

# Pharmacy robots in UK hospitals: the benefits and implementation issues

Stephen Goundrey-Smith looks at the introduction of automated dispensing systems into UK hospitals and examines evidence for their benefits

For many years, hospital pharmacies have adopted new technologies to streamline the dispensing process. In the 1970s the introduction of electronic tablet counters based on optical light-beam technology enabled pharmacy staff to dispense large quantities of routinely used tablets, and such devices became commonplace in the 1980s. Also in that decade, the introduction of computer systems for labelling and stock control had a profound impact on the operational and strategic management of hospital pharmacies.

In continental Europe and the US, where insurance-based healthcare systems are common, dispensing has developed on an original pack basis. Automated dispensing systems designed for original packs were devised for hospitals and healthcare facilities in Europe and America, and there is considerable experience of their implementation.

Patient pack and unit dose dispensing facilitates the use of automated systems for the storage, stock management, picking and labelling of medicines because the need for bulk dispensing of loose tablets and capsules is eliminated and an automated system can control stock on a pack-by-pack or dose-by-dose basis rather than having to maintain a complex database of pack details for every medicine.

Automated dispensing systems were not widely adopted in the UK initially because UK hospitals have traditionally had a mixed dispensing profile, with some bulk dispensing, especially of high use medicines such as paracetamol and co-codamol, together with the use of manufacturer's original packs (of varying quantities) for other formulations.

However, as a result of European Community Directive 92/97, which became law in 1999, the past 10 years have seen a gradual move towards original pack dispensing, encouraged by various UK stakeholders. The adoption of original pack dispensing has facilitated a consistency in prescribing and pack quantities, which has made automated dispensing systems a viable possibility in UK hospital pharmacies. However, the most significant driver for adopting automated dispensing systems in NHS hospitals is the increasing awareness of the organisational benefits that such systems can provide.

In 2001, the Audit Commission report "A spoonful of sugar: medicines management in UK hospitals"<sup>1</sup> highlighted the importance of both original pack dispensing and the use of

pharmacy automation to reduce risks and release pharmacy staff to perform patient-centred services.

Following publication of the Audit Commission report, a number of UK hospitals have implemented an automated dispensing system for their dispensaries. The adoption of these pharmacy robots is likely to continue over the next few years. In addition, a number of community pharmacies have adopted pharmacy robots to streamline dispensing, enabling them to address the requirements of the new pharmacy contract.

The perceived benefits of automation include:

- A reduction in dispensing errors
- Rationalisation of the dispensing process, leading to efficiencies in dispensary throughput and turnaround times
- The enabling of a re-engineering of pharmacy services, which might include developing a ward-based medicines management service and decentralising the clinical pharmacy service

## Systems available in the UK

Automated dispensing systems installed in UK hospitals are the ARX Rowa Speedcase, the Mach4 Pharma Systems (formerly Westfalia Systems) Speedbox and Medimat systems, the Swisslog Pack-Picker and the Baxter Consis System. At present, neither the Swisslog Pack-Picker nor the Baxter Consis system is being sold for new installations in the UK. Automated dispensing systems have also been developed by Robopharma, ScriptPro and Siemens Logistics.

The following is a summary of the operation of the systems installed in the UK. Their technical operation has been reviewed in detail by Swanson.<sup>2</sup>

**ARX Rowa Speedcase** The ARX Rowa Speedcase is the UK market leader, installed in about 120 hospitals.

The Speedcase has a picking head on a track between two parallel sets of vertical shelving. It may be installed as a single unit, but many hospitals opt for tandem installation to increase picking speed, and so that one picking head can provide backup if the other fails.

ARX has developed refrigerator and Controlled Drugs storage units for the Speedcase to increase the proportion of dispensary stock that can be stored by the robot. The performance of the Rowa cold storage units has been independently validated.<sup>3</sup>



Automation can release pharmacy staff to perform patient-centred services

The operating software assigns stock to a random location within the device. The software controls the movement of stock within the machine, alternating between picking, which has priority, and putting stock away, which is done when the dispensing workload is low.

The earlier implementations of the Speedcase required manual and semi-automated loading of stock, where the barcode (European Article Number) of each pack is scanned, and then pack dimensions are measured, to verify pack identification and to assign it to shelf space, before the items are placed on an input conveyor belt. More recently, however, ARX has produced an automatic loading module (the Pro-Logic, or Pro-log), in which items are emptied into a hopper, and the loading process can take place while the device is unattended.<sup>4</sup> It can therefore be run overnight.

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AR also offers combined random access and channel modalities and multiple pack supply functionality (Flash-pack), but, although these increase supply capacity, they are at the expense of in-line labelling.

A recent Rowa development is the Robodose system, a pouch-based unit dose dispensing system. Currently being tested in Germany, this system may provide a solution to monitored dosage system-based dispensing in the UK. UK sites are also considering the application of remote dispensing functions for on-call or out-of-hours supply.

**Mach4 Pharma Systems** Mach4 Pharma Systems has 13 operational sites in the NHS, including the Royal Brompton Hospital, London, and the East Cheshire Hospital, Macclesfield. Mach4 produces two automated dispensing systems — Medimat and Speedbox. The Medimat system, which operates in a similar way to the Speedcase, with random storage and semi-automatic loading, is suitable for low to medium turnover dispensing. The Speedbox system is more suitable for dispensing high-turnover items and is a channel device with manual loading.

The two systems can be installed as an integrated unit to deal with a range of dispensing throughput. In this set-up, the Medimat provides a semi-automatic load for both units but the two devices operate independently as far as picking is concerned.

Mach4 is planning to develop different shaped machines for different departmental space requirements, a ward-based machine and an in-line labelling module.

**Swisslog Pack-Picker** The Swisslog Pack-Picker is in common use in Europe, and has been installed in two UK hospitals — Charing Cross Hospital, London, and the Royal Liverpool University Hospital.<sup>2</sup>

The Pack-Picker consists of two or more storage modules of a honeycomb design, with different cell sizes to cater for a wide range of pack sizes. As with the Speedcase, storage is on a random basis, and the loading process is semi-automatic, with the barcode and product dimensions scanned before the product is assigned shelf space.

**Baxter Consis System** The Baxter Consis system has five UK installations — New Cross Hospital, Wolverhampton, the John Radcliffe Hospital, Oxford, Dartford Hospital (two installations) and Bedford Hospital.

The operation of the system is significantly different to the Speedcase and PackPicker. Product storage is on a channel storage basis, rather than a random storage basis. The stock is loaded manually into pre-determined, gravity-fed channels. The picking head selects a pack from the lower end of each channel. A Consis may have a single picking head, a multiple picking head or a combination of the two modalities.

The advantage of the channel storage system over the random storage devices is a far

higher storage density (around 3,300 packs/m<sup>2</sup>), with a relatively small floor area (footprint). The Consis also has software to perform an accuracy check at the end of the dispensing process, checking the picked product against the label generated by the pharmacy system.

### Robot implementation in UK hospitals

Following the interest in pharmacy automation engendered by "A spoonful of sugar", a number of hospitals have implemented automated dispensing devices and have documented their experiences.

The pharmacy of St Thomas' Hospital, London, installed an ARX Rowa Speedcase device in 2000.<sup>5</sup> At the time, only 150–200 products were stored in the robot. It could not handle Controlled Drugs and refrigerator items, for which Speedcase storage units were not then available, nor could it dispense unlicensed medicines and bulky or fragile items. However, its installation reduced the storage space required in the dispensary and freed space for a counselling area, enabling the pharmacy team to provide a more patient-focused service.

Another early adopter of pharmacy automation was the Wirral Hospitals NHS Trust.<sup>6</sup> In 1999, the trust formulated a business case for an automated dispensing device at Arrowe Park Hospital. The projected benefits were a redeployment of pharmacy staff to the wards and a possible reduction in dispensing errors. The trust chose an ARX Rowa Speedcase and the system went live in 2001. The system held 8,000 items (80 per cent of the dispensary stock) and had an interface with the JAC pharmacy system. At this point, the system still had manual loading, and labelling of items was still a manual process.

In 2003, a number of hospitals installed automated dispensing systems. Among them was the Wolverhampton's New Cross Hospital, which became the first UK site to install a Baxter Consis system.<sup>7,8</sup> The system was set up with two picking heads — one for single items and one for multiple items — and 11,000 items were stored in the device, although Controlled Drugs could not then be stored. The system was extensively evaluated for its benefits during its first year of operation.<sup>8</sup>

The Royal Liverpool and Broadgreen University Hospitals NHS Trust installed a Swisslog Pack-Picker at Royal Liverpool University Hospital, with five picking heads and labelling stations and handling 1,200 high usage product lines.<sup>7</sup> However, the system could not at the time accommodate CDs, refrigerator items or bottles larger than 300ml. The installation enabled the pharmacy dispensing process to be redesigned to support clinical services.

In 2003, ARX Rowa Speedcase machines were also installed in London at the Whittington Hospital<sup>9</sup> and the Royal Free Hospital,<sup>10</sup> and a Swisslog Pack-Picker was installed at Charing Cross Hospital.<sup>2</sup> In the same year, the first automated dispensing device in Wales was installed at the West Wales Hospital,

Camarthen.<sup>11</sup> Again, it was a tandem configuration Speedcase. The device was used for dispensing and ward box filling. Furthermore, it had the capacity to provide remote out-of-hours supplies by on-call pharmacists, an important benefit in a rural area.

### Benefits of pharmacy robots

Much has been made of the perceived benefits of automated dispensing systems in policy documents and the professional literature. However, in the early stages of adoption of these devices in the UK, there was little quantitative evidence for these benefits.<sup>12</sup> For this reason, researchers at the Welsh School of Pharmacy were commissioned to develop an evaluation toolkit for those sites that were planning to implement pharmacy robots.

A number of implementers have published data on the benefits that they have realised on implementing an automated dispensing system. There are three main areas where pharmacy automation has contributed to development of best practice:

**Reduction in dispensing errors** The Wirral Hospitals NHS Trust found that, in the four-month period after implementation of its Speedcase,<sup>6</sup> the incidence of dispensing errors had been reduced by 50 per cent. This is consistent with the fact that, in previous dispensing error logs, the most common dispensing errors were incorrect product selection and incorrect product strength selection,<sup>7</sup> both of which would be almost eliminated by the use of pharmacy automation.

In contrast, the rate of dispensing errors following the introduction of the Baxter Consis at Wolverhampton fell by a more modest 16 per cent during the four months after system implementation, in comparison to the five-month period before implementation.<sup>8</sup> A breakdown of the dispensing error results for Wolverhampton indicates that, although errors such as wrong drug, wrong strength and wrong quantity were reduced, as might be expected, there was an increase in errors in which the product was labelled with incorrect instructions. This may have been because staff had become complacent about the labelling process as a result of the robot implementation, even though the automated dispensing system had no effect on the labelling process, done through the pharmacy system.

These facts suggest that the difference in dispensing error rate reduction between these two centres is possibly due to a different baseline profile of dispensing errors in each department. However, in both cases, these figures would be confounded by the rate of dispensing errors for those items that were not dispensed by the robot, where the error rate would not be affected by the implementation of the system.

Nevertheless, for both of these implementations, the error rate is greater than the absolute error rate cited by the Welsh researchers.<sup>13</sup>

**Dispensing process efficiency** A number of efficiencies in the dispensing process have been observed in system evaluations.

At Arrowe Park, the number of items dispensed per pharmacy technician per hour was observed to rise from 10–12 before system implementation to 15 or more after implementation.<sup>7</sup> The optimised dispensing process there meant that the number of technician-hours in the dispensary could be reduced, with a corresponding increase in the number of technician-hours involved with near-patient services on the wards. This was equivalent to the redeployment of 3.5 whole-time equivalent (wte) pharmacy staff.<sup>6</sup>

At Wolverhampton, dispensing process time allocation data were collected for two similar two-week periods, one immediately before system implementation (August 2003) and one six months after implementation (May 2004).<sup>8</sup> These data indicated, not surprisingly, that the time spent labelling and dispensing was reduced, and restocking the machine took less time than stocking conventional shelves. However, the time spent on performing final checks was increased. Nevertheless, the net effect was that the number of items dispensed increased by 19 per cent and the time spent by staff in the dispensary was reduced by 19 per cent. This latter figure was equivalent to the redeployment of 2.4 whole-time equivalent staff.

As might be expected, surveys of staff attitudes in both the US<sup>14</sup> and the UK<sup>9</sup> indicate that pharmacy support staff are more concerned than pharmacists about the impact of pharmacy automation on their job security. They may therefore see the possibility of redeployment as a threat.

However, such a redeployment enables pharmacy managers to use the best skill mix within the pharmacy team. Thus, the dispensary would have support staff operating the robot, with an accredited checking technician providing the final dispensing check, technicians would run the medicines management service on the wards, and pharmacists would work predominantly on clinical activities. As far as possible, all pharmacist clinical checks of prescriptions should take place on the wards (where it is easier to query issues with clinicians, patients, clinical notes and other patient management systems). In this way, dispensary automation makes possible the re-engineering of pharmacy services throughout the hospital.

It might be expected that pharmacy robots would improve prescription throughput in the dispensary. The Wolverhampton team analysed dispensary throughput using data from their dispensary tracking system before and after system implementation. They found that, while there was an increase in the number of items dispensed in under two hours and a decrease in the number taking longer than two hours, the overall impact on dispensary throughput was modest.<sup>8</sup> Similarly, the Wirral implementers found only a slight improvement in dispensary throughput, expressed as the cumulative percentage of prescriptions completed.<sup>6</sup>



**Installation of automated dispensing devices can reduce the storage space required in the dispensary**

Possible causes of such a modest change in throughput, despite implementation of a robot, are:

- Pharmacy workload generally has increased during the implementation period
- Pharmacy workload has increased specifically because of the adoption of medicines management services, which these reduce bulk supplies but increase the number of individually dispensed items
- A final check on the dispensed item is still required and in a busy dispensary may become the rate-limiting step,<sup>8</sup> limiting the potential of the robot to speed up the dispensary turn-around time

It has also been noted that, following introduction of the robot at Arrowe Park, the time spent ordering medicines has decreased on average by an hour a day.<sup>5</sup>

“A spoonful of sugar”<sup>1</sup> suggested that using automated dispensing systems as a tool for re-engineering pharmacy services would engender increased job satisfaction for pharmacy technicians, by releasing them to be involved in more clinically-focused activities. However, research conducted on staff attitudes to pharmacy automation before and after a robot implementation suggests that the implementation of automation does not have a significant effect on perceived job satisfaction.<sup>9</sup>

**Use of space in the pharmacy** In several centres a major driver for introduction of automated dispensing systems has been the need to reduce shelf space in the pharmacy and to optimise the use of space. In London, at both the Royal Free Hospital<sup>10</sup> and St Thomas’ Hospital,<sup>5</sup> installation of a robot led to more efficient use of space in the pharmacy department.

The effect of robot installation on space use in the pharmacy department was an im-

portant factor in the Wolverhampton system implementation.<sup>8</sup> In their analysis, the footprint (floor space) of the required pharmacy storage space after the installation of the Consis device was 10.2m<sup>2</sup> (equivalent to 7m<sup>3</sup> of space), compared to 14.3m<sup>2</sup> (equivalent to 9m<sup>3</sup> of space) before installation. This space saving was significant in a dispensary with a total area of 77.2m<sup>2</sup>. At Arrowe Park, robot installation led to the reduction of dispensary shelf space by 70 per cent.

### Risks and issues with pharmacy robots

Automated dispensing systems have a number of potential benefits, which have been quantified in detail in some centres. However, as with all automated systems, there are also associated risks. Potential implementers need to be aware of these risks, and that the systems are not promoted to staff as being “risk free”.<sup>9</sup>

The following issues and risks have been noted with automated dispensing systems:

- In their early days, many systems would dispense the required items but would not apply the labels automatically. This meant that a human operator was still required for some of the dispensing process, and that labelling errors were not reduced. This effect is seen in the observed error rate for incorrect instructions on packs at Wolverhampton.<sup>8</sup> This issue has been largely resolved by the development of in-line labelling with pharmacy robots.
- Downtime can occur because of broken bottles, lost bottle caps and split packs in the machine.
- Not all medicines can be stored in pharmacy robots. The potential for service re-engineering and risk reduction is limited by the amount of pharmacy stock still requiring manual dispensing. Again, this was a prominent issue when pharmacy robots were first introduced but it has become less significant with the development of CD and refrigerated storage facilities. However, systems still may not be able to handle large or bulky packs reliably.
- Product barcode mapping is not fully reliable, largely because of barcode anomalies with certain products (in particular, certain branded generics) and a lack of harmonisation across product ranges, due to manufacturer related issues. The recognition rate for medicines by barcode is currently about 70 per cent. For this reason, barcodes are useful for checking that the correct product has been dispensed at the end of the process, but are less useful as a source of information for storing and selecting products.

### Quantification of robots benefits

As automated dispensing systems are, in effect, pharmacy departmental systems operating in a relatively discrete environment, their effects on operational risk are not as complex as with some other healthcare information technology systems, such as electronic pre-

**Table 1: Guidelines for quantification of pharmacy robot benefits**

Parameter	Evaluation recommendation	Other comments
Dispensing incidents	Data on dispensing incidents should be collected, as error rate will be low	—
Distribution incidents	Distribution incidents should be monitored on two separate one-week periods before and after implementation	—
Dispensary turn-around times	Turn-around time data should be collected for inpatient, outpatient and discharge prescription items	It is difficult to get accurate timings for all inpatient dispensed items
Out-of-hours dispensing	Use of the robot remote dispensing function by on-call pharmacists should be analysed	The out-of-hours cost analysis should take into account cost of travel to hospital and time off in lieu
Stock control	Staff resources (cost and time) spent on stock-taking activities should be analysed before and after implementation	—
Dispensing rate	Dispensing rate data should be collected on three consecutive days before implementation and on two intervals of three consecutive days after implementation	—
Distribution workload	Data on time spent on different distribution-related activities should be collected for a one-week period before implementation and a one week period after implementation	Workload survey results should be compared with issue statistics
Support staff attitudes	The attitudes of pharmacy support staff should be surveyed by questionnaire and/or other methods	The design of the survey and methodologies used should be customised to the needs of the department
Ward staff attitudes	The attitudes of ward staff should be surveyed by questionnaire six months before implementation and six months after implementation	—
Outpatient satisfaction	Outpatient satisfaction should be surveyed by anonymous questionnaire for two periods of two weeks, before and after implementation	—

research parameters and endpoints when performing a quantitative analysis of robot performance. They are shown in Table 1.

Analysis of the performance of individual automated dispensing implementations, and publication of the results, will provide information to help other hospitals construct a business case for installing a robot. The availability of quantitative data will also ensure that the stand-alone benefits of pharmacy robots are fully understood before interfaces with other systems become widespread.

### Conclusions

Published evidence suggests that automated dispensing systems (pharmacy robots) provide benefits in the following areas:

- Reducing dispensing errors
- Improving the efficiency of the dispensing process, and enabling the re-engineering of pharmacy services
- Optimising the use of space in hospital pharmacy departments

The extent to which these benefits are realised will depend on the way pharmacy automation is implemented in each hospital, and hospital pharmacy managers should consider their service objectives before embarking on an automation project. Nevertheless, it may be argued that, in general terms, the pharmacy service improvements relating to the use of automation envisaged in “A spoonful of sugar” are now being realised in hospitals that have pharmacy robot implementations. It is to be hoped that pharmacy robot suppliers will continue to develop their systems and provide enhancements to meet emerging functional requirements as hospitals begin to work with re-engineered or decentralised pharmacy services.

As with electronic prescribing, there is a relative dearth of quantitative data on the benefits of pharmacy automation. It is important that hospitals conduct work to quantify the benefits of pharmacy automation and publish their findings. This will provide helpful evidence for hospitals putting together a business case for automation and will ensure that the benefits of pharmacy robots are fully understood before any move is made to integrate them with other electronic medicines management technologies.

scribing. The various methodological issues and confounding factors in evaluating electronic prescribing and prescribing decision support systems are well documented,<sup>15</sup> and have led to a call for standardisation of methodology used to evaluate such systems.<sup>16</sup>

Few published papers provide a quantitative performance analysis of individual pharmacy automation implementations. It is to be hoped that more NHS hospitals publish quantitative data on the performance of their pharmacy robots, to share experience with those still considering implementing such technology and also to enable pharmacy managers to formulate benchmark perform-

ance and risk management data for pharmacy robots.

This will provide a baseline analysis for robot performance while robots are still discrete, departmental systems. When, in the future, pharmacy robots are interfaced with systems outside the pharmacy — such as electronic prescribing systems, oncology management systems and wholesaler systems — other factors will confound the analysis of robot performance.

The Welsh Academic Pharmacy Practice Unit was commissioned to produce a toolkit for the evaluation of robot performance,<sup>12</sup> and this has produced helpful guidelines for

### References

1. Audit Commission. A spoonful of sugar: medicines management in NHS hospitals. London: Audit Commission: 2001.
2. Swanson D. Automated dispensing: an overview of the types of system available. *Hospital Pharmacist* 2004;11:66–8,77
3. Black A, Brice S, Hardy L, Longshaw R. Validation of cold storage shelves in an automated dispensing system. *Hospital Pharmacist* 2006;13:372–4.
4. Brice S, Hardy L, Longshaw R. Evaluation of automatic loading devices with a Rowa Speedcase system. *Hospital Pharmacist* 2006;13:375–8.
5. Gross Z. Robotic dispensing device installed at St Thomas’s Hospital. *Pharmaceutical Journal* 2000;265:653–5.
6. Slee A, Farrar K, Hughes D. Implementing an automated dispensing system. *Pharmaceutical Journal* 2002;268:437–8.
7. Clark C. Pharmacy Automation. *Pharmaceutical Journal* 2003;271:590–1.
8. Fitzpatrick R, Cooke P, Southall C, Kauldhar K, Waters P. Evaluation of an automated dispensing system in a hospital pharmacy dispensary. *Pharmaceutical Journal* 2005;274:763–5.
9. Coleman B. Hospital pharmacy staff attitudes towards automated dispensing before and after implementation. *Hospital Pharmacist* 2004;11:248–51.
10. Royal Free robot launch. *Pharmaceutical Journal* 2003;270:359.
11. Robot will enable remote dispensing. *Pharmaceutical Journal* 2003;271:438.
12. Whittlesea C, Phillips C, Roberts D, Burfield R, Savage J, Way C. Automated dispensing: how to evaluate its impact. *Hospital Pharmacist* 2004;11:283–5.
13. Whittlesea C. What did the research reveal about the effects of introducing automation? *Hospital Pharmacist* 2004;11:453.
14. Crawford SY, Grussing PG, Clark TG, Rice JA. Staff attitudes about the use of robots in pharmacy before implementation of a robotic dispensing system. *American Journal of Health-System Pharmacy* 1998;55:1907–14.
15. Trent Rosenbloom S. Approaches to evaluating electronic prescribing. *Journal of the American Medical Informatics Association* 2006;13:399–401.
16. Summers V. Cited in: Electronic prescribing: the way forward? (report of Association of Scottish Chief Pharmacists meeting). *Pharmaceutical Journal* 2000;265:834.