

# Impact of large-scale automation on healthcare staff

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## Abstract

New technological advancements are often a driver for change in the redesign of services. More research is needed to better understand the impact of socio-technical dimensions on the implementation of new technological systems in hospital pharmacy. This paper aims to analyse the experiences arising from the large-scale automation of medicines distribution. The introduction of new technology may not only lead to unintended first-order consequences, but can also generate potentially serious adverse feedback loops between the social and technical dimensions. In addition, the longer-term impact of new technology may be quite different for different groups of healthcare staff.

**Keywords:** Healthcare operations management, Healthcare technology, Socio-technical systems

## Purpose

New technological advancements are frequently a driver for change in the redesign of healthcare services. Such change often involves a lengthy and challenging process (Hendy et al., 2007). More research is needed to better understand the impact of socio-technical dimensions on the implementation of new technology in hospitals (Sheikh et al., 2011).

### *The pharmacy service redesign project*

This paper reports on research into the large-scale automation of medicines distribution in a large regional health organisation in the UK. The pharmacy service is delivered on 14 hospital sites, involving approximately 530 pharmacy staff and an annual expenditure on medicines of around £120 million (€138 million). In 2008 the Executive Board of the organisation adopted a redesign proposal with the following key objectives: (a) to redefine the core business around ‘patients own medicines’ medication management for hospital inpatients (known by staff as the ‘MyMeds’ initiative); (b) to redesign, consolidate and automate hospital pharmacy medicines distribution, in order to release staff to near-patient tasks as part of integrated clinical teams; and (c) to adopt new technology as an integral part of this redesign.

A key element in the redesign has been the opening of a Pharmacy Distribution Centre (PDC) in the spring of 2010 to replace 11 different in-hospital pharmacy stores. The PDC is now the single facility responsible for the procurement and automated distribution of medicines to replenish ward and site pharmacy stocks for all hospitals and community clinics in the region. Within the PDC, eight advanced robots (ROWA VMAX Extent2) are working in tandem as an integrated storage and distribution system, with an additional robot (ROWA Speedcase Select) installed within a vault for safe and secure handling of narcotic agents. In addition, there are three areas where staff have to hand-pick items that are not suitable for robotic storage. The capital investment in the nine robots and associated equipment was around €1.25 million. This constitutes the largest automation project (by size and scale of activity) for hospital pharmacy in the UK and, to the knowledge of the robotic system supplier, the integrated system of robots is double the size of any other current installation worldwide.

This automation project had significant implications for jobs, work organisation and employees’ experiences. Most pharmacists, many pharmacy technicians and some pharmacy support staff were relocated from dedicated dispensaries at hospital sites to ‘nearer the patient’, ward-based activities. In this, the key role of ward-based pharmacy technicians involved the delivery of the MyMeds initiative: arranging prescriptions for, and gathering information from, patients; and supporting the work of ward-based pharmacists. Other pharmacy technicians and many members of support staff were redeployed to the PDC to manage, maintain and facilitate the automated distribution processes. Finally, a minority of pharmacy staff were retained to deliver the remaining support services provided by hospital dispensaries.

### *A brief note on relevant academic literature*

There is now a fairly extensive literature on the use of pharmacy robots in hospitals. Chapter 4 (on pharmacy automation) in the recent monograph by Goundrey-Smith (2013) provides a useful summary of the current state of knowledge on this topic, with special attention to the situation in the UK. However, most of the attention has so far focused on relatively small-scale dispensing systems (Crawford et al., 1998; Coleman, 2004; Fitzpatrick et al., 2005) rather than large-scale distribution systems, as in the present case. There is considerable evidence on both theoretical and empirical grounds (Hendy et al., 2007; Cresswell & Sheikh, 2009; Greenhalgh & Stones, 2010) that the severity of implementation problems is likely to increase disproportionately with the scale and complexity of a healthcare technology installation. Additionally, from a social and human point of view, there are still important questions about the nature of interactions within a network of human actors and technological entities (such as IT systems or robots) in the longer term (Edmonson et al., 2000; Cresswell et al., 2010; Papadopoulos et al., 2011).

### *The purpose of this paper*

Given the scale of the automation project and its critical role in supporting the intended improvements in the quality of patient care as well as the quality of the pharmacy service and its overall cost effectiveness, the main purpose of this paper is to analyse the impact of the large-scale automation of medicines distribution on healthcare staff, in both the initial stage of implementation (when the risks of overall systems failure were greatest) and the somewhat longer term (when early technical problems had been largely overcome but certain staff concerns were still evident).

From a theoretical perspective, the analysis is primarily set within a socio-technical systems framework, as this enables due attention to be paid to both the technical and the social dimensions of a technological innovation, as well as the interactions between these dimensions (Trist, 1981).

### **Methodology**

The research reported on in this paper was based on two separate waves of interviews with staff involved in the redesign project. Purposive sampling (Mays & Pope, 1995) was guided by the research aims, the on-going discussions within the Project Board and also the information received from hospital sites on their progress. In the first wave of interviews, thirty-six pharmacy staff from four hospital sites (700-900 inpatient beds per site) were interviewed in the summer of 2010. At each hospital site, the set of interview participants included pharmacists, pharmacy technicians (of varying seniority), assistant pharmacy technicians and temporary staff. The interviews were largely unstructured and explored participants' expectations, experiences, opinions, challenges – and also possible solutions to these challenges – with regard to the pharmacy redesign programme, with a particular emphasis on the automation project.

To obtain a somewhat longer-term perspective, another thirty-six pharmacy staff were interviewed in a second wave in the second half of 2012, again including pharmacists, pharmacy technicians and support workers. These interviews semi-structured and focused on the employees' experiences of the redesign programme and impacts on their jobs and work experience. A complementary 'key stakeholder' element of the research involved ten in-depth interviews with representatives of management, employee partnership groups and trade unions.

### **Findings from the first wave of interviews**

The data analysis was iterative and based on a combination of inductive coding and thematic analysis using NVivo software (Fereday & Muir-Cochrane, 2006). Themes emerging from first-pass coding of the first wave of interviews included issues relating to the new PDC, technological issues, personnel issues, and any other apparent areas of staff concern.

These early topics appeared to fit within a socio-technical systems framework, which then enabled six key themes to be identified. Three themes related to the technical dimensions of the newly redesigned system; namely, issues associated with the robotic storage and distribution system, the pharmacy management system, and sourcing medicines unavailable from the pharmacy distribution centre. The other three themes related to its social or human dimensions; namely, understanding staff roles within the new system, the importance of effective communication, and the effect of the redesign on staff morale.

### *The robotic storage and distribution system*

As the new procedures for ordering medicine supplies from the automated PDC were implemented, each of the study sites reported frequent errors in orders received, particularly in their first weeks of going live. Although the picking heads were generally working well, there were numerous malfunctions in the conveyor system that transferred medicines picked by the robots to the correct boxes. When a medicine was ordered from the PDC but did not arrive within the expected time, nursing staff frequently became concerned that the order had been lost and ordered the same item again, thereby creating multiple small orders. On other occasions, local pharmacy staff tried to reduce the time and effort required for unpacking and sorting medicines by ordering bulk quantities – which led to additional frustration if the PDC could not supply such large quantities all at once.

#### *The pharmacy management system*

Staff at all sites reported serious problems with the pharmacy management system to order medicines from the PDC. Before going live, the management systems across all local sites had to be effectively consolidated and integrated, which involved the development of a single centralised medicines database from multiple drug catalogues. Each hospital was required to upgrade the pharmacy system to the most recent, web-based version. This software upgrade was undertaken on a scale several times that of any previous effort, and it proved unexpectedly problematic. This situation was complicated further as not all hospital sites were equally assiduous in enforcing the software upgrade. Attempts by some local staff to stick with the old, familiar version of the system tended to have a further negative effect on the efficiency and accuracy with which information was transmitted and processed.

#### *Sourcing medicines unavailable from the PDC*

At each site, staff raised the problem of having to source particular medicines that were not present in the hospital dispensary, because the PDC could not supply the items when required. In such cases, pharmacy staff had to source the medicine from other wards in their own hospital or from other hospitals. Inaccurate stock level data on the pharmacy management system significantly contributed to this problem. As acknowledged by staff at one site, this was caused by a lack of time to conduct proper stock checks. But a deeper cause of frustration seemed to be that all hospital pharmacies had been asked to reduce their local stock levels by eliminating distribution stock and only holding stock for individual patient dispensing and ad hoc orders required between scheduled PDC deliveries. Pharmacy staff apparently felt that they could not run down their stocks to the recommended levels without losing their ability to cope with unexpected demands.

#### *Understanding staff roles within the automated storage and distribution system*

Interviews pointed towards a feeling of unknown with respect to the centralised storage and distribution system and the precise roles of local pharmacy staff within that system. Despite earlier efforts by senior management to widely inform and consult staff, participants frequently indicated that they did not fully understand the purpose of the PDC or the motivation for the redesign. From the outset, they had felt that management's description of how the PDC would work was "too simplistic and ill-thought-out". They felt alienated from those responsible for the redesign programme and thought that their views had not been sufficiently listened to during the initial implementation phase. This was compounded by the fact that a substantial proportion of technicians and support staff had been moved to the PDC, leaving the pharmacy staff remaining in the hospital sites with the feeling of "too much, too soon".

### *The importance of effective communication*

Interview participants raised a lack of effective communication as an issue in relation to several aspects of the automation project's progress. They reported that, when asked to share their concerns and questions with senior management, they did not know whether their opinions and experiences were taken into account. Some staff also felt that they could not approach their local managers with their worries, as they were aware that management had concerns of their own. They found it hard to prioritise their work, and felt unsupported in this. Local pharmacy staff were unclear about the delivery days and times for their orders and found it hard to coordinate their activities with the order cut-off time set by the PDC for same-day delivery. They often felt like "piggy in the middle": when the PDC failed to send particular items by the time expected, ward staff would complain to the pharmacy department, instead of contacting the PDC

### *The effect on staff morale*

Morale among many pharmacy staff members was low during the early stages of implementation. They felt a personal and professional responsibility to the patients, but doubted whether the new system was the right way to enable them to provide safe care. At one of the sites, for example, the pharmacy team indicated their preparedness "to go the extra mile". However, they felt that staff at the PDC did not fully appreciate the new system's impact on patients: the system was not allowing them to fulfil the philosophy of "getting the right treatments to the right patients at the right time". Some interviewees described what they felt was a "heart-breaking drop in standards", as they strove to provide the best possible service.

### *Discussion of the findings from the first wave of interviews*

The results from the staff interviews discussed above indicate the severe unease among many pharmacy staff from the start of the automation project. One possible reason relates to the specific nature of this project. The radical restructuring of the distribution system for hospital medicines can be thought of as an attempt by senior pharmacy management to take, what Hayes et al. (2005) have termed, a "strategic leap" in order to achieve a "breakthrough improvement" in organisational performance. Breakthrough improvements projects are typically top-down in nature and they tend to be based on a technology-centred model of implementation (Sheikh et al., 2011; Hayes et al., 2005). Such strategic leaps require heavy investments in money and time by senior management, assisted by the necessary technical specialists. In contrast, staff lower down in the organisation will only become actively involved upon the system go-live date: they simply have to work within the technical structure that senior management have devised for them. In such circumstances, an integrated approach to organisational and technical change may be hard to accomplish (Doherty & King, 2005; Clegg, 2000).

The robotic storage and distribution system can be seen as a socio-technical system. The technical dimension includes both machines and the associated work organisation; and the social dimension covers the grouping of individual employees into work groups or teams, as well as the amount of autonomy granted (by management) to such work groups or teams to plan and control their own activities and make operational decisions (Mumford, 2006). The overall effectiveness of such a system depends on how well the technical and social elements shape, fit and complement each other (Cresswell et al., 2010).

The previous (i.e. legacy) design configuration of the storage and distribution system was decentralised in nature, in terms of both its technical and social dimensions. The local

pharmacy team in each hospital formed a cohesive unit, in charge of both distribution and dispensing of medicines. In the new configuration, the technical dimension became strongly centralised through the introduction of a large-scale robotic system in a separate location. Furthermore, the local instances of the pharmacy management system were replaced by a version controlled from the centre. But a key element in the social dimension – namely, the responsibility for the dispensing of medicines to individual hospital patients – was still decentralised and under the control of each local pharmacy team. To the latter, it could easily seem that the previously integrated nature of the distribution and dispensing process had become fragmented and that the centralised characteristics of the technical dimension were no longer in step with the decentralised characteristics of the social dimension.

At the start of the implementation phase, there appeared to be a widespread feeling among pharmacy staff that they were left to their own devices in a system over which they had lost a lot of control. After the go-live dates at each successive hospital, such worries could only be compounded by rapidly emerging failings in the technology, such as the numerous malfunctions in the automated conveyor system at the PDC or the problems with the pharmacy management system at the sites. Unfortunately, although unanticipated in the design phase, such technical problems are not at all uncommon in practice, especially if the new technology is still largely untried – either because of its highly innovative nature or, as in the present case, primarily because of the very large scale of its implementation (Sheikh et al., 2011; Robertson et al., 2010).

In the course of this initial phase of the research project it became increasingly clear that the negative interaction between the technical dimension of the new system and its social dimension was two-way. The technical problems obviously had a negative impact on the ability of each local team to provide an effective pharmacy service to their patients. This reinforced pharmacy staff in their view that labour-saving robotic technology was inappropriate in the context of their professional culture. However, the causation also started to run the other way. Because the local teams doubted the ability of the robotic system to respond to orders with the very high level of consistency required, they took ‘defensive’ action. Instead of trying to drive down medicine stocks in the hospital pharmacies and wards, local teams began to order more and more frequently. As a result, the workload of the PDC only increased, putting even more strain on the distribution system.

This adverse feedback loop is a specific example of a more general observation that the implementation of a large and technically complex system is likely to result in unintended consequences that are almost impossible to specify beforehand and for which standard solutions are not yet available (Greenhalgh & Stones, 2010). In the present case, each of the local pharmacy teams did have some leeway to devise local solutions to the problems they faced. But such efforts were not equally prominent across all sites, which raises the question of how to trace the nature of interactions within a network of human actors and technological entities (such as IT systems or robots) over a longer time period (Edmonson et al., 2000; Cresswell et al., 2010; Papadopoulos et al., 2011).

#### *Progress between 2010 and 2012*

By the summer of 2012, most of the early implementation problems, particularly those of a technical nature, had been surmounted by a combination of efforts directed from the centre and local learning, although more work is still to be done to extract all of the possible benefits. The decision to introduce a PDC nightshift in 2011 was seen as an important event by all involved in the redesign project. Beforehand, the robots would restock themselves with medicines from a conveyor overnight. However, when any jam

occurred then the system stopped, resulting in limiting access to stock for supply and frequent out-of-stock communications to sites. The introduction of the night shift minimised this and ensured the robots were fully stocked for processing orders each day.

External auditing on behalf of the health authority reported the following benefits of this redesign programme: a substantial release of floor space, more effective use of pharmacy staff, patient safety improvements, stock rationalisation and order-processing efficiencies, pharmacy stock waste reduction, and processing and administration enhancements. With respect to the main objectives of the wider redesign of the pharmacy service, clinical pharmacists are now available on more than 90% of inpatient wards (prior to the redesign, this was 60%) and the 'patients own medicines' ('MyMeds') bedside dispensing model is now used for more than 94% of inpatient beds (previously 36%).

However, senior management was still concerned about the longer-term impact of the new technology on social and human issues. Therefore, in-depth interviews were arranged with a sample of pharmacists, pharmacy technicians and support workers to explore the following issues: management-employee communication and consultation on the redesign process; resulting changes in opportunities for learning and progression; and impacts on job quality and especially work intensification.

### **Findings from the second wave of interviews**

In meetings and interviews with the research team, senior managers consistently highlighted the potential for robotics technologies to eliminate repetitive, routine activities, allowing opportunities for staff (especially pharmacy technicians) to use their skills more effectively on hospital wards, and develop new learning through closer collaboration with pharmacists and other clinical professionals. Interviews with employees found that these opportunities for development had been realised, but only partially.

#### *Impact of the redesign project on training opportunities for staff*

Pharmacy technicians reported that, prior to the redesign programme, much of their training was informal and experiential, supported by more senior technicians and pharmacists. This informal training, alongside rotation through the different functions within hospital pharmacies, was seen as important in developing and maintaining technicians' skills. The redesign programme required that new roles for technicians were met with additional and more formalised training opportunities; and technicians reported having undergone an array of training, both formal and informal, to enable them to meet their altered responsibilities. Many technicians recalled positive experiences of retraining, in terms of improved skills utilisation within their job roles, and enhanced self-confidence, particularly in their relationships with patients and clinical professionals.

Among pharmacy support workers, on the other hand, interviewees were split fairly evenly between those who felt that they received insufficient training upon redeployment and those who reported participating in new learning opportunities that they considered useful. The latter, more positive, responses came most often from support workers who had been redeployed to work closely with hospital ward-based pharmacy technicians as part of the MyMeds initiative. However, some among the former group reported being unable to access training, due to lack of resources or staff to cover their absence. This, coupled with increasingly limited opportunities to rotate between teams and roles, limited their access to new skills.

Furthermore, there was consensus among support workers that, even following training, opportunities for progression were severely limited, due to low turnover in higher-skilled (technician) posts and a freeze on additional recruitment. Undertaking full-

time training towards technician grade could require support workers to leave their existing job, with no guarantee of a promoted post upon completion. Such uncertainty had proved a major disincentive to undertake training.

#### *Different experiences between front-stage staff and back-stage staff*

Pharmacy technicians involved in the delivery of ward-based MyMeds services tended to value both the opportunity to work closely with clinical professionals, and the sense that they were directly involved in the delivery of services to patients (although there was some variation in the extent to which these benefits had been realised, depending on the completeness of the MyMeds roll-out across different hospital sites).

Similarly, many pharmacy support workers engaged in front-stage activities reported greater control over how to prioritise their tasks. Again, this was particularly the case for those working closely with ward-based pharmacists and technicians as part of the broader MyMeds initiative. The opportunity to engage in more challenging and collaborative work, rotating within a range of hospital-based environments, had produced considerable benefits in terms of learning, task variety and job satisfaction for these employees.

However, both staff and managers acknowledged that pharmacy technicians redeployed in a back-stage capacity to the PDC could be disadvantaged in terms of opportunities for progression. There were concerns that the specific skills required to work with automated technology in a distribution centre were limited in their transferability; while opportunities to develop a wider range of skills (and the experience of working within inter-disciplinary teams in a hospital setting) were not available to these employees. Rotation between teams and tasks – previously a common feature of pharmacy careers – had been restricted by a redesign programme that rationalised job roles, with negative impacts for back-stage employees.

Similarly, support workers employed in the PDC felt that their roles had become more detached from the delivery of pharmacy services to patients. Concerns were raised that their new job roles offered relatively few opportunities for a broader range of interactions with clinicians, pharmacy colleagues, patients and ways of working.

#### *Discussion of the findings from the second wave of interviews*

Our analysis of the findings from the second wave of interviews identified three recurring themes. First, confirming a key result from the first wave of interviews, there was limited scope for employee engagement in shaping the decision-making or implementation process. Second, different groups of employees had varied post-redesign opportunities for personal development. Third, the redesign seemed to have a polarising impact on perceptions of other aspects of job quality: those delivering front-stage services, ‘nearer to patients’, reported benefits, in sharp contrast to some colleagues redeployed to perform back-stage standardised tasks within the robotics-driven distribution centre.

Front-stage pharmacy staff, specifically those working within fully operational MyMeds wards, had been ‘freed’ by new technologies to engage in more demanding and rewarding work ‘nearer the patient’, rotating between roles and learning through inter-disciplinary collaboration. In effect, the new technology enabled such staff to spend a greater proportion of their time on clinical activities and thereby to enhance their range of professional skills and experience.

However, back-stage pharmacy staff based in hospital dispensaries, and particularly those employed in the PDC, experienced more negative effects on their job quality. They found themselves with relatively few opportunities for collaboration, role rotation and learning, and reported a sense of isolation from mainstream pharmacy work.

Finally, it should be noted that employees across a range of job roles felt that a reliance on technology to try to deliver ‘more with less’, in place of sustaining and growing staff numbers, had negative impacts in terms of intermittent experiences of work intensification and limiting opportunities for training and progression.

### **Contribution**

The empirical evidence on the success of technological innovations in healthcare systems is decidedly mixed (Cresswell & Sheikh, 2009). There is considerable evidence on both theoretical and empirical grounds that the severity of implementation problems is likely to increase disproportionately with the scale and complexity of a healthcare technology installation (Greenhalgh & Stones, 2010). This paper contributes to the academic literature in this area by reporting on theoretically well-grounded empirical research into the complex interplay between the technical and social dimensions of a large-scale automation project.

A key finding from the initial stage of the research was that the introduction of new technology in healthcare may not only lead to unintended (although not necessarily unexpected) first-order consequences such as initial staff resistance, but can also generate potentially serious adverse feedback loops between the social and technical dimensions of the new system. This is a specific example of a more general observation that the implementation of a large and technically complex system is likely to result in unintended consequences that are almost impossible to specify beforehand and for which standard solutions are not yet available (Greenhalgh & Stones, 2010). In the present case, such problems have been largely resolved over time through a mixture of central direction and local initiatives.

A key finding from the second stage of the research is that the longer-term impact of new technology may be quite different for different groups of healthcare staff. In particular, new automated systems may free front-stage staff from more routine administrative activities, enabling them to spend more time directly with patients. On the other hand, back-stage staff may well find that their learning opportunities and promotion possibilities are curtailed as a result. Among the clear practical lessons to be drawn from our research is that managers, employees and other stakeholders should collaborate in order to identify ways to facilitate rotation between roles and teams for the broadest possible population of staff. In the longer term, there would be benefits in a strengthening of planning to facilitate staff training and progression, given the context of tight staffing budgets.

Finally, although due account should be taken of the integrated structure of Health Boards in NHS Scotland (whereby hospitals are directly managed by the acute division of each local NHS Board), a centralised procurement and distribution hub of the kind described here might also be a model for pharmacy services elsewhere, particularly in large population centres serviced by many hospitals.

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