Utilization of a Bar-Code System in a Nuclear Pharmacy

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The need for positive identification and validation of administered radiopharmaceuticals is especially important in nuclear pharmacies. The effects of implementing a bar-code system to help improve the accuracy of this task were evaluated in our nuclear pharmacy. A bar-code system utilizing four wand scanners was incorporated with the Du Pont Nuclear Medicine/ Nuclear Pharmacy Manager® software, run on an IBM Personal System/2™ Model 70 computer. All cold kits and lead pigs were pre-affixed with bar-code labels by the technologists. All the individual components (i.e., cold kit, lead pig, and eluting lead container) were then verified with the bar-code system when preparing a radiopharmaceutical. If an incorrect component was accidently chosen during the procedure, the computer alerted the technologist with a warning beep and message. In the same manner, if the wrong radiopharmaceutical was chosen when drawing a patient dose, the individual was alerted to the mistake. Since implementing this bar-code system in our nuclear pharmacy 23 months ago, we have eliminated misadministrations caused by incorrect kit preparation or selection of the wrong radiopharmaceutical. The biggest disadvantage of the bar-code system is the large amount of time a technologist must spend affixing bar-code labels to the cold kits and lead pigs. The pharmaceutical companies should be encouraged to include bar codes on all cold kits and radiopharmaceuticals because the need for greater accuracy in the performance of nuclear medicine procedures would benefit from a broader application of bar-codes.

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The utilization of bar-codes (*1,2*) has grown dramatically in recent years. Bar-code readers are being used in grocery stores, retail stores, delivery companies, hospital pharmacies, blood banks, and in some radiology departments as a means of identifying various items or products (*3–9*).

At present, most nuclear pharmacies are using various forms of verification such as color coding (*10*) and double-checking between technologists to ensure the accuracy of their work. While these systems are good measures to have in place, we have found they are not foolproof. Many misadministrations (*11,12*) in a nuclear medicine laboratory can be classified as nuclear pharmacy uncontrollable errors, such as: (1) the requesting physician orders the wrong procedure or orders the procedure on the wrong patient; (2) the technologist administers the wrong radiopharmaceutical to the patient; or (3) the technologist administers the radiopharmaceutical to the wrong patient.

Many misadministrations in a nuclear pharmacy that are controllable occur even with multiple verification systems in place, such as the color coding and double-checking. Examples of controllable misadministrations in a nuclear pharmacy are: (1) placing the wrong cold kit in the lead pig which results in the wrong radiopharmaceutical being administered to the patient; or (2) drawing a dose from the wrong vial, resulting in the patient receiving the wrong radiopharmaceutical. Although these mistakes should not occur with the color coding and double-checking system, the fact remains that they do occur. Thus, the need for positive identification and validation is crucial to the daily activities of a nuclear pharmacy.

We feel that the nuclear pharmacy could greatly benefit from the use of current bar-code technology. A system could be put in place that would require the operator to verify every step taken in the preparation of patient doses. We installed a system that utilized bar-code technology, along with the present system of color coding and double-checking of technologists' work. The intent of this paper is to demonstrate how a bar-code system can improve the accuracy of a nuclear pharmacy and also to explain the results of bar-code implementation in our nuclear pharmacy.

MATERIALS AND METHODS

Configuration of Bar-Code System

The bar code system that we implemented consisted of four wand scanners (Model 119-15R; American Microsystems, Euless, TX) connected to two bar-code readers (Model 2000/2002; American Microsystems). The bar-code readers were installed between the keyboard and the personal computer (IBM Personal System/2™ Model 70, IBM, Boca Raton, FL). As illustrated in Figure 1, the two readers were

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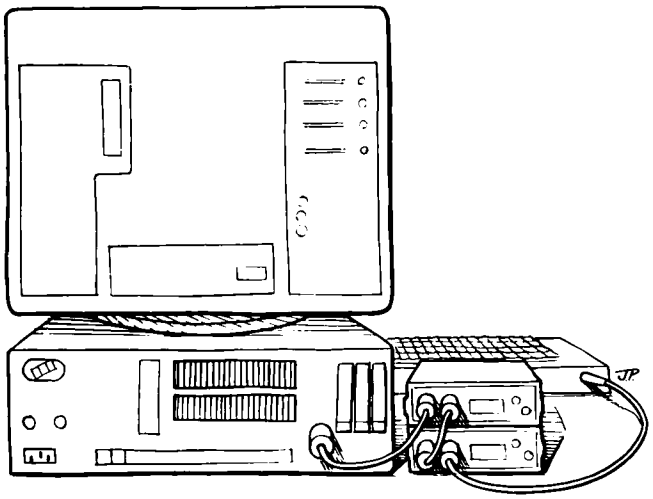

FIG. 1. A drawing showing the proper connections for integrating a bar-code system to a personal computer.

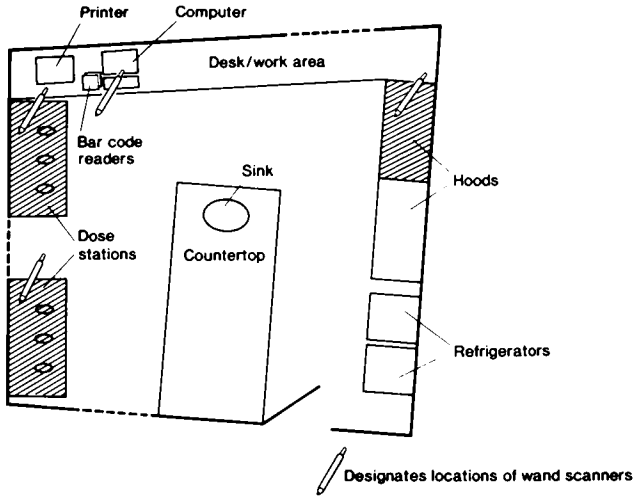

FIG. 3. A diagram of our nuclear pharmacy with the locations of the four wand scanners, two bar-code readers, and a personal computer.

networked to the personal computer by connecting the keyboard cable from the computer to the jack in back of reader #1 and then taking an accessory cable and connecting one end to the computer jack of reader #1 and the other end to the keyboard jack of reader #2. The final connection involved connecting another cable from the back of the computer (to which the keyboard is normally connected) to the "computer" jack of reader #2.

Four wand scanners were connected to these two centrally located bar-code readers using the wand input jacks on the front of each reader (Fig. 2). The resulting configuration allows data to be input from any of the four wand scanners or the computer keyboard. The data read by the wand scanners was sent to the computer through the bar-code reader as if it were typed from the keyboard. No additional hardware changes were necessary when connecting the scanners and readers to our computer system. It is important to note that with this type of configuration only one bar-code scanner should be used at a time. If two individuals try to scan a bar-code simultaneously with two different wands, an incorrect signal could be received by the computer. In our experience, we have not found this to be a problem because only a single job can be performed on the computer at one time, making it difficult for two different tasks to be performed with the bar-code readers simultaneously. Our bar-code system was incorporated into the software utilized by our nuclear pharmacy (Nuclear Medicine/Nuclear Pharmacy Manager®, version 4.0 i; Du Pont Merck Pharmaceutical Co., Billerica, MA). The four wand scanners were placed at various compounding/dispensing workstations within the nuclear pharmacy (Fig. 3) allowing easy accessibility to the bar-code systems.

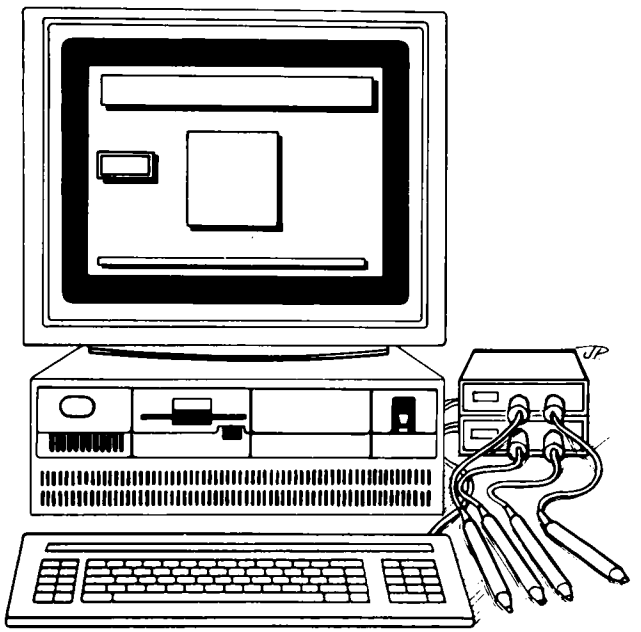

FIG. 2. Connections between four wand scanners and two interconnected bar-code readers.

Bar-Code Inventory System

The type of bar code used on our system is the Code 39 format (*13*), which is currently being used by Du Pont Merck Pharmaceutical Co. (Du Pont Pharma) on their prepared radiopharmaceuticals (e.g., thallium-201, xenon-133, and gallium-67) and cold kits (e.g., Cardiolite®, Microlite®, and Hepatolite®) (Fig. 4). The bar-code readers used at our institution have the capability of reading 10 different bar-code formats. The Code 39 bar-code format used by Du Pont Pharma was specifically intended for the purpose of inventory control. The utilization of the bar-code inventory system has resulted in tremendous time saving when entering a new shipment of isotopes into the computer.

Before the use of a bar-code system, inventory of large shipments of cold kits and radiopharmaceuticals received in our nuclear pharmacy often required 30 min or more: personnel had to enter lot numbers, calibration dates and times, total activity, and the date received. These tasks can now be

FIG. 4. The bar-code labels that are available on select commercial radiopharmaceuticals and cold kits.

done in just a few minutes with the use of a bar-code system and a couple of flicks of the wrist.

The inventory of all ready-to-use radiopharmaceuticals manufactured by Du Pont Pharma is maintained with the Nuclear Medicine/Nuclear Pharmacy Manager® software. When the cold kit or radiopharmaceutical shipment arrives, the new vials are "scanned in" and the inventory on the computer is automatically updated. Currently, only a couple of manufacturers are using bar codes; this presents problems if an institution's cold kits and radiopharmaceuticals are supplied by vendors that do not utilize bar codes.

Bar-Code Verification System

The utilization of bar-codes in the nuclear pharmacy was mainly limited to inventory control; however, we felt that the use of a bar-code system could be extended beyond this scope and could possibly provide a means of verification in the nuclear pharmacy environment. Since the bar-code system was already in place for purposes of inventory, all that was required was the generation of unique bar codes for each radiopharmaceutical or cold kit, which could be affixed to these specific vials along with some minor software revisions. This would allow the bar code to be a means of verifying each step taken in the preparation of patient doses.

The software changes were performed by Du Pont Pharma to meet our specific needs and requirements. Bar-code labels were generated in the Code 39 format and affixed to each specific cold kit, lead pig, and milking lead container (Fig. 5). Once affixed, these labels were scanned with the wands during kit preparations and when drawing up doses (Fig. 6). Our software was designed to ask that each component be scanned when preparing a radiopharmaceutical kit (Fig. 7). If at any time an incorrect component was accidentally chosen, the computer alerted the technologist to the mistake with a warning beep and an error message (Fig. 7E). The preparation was not allowed to continue until the correct component was chosen. In much the same manner as preparing the kits, if the wrong radiopharmaceutical was selected when drawing up a dose, the computer alerted the technologist to the problem. The technologist was unable to fill the dose until the mistake had been corrected.

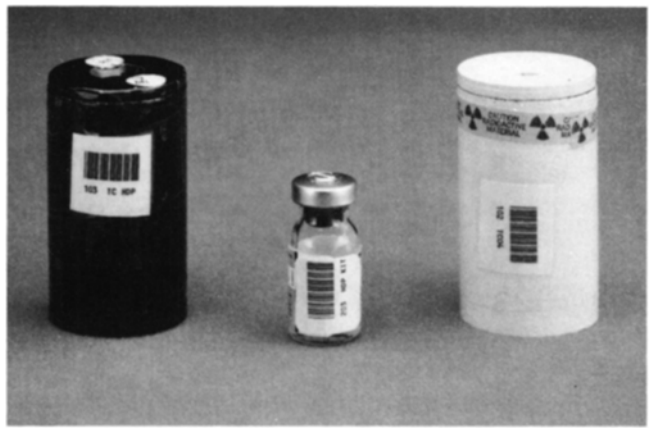

FIG. 5. The bar-code labels used in the verification process must be applied manually to the lead pig, cold kit, and milking lead container.

RESULTS

The bar-code verification was implemented with the specific purpose of reducing any errors and eliminating the potential for errors. In our experience, the bar-code systems utilized for verification do not seem to demonstrate any time saving. However, we feel that the greatest benefit of using the bar codes lies in the accuracy of the systems as well as the improved method of verifying the kit and dose preparation tasks performed routinely in the nuclear pharmacy environment.

Prior to the implementation of the bar-code system, we found that 45% of our misadministrations were controllable by the nuclear pharmacy (i.e., could have been prevented if a bar-code verification system had been in place). These nuclear pharmacy controllable misadministrations consisted of either drawing up a dose of the wrong radiopharmaceutical or preparing the wrong kit.

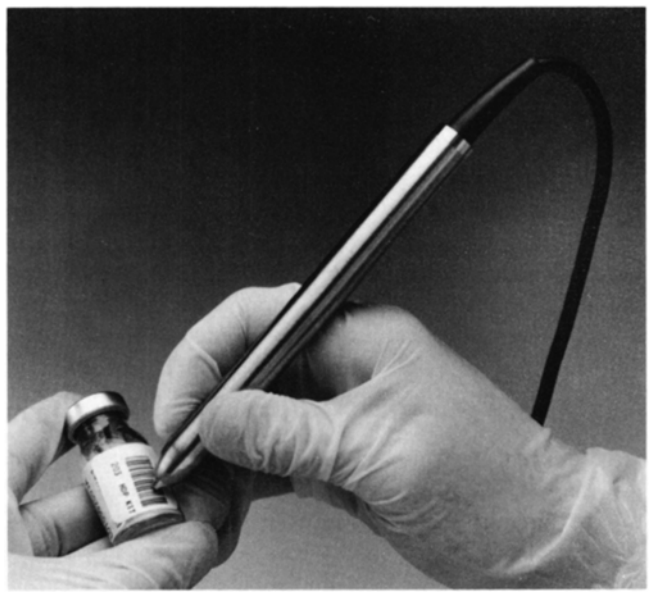

FIG. 6. The proper technique for scanning a bar-code label with a wand scanner.

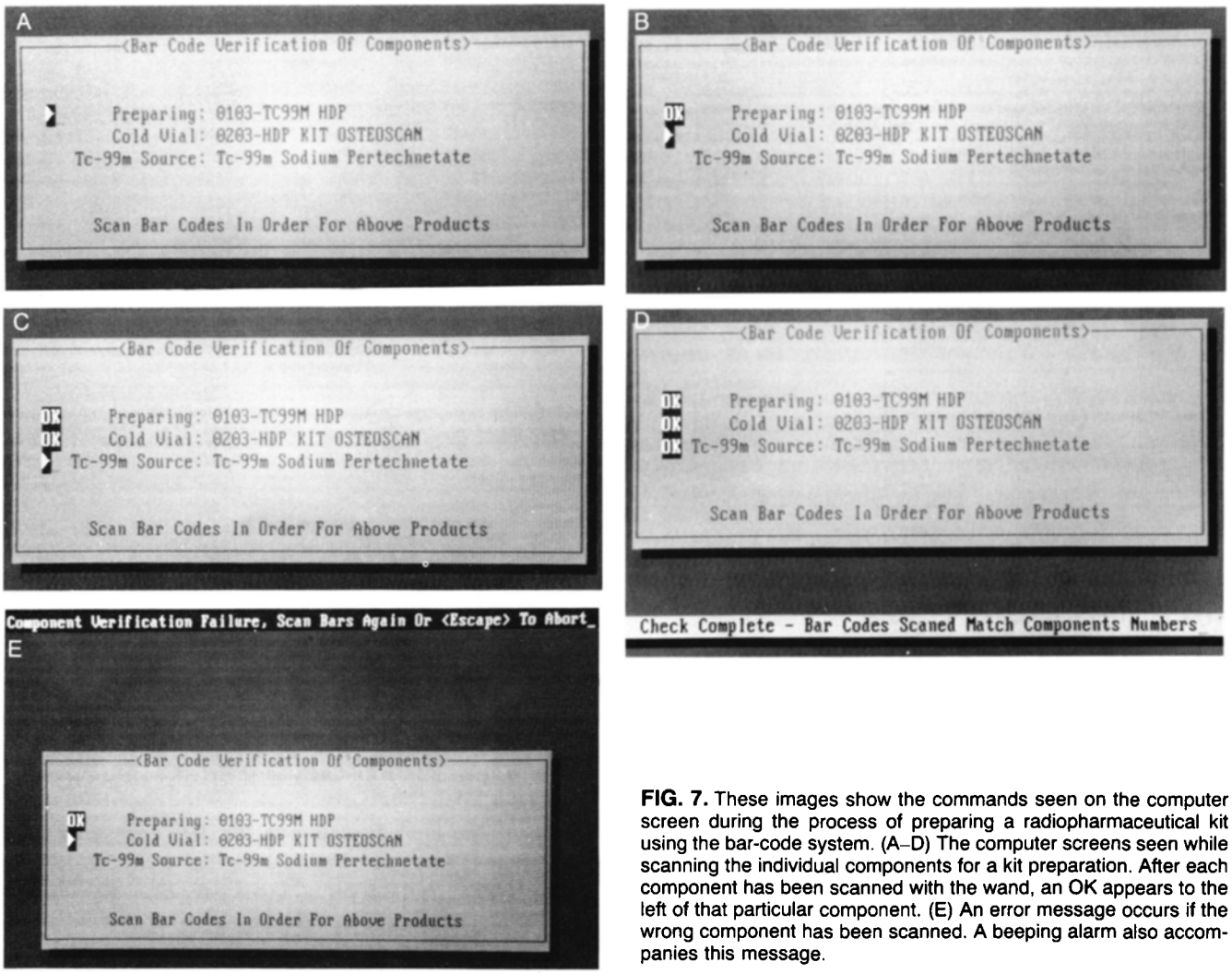

FIG. 7. These images show the commands seen on the computer screen during the process of preparing a radiopharmaceutical kit using the bar-code system. (A–D) The computer screens seen while scanning the individual components for a kit preparation. After each component has been scanned with the wand, an OK appears to the left of that particular component. (E) An error message occurs if the wrong component has been scanned. A beeping alarm also accompanies this message.

During the past 23 months (the time our bar-code system has been in place), we have administered 49,649 doses in our nuclear pharmacy without a single incidence of a nuclear pharmacy controllable misadministration, such as those experienced previously. Judging by these results, we feel that the bar-code system has been worth the expense of installation and the time that was necessary for our personnel to become familiar with this new technology. The true worth of the bar-code system lies in the improved accuracy and additional verification that it brings to a nuclear pharmacy.

DISCUSSION

With strict government regulations for nuclear medicine laboratories, the need for positive identification and validation of administered radiopharmaceuticals is especially important. The use of a simple bar-code system can satisfy these needs and be of tremendous help to nuclear pharmacists and nuclear medicine technologists. The bar code should not be used as a means to relieve the technologists of their responsibility to verify the accuracy of their work, but should be used as an adjuvant.

Since implementing the bar-code system in our nuclear pharmacy, we have eliminated misadministrations caused by selecting the wrong radiopharmaceutical and preparing the wrong kit. We attribute this to the responsibility placed on the technologist by the bar-code system to verify every step taken during preparation of a kit or a radiopharmaceutical dose.

Drawbacks to Bar-Code System

We did encounter some drawbacks to our bar-code system, which we will now discuss. Attaching bar-code labels to all new shipments of radiopharmaceuticals and cold kit vials was a very time-consuming job. Bar-code labels were printed in-house and affixed to all lead containers and cold kits whenever a shipment arrived. Bar-code labels were affixed manually on each of these vials. It took one person ~1 hr to do 500 labels. This often created a staffing shortage for a short period of time. It is important to note that only Du

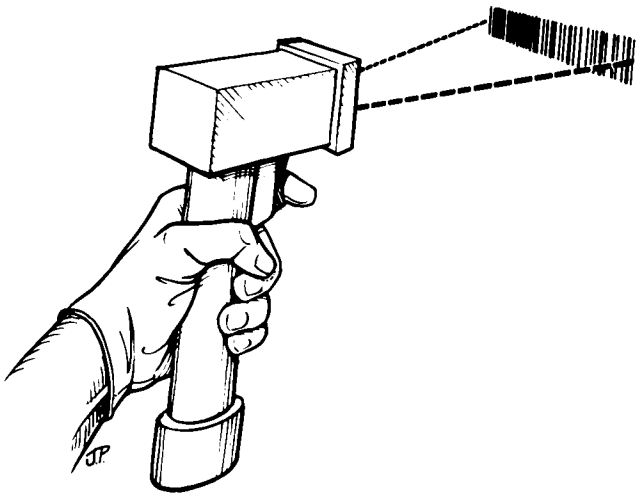

FIG. 8. A more expensive laser scanner for a bar-code system.

Pont Pharma utilizes bar-code labels on items that they supply and these bar codes were implemented for the specific use of inventory control.

Many times the bar-code labels had to be scanned two or three times before the signal was accepted by the bar-code reader. This problem was mainly due to the irregularities in the shape of the vials and pigs used in a nuclear pharmacy. Wand scanners are contact scanners, meaning they must be in close proximity to the bar code; they are also intended to be used on flat surfaces. At a considerably higher expense ($1,195), a laser scanner (Fig. 8) could be used, which would greatly improve the sensitivity of the scanning process. These scanners use a laser signal and therefore do not require the scanner to come in contact with the label; this makes them much more sensitive than the wands.

However, for approximately the same cost as a laser gun, we were able to purchase an entire bar code system ($976), which included two bar-code readers and four wand scanners. The four scanners provided the convenience and flexibility of having a bar-code scanner at each of four different workstations. Further, the wand scanners that we use are bidirectional, meaning that they can scan the bar codes in either direction. This feature allows the bar code to be scanned more than once by simply passing the wand back and forth over the label a few times until the signal is received. We feel that the time saved by a laser scanner would be negligible.

Another drawback of using a laser scanner for scanning bar-code labels is that this device takes up a large amount of space in the compounding and dispensing area. In contrast, the wand scanner can be attached to a wall surface and therefore occupies very little space in the work area (Fig. 9).

Some of the bar-code labels did not adhere very well to the vials and pigs. This problem was easily resolved by switching to a different label with better adhesive properties. Since the change to the improved labels, there has been no problem noted with the adherence of the bar-code labels to the vials.

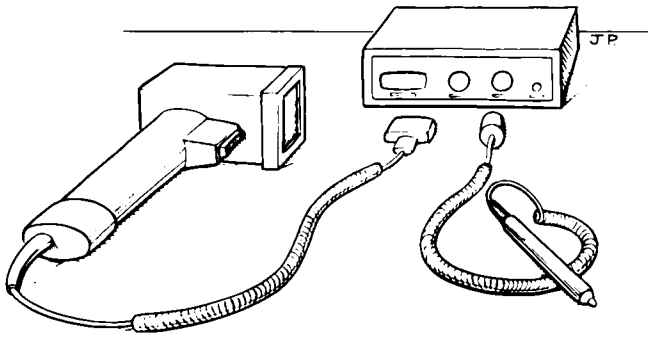

FIG. 9. Size comparison between a laser gun and a wand scanner.

The adhesive bar-code labels would not remain affixed to the kit vials when placed in boiling water baths. The only solution to this problem was placing the bar code on the package box for the cold kits. While this is only a temporary solution, we feel it is not optimal. Consequently, we strongly encourage the manufacturers of cold kits and radiopharmaceuticals to include bar codes on all drug labels because their labels have proven to have better adhesion to the vials even in boiling water baths.

If the radiopharmaceutical companies would incorporate bar codes into their present labels, it would be very simple and economical for any nuclear pharmacy to start utilizing a bar-code system. It would also eliminate the current major drawback to using a bar-code system—the necessity of attaching the bar-code labels to all vials, cold kits, and lead pigs. The cost for including these bar codes will undoubtedly be passed along to nuclear medicine departments. However, the requirement for accuracy placed upon the nuclear medicine field will most assuredly result in a call for a broader application of bar-codes in nuclear pharmacies.

Despite these drawbacks, we have established a bar-code system that is fast becoming routine to everyone involved with it. Further, the rewards we are experiencing by using the system include improved efficiency, less keyboard interaction (resulting in fewer typing errors), and no misadministrations related to the nuclear pharmacy.

The very success of the bar-code system has caused us to wonder if the people using it might become too dependent on it and neglect their responsibility to verify their work. To ensure that the technologists continue to check their work, we continue to use labels with the radiopharmaceutical and cold kit names and color-coded pigs, in addition to the bar-code labels. The bar-code reader then becomes a second check, verifying that everything was done correctly.

We are also examining the possibility of not having the name of the cold kit and radiopharmaceutical on the bar-code label that we generate. This would force the technologist to first look at the manufacturer's label stating its content. The bar-code label would then be a true verification of whether or not the right radiopharmaceutical and component had been selected. With this type of system, a special precaution would need to be taken at the time of attaching the bar-code label, to ensure that the correct bar-code label was attached to the corresponding component.

The implementation of a bar-code system consists of two processes: the placement of the bar-code label on the vials and lead pigs, and the use of this encoded information. Although the first of these steps involves a considerable amount of effort, and the psychology of changing from a manual system to new technology may be initially difficult, the full benefits of bar-codes cannot be fully realized until they are actually used.

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