REVIEW ARTICLE

Automated Dispensing Technologies: Effect on Managed Care

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OBJECTIVE:
The purpose of this article is to describe the various technologies used to process and distribute medications. Also included is a discussion of operation technology and its effect on managed care and the heathcare system.

DATA SOURCES:
Data for this study were collected from telephone interviews with respective company representatives, from attendees at meetings and exhibits focusing on technologies, and from the healthcare literature.

STUDY SELECTION:
Not applicable.

DATA EXTRACTION
Not applicable.

DATA SYNTHESIS
This study presents a review of several automated dispensing technologies that could be used in a hospital, managed care, or long-term care setting. Smaller automated systems reviewed are the Argus, Automated 250FD, Automated Pharmacy Station, Baxter ATC-212, Baxter ATC 240, Medserv, Pyxis Medstation, Medstation Rx, and Selectrac-Rx. Larger automated systems reviewed are the Baker Cell Dispensing Systems, Baker AutoScript II System, Baxter Automated Prescription Bottle Filler System, ScriptPro 200 Dispensing System, Uhlmann UPS 300-M Blister Packing System, and Yuyama YS-TR-250FD Prescription Dispensing System.

CONCLUSION:
Through a cooperative effort, automated dispensing technologies will help managed care organizations focus on operational efficiency, allowing healthcare professionals to focus on patient-care optimization

KEY WORDS:
Automated dispensing systems

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Technology—including automation, communication, and transportation—is sweeping through and transforming both the business and home environments within which people live. Broadly defined, technology in the workplace is how an organization transforms its inputs into outputs, thereby accomplishing its goals. For pharmacy, this process is producing dramatic revolutions in the daily processes and procedures.

Three components essential for channeling inputs through the organization are materials, operations, and knowledge.[1] Materials include the resources being consumed during the initial phase of processing. For example, materials would include the ingredients used in an auto-

mated compounder to prepare parenteral nutrient base solutions. Operation technology refers to the instruments used to transform the inputs into outputs. Technologic knowledge describes the skills and specialized training needed to perform the tasks. The effect of information technology on the organization is discussed elsewhere.[2,3] Together, these three components make up the technical system, an integral part of the organization's operating core.

In this article we describe the various technologies used to process and distribute medications from point A to point B. Systems covered in this discussion could be used in a community, hospital, or managed care pharmacy environment. The specific focus will also include a discussion of

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Table 1. Smaller Automated Systems Designed to Dispense Tablets or Capsules

Equipment (Telephone No.)	Capabilities	Dispensing Rate	Labeling	Estimated Cost[a]
Argus	Holds up to 200 bulk containers	Per request	Prepackaged	N/A
Automated 250FD [AutoMed] (800-537-8575)	Holds up to 250 medication cassettes	60 packages/minute	System generated	N/A
Automated Pharmacy Station	Robotic arm picks medication for carts, using bar code technology	N/A	Prepackaged	$450,000
Baxter ATC-212; Baxter ATC 240 (800-323-4315)	Holds 212 canisters; 240, 360, 480 medications	ATC 212: 15–25 pieces /minute; ATC 240: 50 pieces/minute	ATC host computer; manually	ATC 212: $110,000 ATC 240: $180,000
Baxter Sure-Med (800-323-4315)	Unit dose-based system; 30–50 different lines; up to 200 lines with expansion systems	Point-of-use system	Prepackaged	$12,000–30,000 Dispensing Ctr: $20,000 Cabinet: $29,000 Supply cabinet: $5,000
ScriptPro, LLC ScriptPro 200 Vial Filling System (800-606-7628)	Contains four different vial sizes; holds up to 200 different medications	Two tablets /capsules per second	Pharmacy's host system	$60,000–70,000
Medserv by Medication Management Systems (800-671-0590)	Mobile units (carts) with online communication with pharmacy system	Point-of-use system		$18,000–20,000
Pyxis Medstation and Medstation Rx (800-36-PYXIS)	Controls more than 30,000 different medications		Pharmacy's host system	Lease Only: MedStation $575/mth MedStation Rx: $675/mth
Selectrac-Rx (800-508-4576)	40 automated magazines; can hold up to 1,200 doses	Point-of-use system	Pharmacy's host system	In development

Table 2. Larger Automated Systems Designed to Dispense Tablets or Capsules

Equipment (Telephone No.)	Capabilities	Dispensing Rate	Labeling	Estimated Cost[a]
Baker Cells (800-845-7179)	Cells are approximately 10 by 12 inches	3 –5 seconds for a 30-count vial	Pharmacy's host system	$8.50 for small cell - $16.50 for super cell on monthly lease
Baker AutoScript II System (800-5516578)	Can hold up to 1,000 Baker Cells	400 prescriptions per hour	Pharmacy's host system	$300,000–400,000
Baxter International Bottle Filler System 1 (800-323-4315)	Three filling stations; holds up to 636 different medications	125–500 prescriptions per hour	System generated	$1.1 million
Uhlmann Model UPS 300-M Blister Packing Line	Packages medication into blister packs	900 tablets/capsules per min.up to four different medications in the same blister[b]	Printed directly or separately	$750,000–1,000,000
Yuyama Company TSX-Strip Packaging Machine	250–530 different medications	One pouch per second; up to four different medications in the same pouch	System generated	$180,000

[a] Prices subject to vary with respect to specific needs.
[b] Medication molds can be changed in 15 minutes.

operation technology and its effect on managed care and the healthcare system.

SMALLER AUTOMATED SYSTEMS

Shown in Table 1 are automated dispensing systems that would serve the needs of smaller managed care organizations, community pharmacies, and facilities specializing in long-term care.[1-3] These systems are usually less than $200,000, and several units can be linked together to dispense larger volumes of medication, and many are designed with the acute-care institution in mind. Space requirements are minimal as many of these systems occupy less than 100 square feet.

Argus. The Argus system, developed by Owen Healthcare, is an automated dispensing machine designed for patient-care units. It stores solid dosage form medications, as well as ampuls and vials in bulk containers. The system can hold up to 200 bulk containers and can serve up to 60 patients. Medications are dispensed in individually labeled plastic packages. The Argus system is similar to the Pyxis Medstation Rx in that it is patient-specific. Only those medications active on the patient's medication profile can be dispensed. The system records all transactions and has automatic inventory and billing capabilities.

Automated 250FD. The AutoMed 250FD is a computer-driven system that delivers all of the patients' medications sealed in single-dose or multi-dose packages with name, bar codes, medication information, and dosage time printed directly on each package. It is similar to Baxter's ATC 212, but it is more compact and occupies less space. The AutoMed can package about 60 packages a minute and can hold up to 250 drug cassettes. The cassettes are arranged on a rotary-dispensing unit housed inside the AutoMed.

The AutoMed 250FD is the first automated product introduced by AutoMed Technologies, Inc. The company also plans to introduce a family of products that will automate the entire pharmacy.

Automated Pharmacy Station. The Automated Pharmacy Station uses a robotic arm that reads medication orders from the pharmacy computer system. It glides along a track, picks the requested medications, and places them in patient medication drawers. Medications are packaged in individual plastic packages and are bar coded. Two walls on each side of the track hold the medication packages on pegs. When the robotic arm reads an order, it selects the right medication, adjusts the inventory, and adds the charge to the patient's bill. It also handles returned medications by checking the expiration date, returning the medication to the proper peg on the wall, adjusting the inventory, and crediting the patient's bill. The plastic packages hold a variety of medications and supplies, which include oral solids and liquids, prefilled syringes, ophthalmic drops, topical preparations, and transdermal patches.

Baxter ATC-212. This automated dispensing machine contains a microcomputer that is dispensing unit dose solid oral dosage forms. The medications are housed in individual canisters calibrated according to the size and shape of the product.

Each canister is assigned a numbered location and is designed to fit only into that location. Because a canister cannot be put into the wrong location, dispensing errors are minimized. When the microcomputer receives instructions to dispense a medication, a single tablet or capsule is ejected into a chute where it is packaged using a heat-sealing device. Each individual package is labeled with the name of the drug, identification number, lot number, expiration date, and time of administration.

The microcomputer is interfaced with the pharmacy information system. As the unit dose lists are generated, a computer file is built containing data for the microcomputer to use in filling medication orders for medications in the canisters. A microcomputer reads this file and tells the automated machine to dispense the medications in the order they appear on the unit dose cart fill lists. Each strip of individually packaged doses of medication contain the name and location of the patient. Technicians can separate the strips and place the medications into the patient's medication cassettes for delivery.

The system can also be designed for multidose packaging options. For example, it can package all of the 9:00 a.m. doses for one patient in the same package, all of the 1:00 p.m. medications in one package, and so forth.

The individual canisters can be calibrated for any manufacturer's product. Recalibration is necessary for new medications or vendors. This process takes about three to six weeks, and the cost is about $60 per cell.

Baxter ATC 240. The ATC 240 is a new model of the ATC 212 System. This latest version is smaller and twice as fast as the ATC 212. It can also hold a greater capacity (240, 360, or 480 different medications). The new model is based on the UNIX operating system, whereas the previous ATC 212 system used the MS-DOS. The advantage of the UNIX system is that it will enable the ATC to interface with Baxter's UNIX-based Sure-Med dispensing system. When the amount of any medication in the Sure-Med dispensing system dips below a par level, it will send a message to the ATC, which in turn, will begin picking refill medications for Sure-Med.

MedServ by Medication Management Systems. MedServ is a mobile automated medication dispensing and charting system designed for long-term and acute-care facilities. It has a computer-controlled access and a touch screen terminal on top for electronic charting of medication administration and nurses' notes.

MedServ interfaces with the pharmacy system and enables it to produce an on-line medication administration record (MAR). As new orders are entered or modified in the pharmacy computer, the MedServ cart is updated. MedServ also creates a charge record at the "point of administration" and transmits it to the pharmacy system for billing and inventory tracking.

Pyxis Medstation and Medstation Rx. The Pyxis Medstation System consists of secure storage units located throughout patient care areas; it is primarily used in acute care facilities.

mated teller machine. All of the secure storage units communicate with the Pyxis control console in the central pharmacy. The storage units consist of a series of locked drawers containing the unit dose medications. To obtain a medication, the nurse must first enter an identification number and a password on the computer keypad mounted on top of the unit. A menu-driven screen allows for selection of the patient and the appropriate medication. The drawer containing the medication is released and the nurse takes the medication. The computer system records and maintains all transactions—including the name of the patient and the description and quantity of items removed, which is used for accounting, restocking, and billing purposes. These transactions can be accessed by nursing and pharmacy personnel. The system also records partial doses, drug returns, and drug wastage.

The Pyxis Medstation Rx System builds upon the Medstation System's capabilities through a sophisticated interface to the pharmacy's computer system. The pharmacy's computer system interfaces with the Pyxis central console. The Pyxis console sends the information to each Medstation Rx unit. Medication profiles are created in the pharmacy system by pharmacists entering medication orders written by the physicians. The medication profile for each patient is transferred to the Medstation unit on the appropriate nursing unit. When a nurse accesses the Medstation Rx and selects the patient's name, the patient's medication profile appears on the screen. The nurse selects the specific medication needed, and the drawer and pocket containing the medication is released.

Drugs other than narcotics are contained in matrix drawers; when this type of drawer is opened all medications are available. When the medication is removed from the drawer, the system automatically bills for the medication, adjusts the inventory, and documents the activity with the name and specific directions of the medication, the patient's name, the nurse's name removing the medication, the time of removal, and the medication count (number of medication units left in the pocket after the transaction). Also, a printout informs the nurse when the last dose of the medication was removed for that patient. The system also has an "override" function, which means certain items such as floor stock and stat medications can be obtained even if not on the patient's profile. This system replaces many pharmacy dispensing functions. It also obviates the need for manual charging, crediting, narcotic counts, and narcotic key searching.

Selectrac-Rx. This is an automated dispensing machine that electronically tracks and documents a hospital's medication usage. The system works by a touch screen monitor. Selections include the patient's name and the drug and quantity specified. Selectrac-Rx automatically dispenses a unit dose, records what drug was taken, keeps a running tab of all medications used for a particular patient, and transmits the information to the hospital system for billing purposes. All transactions require an access code. Unit-dose medications are dispensed from security-accessed cabinets so that other medications are not available. Selectrac-Rx's design accommodates

all forms of medications, including liquid vials, ampuls, and unit dose packets of tablets and capsules. The cabinet also features locking drawers for control of bulk medications. Nurses and other authorized personnel access the SelecTrac-Rx by using an electronic code or magnetic card. SelecTrac-Rx is smaller and much more compact than the Pyxis or Sure-Med systems. In fact, the SelecTrac-Rx can be placed on a desk at the nursing station, operating room, emergency room, or another remote location where medications are regularly dispensed and stored.

LARGER AUTOMATED SYSTEMS

A representative sample of larger automated dispensing systems is shown in Table 2. These systems are designed to serve managed care organizations with larger prescription volumes (e.g., mail-service pharmacies, medium-sized and larger hospitals, health-maintenance organizations, and preferred-provider organizations). Adoption of these technologies will influence departmental design as well as determine, to some extent, the structural alignment of managed care organizations. Thus, besides the effects of regulation and competition on healthcare delivery, technologies are also driving the structural reorganization of healthcare providers in the United States.

Baker Cell Dispensing Systems. This system consists of modular, semiautomated counting cells designed to count, hold, and dispense a quantity of tablets or capsules upon demand. The quantity of a medication ordered is transmitted to the 10×12-inch storage cell via data entry to a master counter keyboard.

Once the medication and quantity have been selected from the control board, the tablets and capsules are counted and dispensed through a delivery chute. A digital readout informs the pharmacist when the transaction is complete, and either the pharmacist or a technician places a standard vial under the delivery chute and releases the closure device, thus opening the chute and emptying the tablets into the vial. The pharmacist manually applies a reclosable cap and the corresponding prescription label.

The Baker Cells System is interfaced with the pharmacy's computer system. This enables the pharmacy computer system to activate the drug cell on command as the prescription label is printed. In multi-pharmaceutical or institutional pharmacies, the Baker Cells can be modified to provide several master control modules operating simultaneously from several work stations.

The major advantage of the Baker Cells System is speed and accuracy. The cells can count up to 10 capsules or tablets per second. However, if the pharmacist wishes to dispense different medications, the cassette must be sent to Baker to be recalibrated, incurring an additional charge and temporarily taking the cell out of service.

The Baker AutoScript II System. This system is designed for high-volume outpatient dispensing. The AutoScript II includes a large number of Baker Cells, an AutoScript II Trans-

The Baker AutoScript II System. This system is designed for high-volume outpatient dispensing. The AutoScript II includes a large number of Baker Cells, an AutoScript II Transport, and a system computer. The transport device is a robotic retrieval system that runs on a track between two walls of Baker Cells. The system can contain up to 1,000 Baker Cells. The cells count and dispense the tablets or capsules into labeled vials, while the AutoScript II Transport retrieves the counted prescriptions. It retrieves up to 24 vials at a time and places them in a special tray.

The system computer drives the entire operation and documents all activity, as well as inventory. This system has the capability of counting 400 prescriptions per hour. It maintains accuracy by triple bar code verification—before, during, and after dispensing. Additionally, it can track prescription numbers, expiration dates, lot numbers, and time of day dispensed.

The Baxter Automated Prescription Bottle Filler System. The Baxter automated dispensing system is designed to dispense large volumes of prescription medications for oral use. The Veterans Affairs Medical Center in Nashville was the first to use the system in 1991 for their mail pharmacy and walk-in prescriptions. The hospital increased its production volume from 1,800 to 3,000 per day without additional personnel or overtime. They also reported the accuracy of this system to be far superior to manual filling. The system can accommodate about 636 different medications and is capable of filling up to 4,500 prescriptions per eight-hour shift. The Baxter system automatically selects an appropriately sized prescription vial and aligns it on the filling line. The bottle filler system fills the prescriptions for a patient by filling a vial with the correct type and number of tablets or capsules. Then, the bottle moves into an area containing a labeling device that affixes a patient-specific, bar-coded label. Next, the labeled bottle moves into a filling zone where medications are counted, bottled, filled, and channeled to the vial "capper," where a child-proof cap is placed. A laser reader ensures that the label information is legible, the cap is on straight, and the medication and count are correct. Completed vials are transported to an accumulator where they are held until they are dropped into the appropriate patient tote or carton, which moves underneath on a sorting conveyor loop.

ScriptPro 200 Dispensing System. The ScriptPro 200 is an automated tablet- and capsule-dispensing system that retrieves prescription information from the pharmacy's host computer, selects an appropriately sized vial for filling, selects the correct solid oral medication from a bank of storage cassettes, counts the dosage forms, fills the vial with the dispensed items, and places the vial on a carousel for labeling and delivery to the patient. After this step, the pharmacist retrieves the vial from the carousel, places a closure cap and a corresponding prescription label on the vial, and delivers the medication to the patient.

The ScriptPro 200 handles four different vial sizes and up to 200 different medications. Items are dispensed at rates up to two tablets or capsules per second, depending on product size, shape, and fill characteristics. The ScriptPro machine is highly accurate, with only one error per 3,000–5,000 pieces. Moreover, errors in counting are usually over by one tablet or capsule, with 100% accuracy in medication selection.

Medication labels are generated by the pharmacy's host computer. The ScriptPro computer interfaces with the host computer to retain prescription information and inform the host computer of the dispensed medication and the corresponding position on the carousel. Prescriptions can be filled automatically via interface to the pharmacy computer or by directly entering through ScriptPro's keyboard.

The Uhlmann UPS 300-M Blister Packing System. The Uhlmann UPS 300 system is a tablet and capsule dispensing machine that packages medications into blister packages ("bingo cards") as opposed to vials. The Uhlmann is designed for a high-volume manufacturing or a repackaging environment but can be adapted to other types of processing if an operation's volume is large enough.

The first process involves feeding products into the machine. After products are fed into the machine, the tablets or capsules are dispensed onto preshaped "blister molds." Each tablet or capsule shape and size may require a different blister mold (which costs approximately $5,000 for each mold), and various blister configurations are needed for different card sizes and card counts. This factor increases the initial cost of the system because some 10–50 molds may be needed. The medications are transferred into the blister-pack cavities created by the mold, and the system then transfers the filled card to a sealing station where a backing is applied and the package is sealed. Labels can be applied in two ways: the label is printed directly onto the material that seals the package or a separate label can be applied. The system processes approximately 900 tablets or capsules per minute. However, a 15-minute changeover time is required to change to a different blister mold.

Yuyama YS-TR-250FD Prescription Dispensing System. This machine is a fully automated tablet or capsule dispensing system that receives the prescription order from the pharmacy host computer, selects the appropriate medicine, dispenses the appropriate quantity into a strip of plastic pouches, and prints a bar-coded label containing prescription label information and patient instructions on the back of the pouches.

The system is highly versatile, holding 250–530 medicines in as many as seven different sizes of storage cassettes. The Yuyama system is capable of dispensing an entire prescription at a rate of one pouch per second with up to four different medicines in each pouch. Medicine integrity is maintained in the cassettes using a bar-code scan, which verifies the placement of each medication in the location (cassette). Although the system is used extensively in Japan, availability in the United States is limited. Moreover, improvements are occurring regularly to make the system more compatible with American medication-packaging needs.

EFFECT OF AUTOMATED DISPENSING TECHNOLOGIES ON MANAGED CARE ORGANIZATIONS

Although automated dispensing machines are purchased as separate systems, their effects will be felt throughout the entire organization as positions are replaced and individuals are reassigned. Some of these issues can be anticipated early if managed care administrators are aware of the effect that automation has on an organization's department. In general, automation will influence four major aspects of the organization:

▼ Design
▼ Intelligence
▼ Decision-making
▼ Performance

Automated dispensing technologies affect the organization's design via departmental structure and process. For example, adoption of an automated dispensing technology would in general reduce departmental diversity. Tasks performed separately at various work stations will now become more centralized and standardized. Reductions in paper work, record storage functions, and documentation can be anticipated, as well as a shift in responsibilities by individuals. With an automated dispensing system, the volume should be large enough to allow batch processing of orders, resulting in substantial departmental savings.

Required technical support staff will become more elaborate, particularly during the planning and initial operation of these machines. Therefore, managed care administrators should seek support from these individuals early in the development phase to ensure continuity in the distribution process. With a separate team focusing on the operational aspects of automated dispensing technologies, pharmacists and nurses will have more time to focus on professional activities. Once these systems are operational, pharmacists and nurses should no longer have to substitute their professional skills for distributive functions during service gaps (e.g., lunch breaks, vacations, holidays).

Consolidation of the dispensing function through automation will create a flatter organization. Fewer administrative functions will expedite the storage, transmission, and retrieval of information. More efficient decision-making will increase the likelihood of successful outcomes as all professional efforts will be directed toward problem-solving. Although the effects of automation on the department will be standardization and conformation, some diversity will also be created as additional staff positions will be needed in categories such as computer support staff, troubleshooter, data entry, and liaison role. In summary, communication will become more open because the units that must participate in departmental endeavors will be easily identified.

Organizational performance can be measured in several ways. One, organizational members will be able to reach their financial goals and satisfy employees and shareholders. Second, quality of care can be improved, as measured by patients' perspectives and internal standards established by designated committees. Third, patient satisfaction with services will help build service equity. Executive officers want patients to associate the name of the organization with quality of care and patient satisfaction. Fourth, performance can be measured as innovative pathways taken by a managed care organization to gain market share and service domains. Customers will identify organizational members for their leadership qualities and their ability to survive in a highly competitive market.

EFFECT OF AUTOMATED DISPENSING TECHNOLOGIES ON SERVICE DELIVERY AND INTEGRATION

The ability to transform loosely coupled healthcare organizations into an integrated healthcare network of providers is contingent upon the use of technology. Companies in the communication business will provide the access and transport systems needed to transmit large databases throughout the network. Networks will be managed at the interface through information technologies in which client server technology will allow the exchange of patient, clinical, diagnostic, billing, accounting, and pharmacy information among various healthcare providers. The major advantage of an integrated healthcare network is the ability to monitor patients' medication use proactively rather than reactively when a medication problem is not identified until a patient enters the community pharmacy. Automated dispensing technologies will improve operational efficiency as well as increase the time available for professional interaction.

Once operational efficiency reaches the healthcare system, critical care pathway development and health management will no longer be the responsibility of one caregiver. Dispensing and information technologies are already triggering a structural realignment of the healthcare system, manifest by the number of healthcare organization mergers, acquisitions, and joint ventures. Many of these organizations are positioning themselves to take advantage of the technologic revolution in healthcare. This integration process will provide an environment for the realization of pharmaceutical care.

CONCLUSION

Technology is influencing the integration and alignment of organizations in the managed care environment. Automation is a specific type of technology that directly affects the organization's design, intelligence, decision-making, and performance. Managed care administrators need to prepare their departmental units for the dramatic effects of technology to ensure the acceptance of automation by professional care givers and staff members. Through a cooperative effort, automated dispensing technologies will help managed care organizations focus on operational efficiency, allowing healthcare professionals to focus on patient-care optimization.

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