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## Evaluation of medication kit processing time using radio frequency identification (RFID) technology

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### Abstract

*A study was conducted to evaluate the time devoted to medication kit processing using radio frequency identification (RFID) technology versus traditional processing. The article reviews the traditional, non-automated process as well as the automated RFID-based process. The comparative methodology is reviewed, including limitations. The result shows a statistically significant time savings with the RFID-based technology in both process components (restocking and verifying) and the total. Other elements important in institution decision-making are reviewed.*

### Introduction and Background

Pharmacy departments routinely assume the responsibility for processing medication-based kits (including trays and boxes) in their institutions. These kits are used for emergencies, or they provide a convenient source of floor stock for non-emergent use, such as procedures. Standard practice is for kits to be returned to the pharmacy after the kits are opened or before the kits expire.

Kit processing activities include inventorying returned kits, identifying the dosage units that need to be replaced, restocking those units, and verifying content accuracy, including expiration dates, before release. Although regulations vary from state-to-state, pharmacy technicians generally perform all the functions except for reviewing and approving the contents prior to release, which is performed by a pharmacist.

Manual processing is considered to be time-consuming and tedious. Also, it is considered to be error-prone because of the variance in human performance during restocking and verification. Finally, human vigilance is challenged in manually identifying and retrieving recalled medications and soon-to-expire medications.

Radio frequency identification (RFID) is the wireless use of electromagnetic fields to transfer data for the purposes of

identifying and tracking tags attached to objects.<sup>1</sup> RFID devices are being used in healthcare for a variety of purposes, including asset tracking, inventory control, patient tracking, and document and data file tracking.<sup>2</sup> RFID is an alternative to bar codes. The advantage of RFID is that it does not require direct contact or line-of-sight scanning.<sup>3</sup> Although RFID has yet to significantly permeate the pharmacy and medication-use environments, RFID technology is now available to provide an automated alternative to manual medication kit processing. Two experience-based, descriptive articles from one major academic medical center have been published.<sup>4,5</sup> This academic medical center's evaluation of the RFID technology is positive but primarily observational and subjective.

The technology is applied to medication kit processing as follows: A RFID tag is affixed to each dosage unit before the dosage unit is placed into a kit (see Figure 1). The RFID tag identifies the specific dosage unit via the national drug code (NDC) number (drug, dosage form, strength or concentration, size, and manufacturer), the expiration date, and the lot number. The NDC number is scanned into the system, but the lot number and the expiration date are entered manually. To improve the efficiency of the restocking process, these tags are affixed to products as a batch process, either at the institution or by a contracted company.

When a kit is returned to the pharmacy, a technician reviews the contents to ensure that no opened or partially-used dosage units are present. If present, they are removed. The technician then places the kit into the RFID-based scanning device (25 inches wide, 15 inches tall, 18.75 inches deep) (see Figure 2). The scanning device is equipped with a RFID

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reader. Once activated, the scanning device compares the kit's contents with the contents specified by a data table pre-built and maintained by the facility. An adjacent monitor then displays discrepancies, including missing dosage units, extra dosage units, expired dosage units, and dosage units with expiration dates within the institution's predetermined period ("soon to expire," e.g., 30 days).

Based on the discrepancies identified by RFID, the technician stocks the kit by inserting missing items, removing extra items, and replacing the items identified as expired or soon-to-expire. Depending upon state law, a technician or pharmacist re-inserts the kits into the scanning device, which identifies further adjustments that need to be made, or verifies the kit's accuracy.

Once kit accuracy is confirmed, the technician or pharmacist prints a content sheet, which lists all the dosage units in the kit, including an indication of which dosage unit is first to expire. That expiration date represents the kit's expiration date. The technician or pharmacist seals the kit containing the content sheet.

For each kit, the technician enters an intermediate or final destination into the software during dispatch. In the event of a recall, a technician or pharmacist searches the database to identify the kits containing recalled items and their destinations. Pharmacy personnel review the database regularly to identify the kits that contain soon-to-expire items.

### Methods

A time study was conducted to evaluate the time devoted to medication kit processing using radio frequency identification (RFID) technology versus traditional manual processing. The study was conducted at three non-profit facilities. Facilities "A," "B," and "C" are 569-beds, 687-beds, and 276-beds, respectively.

The study sponsor (Kit Check®) contributed to the study design; however, it had no role in execution, data collection and analysis, and the writing of the manuscript. The primary investigator, who was sponsored by the vendor but not a sponsor employee, performed all data collection. The primary investigator takes full responsibility for the integrity of the data and the accuracy of the data analysis.

The time consumed by the dispatch process, including the entry of kit destinations, was not included in the study. The study did not assess differences in kit accuracy or perceived work satisfaction. The possible impact of direct observation on processing times is unknown, even though efforts were

made to limit interference with actual processes.<sup>6</sup> Technicians and pharmacists did not time their own activities to avoid distraction and to maintain the integrity of the process.

A matched kit design was used to compare time efficiency of manual kit processing with that using RFID technology. It was expected that different types of kits would be used during the study and differences in processing times for different kits would confound the comparative study because kit types vary as do the average times devoted to different kit types. For example, sampling a large number of simple kits of a few items during one phase could skew the time data lower for that phase. By pairing and comparing processing times of the same kit types processed manually and with RFID technology, the study design should provide evidence for the impact without bias by the different combinations of kits that may happen to be observed before and after system implementation. Also, observations at three facilities should provide a better sense of the range of values and better approximate the potential time savings other institutions might expect. Most kits contained between 30 and 50 items. Time data for restocking and verification were collected during manual kit processing and during RFID technology supported kit processing. At Facility A, manual kit processing was observed prior to implementation of the RFID technology, and RFID technology supported kit processing was observed after implementation of the RFID technology.

At Facilities B and C, data collection was conducted 19 and 7 months, respectively, after implementation. The kit processing was reverted to manual for a day to allow observation. The approach taken with facility B and C was necessitated by the difficulty in locating institutions, other than A, that could accommodate the manual time study before implementation.

The Wilcoxon rank-sum tests was used for assessing statistical significance, set at  $p < 0.05$ , of the differences in restocking time, verification time, and total processing time. Wilcoxon rank-sum tests were used because timing data were not normally distributed.

In Facilities A and B, technicians performed the restocking and pharmacists performed the verifying. In Facility C, technicians performed the restocking and the verifying.

The manual process was as follows. Restocking comprised retrieving a kit from a pharmacy-based storage area, ensuring the integrity of the items, comparing the content and quantities against the standard for that kit, replacing the

expired or used products, completing the paperwork for charging, completing new paperwork, and presenting the kit for pharmacist verification. Verifying comprised a repeat of the core element, i.e., comparing the content and quantities against the standard for that kit, correcting mistakes, and preparing the kit for distribution, including sealing and securing, if appropriate.

The RFID process was as follows. Restocking comprised retrieving a kit from a pharmacy-based storage area, ensuring the integrity of the items, placing the kit into the scanning device, and activating the device through the associated computer. Also, retrieving those products listed on the computer screen as missing or soon-to-expire. Verifying comprised a second scanning until an indication of complete displays on the screen, printing a new content sheet, and preparing the kit for distribution, including sealing and securing, if appropriate.

The study observer used a stop-watch to time each transaction from the beginning of each transaction (either restocking or verifying) to completion. Interruptions not related to the restocking or verifying transactions were excluded. For each kit processed, the observer recorded the times onto a data collection sheet, along with the identification (the institution's name, the kit type, and the kit serial number). Kit identifications were used to match kits during manual and RFID processing.

For the RFID process, each item (vial, ampule, syringe, etc.) must be labeled with the RFID-labels, i.e., "tagged," before use. Most institutions tag product as a batch process before use. This time was not included in the data collection described above in order to provide a comparison of the time solely devoted to restocking and verification processes between the manual and RFID processes. The time consumed by the tagging process was measured as a separate component.

A total of 120 kit operations were observed during manual (N=62) and RFID (N=58) processing, with 12, 7, and 11 matched kits observed at Facilities A, B and C, respectively.

## Results

Time savings were observed in both restocking and verification steps at each of the facilities ( $p < 0.001$ ). Also, the total processing time was consistently reduced in the 30 matched kits with RFID technology (see Figure 3 and Table 1). The amount of processing time reduced by using RFID technology varied among the matched kits, with a median time savings per kit of 7.0 min (range 2.5-20.0 min; inter-quartile interval [IQI]: 7.6 min). Figure 3 illustrates that the longer the manual processing time, the larger the time saving

with RFID technology. Proportionally, the median reduction with RFID in processing time was 80.4% (range: 26.4-92.2%; inter-quartile interval [IQI]: 11.9%,  $p < 0.001$ ).

Projected labor savings per kit processed with the RFID averaged between \$4.20 and \$9.30 (see Table 1). This savings was estimated based on \$20.50/hour (including benefits) for technicians and \$61/hour (including benefits) for pharmacists. This savings excludes the cost associated with labeling the items if the items are labeled in-house.

The study showed that tagging consumes about 11.30 seconds of technician and pharmacist time per item; therefore, an institution that consumes 100 products per day will invest an additional 20 minutes to label the product. The pharmacist verifies the accuracy of the product by entering the NDC number, lot number, and expiration date from one dosage unit and re-scanning all units in that batch to ensure a match.

## Discussion

The study showed a range of median manual processing time per kit from slightly over eight minutes for Facility C to close to 17 minutes for Facility B. The variability may be due to several facility-specific variables, the most likely being the complexity of the kits, the kit types that were studied, and the adherence to detail and procedures.

The study demonstrated a reduced variability among the facilities for the RFID-based process, likely a benefit of the automated nature of the RFID process (see Table 1 and Figure 3). Regardless of the number of items per kit, the scanning device displays the results of the initial scan or verification scan within seconds.

State regulations permit Facility C to employ a technician-based verification process. At this facility, the median verification time was shortest, perhaps due to a technician-versus-pharmacist heightened familiarity with the RFID technology.

The time savings in kit processing with the RFID technology was about 80%. The actual time savings may vary as a function of type and complexity of the kits used, but the consistency in the proportion of time saved (80%) should provide a reasonable estimate of the expected savings if an estimate of the time devoted to manual processing is obtained.

Labor cost savings for the restocking and verification portions of the process were estimated to range from about \$4 per kit

to \$9 per kit. Additional savings may be realized by replacing a pharmacist verification process with a technician based process.

In evaluating the cost/benefit of the RFID-technology, there are two other considerations: The first is the cost of the RFID tags. If an institution has 100 kits with an average of 25 items per kit, 2500 tags must be purchased to accommodate the initial set-up. Also, each institution should estimate the average number of products replaced per day to assess the daily on-going cost of the tags. (The cost of the labels can be obtained from the vendor.) The second is the time devoted to the tagging, which should be subtracted from the estimated time differential to obtain an estimate of the total time savings. The labor cost devoted to the tagging should be estimated as well and subtracted from the estimated labor cost savings.

The use of the time savings will depend upon each institution's preferences. Some institutions may be able to reduce overtime. In others, the saved technician time and pharmacist time could be redeployed to other activities.<sup>7,8</sup> Alternatively, some institutions may be able to reduce staff based solely on the time savings secondary to RFID-based kit checking, or the technology might provide an incremental time savings resulting in staff reductions in concert with other efforts.

### Conclusions

A study was conducted to assess time efficiency and labor costs related to implementing a RFID-based technology for processing medication kits. The study showed a consistent reduction of kit processing times and associated labor costs for each kit observed when comparing manual with RFID technology processes. Each facility must examine the data and estimate value based on factors such as kit mix and volume and projected technician and pharmacist time savings. Each institution must evaluate the need to achieve actual cost savings or alternatively, to redeploy technician time and pharmacist time to other distributive and patient care activities. Finally, factors such as the potential impact on work satisfaction and potential for error reduction, which were not measured, can be considered.

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Figure 1.



Figure 2.

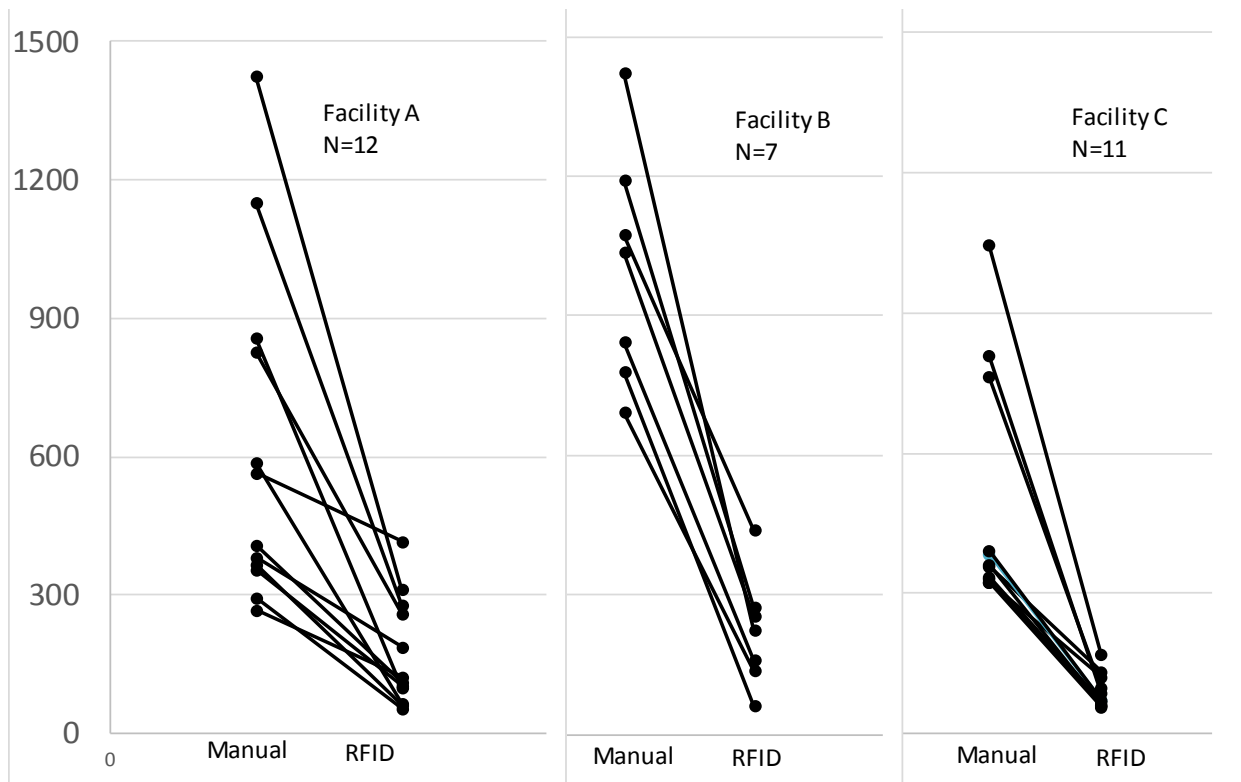


Figure 3. Each bar represents manual time versus RFID time comparison for one kit. Time (y-axis) is in seconds.

Table 1. Median processing times at the three facilities, and estimated cost savings with RFID technology.

	Restocking Time		Verifying Time		Total Time		Savings per Kit	
	Manual	RFID	Manual	RFID	Manual	RFID	Time	Labor cost
Facility A	7'18"	2'12"	3'7"	42"	10'25"	2'53"	7'32"	\$4.20
Facility B	8'9"	2'13"	8'36"	1'27"	16'45"	3'41"	13'3"	\$9.30
Facility C*	4'5"	1'4"	4'11"	29"	8'16"	1'33"	6'43"	\$5.11

\*Note: at Facility C, verification was performed by pharmacy technicians after the implementation of RFID technology. Estimated cost labor cost was adjusted accordingly.