality improvement. Though each of these have specific definitions they can be collectively defined under the general heading of quality management. Therefore, quality management is defined as a comprehensive system of assessment and improvement, which complies with established requirements and standards, that continually monitors, measures and evaluates any activity or process that anticipates, acknowledges and improves a product or service (ASRT, 1997; Quality Management Principle, 1998).

REVIEW OF LITERATURE

An investigation of related literature was conducted seeking methods for instructional material development. The review included development of general instructional design and training, instructional design for adult learners, textbook design and development, procedural task writing, and job performance aids. The objective of this review was to determine current practice for instructional material development. This included specific techniques in organizing, formatting, and determining content of various instructional methods.

A keyword search was conducted, using the ERIC database, an on-line multi-search engine, (Dogpile.com), local university and municipal library holdings and interlibrary loan services. Locating resources that provided guidelines and examples of instructional design was essential in understanding the various components of materials used in education and training. The keywords used were *manual (s), text (s), textbook (s), job aids, study guides, operating manuals, procedural manuals, training manuals, resource manuals, procedural texts, instructional materials, training, training and development, and on-the-job training.* Furthermore, an additional search attempted to identify specific components of instructional material construction. The keywords used were *layout, organization, formatting, content, material and manual development, books, manuals, and workbooks.*

In addition to the literature review of instructional material development a separate review of literature was conducted to determine the best approach for developing a questionnaire that would assess the instructional needs of practicing technologists. The resultant survey instrument was developed to aid, direct, and support the construction of the outline for a comprehensive QM manual.

Extensive research has been conducted regarding methods of instructional design and instructional material development. Determining what was important to include and exclude remained closely linked to the primary objective of the project. That objective was to evaluate the many techniques necessary for constructing an effective instructional aid to be used by practicing technologists.

As previously indicated, an itemized keyword search revealed several sources regarding instructional design and development. The results of these searches were categorized and consolidated for ease of dissemination. These categories included: General instructional design (Rothwell and Kazanas, 1994; Dick and Carey, 1990; Tight, 1996), curriculum design and development (Pratt, 1980) instructional design for adult learners (Dean, 1994; Richey, 1992), textbook design, development and theory (Willis, 1993; Pucel and Knaak, 1975; Thomas, Stahl, and Swanson, 1984; Tyree, Fiore and Cook, 1994; Mayer, Steinhoff, Bower and Mars, 1995; Bettex, 1995), hypertext and hypermedia (Hillinger, 1993; Romiszowski, 1992), procedural task writing (Burnham, 1992), and job aids (Rothwell and Kazanas, 1992; Branson, 1991; Burton and Merrill, 1991; Clark and Taylor, 1994; Filipczak, 1996, Tilaro and Rossett, 1993; Lee and Zemke, 1995; Campbell, 1996). The information that follows attempts to evaluate the guiding directives of material design and development from which a

QM manual outline will be created.

It may be necessary, at this point, to briefly discuss the reasoning behind the need for material development in QM. The primary reason for conducting the research associated with this paper, and investigating what is written on instructional material design and development, was due to a lack of comprehensive materials available for practicing technologists. The results of the survey supported this assumption and will be discussed in the latter portion of this paper.

The primary organization that measures the level of knowledge possessed by radiologic technologists is the American Registry of Radiologic Technologists (ARRT). This independent agency certifies technologists in primary and advanced level areas of practice. On several occasions it has clarified the organization's position regarding instructional material usage. The ARRT (Reid, 1997) states that, when preparing for primary or advanced-level examinations, the "Registry publishes an outline of topics covered on the examinations, but does not develop study materials for any of its examinations" (p. 350). It endorses no materials available to the professional community of technologists. Furthermore, "the purpose of the ARRT is to assess knowledge in the areas covered by the examinations. The applicant is responsible for becoming prepared in the area of interest" (p. 350). Therefore, it is concluded that material development for exams administered by the ARRT must be independently sponsored by radiologic technology programs, independent publishers, or the efforts of ambitious individuals.

The fundamental methods of material development and design play a pivotal role in establishing guidelines regarding instructional material development for this project. The ideas and concepts that follow will be the basis for developing a QM outline for practicing technologists. Each topic listed above will be individually evaluated. The reasoning for this was to highlight key points in the material development process that warrant inclusion in the structural framework of a proposed outline.

General Instructional Design and Training

In an attempt to understand instructional design and training, several authors have presented various approaches in describing educational models (Tight, 1996), instructional development (Rothwell and Kazanas, 1992; Dick and Carey, 1990; Willis, 1993), systematic approaches in instructional design (Rothwell and Kazanas, 1992), and evaluation techniques (Dick and Carey, 1990). What follows is a brief discussion of the relevant concepts pertinent to this project.

Tight (1996) presents several concepts in adult education. His conclusions are based on Bines and Watson's 1992 work that identified three successive models of professional education. The framework and context of these models are applicable to a wide variety of professions. However, as descriptive models, the conceptual application is readily apparent for professionals working in the radiologic sciences.

The first model takes place on the job and is called an 'apprenticeship' or 'pre-technocratic' model. The method of delivering instruction is knowledge based, with practical application and mastery of routines. Tight (1996), also indicates that instructor involvement often takes the form of experienced practitioners.

The second model, called 'technocratic,' takes place in association with institutions of higher education. Its characteristics are subdivided into three constructs of professional education. First, "development and transmission of a systematic job base." Secondly, "the interpretation and application of the knowledge base to practice." And thirdly, "supervised practice in selected placements" (Tight, p. 85).

The final model that Tight (1996) cites, 'post-technocratic,' is still in the process of development. This model emphasizes acquiring professional competencies through practice and reflection. Professional development, such as continuing education, has become increasingly significant for practicing professionals in maintaining or expanding skills. Finally, the use of skilled practitioners, i.e., mentors, coaches, provides learners with valuable resources for enhancing their development.

The three parts of this model provide insight into the stages learners may transcend during their professional development. It is reasonable to assume that at some point in their career, radiologic technologists will experience portions of these models. However, their full experience with each concept will be largely dependent on the goals and professional objectives of the individual.

Tight's (1996) presentation of Bines and Watson's (1992) three part model establishes a conceptual approach for understanding the progressive nature of professional education, learning, and training. This model is the basis for developing learning materials for working professionals and should assist in targeting job related learning objectives and promoting applicable learning outcomes.

With a fundamental appreciation of the stages learners can expect to transcend attention can be focused on realizing various aspects of systematic instructional design and evaluation. Rothwell and Kazanas (1992) as well as Dick and Carey (1990) have outlined key aspects of systematic instructional design (SID) and evaluation.

Rothwell and Kazanas (1992) sequenced several steps necessary for developing instructional materials. They suggest identifying needs and conducting a needs assessment as well as recommend conducting research to "identify materials available inside or outside an organization" (p. 198). They also suggest identifying knowledgeable people such as experienced workers, supervisors, union officials, top managers, human resource managers, or trainers who can contribute greatly to the material identification process.

Once the review of resources is completed, Rothwell and Kazanas (1992) advise asking three key questions to narrow the focus of material development. These questions focus on localizing subject matter experts within the organization, targeting specialized departments that may provide training, and seeking individuals who can identify resource items used on-the-job. Collecting this information should guide any subsequent efforts in formatting materials for presentation.

Rothwell and Kazanas (1992) define two vital components of material design that will effect the resultant product. Formatting and details are crucial to properly construct effective instructional materials. According to Rothwell and Kazanas (1992), formatting literally means the print or audiovisual layout of the instructional materials of a given medium. They also state "Instructional materials have no one 'right' format; rather, there are many possibilities" (p. 208). Techniques used in formatting instructional materials include learner directions or guidesheets, instructional materials, tests, and instructor directions or guidesheets

Details can include "visual aids, graphics, text, side bars, hypertext formatting, directions, other sources for inquiry, etc...." (Rothwell and Kazanas, 1992, p. 207). However, details without descriptive text and proper formatting will ultimately be ineffective. Therefore, it appears obvious that collectively integrating these components in a systematic process would provide effective instructional materials. Rothwell and Kazanas (1992) use the student manual as an example of a conceptual idea for formatting materials designed to be used as potential job aids.

Dick and Carey (1990) have done extensive research regarding instructional design. Focused in traditional classroom settings, Dick and Carey define instructor and learner roles, characteristics, motivations, and responsibilities in the context of instructional design, presentation, criterion, and evaluation. For the purpose of this study, the author chose to include their insights. Their extensive knowledge provides guidance in compiling information that will assist in the material development process.

Dick and Carey (1990) suggest that when developing materials for the first time one should consider producing self-instructional materials. Instructional materials should provide the means for students "to learn the criterion behaviors without any intervention from an instructor or fellow students" (p. 200). The student in this case can be any learner who is involved in individualized instruction or instruction that requires consultation with instructional resources other than a mentor, teacher, or co-worker.

Several authors note that instructional design should determine if material resources are already available for the subject being taught (Dick and Carey, 1990; Rothwell and Kazanas, 1992; Willis, 1993). Certain materials may serve all or part of the instructional needs. Once again, it is important that, all available resources are utilized when creating materials.

One of the primary concerns regarding this project was determining how the material contained within the manual should best be presented. Unfortunately, there is no clear standard which combines learner characteristics and task performance. However, matching learning domains with instructional objectives and outcomes was among several considerations Dick and Carey (1990) suggest.

In conclusion, the concepts described above provide an effective framework for creating a user's manual for working technologists in QM. The information included must be comprehensive enough to accommodate learners with varying levels of experience in QM activities. Finally, the need for a readable, reliable, and accessible resource is vital for practical application.

Evaluation Criteria for Instructional Design

Development of instructional materials is effective if the design approach recognizes how the learner processes the intended information. A tremendous amount of research has been conducted regarding learning behavior and domains. To detail these behaviors and domains here would be somewhat redundant, as this has already been accomplished more effectively elsewhere. However, the taxonomy developed by Bloom, and his colleagues, in the late 1940's and early 1950's, has subsequently been the guiding principle in classification and evaluation of educational methods. Therefore, a brief overview is provided for clarification and application to this project.

Dick and Carey (1990) suggest several considerations for properly evaluating media selection. They suggest that understanding learning domains is an essential part of properly matching learning objectives with learning outcomes. Also, determining whether materials can be used in several settings is critical when distinguishing resource compatibility with systems of delivery. They further state that compromise, flexibility, durability, convenience, and cost-effectiveness of materials should also be considered.

Dean (1994) outlines the use, application, and implementation of goals and objectives as they relate to learning behaviors. His concern for learning outcomes or domains considers the nature of the learner. Dean identifies the following five outcomes/domains: (1) intellectual skills; (2) cognitive strategies; (3) verbal information; (4) attitudes; (5) psychomotor skills. However, Dean (1994) emphasizes the use of cognitive knowledge, attitudes, and psychomotor skills as primary domains for most instructional design.

Evaluative standards regarding learning, teaching, and the education process resulted in the development of classifications known as Cognitive (knowing and thinking); Affective (motivations and feelings); and Psychomotor (controlling and doing) domains. Krathwohl (1994) has suggested creating parallel constructs integrating the goals and objective of each domain. The resultant application make it easier to implement the taxonomy's principles across a broader educational spectrum.

The approach necessary in executing this project references the taxonomy in an attempt to conceptualize the collective application of all three domains. Therefore, the fundamental precepts of these domains are considered as follows. The cognitive domain provides the opportunity for understanding, knowing, reasoning, and judging which requires the learner "to use facts or apply previously learned ideas, concepts, and procedures or solve problems by combining new ideas" (Hone, 1988, p. II-14). Krathwohl (1994) asserts that "achievement in the cognitive domain is often used as a means of achieving goals in the affective domain" (p. 199).

The affective domain deals predominantly with motivation and feelings and impacts the learners attitude, motivation, disposition, interests, values, and beliefs (Kraftwohl, 1994; Pratt, 1980; Hone, 1988). Therefore, it has been established that achieving measurable behavior changes as a result of establishing goals and objectives for instructional materials are attainable.

The final domain, psychomotor, develops the learner's behavioral skills in the performance of a physical application as a result of learning. "The learner must demonstrate anything from a simple manual skill to performing complex tasks which require extensive neuromuscular coordination" (Hone, 1988, p. II-15).

Technologists collectively integrate these three domains as part of their daily activities. As an example, most radiologic technologists integrate the cognitive activities which process an understanding of physical principles (knowing: theory recognition) governing radiation production (thinking: theory application) with affective activities that address the needs and concerns of patient condition (feeling: empathy), and the need to assist in the process of diagnosis (motivation: providing care), resulting in manipulation of equipment and selecting proper exposure factors (controlling: adjusting equipment and technical factors), and correctly positioning the patient (doing: performing routine procedures) to obtain a diagnostic radiograph.

Therefore, the technologist must incorporate knowledge, comprehension, application, analysis, synthesis, and evaluation with attitudes, motivations, dispositions, values, interests, and beliefs (Bloom, 1994). This is done to accomplish procedural tasks requiring the physical manipulation of equipment, patients, or other related factors that produces a consistent and favorable result.

Instructional Design for the Adult Learner

Dean (1994) and Richey (1992) described two types of instructional design paradigms that root themselves in adult education. Dean (1994) asks why we need instructional design in adult education, "First, lack of formal training in developing instructional material and activities can result in activities and materials that do not meet the needs of the learners" (p. 4). He further states that "systematic approach to developing instructions based on thorough assessments of instructors, content, learners, and context should result in a balanced approach" (p. 4).

Dean's (1994) comprehensive instructional design for adult learners includes assessing needs, determining educational goals and objectives, designing learning activities, and developing evaluations. Furthermore, goals, content, method of delivery, and evaluation of materials must occur to insure the objectives of instructional design have been met. Ultimately, the instructional goal should be "development of instructional knowledge activities and materials" (Dean , 1994, p. 1). Therefore, the goal of instructional design "is a decision-making process used to plan and develop instructional materials and activities" (p. 7).

Dean (1994) recognizes when developing instructional materials there are certain limitations that must be addressed. Level of commitment, time, interest, and resources are cited by Dean as determinants for appropriate instructional design. Development and sequencing of goals and objectives are other considerations. Acknowledging the complexity of constructing and sequencing task goals and objectives, the author determined that including goals and objectives was beyond the scope of this project.

One of the first steps in developing materials is to initiate a task analysis of procedures performed for a given occupation. The task analysis is performed to acquire the content knowledge for developing instructional activities and materials (Dean, 1994). The American Registry of Radiologic Technologists (1996) initiated a job analysis and task inventory for the development of the advanced level examination in QM. Their process was comprehensive and provided valuable guidance in developing the preliminary outline for the QM manual.

Richey (1992) attempted to formulate a new theory of instructional design. Certainly the most prominent method of creating instructional training materials or programs is the Instructional Systems Design (ISD) technique. This method is "used to ensure knowledge acquisition as well as transfer to on-the-job applications" (p. 4). Rothwell and Kazanas (1992), Dick and Carey (1990), and Dean (1994) all rely on ISD techniques in their presentations of instructional design. Richey (1992) acknowledges that "instructional systems design techniques are a series of recommended steps which have been substantiated by experience in many settings, including the military, business, industry, health care and education" (p. 2).

Richey (1992) elaborates by exploring the construct of her proposed theory, systemic training design (STD), which she carefully outlines throughout her book. Her theory focuses on "outcomes, emphasizing learning, specifically adult learning, in the training environment" (p. 26). The theory includes aspects of knowledge retention, attitude changes, and transfer of training content to on-the-job behavior. It is primarily "cognitive in orientation with consideration of external and internal interactions that influence the complexities of learning" (p. 26-27). Her theory describes the learning process while prescribing the design process. She offers a procedural model to guide design practice as a result of conceptual model constructs which includes several factors that affect adult learning in the training environment. The result of Richey's research, which may be oversimplified here, establishes a theory of systemic training design which employs adult training techniques. However, she concedes that there is no best method appropriate for instructional training.

Though its basis is founded on academic principles of theory formulation, the detailed complexity and application demonstrate that designing instruction is still exploring several possibilities of alternative applications. However, as contrasting proposals, ISD and STD provide a number of insights that must be considered when developing instruction or instructional materials.

In a continued effort to establish the basis for material construction in the radiologic sciences some practical application for combining general instructional design, adult learning, and instructional design theory into a deliverable median must be addressed. Therefore, in the following three sections exploration of textbook design and development, hypertext and hypermedia applications, procedural task writing and job performance aids will be analyzed.

Textbook Design and Development

Several authors (Bettex, 1995; Mayer, Steinhoff, Bower and Mars, 1995; Thomas, Stahl and Swanson, 1984; Tyree, Fiore and Cook, 1994; Pucel and Knaak, 1975) describe the virtues of textbooks and their use as instructional media. Others (Hillinger, 1993; Romiszowski, 1992) present the use of hypertext and hypermedia as an alternative to paper-based materials. A discussion of text development and proposed alternatives will establish certain content and design principles for this project.

Bettex (1995) asserts that the textbook will be a useful educational tool past the year 2000. He states that its usefulness will be dependent on its attractiveness. Citing findings presented at the Braunschweig Workshop in 1990, he states that textbook research should focus on "format, type of print, underlinings, squares, frames, photos, drawings, tables, diagrams, etc....," and "...deliberately chosen with particular educational purpose in mind" (p. 48).

The new generation inquiry-centered educational textbook "will look like a guide providing varied paths of learning, lots of suggestions, enticing ideas to motivate personal research, together with example or models that are on the pupils level" (Bettex, 1995, p. 48). This appears to be the direction of future textbook development.

Hillinger (1993) and Romiszowski (1992) have offered an alternative describing the basic premise of Bettex's proposal. Hypermedia and hypertext varies from print-based materials only in method of delivery. The advent of computers and ease of use, provided a technology media that provides quick and flexible interactivity with subject matter. Hillinger and Romiszowski describe several advantages of hypertext in today's society. Hillinger (1993) cites shortcomings of text-based materials in promoting his concepts of hypertext and hypermedia. His conclusions point out that both hypertext and hypermedia can provide responsive text for learners of variable abilities.

Romiszowski (1992) defines and describes the use of hypertext and hypermedia in the context of job aids. His reasoning and application of these interactive computer based presentation methods is mitigated by their use in performing job functions. Hillinger (1993) and Romiszowski (1992) acknowledge that linking concepts, ideas, and topics, sequenced in no particular way, is an ideal method for expanding understanding and comprehension.

Similarities can be seen between both print-based material and hypermedia formats. Bettex (1995) states that the new textbook will provide (1) routes giving access to knowledge, (2) suggest different working methods, (3) ask questions that encourage learning, (4) motivate the learner to know more, (5) facilitate personalized learning strategies. He also sees the textbook as "the indispensable link between practice and theory" (p. 49).

Obviously, integrating modern technology with traditional textbook construction is the greatest challenge for publishers of the next generation of textbooks. The combination of technology and print-based formatting is becoming increasingly popular. Texts now include CD-ROMs or floppy discs that accompany basic text materials which provide enhanced learning opportunities for the student. Unfortunately, not all types of instruction warrant its use. Moreover, not all learners have computer access.

On-the-job use of multimedia formats is less controlled and introduces variables that may limit efficient decision making and problem solving. Coupling these limitations with certain indicators of the locally administered survey, it was decided that a print-based format would serve technologists best in performing the infrequent tasks associated with QM.

Mayer, Steinhoff, Bower and Mars (1995) suggest that theory of textbook design should be coordinated with the theory of meaningful learning. Their study concluded that textbooks should be designed

> ....in ways that elicit the cognitive processes required for meaningful learning:--namely selecting relevant verbal information to build a text base and selecting relevant pictorial information to build an image base, organizing these representations into coherent situation models of the verbal material and of the visual material, and integrating across these two representations of material. (p. 39-40)

Mayer et al. (1995) described the value of graphic information as important to meaningful learning. Their suggestions provided insight into the use of annotated illustrations to signal, summarize, and expand the integration of words and images into an effective textbook presentation.

Tyree, Fiore and Cook (1994) emphasize text organization, organizational aids, and audience appropriateness as key elements in textbook design. They postulate that the ideal text is one that

> ....is seen as a resource that has been informed in its design, selection and application by experts in the relevant fields of thinking....and by the invested constituents in assuring its accessibility to the broad range of learners within a specific learning context. (p. 363)

Finally, Thomas, Stahl, and Swanson (1984) conclude that "there exists no specific text design procedures or guidelines which hold true across all text materials, literary genre, and/or prose narratives for all learners" (p. 16). These conclusions were drawn in 1984, however, they appear to be relevant today given the array of current design practices.

Thomas et al. (1984) further contend that the effectiveness of text depends on how it is ultimately used. "Research on how text is used, from just that pragmatic perspective, appears to be generally lacking" (p. 16). They conclude that "there is no viable substitute for well-written, clearly presented, and well organized prose as far as maximizing the facilitative effects of written text" (p. 16).

Pucel and Knaak (1975), in addressing vocational and technical instruction concerns, recognized that "textbooks may have lost some of their primacy as the sole data source in many educational programs, but they still remain a major educational force, particularly as references" (p. 110-111).

Procedural Task Writing

Another approach to preparing instructional material is through procedural task writing. This technique is usually reserved for specific tasks, ordered and sequenced, with clear and concise statements that guide the learner through critical and/or infrequently performed jobs. Burnham (1992) condenses what is known about improving written instructions for procedural tasks. Table 1 summarizes those findings.

The extension of Burnham's (1992) guidelines generates the basis for introducing a format and design suitable for their use. Job performance aids (JPAs) use this basic technique to create effective on-the-job instruction to facilitate consistent and reliable job performance. Therefore, procedural task writing will be included as a contributing component to job performance aid development discussed in the following section.

Many authors detailed the creation, application, and integration of job performance aids within the context of the work environment. This type of on-the-job aid encapsulates the fundamental framework necessary for achieving the objectives of this project. What follows is a explanation of job performance aids and their use as performance enhancing instructional tools.

Table 1

Procedural Task Writing Guidelines.

Guidelines	
1.	Provide adequate introductory exposition about the outcome of the instructions. Short paragraphs with a pictures appear very useful. Define important terms.
2.	Represent the procedure in a list of separate, executable actions. Hierarchal format which explains materials as well as steps. Presenting a relationship between actions and progress on the procedure seems helpful.
3.	Use numbers as markers for each steps
4.	Advice and warnings should be separate from the procedural tasks steps.
5.	Give reader access to outcomes in the actual text. Action information first versus conditioned information. e.g., "Do X when Y happens." Give organization information before step information. e.g., "To accomplish A do B."
6.	Use pictures about outcome. Line drawings seem most useful for spatial content information.
7.	Provide places for the reader to stop and examine the product. Comparing it to a representation of how it should appear.
8.	Consider including suggested corrections for common problems in the procedure.
9.	Test those who are novices at the task to insure instruction does what it is supposed to do.

Note. From Improving Written Instructions for Procedural Tasks. Working Papers, by C. Burnham, 1992, (ERIC Document Reproduction Services No. ED 351 524), p. 15. Copyright 1992 by the National Center for Research in Vocational Education.

Job Performance Aids

Job performance aids (JPAs) are encountered everyday. They can be anything from simple instructions on how to set a watch to an in-depth process on repairing a diesel engine. Rothwell and Kazanas, (1992), Tilaro and Rossett (1993), Clark and Taylor (1994), Filipczak (1996), and Branson (Briggs, Gustafson and Tillman [Ed], 1991) provide comprehensive definitions of JPAs. Collectively, they have established that JPAs are tools to enhance performance (Branson, 1991; Tilaro and Rossett, 1993), reference sources for task assistance (Filipczak, 1996), cookbooks, procedure guides, operators or equipment manuals, and institutionally-developed procedural manuals (Tilaro and Rossett, 1993), memory supplements (Clark and Taylor, 1994), and alternative information storage mechanisms for task performance (Filipczak, 1996; Rothwell and Kazanas, 1992). However, certain skills are required of the worker which "include (among other things) using diagnostic instruments, tools or performing standard tests" (Branson, 1991, p. 378).

Based on Instructional Systems Development (ISD), which was described briefly by Dean (1994) and referenced by Richey (1992), JPA development relies on the common management model of Analysis, Design, Development, Implementation and Control. Its similarities to ISD include an assessment of needs for performing a particular task and front-end analysis to determine what tasks should be accomplished by JPAs (Branson, 1991).

Branson (1991) describes a four step process determining "what tasks or functions are done on jobs, which tasks require training or other actions, measuring results of job performance, and determining the setting in which the training or other action should take place" (p. 379). He suggests an evaluative technique that includes the following items: (1) occupational surveys, which "are the most reliable and valid ways known to discover what people need to know to perform a job" (p. 382); (2) job-oriented materials that include "common tasks inherent to a specific job with organizational differences in administrative practices" (p. 391); (3) training materials development which includes "videotapes, videodiscs, print-based programmed instructional materials and case studies" (p. 382); (4) needs assessment determines what is available and may identify what is desired. This assessment process should narrow the focus of material construction.

Tilaro and Rossett (1993) recommend the use of a systematic approach in designing job aids which includes planning, building, installing, and maintaining. Though planning, building, and installing are time consuming and extensive, they establish the basis for format and presentation. Maintaining current information has proven difficult to ensure. It is recommended that continuous and relevant updates be provided often.

Tilaro and Rossett (1993) note one major strength of job aids as the ability to summarize and crystallize large amounts of information. Job aids should not be extensively detailed or encumbered with charts and graphs that do not support the performance objectives. They should, however, contain exacting information for the learner to execute any task encountered within the scope of practice.

Clark and Taylor (1994), in their article outlining the pitfalls of learner burnout, make several recommendations concerning techniques to avoid information overload. Their recommendations regarding job aids are described here.

First, job aids should be designed as "memory supplements to be used during and after training" (Taylor and Clark, 1994, p. 42). Secondly,

> as you look at the content your learners should master, locate all major blocks of factual or procedural information, such as computer codes or commands, product specifications, formulas, and steps to follow to perform tasks. In any case in which the employee does not have to use these facts or tasks instantaneously on the job, provide a job aid. (p. 42).

Thirdly, recognize that "job aids come in many forms, ranging from small cards containing tables, lists, or step-by-step guides with illustrations, to the more sophisticated automated job aids know as electronic performance support (EPS) systems" (Clark and Taylor, 1994, p. 42). One must (1) "identify factual or procedural information employees need to perform tasks;" (2) "organize the information in a format that best fits the way information would be accessed on the job;" and (3) "embed the job aid in a medium that fits the work environment, whether it is a computerized data base, laminated wallet card, or desktop card file" (p. 42-43).

Thus far, the author introduced JPAs in respect to theory, application and use. Next, examination of training uses, financial considerations, practical advantages, formatting, constructing, and presenting effective JPAs is conducted.

Lee and Zemke (1995) describe the present situation confronting service and industry which attempts to provide training in an environment where time is a valued commodity. They indicate that workers have difficulty completing their jobs, much less find the time to attend training sessions. However, they do offer various techniques as alternatives to traditional training. Job aids were found to be more efficient and effective than providing classroom training for employees. Infrequently performed tasks can now be available to employees, in their job environment, in the form of job aids.

Lee and Zemke (1995) note that the majority of knowledge and skills is developed and cognitively encoded on-the-job, or more precisely, while actually performing a required task. The amount of time invested in formal training still overwhelms organizations who focus time, money, and resources on the traditional classroom method of training. Yet the results for improving efficient, effective, and lasting outcomes remain suspect. Lee and Zemke (1995) propose that organizations should focus their training efforts on performance support. Provide the learners with structured materials and the tools for understanding these materials and the end result will be employees applying newly acquired knowledge and skills on-the-job where they can be most effective.

Filipczak (1996) highlights the costs associated with training employees. He cites TRAINING magazine's 1995 Industry's Report noting that companies spent over $52 billion in formal training. It was estimated that the figure exceeds $100 billion if salaries and lost production time were factored. However, Filipczak shares insights when establishing ways to save money when training is a necessity.

Filipczak (1996) encourages companies to develop their own job aids. Using subject matter experts (SMEs), the development of a job process can be greatly simplified into a usable medium for several employees. Filipczak suggests that creating job aid templates could assist in simplifying SME's jobs in constructing relevant materials. Simply assembling a resource manual of references could be considered a job aid if effectively used.

Filipczak (1996) provides some synthesized guidelines for creating job aids. Finding the reason why employees need such aids is essential in designing and developing materials that will help them when they require it. Job aids should include "a list of tools needed, all the steps in the right order, a description of the outcome, and something that tells the employee if they performed the task correctly" (p. 30). Creating a quick and easy reference aid and locating it close to where the primary tasks are performed is also important. Furthermore, job aids should be presented in such a way that it encourages its use and is easily accessible without being an obstacle.

However, Filipczak (1996) warns, that upon introduction of the job aid, the impression of it as a fix-all be dispelled immediately. Job aids are materials to assist in task performance; they are not going to make the employees job simpler. Job aids provide guidance for newly learned or infrequently performed tasks.

Campbell (1996) produced the most comprehensive assessment of job performance aids. From defining them as "precise user guides based on job and task analysis information" to outlining, in detail, the process necessary for creating effective, efficient, and consistently reliable job aids, Campbell has provided a comprehensive, practical guide to job aid construction.

He begins his discussion by pointing out that JPAs provide procedural or factual guidance in the performance of a task. He also states they are used to guide performance while skill is being developed and can be used as "a reference guide to clarify or update the learner on a particular task" (Campbell, 1996, p. 3). He supports his findings by highlighting the appropriate use of JPAs. Campbell has determined that "almost any task that needs sustainable, proficient performance, and is too complex or important to leave to pure memory, is a candidate for JPA guidance" (p. 4).

Campbell (1996) provided a valuable process guide for developing and designing JPAs. Examples of job aids are outlined and defined. Effects on training are discussed and advantages are presented. Forms of presentation are briefly detailed. Campbell identified, defined, and outlined the five basic types of job performance aids available mentioned previously by Rothwell and Kazanas (1992). These can be effectively presented in the context of procedural tasks performed by radiologic technologists.

Procedural guides present task steps with or without illustrations. These task steps are performed in sequential order. First, an example of procedural guides for radiologic technologists are equipment start-up procedures and processor sensitometry. Secondly, worksheets provide short, simple directions with blank space, where responses can be entered. Examples of worksheets are purchase order forms and employee evaluation forms. Thirdly, checklists are used to list questions or actions when considering or performing tasks that require planning, observing, comparing, inspecting, etc. Usually, marking a box or line indicating the task has been accomplished is necessary. Examples of this type of aid are a daily maintenance log and a monthly equipment inspection sheet. Fourth, decision tables are ideal when performing tasks that include multiple conditions that may effect decisions regarding actions to be taken. An example would be selecting the proper job performance aid to assist in resolving a task problem. Finally, flowcharts present graphic information in a series of ordered action steps or questions with yes or no answers. Following the path which applies to the circumstances of the task problem is self explanatory and somewhat uncomplicated.

These five types of JPAs establish options for developing user guides when administering job related tasks. Campbell (1996) expanded upon JPA types and created criteria for deciding which JPA to prepare. His presentation addresses the details of each JPA described above.

Campbell (1996) begins by developing the association JPAs have with print-based media. The use of concise narrative, referenced illustrations, and step-by-step instructions for process specific and on-the-job performance tasks are the basis of JPAs. Initially, a job and task analysis should be administered to determine what relevant tasks can be outlined in the form of JPAs. As mentioned earlier, this analysis has been performed by the ARRT (1996). Once the job and task analysis was established, attention to layout and format is considered. Presentation of material should fit the functional aspects of user needs.

Campbell (1996) suggests incorporating the following when developing job aids: (1) Illustrations that enhance and add value to task description (simple line drawings are preferred); (2) Proper labeling of illustrations is necessary for logical understanding (figure and table distinctions should be made); (3) Basic formatting should appear as an outline using headings and sub-headings with key points to add emphasis or clarification of task performance; (4) Strict adherence to writing guidelines is essential. Procedural and precautionary headings should be unambiguous. Reliable content accuracy must be assured. The use of non-offensive language minimizes misunderstandings. Clear and concise writing techniques should be employed to insure text readability and accurate task descriptions; (5) Some techniques to help minimize problems are reduce sentence length, avoid losing main points in wordy detail, limit abstract word and phase usage, use formats and headings, avoid reliance on resources located elsewhere, and resist using weak illustrations; and (6) Key points to remember for improving JPAs are: accurate spelling and meanings of words used, proper sentence structure, punctuation, capitalization, and word tense.

Finally, Campbell (1996) recommends a quality control process for review of the developed JPA. Using a self-review technique is the first step. However, using experts to review the draft version of the JPA is essential before implementation. A beta test is then conducted to establish the effectiveness of the JPAs outcomes.

Several authors acknowledge inherent limitations of JPAs (Clark and Taylor, 1994; Tilaro and Rossett, 1993; Rothwell and Kazanas, 1992; and Patterson, 1991). According to Clark and Taylor (1994) "job aids are not practical for information that's necessary for taking fast, critical action" (p. 42). Tilaro and Rossett (1993) and Rothwell and Kazanas (1992) suggest that tasks must be infrequently performed, complex or complicated, the consequences of error are high, knowledge of procedures change often, or resources for training are limited or unavailable to warrant a job aid. Furthermore, job aid usage should be avoided when employees have little or no time to refer to them during work tasks or when employee's credibility with customers will be compromised by referring to job aids during the performance of work tasks.

Rothwell and Kazanas (1992) provide an outline which describes five possible formats in JPA design and use. Checklists, decision aids, algorithms, procedure manuals, and work samples are all discussed noting the practical application of each given the proper work setting.

Patterson (1991) recommends that job aids should be used only if they can be used on a need to know basis. Patterson cites the following advantages to job aid development (1) Faster to develop; (2) Faster to deliver; (3) Less expensive to provide; (4) Offers more dependable results; (5) Improves the leverage of talent; and (6) Focuses on performance. Restrictions on use are also noted. Performance must not require memorization and the function or task must be susceptible to detailed description. Patterson suggests formats include cookbooks, decision tables, checklists, and flowcharts, or any combination.

The suggestions, guidelines, and recommendations presented above provide solid parameters for JPA creation in the radiologic sciences. QM activities are often performed as process functions which are not visible to the customer. QM procedures can be complicated and infrequently performed, and if done improperly, can result in errors of interpretation by those with limited experience. If training resources are limited, as well as financial resources to support such training, then the need for a reference manual or JPA appears warranted.

Questionnaire Development

The literature review of questionnaire design produced several ideas and philosophical perspectives which focused the questionnaire development process. Kellerman and Thoms (1996) proposed a guide for questionnaire construction based on responses that represent the participant's "true feelings, beliefs, and knowledge base" (p. 36). Most standard questionnaires are able to capture feelings and beliefs using a graduated scale technique which assigns a qualitative value equidistant to preceding or succeeding responses. This is characteristic of the Likert scale. Such a scale was constructed for the first question of this survey.

Standard procedure in identifying a need within a population is not as clearly defined in questionnaire construction. Rothwell and Kazanas (1992) proposed identifying needs as a basis for developing materials. They provided a working definition for need and needs assessment. A need "is a performance gap separating what people know, do or feel from what they should know, do or feel to perform competently" (p. 45). Moreover, "a need should always be linked to the essential knowledge, skills, and attitudes an individual must possess to perform work competently and thereby accomplish the desired results" (p. 45).

Furthermore, Rothwell and Kazanas (1992) define a needs assessment as "an evaluation of instructional requirements and is often a traditional starting point for instructional material development" (p. 45). They also conclude that certain needs assessments are "situation-specific" and play an important part in addressing the needs of a specific group (p. 45).

Based on these definitions, the framework for a material needs assessment survey was established. It was anticipated that this questionnaire would assist in evaluating the gap between what technologists use and what they need when performing QM tasks.

In a study compiled by Barauski (1995), several conclusions were drawn concerning the needs assessment process of educational programs in Illinois. Barauski noted that "the needs assessment process identified areas of need and also areas of successful practice" (p. 13). She also states that the assessment process "guided programs to closely examine the way they did or did not use local resources and to explore more efficient and effective ways to use these resources" (p. 13). Further support for this premise was defined by Burton and

Merrill (Briggs et al., 1991) describing needs assessment as "the process of determining goals, measuring needs, and establishing priorities for action" (p. 23). This type of need is normative and addresses what is felt or wanted.

According to Berkowitz (Revieve, Berkowitz, Carter and Ferguson, 1996) a qualitative approach in needs assessment offers "the opportunity to probe an issue or questions in depth, and to explore respondents' views and perspectives in their own terms and framework of understanding" (p. 54). Including this technique in questionnaire construction provided technologists the opportunity to share their thoughts concerning what they need as an effective resource.

Berkowitz (Revieve et al., 1996) highlighted some of the advantages of a combined quantitative and qualitative approach for a survey study indicating that it would "add depth and breath, understanding and generalizability, closeness of context and standardization across settings" (p. 69). Therefore, it was concluded that a combined quantitative and qualitative method be used to construct a materials assessment questionnaire used for this project. Certainly, any method of survey development has limitations. The selection of a combination technique increases the likelihood for sampling, respondent, and researcher bias. Also, errors in survey construction (focus too narrow, questions not understood, lack of options prohibited respondent answers), selection of sample (in this case a specific type of participant was targeted), and sample size (may exclude more knowledgeable individuals) all introduce variability in analyzing results (Shi, 1997).

Finally, a note should be made regarding the demographic information obtained for this survey. The ARRT's 1996 final report of the job analysis and content specifications project for QM provided guidance in developing these demographic questions. Those used in the ARRT's initial survey obtained crucial information regarding technologists background in performing QM activities (ARRT, 1996). The questions used in this needs assessment survey paralleled similar questions posed by the ARRT's 1996 survey. It was determined that these questions provided a valid indication of the experience, knowledge, and time spent on QM initiatives.

METHODOLOGY

Study Design

This was a self-administered survey questionnaire which asked participants to respond to and comment on resource materials they use while performing QM functions. A list of eight background questions was included to confirm demographic information of all participants.

The targeted audience was based on purposeful sampling, which is selecting respondents because of certain characteristics they possess. For example, this survey focused on radiologic technologists who are department directors/administrators, supervisors, chief technologists, or technologists who possess unique skills and have gained a degree of familiarity with QM issues (Dean, 1994).

Survey distribution was initiated by contacting prospective participants. A sample size of ten was selected as a reliable indicator of current practice of those who work in QM. Presently, approximately two-tenths of one percent (343/222,547) of all registered technologists are registered in QM (ARRT, 1997). In Alaska, one-half of one percent (2/384) of all registered technologists are registered in quality management (ARRT, 1997). The sample size exceeds the ARRT's known quantity of registered QM technologists. It is understood that not all technologists who work in QM will seek to become registered in the discipline.

It was resolved, after careful consideration, that eight types of resources were available to technologists. To simplify the presentation of these materials it was decided that combining certain types would not detract from the fundamental nature of the material. Texts and Guides as well as Professional Journals and Magazines were combined based on their similar design, structure, and content. Manufacturer/Vendor Support, On-Site Support, Computer Software, and Audio-Visual Resources were individually identified as materials that could assist technologists in performing QM activities. A list of definitions are included in Appendix B.

This particular study utilized a combination of assessment techniques in acquiring desired information. As previously discussed, a qualitative and quantitative approach was deemed necessary for generating the desired information. Therefore, a material needs assessment questionnaire was developed to secure objective ratings and subjective opinions of materials presently used. Technologists, using a Likert scale (1, very poor; 2, poor; 3, neither; 4, good; 5, very good), rated the effectiveness of six categorically defined resource materials. They were then asked to determine, under the headings of these six categories, whether the material contained certain content features. These content areas were developed by the ARRT as a result of their nationwide job/task analysis survey of QM practices (ARRT, 1996). Finally, technologists were asked to comment on how the materials could be improved.

Limitations

Projects which include survey data often encounter certain limitations. Participants daily lives are complicated without additional requirements being made of their valuable time. Therefore, it was emphasized that completion of the survey was voluntary.

Incomplete questionnaires were expected, which means that the issue of non-response must be addressed. Non-response is an inherent feature of virtually all surveys. It ultimately damages "the inferential value of the sample survey method, with implications not only for data quality but also for the cost of data collection" (Couper and Groves, 1996, p. 63).

Other considerations proposed by Couper and Groves (1996) state that survey participation is influenced by "various attributes of each person sampled, such as knowledge of the survey's topic, prior experience as a respondent, and affective states at the time of the request" (p. 64). Additional factors cited include survey design, survey length, question construction, researcher characteristics, research subject, survey agency, survey mode preference, and survey administration technique. Couper and Groves suggest that this array of potential factors will effect the respondents' degree of participation.

Subjects

Subjects were selected from diagnostic imaging facilities located in Anchorage, Alaska. A criterion for participation suggested that individuals be registered radiographers in good standing with the American Registry of Radiologic Technologists (ARRT). Ideal participants were either department directors/administrators, supervisors, chief technologists, or qualified technologists actively involved in quality management. Preferably, these individuals should be registered in more than one imaging modality.

Ten ARRT registered technologists were selected to participate based on the criterion stated above. The sampling technique selected was a non-probability type called purposive sampling (Shi, 1997). This sampling method is used with small sample sizes and selects participants based on the representation of a particular group. Shi (1997) notes that prior knowledge of the population being sampled is necessary for generating a 'typical' or 'representative' sample.

The participant selection for this survey was considered a reasonable sample based on the number of local imaging facilities. Also, fiscal limitations and time constraints prohibited sampling a larger group. Therefore, the sample included respondents who possessed unique characteristics specific to individuals working in QM.

Instrument

After a thorough search of literature regarding questionnaire construction and clarification of questionnaire types, a multiple page survey instrument was drafted. Upon careful consideration of what subject matter to include in the questionnaire and a review of available QM resources, a list of eight such resources was developed. The content of all eight was categorized under six headings. These headings were Reference Texts and Guides, Professional Journals and Magazines, Manufacturer/Vendor Support, On-Site Support, Computer Software, and Audio Visual Resources. Questions were constructed focusing on identifying effective resources, determining specific content for each, and soliciting suggestions for improving targeted resources.

The purpose of this survey was to identify what resources technologists use when confronted with QM issues. The approach taken combined various elements of survey construction. The information obtained was evaluated to determine the most effective way to construct a useful outline.

Procedure

The survey was distributed to 10 selected participants who were known to be involved with QM activities. The purpose of this survey was to identify reference techniques used when applying QM practices in the imaging environment. The information obtained was utilized to assess reference needs for those technologists practicing QM procedures as determined by the ARRT (ARRT, 1996). Correlation with the ARRT's published examination guidelines was made to determine topics to include or exclude and areas in need of greater emphasis.

Finally, the survey results were analyzed. In addition to the literature review outlining techniques and procedures used in material development, relevant information from the needs assessment survey was included to create a format for outlining a resource manual in QM for the radiologic sciences.

RESULTS AND DISCUSSION

Of the 10 personally administered surveys eight were returned for an 80 percent response rate. Each questionnaire was numbered and codes were assigned to individual questions for analysis. Questions without responses regarding effectiveness were excluded from the mean calculation. Comments provided by respondents as a part of question three, were summarized. What follows is a summary of each survey question. For clarification purposes, brief explanations are included where appropriate. A summary of demographic information is presented first to describe the characteristics of the sample participants.

A Survey of Quality Management Resources in Diagnostic Imaging: Questionnaire Results.

Summary of Respondents

To establish the degree of activity technologists assume in QM functions, each was asked eight background questions. These questions were presented on the last page of the questionnaire. The information was used to gain a better understanding of the characteristics of the target sample. The results are presented in Table 2.

Table 2

Characteristics of Target Sample (N=8)

A Survey of Quality Management Resources in Diagnostic Imaging

Job Title	Frequency	Percent
Superintendent	2	25
Director	1	12.5
Chief Technologist	1	12.5
Manager	1	12.5
Assistant Manager	1	12.5
Technologist	1	12.5
Supervisor	1	12.5

Level of Education	Frequency	Percent
Certificate	3	37.5
Associate Degree	0	0
Baccalaureate Degree	4	50
Master's Degree	1	12.5

Hours of Work Per Week	Frequency	Percent
less than 11 hours	0	0
11-20 hours	0	0
21-30 hours	0	0
more than 30 hours	8	100

Years Involved in QM	Frequency	Percent
less than 1 year	1	12.5
1-2 years	1	12.5
3-5 years	1	12.5
6-10 years	0	0
more than 10 years	5	62.5

Hours Performing QM Activities	Frequency	Percent
less than 1 hour per day	3	37.5
1-2 hours per day	2	25
2-4 hours per day	0	0
4-6 hours per day	0	0
6-8 hours per day	2	25
no indication	1	12.5

Professional Credentials	Frequency
Radiography	7
Mammography	3
Nuclear Medicine	2
Quality Management	1
Computed Tomography	1
no indication	1

Facility Size	Frequency	Percent
don't work in a hospital	2	25
less than 100 beds	1	12.5
100 to 250 beds	5	62.5
251 to 500 beds	0	0
more than 500 beds	0	0

Daily Exam Volume	Frequency	Percent
unknown	1	12.5
9-12	1	12.5
100	1	12.5
130	2	25
150	3	37.5

The first question asked what job title each technologist held. This was a 'write-in' response. Seven different job titles were identified by the respondents. Six were, categorically, managerial/supervisory positions. The sole non-managerial position was identified as a technologist. These job titles are consistent with those identified by the ARRT (1996).

Question two asked what level of education each technologist achieved. Of the four possible levels presented, four had obtained a Bachelor's Degree; three indicated obtaining a certificate; and one had obtained a Master's Degree. No response was indicated for an Associate Degree. Nearly 63 percent of those surveyed had achieved a higher level of education than necessary to work in diagnostic radiology. However, the level of education is appropriate for management personnel in diagnostic imaging. As job responsibilities increase and diversify, additional education becomes a factor in obtaining certain career objectives. However, the level of education, of this particular sample may not be representative of the practicing technologist community.

Questions 3, 4, and 5 focused on time spent in quality management. Question three asked how many hours per week each technologist worked. All respondents indicated they worked more than 30 hours per week. This finding is similar to the ARRT's 1995 QM survey which indicted 97 percent of respondents worked more than 30 hours per week. Question four inquired about the number of years each were involved in QM. Five of eight (62.5%) respondents indicated their involvement in QM was greater than 10 years. The remaining 37.5 percent indicated less than five years of QM experience. ARRT findings demonstrated that 37 percent of those responding had greater than five years of QM experience. Forty-eight percent possessed less than five years of QM experience (ARRT, 1996, p. 54).

Finally, question five asked what amount of time each technologist spent performing QM functions. Nearly 38 percent spent less than one hour per day, while 25 percent indicated 1-2 hours per day, with another 25 percent spending 6-8 hours per day. One respondent did not indicate the amount of time. Fifty percent of those responding spent from 5-10 hours to 30-40 hours per week on QM activities. This particular range of time made up 100 percent of the respondents from the 1995 ARRT survey (ARRT, 1996, p. 54). The remaining 38 percent spent less than one hour per day, which equates to less than 5 hours per week. The ARRT's findings excluded "individuals working less than 5 hours per week in QC or QI" from the target sample (p. 54). This raises the question whether the individuals targeted were actually working in QM. If they were, it is possible that they may not distinguish QM responsibilities separate from their other imaging activities.

Collectively, these questions demonstrate that the respondents work more than 30 hours per week, have variable experience in QM (avg. 7.25 years), and spend from 12.5 percent to nearly 100 percent or their work day performing what they determined to be QM functions.

Question six asked the respondent to indicate the number of imaging credentials they presently hold. Five of the eight technologists surveyed held more than one registry credential. One technologist was registered solely in radiography. One respondent did not answer.

The sample targeted two federally administered hospitals and two private hospitals (7 questionnaires). Two radiology clinics were also sampled (3 questionnaires). Since participation was voluntary, one clinic and one hospital elected not to respond. Questions seven and eight addressed facility size and exam volume respectively and were included to determine the patient care environment in which technologists work.

Question seven sought information on facility size. Five of eight (62.5%) worked in 100 to 250 bed hospitals. One technologists worked in a hospital with less than 100 beds. Two respondents did not work in a hospital. Therefore, 75 percent of the technologists surveyed worked in a hospital environment and 25 percent worked in a non-hospital setting. This compares favorably with the ARRT's 1995 survey of QM technologists which indicated 61 percent worked in hospitals and another 36 percent worked in non-hospital settings (ARRT, p. 53).

Question eight asked participants to indicate daily exam volume. Table 2 illustrates that 75 percent of those responding worked in a department that produced from 100 to 150 exams per day. One respondent did not respond, while one indicated 9-12 exams. This latter figure may represent individual productivity. There are no comparable figures for this data.

In summary, the 'typical' respondent working in QM has a managerial or supervisor job title, holds a Baccalaureate or Master's degree, works more than 30 hours per week, has an average of 7.25 years experience in QM, works approximately 2-4 hours per day in QM, holds more than one ARRT credential, and works in a hospital environment which performs approximately 130-150 exams per day.

Question 1: Rate the effectiveness of (identified resource) in quality management as.

Table 3 illustrates the mean scores, the number of respondents, and the percentage of the sample size responding. As indicated in the Design section, a Likert scale was used to determine material effectiveness. Not applicable and non-responses were not included in the calculation of the mean score.

Professional Journals and Magazines (M=4.29) and Reference Texts and Guides (M=4.00) were both viewed favorably by those responding. These resources were the most inclusive of the six categories, containing two types of materials under one heading. However, these are the most prominent materials available to technologists. For those working in QM, the available resources correspond well with the selection of useful materials.

The remaining materials identified did not achieve a mean rating of good or very good. However, some respondents did find them useful as indicated by at least one respondent noting the material was good or very good. The data reveal that material effectiveness may lie in familiarity with the resource. Certainly every technologist cannot be expected to know all formats in which resources are presented. Therefore, reliance on the more familiar types such as texts and guides as well as professional journals and magazines would be expected.

Each of the remaining four materials identified; Manufacturer/Vendor Support (M=3.5), On-Site Support (M=3.2), Computer Software (M=3.0), and Audio-Visual Resources (3.25); may have achieved a low mean rating due to the low level of familiarity with these materials, or the inherent limitations of a small sample size. In either case material effectiveness may be ascribed to the level of specialization each technologist attained in adapting learning skills with various resource formats. Therefore, as indicated by the favorable ratings, and given the general availability of text and journal materials, the format most often utilized appears to be print-based.

Table 3

Mean Ratings of the Six Resource Materials Identified for this Study (N=8)

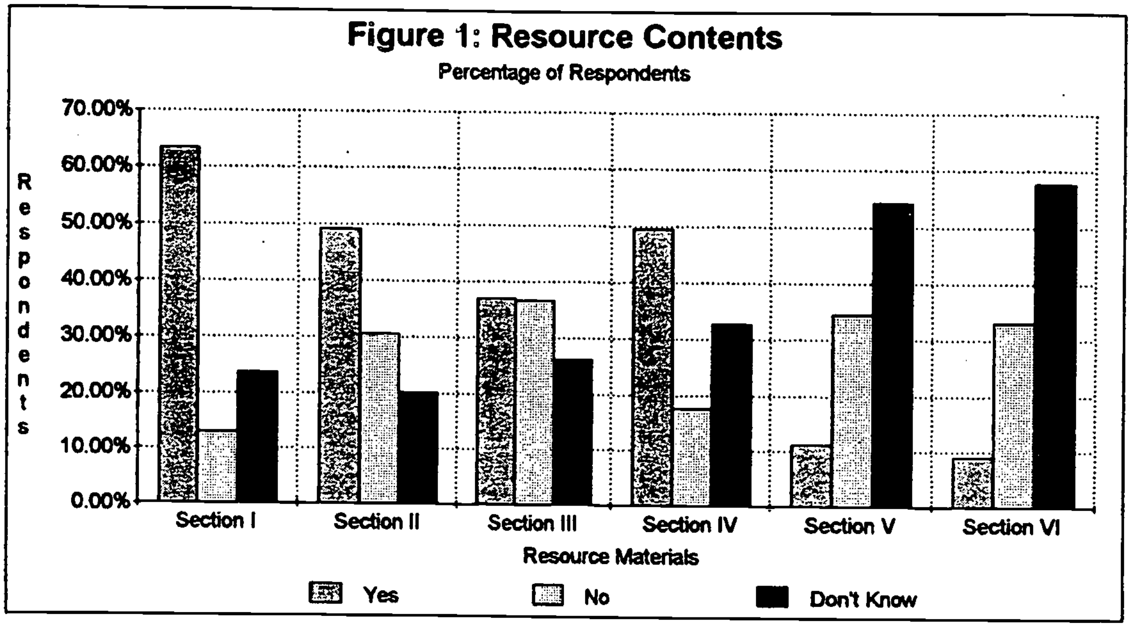
	Mean	N	Percent of Respondents
Reference Texts and Guides	4.00	7	87.5%
Professional Journals and Magazines	4.29	7	87.5%
Manufacturer/Vendor Support	3.50	6	75%
On-Site Support	3.20	5	62.5%
Computer Software	3.00	4	50%
Audio-Visual Resources	3.25	4	50%

<u>Question 2: Do your (identified resource) resources contain information on the following?</u>

A list of 29 content items, determined pertinent to job performance by the ARRT's job task inventory, were included in each of the six categories. This was necessary to identify subject matter content of each resource material. Each participant was asked to indicated whether the material contained certain content features by marking boxes yes or no. If they did not know whether the material contained specific subject matter, they were asked to leave the boxes blank. The code established for analysis was 1 for yes, 2 for no and 0 if they didn't know. Calculations were made by determining the percentage of respondents who indicated the inclusion of some or all content areas for a given category (see Figure 1).

Determination of a pattern or trend was sought to detect the content each resource material contained. Since the purpose of the survey was to seek a better understanding of what materials generally contain, it was decided that summarizing the data would establish a trend of use or non-use of certain materials among practicing technologists. Figure 1 graphically illustrates the trend of material content as determined by those sampled.

The section titles correspond to the questionnaire's categorization of each resource material. Section I refers to Reference Texts and Guides; Section II, Professional Journals and Magazines; Section III, Manufacturer/Vendor Support; Section IV, On-Site Support; Section V, Computer Software; and Section VI, Audio-Visual Resources.



Approximately 63 percent of those responding to Section I, Reference Texts and Guides, noted that the material they used contained some or all of the 29 content areas identified. Nearly 13 percent of those responding reported no content areas where included. Finally, 24 percent indicated that they did not know if the material contained certain content areas.

In Section II, Professional Journals and Magazines, some or all of the 29 specified content areas were included as identified by 49 percent of those responding. Just over 30 percent of those responding reported that some or all content material listed was not included. The final 20 percent noted that they didn't know if the material contained any or all of the listed content specifications.

Section III's, Manufacturer/Vendor Support, noted that 37 percent of those responding said that this material contained some or all of the content items listed. Another 37 percent indicated that the material did not contain some or all of the items listed. Finally, 26 percent of those responding did not know whether manufacturer/vendor material contained the listed content information.

On-Site Support, Section IV, reported approximately 50 percent of the respondents indicating that this resource contained some or all of the content specifications listed. Nearly 18 percent said this resource did not contain some or all of the listed areas, while the remaining 33 percent did not know if this resource included some or all of these content features.

Section V, Computer Software, reported that 11 percent of those responding noted this material contained some or all content areas. Nearly 35 percent of those surveyed said this material did not contain some or all of the listed specifications. Just over 54 percent of those responding did not know whether this material included some or all content areas listed.

Finally, Audio-Visual resources, Section VI, reported 9 percent of those responding indicated that this resource material did contain some or all the content tasks listed. Another 33 percent indicated that this resource did not contain some or all the listed task areas. And finally, 58 percent of the respondents stated that they did not know whether this resource contained some or all of the listed content areas.

Figure 1 clearly demonstrates a trend over the range of resources identified. Reference texts and guides, professional journals and magazines, and on-site support were evaluated as containing some or all content specifications by 49-63 percent of those responding. Conversely, as respondents progressed through each section, an increasing percentage indicated that they did not know whether the material contained certain content features. Manufacture/Vendor materials were evenly split, at 37 percent, regarding whether the material did or did not contain various content items. This may be due to the specificity of manufacturer/vendor support initiatives or, as one respondent indicated, "the proprietary" nature of equipment technology.

Question 3: How could (identified resource) be improved?

This particular question was included in an effort to solicit respondents' views on how resource materials could be improved. This was the qualitative component of the survey instrument. A total of 10 comments were submitted with a potential number of 48 comments possible (6 categories X 8 respondents). A summary of categorical responses is included here.

Due to an undetected printing error, Section I's question regarding suggestions for reference text and guide improvement, actually contained Section III's manufacturer/vendor support question. Unfortunately this was detected after the retrieval of the first several surveys. Attempts were made to contact all participants for correcting this error. However, due to circumstances beyond control of the researcher, a uniform sample of the initial respondents was not successful. Consequently, given the limited participation (10/48, 20.83% response) it was determined that little could be gained from further inquiry.

Each participant was asked to comment on how the resource he/she was evaluating could be improved. Of the eight surveys received, four provided some form of comment regarding at least one resource. Appendix C provides all comments from the survey data. What follows is a summary of respondent comments.

Comments ranged from addressing vendor support to expressing the need for developing a QM manual in the format of the American College of Radiology (ACR) Mammography Manual for Technologists. Respondents noted the need for "more teleconferences", "exact procedures and guidelines" for quality management administration, and the desire to "have the vendor totally responsible for equipment QC and QA." Furthermore, it was suggested that the "manufacturer and vendors are too proprietary with their technology." Other comments included the need for the existence of on-site support, determining the vendors role in quality management support, and general satisfaction with on-site biomedical services.

Of the comments pertaining to material presentation, one respondent indicated that the material was "fine for what it is targeted for." The other elaborated on the usefulness of the ACR Mammography Manual for Technologists and suggested development of similar materials for other areas of diagnostic imaging.

No respondent commented on how to improve computer software or audio-visual resources. Possibly, the availability of and familiarity with these types of resources may be limited for technologists or maybe they are adequate.

As outlined in the Statement of Problem section, the purpose of this project was to create an outline for developing a comprehensive resource manual pertaining to QM practices in diagnostic imaging. Guidelines in construction, organization, formatting, and content determination of successful methodologies and materials currently used was deemed necessary to create an efficient and effective resource.

The results of the survey indicate that technologists working in QM prefer professional journals and magazines and reference texts and guides as indicated by the favorable mean scores of 4.29 and 4.00 respectively. It is probable that familiarity with these types of resources contributes to their good to very good ratings. Reliance on such materials was anticipated and the survey's results tend to support this assumption. Of those responding 63 percent and 49 percent noted that journals and magazines and reference texts and guides contained some or all of the content areas listed. For most technologists, availability of resources seems inconsistent which is somewhat inherent to the profession. Not everyone can be expected to have access to identical materials.

The remaining resources surveyed provide limited support for administering QM activities. As resource effectiveness declined, the knowledge of material content also declined. An increasing percentage of respondents did not know if Manufacturer/Vendor Support (26%), On-Site Support (33%), Computer Software (54%), and Audio-Visual Resources (58%) contained some or all content features listed. Possible explanations for this may be the familiarity with each resource or possibly the availability of resources for those participants of this sample.

Comments made regarding improving resources were limited. Little was said about improving specific aspects of these materials. Generalized summaries demonstrate a minimal amount of thought or constructive suggestions from participants who indicate varying degrees of involvement in QM. Possible explanations for this limited participation could be lack of resource familiarity, lack of knowledge concerning methods of material presentation, lack of experience in QM functions, lack of experience in using resources to affect job performance, lack of primary involvement with events that directly effect QM processes, lack of interest in this component of diagnostic imaging, limited scope of involvement in QM activities, or minimal understanding of QM initiatives.

Summary

Based on the survey findings, it appears that comprehensive resource materials are not uniformly available to QM technologists in the greater Anchorage area. These findings may not be generalized to the national community of radiologic technologists. However, the results provide indications that a need does exist for the development of a comprehensive resource for QM. These results also seem to support a print-based method of delivery.

Of course, if such a manual is developed there is no guarantee that its use would be any more effective than those resources identified for this study. Technologists' reasoning abilities, the degree to which they can critically problem solve, and the initiative they apply to their responsibilities are serious concerns that warrant further investigation. In fact, the researcher speculates that QM activities may be initiated as a selective application of task responsibilities when process problems cause an interruption or delay in service. Only then is there a need for applying scientifically-based assumptions requiring corrective measures for maintaining continuity of service.

CONCLUSIONS AND RECOMMENDATIONS

In the radiologic sciences educational resources come in a variety of forms and formats. Textbooks, study guides, procedure manuals, and protocols are generally considered essential in the dissemination of knowledge. Journals and magazines are other types of resources, usually supplemental, that provide a secondary perspective on relevant professional issues. These examples of print-based materials provide technologists with a significant portion of their introductory education and continued on-the-job learning. The results of the survey tend to support this conclusion.

Rothwell and Kazanas (1992) summarize the purpose of instructional materials, indicating that they help the "learner rectify past performance problems, meet present job performance requirements, prepare for future job needs, and prepare for increasing responsibility and advancement" (p. 253). Therefore, given the general acceptance of print-based materials as learning aids and the inclinations of those practitioners surveyed to use these familiar resources, it was concluded that developmental methods of text-based materials be utilized in the construction of a QM resource manual outline.

The QM manual outline was constructed using a variety of resources and related methods for material development. The methods of instructional design reviewed from available literature provided some guiding concepts that were considered throughout the development process. Instructional design and training, instructional evaluation criteria, and instruction for the adult learner were evaluated as principles that govern current methodological practice. An effort was made to assess textbook design and development, procedural task writing, and job performance aids in the context of deliverable media. Therefore, the outline includes elements from textbook design and procedural task writing integrated with job performance aids, all maintaining a basis in the various concepts of instructional design and development.

This instructional manual outline is intended to establish guidelines for future manual development dedicated to on-the-job use by radiologic technologists. QM activities are often included in job performance requirements. With little or no formal training in QM theory or practice, most technologists call upon co-workers, supervisors, department managers, or equipment repair personnel for assistance.

Again, every attempt was made to incorporate the methodology outlined in the literature review and the results of the survey of local technologists in the manual's outline construction process. In an environment that expects more from staff technologists, the use and need for independent reference materials become apparent. It is anticipated that a resource manual would benefit working technologists, students in radiologic technology, medical imaging supervisors, chief technologists, and administrators.

Instructional Manual Outline

The manual is divided into six sections. Each section derives its outline format from the prior work of practitioners in radiology QM (ARRT, 1996; Burkhart, 1980; ASRT Curriculum Guide for Radiography Programs, 1990).

Section one introduces definitions and historical perspectives that govern QM. Definitions of quality management, quality assurance, quality control, and quality improvement are clarified. Four influential theorists, who shaped the origins of QM, are discussed. Finally, qualifications and job description of technologists responsible for QM administration are outlined. (ASRT, 1997; Cofer et al., 1994; McKinney, 1995).

Section two covers general principles of quality control (QC). This includes radiation production and describes waveform characteristics and target design. X-Ray beam characteristics are reviewed, focusing on beam quality, radiation output, and beam modification (ARRT, 1996, p. 90).

Section three outlines the elements associated with QC monitoring, evaluation, and maintenance. Twelve areas are outlined for monitoring and maintenance that require specified procedures for proper evaluation of performance. The presentation headings for the first ten items include the following: (1) Test Material/Equipment, (2) Test Procedures, (3) Evaluation/Interpretation, (4) Preventive Maintenance, and (5) Corrective Maintenance (ASRT Curriculum Guide, 1990). The final two topics, repeat analysis and standardized technique charts, discuss the following subject matter: (1) Definitions, (2) Objective, (3) Procedure, (4) Evaluation, and (5) Maintenance (ASRT, 1996, p. 171).

Section four, General Principles of Quality Improvement (QI), utilizes the outline format produced by the ARRT to elaborate on QI philosophy, problem solving strategies, and tools for QI (ARRT, 1996, p. 91-92). Section five, Elements of QI Monitoring, Evaluation, and Maintenance expands upon the foundational information provided in section four. Once again the ARRT's prior work in producing a task content outline was drawn upon to formulate this component of the manual's outline. Aspects of Clinical Performance, Performance Improvement Areas, Methods of Data Collection, Analysis of Data, and Evaluation of Outcomes are detailed (ARRT, 1996, p. 92).

Section six, Documentation and Forms, provides a list of resource publications, expectations of QM reports (Burkhart, 1980), and several sample forms that may assist in administration and documentation. See Appendix D for the complete outline of the manual.

The outline provides the initial step for developing a resource manual in QM for radiologic professionals. Whether the next step is accomplished, the information presented here may facilitate further inquiry and possible development of a QM manual. Finally, the author recommends that an evaluative assessment of the outline be conducted before further work is attempted.

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Appendix A

Survey Questionnaire

A Survey of Quality Management Resources in Diagnostic Imaging

Dale E. Collins

VE 698 Graduate Project

University of Alaska Anchorage

May 1998

March 5, 1998

Dear Colleague:

Thank you for taking the time to complete this questionnaire. The purpose of this survey is to identify the type and content of resources you use when solving quality management issues. As you know, the use of various resources is often dependent on time, training, finances, and personnel and may not be uniform throughout the radiology community. Your assistance in completing this questionnaire will help establish guidelines for the format and content of a proposed quality management manual.

I have identified eight resource categories and defined them under six headings. The accompanying questions ask you to: (1) rate the effectiveness of each resource, (2) determine content of materials from the list provided, and (3) specify how each resource might be improved to help you effectively perform QM responsibilities. These content specifications are outlined by the 1997 American Registry of Radiologic Technologists Advanced Level Examinee Handbook.

Please complete this questionnaire by March 12th. I will call to schedule a time when I can retrieve the questionnaire and obtain feedback on this survey instrument. Your responses will remain anonymous. Thank you for your time and assistance.

Sincerely,

Dale E. Collins, B.S., R.T. (R)(M)(QM), RDMS

SECTION I
REFERENCE TEXTS AND GUIDES

Reference texts and guides includes books, guides, government or professional organization publications that contain general or specific information on subject matter that has relevance to diagnostic imaging quality management.

1) **I rate the effectiveness of reference texts and guides in quality management as:** (Circle one)
1 - Very poor 2 - Poor 3 - Neither 4 - Good 5 - Very good 6 - Not applicable

2) **Do your reference texts and guides contain information on the following?**
(Leave blank if you don't know.)

Yes	No	
☐	☐	radiation production
☐	☐	x-ray beam characteristics
☐	☐	screen-film characteristics
☐	☐	film processing
☐	☐	generator performance
☐	☐	beam characteristics
☐	☐	ancillary equipment evaluation
☐	☐	processor performance
☐	☐	imaging system performance
☐	☐	kVp meter
☐	☐	radiation detector
☐	☐	exposure timer
☐	☐	test objects
☐	☐	sensitometer
☐	☐	densitometer
☐	☐	light meter
☐	☐	philosophical basis of quality improvement
☐	☐	quality improvement problem solving strategies
☐	☐	tools for problem identification and analysis

Yes	No	
☐	☐	development of indicators
☐	☐	data collection methods
☐	☐	data analysis
☐	☐	assessment of outcomes
☐	☐	NCRP (National Council on Radiation Protection and Measurements) Report #99
☐	☐	NCRP (National Council on Radiation Protection and Measurements) Report #105
☐	☐	ACR (American College of Radiology) Mammography Quality Control Manual
☐	☐	OSHA (Occupational Safety and Health Administration) publications covering blood borne pathogens/universal precautions
☐	☐	MSDS (Material Safety Data Sheets)
☐	☐	SMDA (Safe Medical Devices Act) legislation publications for general provisions and reporting procedures

3) **How could reference texts and guides be improved?** ____________________

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SECTION II
PROFESSIONAL JOURNALS AND MAGAZINES

This section includes journals or magazines which contain technical or professional information regarding operational aspects of diagnostic imaging.

1) I rate the effectiveness of professional journals and magazines in quality management as:(Circle one)

1 - Very poor   2 - Poor   3 - Neither   4 - Good   5 - Very good   6 - Not applicable

2) Do your professional journals and magazines contain information on the following?

(Leave blank if you don't know.)

Yes	No	
☐	☐	radiation production
☐	☐	x-ray beam characteristics
☐	☐	screen-film characteristics
☐	☐	film processing
☐	☐	generator performance
☐	☐	beam characteristics
☐	☐	ancillary equipment evaluation
☐	☐	processor performance
☐	☐	imaging system performance
☐	☐	kVp meter
☐	☐	radiation detector
☐	☐	exposure timer
☐	☐	test objects
☐	☐	sensitometer
☐	☐	densitometer
☐	☐	light meter
☐	☐	philosophical basis of quality improvement
☐	☐	quality improvement problem solving strategies
☐	☐	tools for problem identification and analysis

Yes	No	
☐	☐	development of indicators
☐	☐	data collection methods
☐	☐	data analysis
☐	☐	assessment of outcomes
☐	☐	NCRP (National Council on Radiation Protection and Measurements) Report #99
☐	☐	NCRP (National Council on Radiation Protection and Measurements) Report #105
☐	☐	ACR (American College of Radiology) Mammography Quality Control Manual
☐	☐	OSHA (Occupational Safety and Health Administration) publications covering blood borne pathogens/universal precautions
☐	☐	MSDS (Material Safety Data Sheets)
☐	☐	SMDA (Safe Medical Devices Act) legislation publications for general provisions and reporting procedures

3) How could professional journals and magazines be improved? ______________________________

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SECTION III
MANUFACTURER/VENDOR SUPPORT

Manufacturer or vendor support includes texts, manuals, guides and technical support provided by the equipment manufacturer or contracted service vendor for repair or maintenance of primary or ancillary diagnostic equipment.

1) **I rate the effectiveness of manufacturer/vendor support in quality management as:** (Circle one)
   1 - Very poor 2 - Poor 3 - Neither 4 - Good 5 - Very good 6 - Not applicable

2) **Do your manufacturer/vendor support resources contain information on the following?**
   (Leave blank if you don't know.)

Yes	No	
☐	☐	radiation production
☐	☐	x-ray beam characteristics
☐	☐	screen-film characteristics
☐	☐	film processing
☐	☐	generator performance
☐	☐	beam characteristics
☐	☐	ancillary equipment evaluation
☐	☐	processor performance
☐	☐	imaging system performance
☐	☐	kVp meter
☐	☐	radiation detector
☐	☐	exposure timer
☐	☐	test objects
☐	☐	sensitometer
☐	☐	densitometer
☐	☐	light meter
☐	☐	philosophical basis of quality improvement
☐	☐	quality improvement problem solving strategies
☐	☐	tools for problem identification and analysis
☐	☐	development of indicators
☐	☐	data collection methods
☐	☐	data analysis
☐	☐	assessment of outcomes
☐	☐	NCRP (National Council on Radiation Protection and Measurements) Report #99
☐	☐	NCRP (National Council on Radiation Protection and Measurements) Report #105
☐	☐	ACR (American College of Radiology) Mammography Quality Control Manual
☐	☐	OSHA (Occupational Safety and Health Administration) publications covering blood borne pathogens/universal precautions
☐	☐	MSDS (Material Safety Data Sheets)
☐	☐	SMDA (Safe Medical Devices Act) legislation publications for general provisions and reporting procedures

3) **How could manufacturer/vendor support be improved?** ______________________________

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SECTION IV
ON-SITE SUPPORT

On-site support such as peers or biomedical staff who provide technical assistance with the repair or maintenance of primary or ancillary diagnostic equipment are included in this category.

1) **I rate the effectiveness of on-site support in quality management as:** (Circle one)
1 - Very poor 2 - Poor 3 - Neither 4 - Good 5 - Very good 6 - Not applicable

2) **Do your on-site support resources contain information on the following?**
(Leave blank if you don't know.)

Yes	No	
☐	☐	radiation production
☐	☐	x-ray beam characteristics
☐	☐	screen-film characteristics
☐	☐	film processing
☐	☐	generator performance
☐	☐	beam characteristics
☐	☐	ancillary equipment evaluation
☐	☐	processor performance
☐	☐	imaging system performance
☐	☐	kVp meter
☐	☐	radiation detector
☐	☐	exposure timer
☐	☐	test objects
☐	☐	sensitometer
☐	☐	densitometer
☐	☐	light meter
☐	☐	philosophical basis of quality improvement
☐	☐	quality improvement problem solving strategies
☐	☐	tools for problem identification and analysis

Yes	No	
☐	☐	development of indicators
☐	☐	data collection methods
☐	☐	data analysis
☐	☐	assessment of outcomes
☐	☐	NCRP (National Council on Radiation Protection and Measurements) Report #99
☐	☐	NCRP (National Council on Radiation Protection and Measurements) Report #105
☐	☐	ACR (American College of Radiology) Mammography Quality Control Manual
☐	☐	OSHA (Occupational Safety and Health Administration) publications covering blood borne pathogens/universal precautions
☐	☐	MSDS (Material Safety Data Sheets)
☐	☐	SMDA (Safe Medical Devices Act) legislation publications for general provisions and reporting procedures

3) **How could on-site support be improved?** ______________________________

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SECTION V
COMPUTER SOFTWARE

In this section evaluate software that provides information regarding monitoring, maintenance, evaluation or other guidance and support for your quality management program.

1) I rate the effectiveness of computer software in quality management as: (Circle one)
1 - Very poor 2 - Poor 3 - Neither 4 - Good 5 - Very good 6 - Not applicable

2) Do your manufacturer/vendor support resources contain information on the following?
(Leave blank if you don't know.)

Yes	No	
☐	☐	radiation production
☐	☐	x-ray beam characteristics
☐	☐	screen-film characteristics
☐	☐	film processing
☐	☐	generator performance
☐	☐	beam characteristics
☐	☐	ancillary equipment evaluation
☐	☐	processor performance
☐	☐	imaging system performance
☐	☐	kVp meter
☐	☐	radiation detector
☐	☐	exposure timer
☐	☐	test objects
☐	☐	sensitometer
☐	☐	densitometer
☐	☐	light meter
☐	☐	philosophical basis of quality improvement
☐	☐	quality improvement problem solving strategies
☐	☐	tools for problem identification and analysis

Yes	No	
☐	☐	development of indicators
☐	☐	data collection methods
☐	☐	data analysis
☐	☐	assessment of outcomes
☐	☐	NCRP (National Council on Radiation Protection and Measurements) Report #99
☐	☐	NCRP (National Council on Radiation Protection and Measurements) Report #105
☐	☐	ACR (American College of Radiology) Mammography Quality Control Manual
☐	☐	OSHA (Occupational Safety and Health Administration) publications covering blood borne pathogens/universal precautions
☐	☐	MSDS (Material Safety Data Sheets)
☐	☐	SMDA (Safe Medical Devices Act) legislation publications for general provisions and reporting procedures

3) How could computer software be improved? ______________________________

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SECTION VI
AUDIO-VISUAL RESOURCES

This category consists of video resources that provide general or specific information and/or technical/professional information pertaining to quality management in diagnostic imaging.

1) I rate the effectiveness of audio-visual resources in quality management as: (Circle one)

1 - Very poor 2 - Poor 3 - Neither 4 - Good 5 - Very good 6 - Not applicable

2) Do your audio-visual resources contain information on the following?
(Leave blank if you don't know.)

Yes	No	
☐	☐	radiation production
☐	☐	x-ray beam characteristics
☐	☐	screen-film characteristics
☐	☐	film processing
☐	☐	generator performance
☐	☐	beam characteristics
☐	☐	ancillary equipment evaluation
☐	☐	processor performance
☐	☐	imaging system performance
☐	☐	kVp meter
☐	☐	radiation detector
☐	☐	exposure timer
☐	☐	test objects
☐	☐	sensitometer
☐	☐	densitometer
☐	☐	light meter
☐	☐	philosophical basis of quality improvement
☐	☐	quality improvement problem solving strategies
☐	☐	tools for problem identification and analysis

Yes	No	
☐	☐	development of indicators
☐	☐	data collection methods
☐	☐	data analysis
☐	☐	assessment of outcomes
☐	☐	NCRP (National Council on Radiation Protection and Measurements) Report #99
☐	☐	NCRP (National Council on Radiation Protection and Measurements) Report #105
☐	☐	ACR (American College of Radiology) Mammography Quality Control Manual
☐	☐	OSHA (Occupational Safety and Health Administration) publications covering blood borne pathogens/universal precautions
☐	☐	MSDS (Material Safety Data Sheets)
☐	☐	SMDA (Safe Medical Devices Act) legislation publications for general provisions and reporting procedures

3) How could audio-visual resources be improved? ______________________________

____

____

____

____

A Survey of Quality Management Resources in Diagnostic Imaging

The questions that are listed below will be personally administered when the initial survey questionnaire is retrieved. These questions will establish the demographic information needed to confirm that respondents were actively involved in quality management activities.

1) What is your current job title? ________________________________

2) What is the highest level of education that you have achieved? (Please mark one)
_____Certificate (includes military, hospital, and college/university based programs)
_____Associate Degree
_____Bachelor Degree
_____Master's Degree

3) How many hours per week do you work?
_____less than 11 hours
_____11-20 hours
_____21-30 hours
_____more than 30 hours

4) How long have you been actively involved in quality management programs?
_____less than 1 year
_____1-2 years
_____3-5 years
_____6-10 years
_____more than 10 years

5) How many hours do you spend performing quality management activities?
_____less than 1 hour per day
_____1-2 hours per day
_____2-4 hours per day
_____4-6 hours per day
_____6-8 hours per day

6) What professional credentials do you currently hold? (Mark all that apply)
_____Radiography (R)
_____Radiation Therapy (T)
_____Nuclear Medicine (N)
_____Diagnostic Medical Ultrasound (RDMS)
_____Mammography (M)
_____Cardiovascular (CV)
_____Computed Tomography (CT)
_____Magnetic Resonance Imaging (MR)
_____Quality Management (QM)
_____None of the above

7) What is the approximate size of your facility?
_____don't work in a hospital
_____less than 100 beds
_____100 to 250 beds
_____251 to 500 beds
_____more than 500 beds

8) What is the approximate volume of exams performed daily? ________

Appendix B

Definitions of Identified Instructional Resources

Definitions of Identified Instructional Resources.

Resources	Definitions
REFERENCE TEXTS AND GUIDES	Books, guides, government or professional organization publications that contain general or specific information on subject matter that has relevance to quality management in diagnostic imaging.
PROFESSIONAL JOURNALS AND MAGAZINES	Journals or magazines which contain technical or professional information regarding operational aspects of diagnostic imaging.
AUDIO-VISUAL RESOURCES	Video resources that provide general/specific information and/or technical/professional information pertaining to quality management in diagnostic imaging.
COMPUTER SOFTWARE	Software that provides information regarding monitoring, maintenance, evaluation, guidance and support for your quality management program.
MANUFACTURER/VENDOR SUPPORT	Texts, manuals, guides and technical support provided by the equipment manufacturer or contracted service vendor for repair or maintenance of primary or ancillary diagnostic equipment.
ON-SITE SUPPORT	Peers, biomedical staff who provide technical assistance with the repair or maintenance of primary or ancillary diagnostic equipment.

Appendix C

Participant Comments

Respondent Comments:

A Survey of Quality Management Resources in Diagnostic Imaging.

RESPONDENTS	1	2	3	4	5	6	7	8
SECTION I	N	N	2	N	N	6	N	10
SECTION II	N	N	3	N	N	7	N	N
SECTION III	N	1	4	N	N	8	N	N
SECTION IV	N	N	5	N	N	9	N	N
SECTION V	N	N	N	N	N	N	N	N
SECTION VI	N	N	N	N	N	N	N	N

1-- "I have not talked with the vendor about quality management. Vendor support has always talked about equipment function and how the services is"

2-- "More teleconferences"

3-- "I think each one is fine for what it is targeted for"

4-- "Manufacturer and vendors are too proprietary with their technology"

5-- "We are fortunate to have very good biomed support"

6-- "Have the vendor totally responsible for equipment QC and QA"

7-- "Need to publish exact procedures and guidelines"

8-- "see page #1"

9-- "It could exist"

10-- "I am very new to the management role, therefore not very familiar with the available resources. I am however, very familiar with the MQSA and ACR mammography requirements. I think that the ACR manual is extremely helpful and would love to see one developed in the same format for diagnostic x-ray. (Separated for each modality)"

Appendix D

Instructional Resource Outline for

Quality Management in the Radiologic Sciences

INSTRUCTIONAL RESOURCE OUTLINE FOR QUALITY MANAGEMENT IN THE RADIOLOGIC SCIENCES

I. INTRODUCTION

A. Definitions
1. Quality Management (QM)
2. Quality Assurance (QA)
3. Quality Control (QC)
4. Quality Improvement (QI)

B. Historical Perspective
1. Philosophies of QM
    a. Deming
    b. Juran
    c. Crosby
    d. Joiner

C. Qualifications of Individuals Responsible for QM Program
1. training and experience
2. job description

II. GENERAL PRINCIPLES OF QUALITY CONTROL (QC)

A. Radiation Production
1. waveform characteristics
    a. single phase
    b. three phase
    c. high frequency
2. target design
    a. target angle
    b. target material

B. X-Ray Beam Characteristics
1. beam quality
2. radiation output
3. beam modification
    a. filtration
    b. collimation

III. ELEMENTS OF QC MONITORING, EVALUATION AND MAINTENANCE

- A. Film Processing
  - 1. Test Materials/Equipment
    - a. sensitometer
      - 1. design characteristics
      - 2. function
    - b. densitometer
      - 1. design characteristics
      - 2. function
    - c. selected radiographic film (control film)
    - d. radiographic film processor
  - 2. Test Procedures
    - a. Processor QC Control Charts
      - 1. speed index
      - 2. contrast index
      - 3. base-plus-fog index (dmin.)
      - 4. average gradient
      - 5. gamma
      - 6. dmax.
      - 7. development time
    - b. Solution Temperatures
      - 1. developer
      - 2. fixer
      - 3. water
        - a. wash water volume
    - c. Replenishment
      - 1. types of replenishment
      - 2. recommend rates of replenishment
      - 3. volume management
    - d. Fixer Retention
      - 1. archiving
    - e. Film Artifact Identification
      - 1. Sensitometric (measurable)
      - 2. Physical
        - a. processing
        - b. exposure

3. Evaluation/Interpretation
    a. Performance Criteria
        1. HEW 76-8043
        2. HEW 77-8018
        3. NCRP Report 99
        4. McKinney
        5. Haas et al.
    b. OSHA
        1. requirements
        2. recommendations
4. Preventive Maintenance
    a. required tests
    b. frequency of tests
5. Corrective Maintenance

B. Radiographic Units
1. Test Materials/Equipment
    a. kVp meter
        1. Wisconsin Test Cassette
        2. digital kilovolt meter
    b. exposure timer
        1. spinning top test
        2. synchronous motor driven disc
        3. digital meter
    c. radiation detector
        1. exposure meter
        2. film
    d. resolution patterns
    e. system performance phantoms
        1. anthropomorphic phantoms
            a. phantom analysis
                1. density
                2. contrast
                3. recorded details
2. Test Procedures
    a. Reproducibility of x-ray output (Generator)
    b. Linearity and reproducibility of mA station (Generator)
    c. Reproducibility and accuracy of timer stations (Generator)

- d. Reproducibility and accuracy of kVp stations (Generator)
- e. Accuracy of source-to-film distance indicators (Assembly)
- f. Light/x-ray field congruence (Beam)
- g. Half-value layer (Beam)
- h. Focal spot size consistency (Beam)
- i. Representative entrance skin exposure (Beam)
  1. mR/mAs

3. Test Procedures for Automatic Exposure Control (AEC)
   - a. Reproducibility (Generator)
   - b. kVp compensation (Generator)
   - c. Field sensitivity matching (Beam)
     1. image receptor
     2. field alignment
   - d. Minimum response time (Generator)
   - e. Back-up timer verification (Generator)
4. Evaluation/Interpretation
   - a. Safe Medical Devices Act (SMDA)
   - b. NCRP Report 99
   - c. HEW 79-8094
   - d. Gray et al.
5. Preventive Maintenance
   - a. frequency
   - b. visual inspection checklist
6. Corrective Maintenance

C. Fluoroscopic Units

1. Test Materials/Equipment
   - a. see radiographic materials/equipment
2. Test Procedures
   - a. Table-top exposure rates
   - b. Centering Alignment
   - c. Collimation
   - d. kVp accuracy and reproducibility
   - e. mA accuracy and reproducibility
   - f. Exposure timer accuracy and reproducibilit
   - g. Reproducibility of x-ray outpu
   - h. Focal spot size consistency
   - i. Half-value layer

j. Representative entrance skin exposure

3. Test Procedures for Imaging Intensifiers
    a. Resolution
    b. Focusing
    c. Distortion
    d. Glare
    e. Low contrast performance
    f. Physical alignment of camera and collimating lens
4. Evaluation/Interpretation
    a. SMDA
    b. NCRP Report 99
    c. HEW 80-8095
    d. Gray et al.
5. Preventive Maintenance
    a. frequency
    b. visual inspection checklist
6. Corrective Maintenance

D. Tomographic Units

1. Test materials/equipment
    a. see radiographic unit procedures
    b. tomographic phantom
2. Test Procedures
    a. accuracy of depth and cut indication
    b. thickness of cut plane
    c. exposure angle
    d. completeness of tomographic motion
    e. flatness of tomographic field
    f. resolution
    g. continuity of exposure
    h. flatness of cassette
    i. representative entrance skin exposures
        1. mR/mAs
3. Evaluation/Interpretation
    a. SMDA
    b. NCRP Report 99
    c. HEW 80-80-96
    d. Gray et al.

4. Preventive Maintenance
    a. frequency
    b. visual inspection checklist
5. Corrective Maintenance

E. Darkroom
1. Test Materials/Equipment
    a. anthropomorphic phantom--if available (mammography)
    b. densitometer
    c. radiographic control film
    d. film masking device
    e. black light--optional
2. Test procedures
    a. cleanliness
    b. integrity
    c. fog test
    d. safelight conditions
    e. temperature and humidity
3. Evaluation/Interpretation
    a. Occupational Safety and Health Act (OSHA)
        1. compliance
    b. Local effluent discharge/sewer use codes
    c. NCRP Report 99
    d. McKinney
    e. Haas et al.
4. Preventive Maintenance
    a. frequency
    b. visual inspection checklist
5. Corrective Maintenance

F. Silver Recovery
1. Test Materials/Equipment
    a. electrolytic collection device
    b. metallic displacement cartridge
    c. chemical precipitation
    d. resin systems
    e. pH test paper
    f. a penny

2. Test Procedures
    a. electrolytic monitoring for proper amperage setting
    b. secure recovered silver for shipment and refinement
    c. effluent sampling and analysis
3. Evaluation/Interpretation
    a. OSHA requirements
        1. compliance with minimum standards (.5ppm)
    b. NCRP Report 99
    c. McKinney
    d. Haas
4. Preventive Maintenance
    a. frequency
    b. scheduled recovery unit replacement
    c. record maintenance
5. Corrective Maintenance

G. Illumination/View Conditions
1. Test Materials/Equipment
    a. Light meter
        1. design characteristics
        2. function
2. Test Procedures
    a. consistency of light output with time (luminance)
    b. consistency of light output from one box to another
    c. conditions
    d. cleaning
    e. illuminance
3. Evaluation/Interpretation
    a. ACR Manual for technologists
    b. NCRP Report 99
4. Preventive Maintenance
    a. frequency
    b. visual inspection checklist
5. Corrective Maintenance

H. Cassette/Intensifying Screens
1. Test Materials/Equipment
    a. Radiographic Unit - use same unit for all tests

b. Wire mesh
   1. 40 mesh (40 lines per inch) for mammography
   2. 9 mesh (9 lines per inch) for radiography
c. Screen cleaning solutions
d. Lint free cleaning cloth

2. Test Procedures
   a. screen-film characteristics
      1. speed
      2. resolution
      3. contact (contact test)
      4. spectral matching
   b. cleaning
3. Evaluation/Interpretation
   a. screen-film characteristics
      1. speed
      2. resolution
      3. contact (test)
      4. spectral matching
   b. NCRP Report 99
4. Preventive Maintenance
   a. frequency
   b. documentation (records)
5. Corrective Maintenance
   a. retest screens/cassettes
   b. remove screens/cassettes
   c. replace screens/cassettes

I. Grids
   1. Test Materials/Equipment
      a. radiographic unit
      b. water phantom
      c. lead diaphragm
      d. grid
      e. detector
   2. Test Procedures
      a. alignment
      b. focal distance
      c. artifact identification
      d. condition

- e. Bucky factor
- f. primary transmission
- h. contrast improvement factor

3. Evaluation/Interpretation
   - a. alignment criteria
     1. types of grid cutoff
        - a. upside down focused grid
        - b. lateral decentering (grid angulation)
        - c. focus-grid distance decentering
        - d. combined lateral and focus-grid distance decentering
   - b. focal distance parameters (tolerance)
4. Preventive Maintenance
   - a. frequency
   - b. NCRP Report 99
5. Corrective Maintenance

J. Radiation Protective Devices

1. Test Materials/Equipment
   - a. fluoroscopic unit
   - b. radiographic unit (for facilities without fluoroscopy)
   - c. personnel monitoring vendor
   - d. radiation detection device
2. Test Procedures
   - a. aprons
   - b. gloves
   - c. gonadal shields
   - d. artifact identification
   - e. personnel monitoring
   - f. structural integrity of protective barriers
3. Evaluation/Interpretation
   - a. NCRP Report 99
   - b. standards NCRP Report 105
   - c. guidelines NCRP Report 105
4. Preventive Maintenance
   - a. frequency
   - b. NCRP 105
5. Corrective Maintenance

K. Repeat Analysis
  1. Definitions
     a. repeat (substandard exam)
     b. reject (non-examination film)
     c. waste (repeat + reject)
  2. Objective
     a. minimize patient exposure
     b. maximize cost benefit to patient and facility
  3. Procedure
     a. categorize reject and repeat films
     b. count reject and repeat films
     c. divide repeats by rejects to determine ratio
     d. time interval of waste collection must be known
     e. determine total film volume for time interval
     f. divide <u>repeat total</u> by <u>total film volume</u> for time interval
     g. divide <u>reject total</u> by <u>total film volume</u> for time interval
  4. Evaluation
     a. HEW 79-8097
     b. frequency
     c. national standards
     d. sort repeated exams into anatomical categories
  5. Maintenance

L. Standardized Technique Charts
  1. Definitions
     a. variable kVp, fixed mAs
        1. advantages/disadvantages
     b. variable mAs, fixed kVp
        1. advantages/disadvantages
  2. Objective
     a. statement of purpose
  3. Procedure
     a. phantom (12cm X 12cm container of water)
     b. test all radiographic units
     c. administer according to film manufacturer specifications
  4. Evaluation
     a. frequency

5. Maintenance
    a. inconsistent radiographic densities
    b. localized problems

IV. GENERAL PRINCIPLES OF QUALITY IMPROVEMENT (QI)

A. Philosophy of QI
    a. customer focus
    b. planned, systematic evaluation
    c. process orientation
    d. data driven

B. Problem Solving Strategies
    1. define process
        a. supplier
        b. input
        c. process (action)
        d. outcome
        e. customer
    2. identify relevant process variables
        a. supplier
        b. input
        c. process (action)
    3. identify quality characteristics
        a. outcomes
        b. customer

C. Tools for QI
    1. group dynamics
        a. QI teams
        b. focus groups
        c. brainstorming
    2. information analysis
        a. flowcharts
        b. cause-effect diagrams
        c. scatter plots
        d. bar charts (graphs)
        e. histograms
        f. Pareto charts

g. trend charts
h. control charts
i. run charts
j. check sheets

V. ELEMENTS OF QI MONITORING, EVALUATION AND MAINTENANCE

A. Aspects of Clinical Performance
1. appropriateness of care
    a. defined
2. continuity of care
    a. defined
3. effectiveness of care
    a. defined
4. efficacy of care
    a. defined
5. efficiency of care
    a. defined
6. respect and caring
    a. defined
    b. patients rights
    c. patient satisfaction
    d. complaint management
7. safety in the care environment
    a. defined
    b. OSHA
    c. Materials Safety Data Sheets (MSDS)
8. timeliness of care
    a. defined
9. cost of care
    a. defined
10. availability of care
    a. defined

B. Performance Improvement Areas
1. high volume
    a. chest radiography
2. high risk
    a. angiography

3. problem prone
    a. IV contrast use

C. Methods of Data Collection
1. surveys
    a. definition
    b. use/purpose
2. questionnaires
    a. definition
    b. use/purpose
3. patient records
    a. use/purpose
4. focus groups
    a. definition
    b. use/purpose
5. logs (diaries)
    a. definition
    b. use/purpose

D. Analysis of Data
1. measures of frequency
    a. counts
    b. percents
    c. ratios
    d. rates
2. measures of central tendency
    a. mean
    b. median
    c. mode
3. measures of variance
    a. range
    b. standard deviation
    c. variance

E. Evaluation of Outcomes
1. identify reference standards
    a. internal
        1. baseline performance
        2. customer expectations

b. external
 1. government regulations
 a. federal
 b. state
 2. practice standards
2. evaluation of outcomes
 a. internal standards
 b. external standards

VI. DOCUMENTATION AND FORMS

A. List of Resource Publications
 1. monitoring and maintenance publications
 2. applicable government regulations
 a. Local
 b. State
 c. Federal
 3. NCRP Report 99
 4. NCRP Report 105

B. Quality Reports
 1. purchase specificatons for new equipment
 2. acceptance testing for new equipment
 3. length of time documents should be maintained
 4. summary of QM tests

C. Sample Forms for QM Administration and Documentation
 1. darkroom checklist
 2. federal registry requirements
 3. repeat/reject analysis worksheet
 4. daily tube warmup log
 5. screen cleaning log
 6. minor equipment repair log
 7. uniformity of radiographic illuminators worksheet
 8. annual quality control tests checklist
 9. cassette-screen contact test log
 10. portable radiographic equipment visual/mechanical checklist
 11. portable fluoroscopy equipment visual/mechanical checklist

12. fixed radiographic equipment visual/mechanical checklist
13. fixed fluoroscopic equipment visual/mechanical checklist

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