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NHS Greater Glasgow and Clyde Acute Pharmacy Redesign Program

NHS Greater Glasgow and Clyde

Acute Pharmacy Redesign Project

This work was undertaken by the Strathclyde Institute of Pharmacy and Biomedical Sciences, and the Department of Management Science, University of Strathclyde, in collaboration with the NHS Greater Glasgow and Clyde Acute Pharmacy Redesign Project Team

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1.0 Executive Summary

NHS Greater Glasgow and Clyde are in the midst of a major pharmacy redesign program which aims to maximise the application of technology within the medicines supply chain and release staff to deliver improved patient care through the Making the Most of My Medicines (MMyM) service.

This report discusses the findings from a study undertaken by a team of researchers from the University of Strathclyde and the Pharmacy & Prescribing Support Unit (PPSU), in support of the redesign programme. In particular, the study focused on the implementation of a new approach to in-patient medicines management, designed by the PPSU. This approach takes the form of a robotic pharmacy distribution system, installed in a newly-built, centrally-located Pharmacy Distribution Centre (PDC). The study was conducted January to September 2010.

The aims of the study were, first, to develop a suitable metrics framework for the new pharmacy distribution system and, second, to capture the organisational learning gained from the initial implementation phase of the PDC. However, as the project progressed it became clear that the primary focus would be on capturing organisational learning and providing expert advice to support implementation before a more effective performance measurement framework could be designed.

The key challenges faced during the initial implementation of this complex redesign programme are summarised under three areas:

Role of the new PDC in the medicine supply chain: technical problems with the ARx robotic system; lack of functionality of the Ascribe software; communication between the PDC and the hospital sites; absence of comprehensive and up-to-date management information; and the need for further process analysis and measurement across the system.

Use of inventory management approaches and procedures: variety of approaches in use (continuous review at the PDC / periodic review at the hospital sites); comparative informality of many procedures and decision rules across the system; minimal confidence in the dependability of inventory replenishment; and functionality of Ascribe software.

Organisational change: issues highlighted through the PPSU Work Positive Survey, supported by a range of site visits, interviews and group discussions included: concerns with staffing levels; communications within and between sites and the PDC; staff morale; and specific problems relating to the operation of the new distribution system.

As a result of these findings, the report makes three sets of recommendations relating to:

- (1) standardising processes, improving quality and sharing best practice
- (2) improving staff morale
- (3) analysing and improving inventory management procedures.

These recommendations are complemented by a proposal for a new, multi-layered performance measurement framework. This would consist of a Balanced Scorecard for strategic control (quarterly, monthly), into which feeds an Operational Dashboard for operational control (weekly, daily), all of which would be underpinned by a lean six sigma improvement framework (incorporating FMEA and HACCP techniques, wherever possible).

In conclusion, the implementation of the new pharmacy distribution system has been an incredibly challenging and rewarding experience for those involved. When fully operational the system will represent a considerable innovation in the pharmacy supply chain community.

2.0 Introduction

The NHS continues to be one of the most advanced and well-respected health care providers in the world. This reputation can, in part, be attributed to the patient-focussed nature of the service coupled with innovative and efficient practice permeating all levels of the organisation. With recent developments in automated technology offering improvements in speed, accuracy and cost, the pharmacy distribution function could be considered ripe for redesign. There has, however, been a lack of any comprehensive reform of practice UK-wide over the past few decades, and as a result, the NHS has failed to keep pace with private sector organisations in terms of logistics and distribution. When the scale of pharmaceutical consumption across the UK is considered, it is perhaps surprising to find that only a limited number of forays have been made into new technological areas such as automating pharmacy distribution – though a building momentum looks set to change this.

There are manifold reasons for Health Boards to consider automated dispensing systems (ADS). Firstly, accuracy is considered a chronic problem in healthcare systems worldwide (1). At every stage in the supply chain that a different worker has contact with a patient's medicine, the risk of error increases exponentially. Secondly, ever increasing constraints on healthcare budgets force a continuous cycle of efficiency and cost cutting - normally with the stipulation that challenging key performance indicators (KPI's) are maintained. ADS systems, in theory, allow pharmacy functions to free up resource from time-consuming order filling activities, and to reallocate manpower to front-line, value-adding activities that involve patient contact. A considerable financial benefit can also be realised by reducing stockholding, improving efficiency and rationalising inventory management processes (See section 5.2 - Process Analysis, and 5.3 - Inventory Management for more detail).

2.1 The Scottish Context

NHS Scotland is composed of a number of smaller semi-autonomous Health Boards: NHS Ayrshire and Arran, NHS Borders, NHS Dumfries and Galloway, NHS Western Isles, NHS Fife, NHS Forth Valley, NHS Grampian, NHS Greater Glasgow

and Clyde (NHS GG&C), NHS Highland, NHS Lanarkshire, NHS Lothian, NHS Orkney, NHS Shetland and NHS Tayside. Each Health Board is responsible for managing its own budget and each Health Board must respond to unique problems that are faced within an area, be it problems associated with providing healthcare in remote areas (NHS Highland), or those associated with densely populated urban areas (NHS GG&C).

As a result of these different needs, there has been a considerable variance in the way automation has been adopted in Scotland. A recent survey of six Health Boards (2) has shown that pharmacy distribution functions in NHS Tayside, NHS GG&C, NHS Forth Valley, NHS Grampian and NHS Ayrshire & Arran, have all implemented some form of ADS (Table 1). The difference that exists between Health Boards however normally lies in how the particular robot is utilised, whether for dispensary purposes alone, distribution, or a combination of the two. One notable exception that exists in Scotland is NHS Lanarkshire, which has effectively outsourced parts of the pharmacy distribution functions to the specialist provider AAH Pharmaceuticals. Although NHS Lanarkshire do not have any direct contact with automated machinery as a consequence of this setup, indirectly, the systems at AAH Pharmaceuticals which supply the Health Board involve state-of-the-art advanced automation and follow lean management principles.

On reflection, automation can be considered generally successful in the majority of rollouts across Health Boards in Scotland. Many of the ADS schemes began on a relatively modest scale and are physically located in hospital sites, meaning that any cultural changes associated with the technological transformation have been gradual rather than sudden. Health Boards such as NHS Grampian and NHS Tayside have also benefited from existing, centralized distribution models going back over 20 years that have allowed for a relatively smooth transition to the new automated systems.

Table 1: The extent of automation in Scottish Health Boards

Health Board	Automated Dispensary	Automated Distribution	Outsourced
NHS Tayside	x	x	
NHS Forth Valley	x	x	
NHS Grampian	x		
NHS Ayrshire & Arran	x	x	
NHS GG&C		x	
NHS Lanarkshire			x

2.2 NHS Greater Glasgow and Clyde

NHS Greater Glasgow and Clyde (GG&C) is Scotland's largest Health Board, which, despite a relatively small geographical spread, serves a population of 1,196,335. NHS GG&C initiated a major service redesign programme that was approved in August 2008. The project's main aims were:

- To provide a single procurement department for Glasgow Pharmacy
- To have a centralised distribution centre (PDC) for all of Greater Glasgow & Clyde (GG&C)
- To introduce ward level IT
- To release staff resources to deliver the Making the Most of My Medicines (MMyM) service, and
- To introduce 3 automated dispensaries.

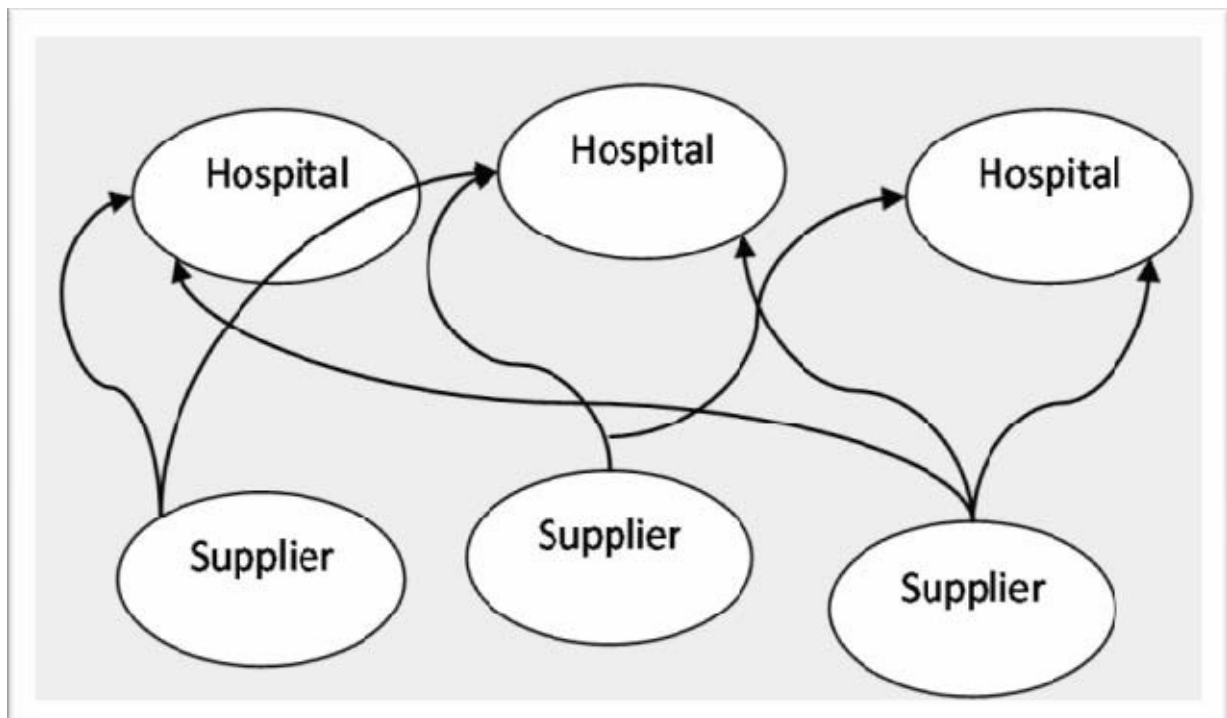
The main objectives of the programme were:

- To centralise services, to make the most of technology and in relation to MMyM
- To improve patient care
- To reduce waste and to improve pharmacy cost-effectiveness by using a patient's own medications.

The project has already passed several significant milestones, including the centralisation of procurement and distribution functions and the rollout of the Making the Most of your Medicines (MMyM) scheme. As of September 2010, the Pharmacy Distribution Centre (PDC) is now responsible for procurement and distribution at 10 hospitals: Leverndale Hospital, Southern General Hospital (SGH), Victoria Infirmary (VIC), Western Infirmary (WIG), Inverclyde Royal (IRH), Royal Alexandria Hospital (RAH), Stobhill Hospital, Vale of Leven (VOL), Gartnavel General Hospital (GGH) and Glasgow Royal Infirmary (GRI).

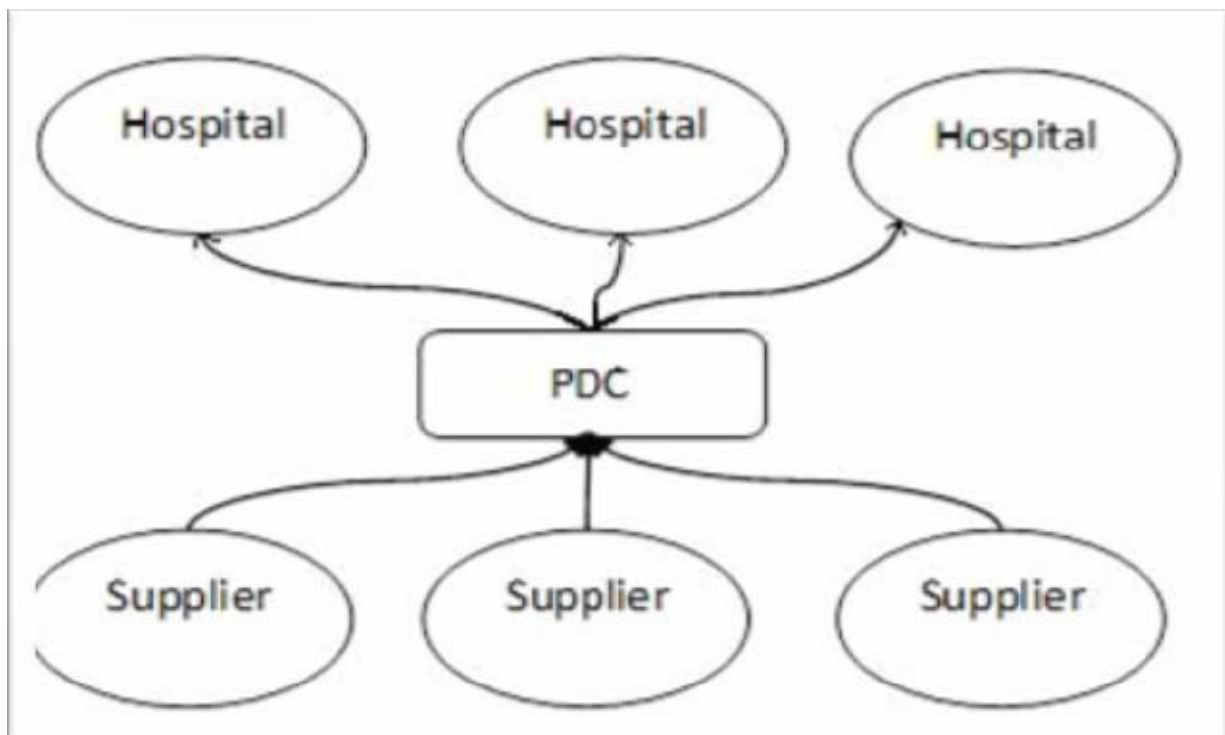
Pharmacy redesign in the GG&C Health Board is perhaps incomparable with any of the other ADS schemes currently in operation in Scotland, or even the UK for that matter. The initiation of the project signalled a move away from a system of multiple suppliers servicing multiple sites (Figure 1), towards a centralised hub and spoke system (Figure 2).

FIGURE1. PRE-PHARMACY REDESIGN



Unlike the other ADS implementations in Scotland, the distribution centre is not based in a hospital; rather it is housed in a specially adapted warehouse in an industrial district on the periphery of the city centre, and near the main transport artery in the city, the M8 motorway.

FIGURE 2. POST-REDESIGN DISTRIBUTION SYSTEM



3.0 Study Overview

The purpose of this report is to capture the learning generated during the course of the NHS GG&C pharmacy redesign project. As it is the first time an automation project of this scale and ambition has been implemented in the UK, documenting both the challenges and successes of the project, while also making explicit some of the valuable tacit knowledge that was created, will provide critical guidance for Health Boards considering similar projects in the future. The authors of this report draw from their own disciplinary specialisms; which include Operations & Logistics, Organisational Psychology, Change Management and, of course, Pharmacy, to both describe and offer commentary on the progress of the project.

The initial outline document for this report (Appendix 1) identified several key objectives. In brief, they include:

- Area 1: Development of a metrics framework to enable measurement of benefits and inform the basis for a sustainable quality management system.
- Area 2: Capture of the learning generated from the project implementation to inform the next steps in the acute pharmacy design program.

As the Strathclyde University team visited the PDC to carry out this work, it was clear that technological issues were causing serious problems for the implementation group. PDC workers were in an almost permanent state of 'fire fighting' as they tackled unpredictable problems while simultaneously attempting to maintain a reliable supply of drugs to hospital sites. This understandably made initial attempts to gather data problematic - any additional distractions in the PDC could potentially have had serious consequences.

The first two months of the study established that finding suitable time to interact with key employees would be challenging. Senior management, realising that the members of the project team from the University of Strathclyde could be utilised more effectively to offer expert advice and an objective sounding board for ideas and problem solutions, agreed to redraw the project boundaries to allow a more direct operational relationship. A project working group was formed consisting of

Strathclyde University Researchers Dr. Robert Van Der Meer, Dominic Chalmers and Emma Dunlop; Adriana Orlandi who headed the operational aspects of the PDC; Angela Munday and Marie Brady who represented the hospital sites; and Prof. Norman Lannigan who was the project sponsor. The group met regularly, often every week, to discuss any pertinent issues, and it was an opportunity to share information and feed back any interim findings with others in the working group. Some of these interim reports have been incorporated into this document, for example, the detailed analysis of a selection of internal PDC processes (section 5.2 Process Analysis), and provide an example of how the fluidity of the project allowed the Strathclyde team to make both an immediate impact on the implementation, as well as providing the longer-term reflection on progress that was initially proposed.

3.1 Study Objectives

3.1.1 Section 1 (Supply Chain Analysis)

- To review existing literature relating to supply chain management in the healthcare setting, making particular reference to prior ADS implementations
- To describe and comment on aspects of the new supply chain including hardware, software and functionality
- To examine several key processes in depth and suggest possible efficiency measures.

3.1.2 Section 2 (Organisational Change)

- To review existing literature relating to organisational change in healthcare settings
- To capture the staff experiences of the new PDC system, and to capture the tacit knowledge experienced so far
- To identify main workforce issues regarding the new PDC system through qualitative data collection

4.0 Methodology

4.1 Stakeholder Engagement

This study is a collaboration between the NHS GG&C and the University of Strathclyde, specifically the Strathclyde Institute of Pharmacy and Biomedical Sciences and the Department of Management Science. The study team engaged with the established Project Board who had representatives from NHS Senior Management, PDC & hospital representatives and IMT. Day to day engagement was achieved through the project working group who met regularly (often weekly) from the March to September period.

4.2 Section 1 – Supply Chain Analysis

4.2.1 Methodological Approach

The research in **Section 1 – Supply Chain Analysis** is philosophically underpinned by the ethnographic approach. Ethnography is the description and interpretation of a particular culture and involves the researcher spending considerable time within the research setting, observing, interviewing and participating in cultural events (3). The approach is characterised by:

- A focus on the cultural and social content of people's action and beliefs,
 - Allowing people to use their own language to describe their world, and
 - Looking at behaviour in the place and time in which it actually occurs.
- (4, 5)

Ethnography attempts to balance insider and outsider views, and as Bresler (3) notes:

“The issues uncovered derive from a combination of emic (insiders') and etic (researchers') perspectives, and are progressively focused: the direction of the issues and foci that shape a study often emerge during data collection and analysis, rather than from an a priori research plan.”(pg 4)

This is particularly apt for the PDC project as much of the richness of the research stemmed from material that was out with the scope of the initial research brief. The

ethnographic approach allowed many of the themes to emerge organically during the course of the study period.

4.2.2 Data Collection & Analysis

Data for this section of the report was gathered using qualitative research instruments. Internal documentation relating to the project provided much of the contextual information for the PDC project and this was supplemented by discussions with key members of the project team. The findings were then triangulated so they could be verified with a high a level of confidence. This was achieved by seeking out different sources of information (through interview and observation) that corroborated or disagreed with findings.

4.2.3 Subjects and Settings

A total of 19 separate visits were made to the PDC warehouse, from February through August 2010, to observe and interview Pharmacy Technicians and others directly involved in the pharmacy distribution process. This facilitated both an understanding of how the processes worked, while also allowing an insight into some of the unique cultural aspects of the new PDC. In addition, regular meetings were held at the PDC boardroom with members of the project working group, including: Adriana Orlandi, Angela Munday, Prof. Norman Lannigan, Marie Brady and Ellen Griffith.

External visits were also made to both the Western Infirmary and Leverndale Hospital in order to gain a fuller picture of non-PDC aspects of the supply chain. One of these visits included attending a Sector Chief meeting with Marie Brady, who was also a member of the project implementation group. This helped to refine understanding of how the change process was affecting the nursing staff across the various sites and exposed some causal links between problems in the PDC and problems further down the supply chain.

4.3 Section 2 – Organisational Change

4.3.1 Methodological Approach

The study objectives for **Section 2 – Organisational Change** required the researcher to interact with staff in their place of work. It was important therefore, to

use an approach that was both sensitive to these circumstances, while at the same time obtaining quality, robust data.

It was decided that Action Research, first used by Lewin in 1946 (6), would be the most appropriate methodology with which to conduct the study. Action Research can be characterised by the way investigators 'work explicitly with and for people rather than undertake research on them' (7). It has also been termed participatory research, collaborative inquiry, emancipatory research, action learning and contextual research (8). It is a research method not only aimed at investigation, but also at problem solving and generating solutions for real-life situations, not experimental ones (7). The three important elements of Action Research are its participatory nature, its democratic motivation and simultaneous contribution to change (7, 9). This kind of research therefore takes into consideration the current and future challenges being met by the participants, and works in a way to actively influence change and improvement, thus making the research findings meaningful and useful to participants. Action Research generally utilises qualitative research methods such as interviews, focus groups, observation, case studies and questionnaires (10).

Winter (11) describes the main principles of Action Research, which have guided the current study. These include:

- Reflexive critique: an account of the situation for example, notes, transcripts, organisational documents etc.
- Dialectical critique: the analysis of what people say and the relationship between what is said about the situation and the situation itself
- Collaborative resource: participants as co-investigators (participants' own input is as valuable as any other resource)
- Risk: the change process can create fear among participants, and the data collection process can also be frightening and unsettling
- Plural Structure: many accounts of the situation should be made, and all should form together allowing for multiple actions and possibilities
- Theory, Practice Transformation: theory informs practice and practice refines theory in a continuous transformation.

Based on the particular context of the pharmacy redesign, and with reference to the study aims, Action Research was deemed to be the most appropriate approach for the data collection. The relevance and validity of this method in the Healthcare sector is confirmed by East & Robinson (12), who reported the increased usage by researchers investigating this particular domain.

4.3.2 Subjects & Settings

A purposive sample of hospital sites were selected to visit for the purpose of data collection. These sites are listed in Tables 2 along with details of each visit and demographic data. Individual sites were chosen based on their geographical spread, varied size and medical specialism. Some sites were also identified by the project working group as having particular issues relating to the redesign. Collecting data at these sites provided detailed information on some of the operational difficulties being experienced.

Staff that participated in the study included: Technicians, Pharmacy Distribution Staff, Pharmacists, Senior Technicians and members of management. There was a mixture of age and gender, and all staff had worked in their field for varying lengths of time, from several months to several years. Each site visit lasted for no more than 2 hours.

TABLE 2: HOSPITAL SITES, BED NUMBERS, SPECIALIST CLINICS, DATES OF GOING LIVE, VISIT TIMELINE AND NUMBER OF PARTICIPANTS

Hospital	No. Beds/ Specialist Clinics	Gone Live Date	Visit Timeline	No. Participants
The Western Infirmary (WIG)	N/A	N/A	25/05/2010- 26/06/2010 = 5 visits	8
The Southern General	895 Neurology, Orthopaedics, Obstetrics, Gynaecology and Maternity, Max fax, Medicine, Urology, General Surgery, Haematology/Oncology, and Care of the Elderly	N/A	10/07/2010-17/07/2010 = 2 visits	4
The Victoria Infirmary	632 Surgical, Medical and Care of the Elderly	N/A	10/08/2010-17/08/2010 = 2 visits	15
The Glasgow Royal Infirmary (GRI)	720 Audiology/ENT, Renal Operations, Cardiac Rehabilitation, Diabetes Clinic, Gynaecology, Ophthalmic, Orthodontic, Podiatry, Renal Dialysis, Rheumatology, Gastroenterology, Nuclear Medicine, Day Surgery, Dermatology, Cardiology, Oral Surgery, Plastics Operations	01/09/2010	24/08/2010-14/09/2010 = 2 visits	9

4.3.3 Data Collection & Analysis

The first site visited during data collection was the Western Infirmary. Initially a drop-in surgery on location was set up and staff were notified to attend when possible. Initially however, staff were unable - and perhaps unwilling - to come and engage with the investigator. It was decided that a more informal shadowing and interviewing approach would be more effective. Staff spoke with the investigator in their workplace environment, with some choosing to discuss matters privately upon their own arrangements. It was then, on reflection, decided that this approach would provide the model for visits following those at the Western Infirmary.

Before the investigator attended the sites to collect data, management from each hospital informed staff of the imminent visit. This gave staff an opportunity to gather their thoughts on the PDC as well to prepare for the perhaps unfamiliar situation of participating in a research project. Upon arrival, the investigator was shown around the Pharmacy Department by the management representative. During this tour, the basic processes, along with any problems were detailed. These 'tours' also served the dual purpose of allowing informal interview time with members of staff. After being shown around, local management selected staff they felt would give an honest and open insight into the challenges and successes experienced in the new system.

Owing to the nature of Action Research, interviews, observations and note taking often occurred simultaneously. While conducting the observation, the investigator paid close attention to environmental factors and recorded data on aspects including workplace environment, workspace, levels of activity, perceived camaraderie and the general mood between team members.

On completion of the interviewing and observation, the investigator redrafted the written notes and collected together all of the disparate sources of recorded data. These notes were organised thematically in terms of PDC issues, technological issues, personnel issues and any other emergent areas of concern. As the interviews were not tape recorded, there was no verbatim data, though any particularly interesting or poignant statements made were recorded during the interview in note form, to give an accurate and personal (yet objective) account of how staff were experiencing the new PDC system.

5.0 Key Findings

5.1 Section 1 – Supply Chain Analysis

5.1.1 Literature Review

Effective supply chain management (SCM) has helped define successful organizations since Ford and the introduction of the production line. Firms seeking a competitive advantage over rivals have continued in this vein, directing attention towards supply chain innovation as a means of reducing costs, coordinating heterogeneous suppliers and fulfilling increasingly complex and customized orders. A sufficiently optimized supply chain is considered a primary factor in the success of global brands such as Wal-Mart, Amazon and Procter and Gamble.

Simchi-Levi, Kaminsky et al.(13) define the discipline of supply chain management as:

“...a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements.” (pg 1).

A considerable body of empirical research has developed examining effective supply chains in complex, multifunction environments. From this, several key principles have emerged that, it is proposed, should underpin any supply chain redesign. These principles can be generalised into points that highlight the need to be responsive and customer focussed and to avoid taking a monolithic, ‘one-size fits all’ approach to the system in question (14).

Several influential approaches to manufacturing and logistics have been widely embraced by supply chain managers over the past twenty years. The principles of ‘lean,’ and ‘Just in Time’ (JIT) - both widely associated with Japanese car manufacturers such as Toyota - have helped to refocus the supply chain as an area of strategic importance to the firm. ‘Lean’ SCM concentrates on eliminating waste from a system, through activities such as controlling the unnecessary movement of products and people, correcting ineffective inventory control, reducing incorrect orders and other overlooked, yet important, processes such as reducing the

employee waiting time between tasks. 'Just in Time' is a strategy that, in simplified terms, reduces inventory wastage by only stocking exactly what is required at any particular time. Adopting these methods however, is rarely straightforward; as van Bodegraven & Ackerman (15) note, "it is not easy being lean" (pg1). It is also argued by these authors that buy-in is necessary from both management and workers alike for successful SCM, with failure an inevitability if initiatives are rolled out in an inconsistent manner.

One of the major drivers of SCM improvement has been the increasing sophistication of information technology (IT), enterprise resource planning systems (ERP) and affordable robotic hardware. Information technology has increased the speed and reduced the costs associated with tracking and managing items in supply chains, and specialist software has aided advanced quantitative modelling and forecasting. Computer processing capability allows for a previously unthinkable number of activities to be performed in a short period of time, while automation reduces the number of employees needed to carry out particular tasks. This reduction in human labour – in theory – should increase accuracy and improve productivity, though the move towards automation in supply chains does carry some risk; robots and machinery are susceptible to their own inherent problems which include: breakdowns, software crashes and, in some cases, fairly rapid obsolescence - despite often significant initial capital outlay.

That said, the principles of effective supply chain management and the use of automation have been steadily filtering into non-commercial and public sector organizations (16, 17). In the health sector, it is widely recognized that there is extraordinary scope to reduce cost and improve efficiencies by rethinking some of the systems that have developed organically since the inception of the NHS. Processes and practices that have gradually emerged are often irrational and represent a costly way of operating. Introducing any meaningful improvement to the supply chain however, requires more than a localised incremental change. Given the deeply ingrained processes and practices, coupled with the often competing priorities found in large supply chains, a paradigm shift at *all levels* of the organization is necessary for effective redesign of a supply chain.

5.1.2 Automated Dispensing Systems

The most significant usage of robotic automation in pharmacy systems has been through the use of automated dispensing machines. These machines replace the need for humans to pick individual orders and, it is proposed, increase accuracy while freeing up time for technicians to complete other, 'higher-value,' tasks (18).

The literature examining these systems is to-date, patchy and underdeveloped. Though a considerable number of Automated Dispensing Systems (ADS) have been implemented around the world, there have been no longitudinal or sufficiently robust empirical studies into the qualitative and quantitative impact of the technology. That said, existing literature does point to some considerable benefits that can be realised, and case studies have provided an insight into some of the common implementation issues that have been experienced.

White (19), Coleman (20) and Bepko, Moore et al. (18) examine these implementation problems across a variety of different healthcare contexts, from Australian community pharmacies to large hospitals in the USA. While findings can generally be considered to be positive, a pattern of recurring issues emerge across the different implementations. Resistance to change by healthcare employees who feel threatened by the new system and technological problems experienced by the robot are common and problematic. White (21) found that almost all respondents complained about the ADS malfunctioning and "there was a relatively strong perception that limited software compatibility was also a disadvantage" (3). This was compounded by the general belief that the ADS vendors did not provide a good follow-up service after the system was installed. Despite these initial problems however, it was felt that users gradually accepted the robots as they became increasingly familiar and comfortable operating the machines. Coleman (22) reported an improvement in attitude scores post-implementation while a similar report produced by NHS King's College described only an initial dip in staff perception of pharmacy service to patients post-implementation, with job satisfaction ultimately remaining the same (28).

Another branch of the literature examines drivers of Automated Dispensing Systems, in particular focussing on the accuracy of distribution systems. Crane (23) highlights some startling research from the USA that suggests between 44,000 and 98,000

patients die each year from medical errors (24). Though these deaths can be attributed to many other factors, dispensing errors are still thought to contribute significantly to the problem. Alongside ADS systems, technological solutions such as bar-coding and computerized physician ordering entry (CPOE) are offered as part of a package of measures to reduce errors (25, 26). What is striking however is the degree of caution and trepidation with which most authors approach these technological solutions. Bates (27) states that technology is not a panacea, and that it may in fact make “some things better and others worse”(pg789) while Coleman (22) stresses the importance of not setting unrealistic expectations by selling the ADS as “error-free”. There is agreement that errors tend to be systemic in nature (23), and this is confirmed by Hakk (26) who stresses the need for greater management information and the introduction of supply chain management. Crane and Crane (1) also recommends using techniques more commonly found in engineering and manufacturing such as Failure Mode and Effect Analysis (FMEA) to overcome errors and improve quality.

It is not fully clear whether automated systems have fulfilled their anticipated promise in relation to accuracy. Bonnabry (25) finds that “reduction in medication errors has not been universally realised” (pg 21) since the introduction of automated dispensing, and suggests that there has been insufficient research to support claims otherwise. Franklin *et al.* (28) report modest benefits at two NHS hospitals in terms of “reduced dispensing errors, reduced picking times, increased staff satisfaction and increased storage capacity” (pg 47). This contrasts with King’s College Hospital (29) who reported a 65% decrease in dispensing errors, Order of St. Francis Medical Centre (Bloomington, USA) who reported a 50% decrease in error (23) and Norwalk Hospital (USA) whose medication variance fell from an average of 2.9 to 0 (18). There remains however some disagreement around whether some of the intended savings in staffing and other areas have been overstated, with Rhule, Braun *et al.* (30) only reporting modest savings in personnel costs.

Though the literature identifies interesting NHS findings, many of which will be recognisable to those working on the GG&C redesign, the scale and position of the ADS in the supply chain limits the relevance of existing work. There is a clear gap in the literature describing or analysing robotic systems used as a central distribution point for multiple hospitals, and almost no work has been published that critically

assesses some of the ADS manufacturer claims relating to savings and efficiencies. The report by King's College Hospital (29) is perhaps the most well constructed examination into the benefits of an ADS, however the fact that it concentrates on only one site, means that it fails to take into consideration some of the unique challenges that are experienced in larger multi-site projects such as the one in Glasgow.

5.1.3 NHS GG&C Supply Chain Analysis - Pre-PDC Supply Chain

Before the pharmacy redesign project was implemented, each hospital in the NHS GG&C area was responsible for managing its own pharmacy supply chain. Each site dealt with wholesalers directly and was individually responsible for creating processes around the management of medicines. This led to variability in the way hospital pharmacies operated and created considerable wastage in terms of stock hoarding and duplication of effort. Though examples of individual good practice were common, and - in fact - continue to tacitly guide today's system, there was no oversight of the *entire* system or transparency over how different systems operate. The pre-PDC system was fragmented, and was not fully effective in supporting medicine management for the Health Board.

5.1.4 NHS GG&C PDC Supply Chain

Replacing the numerous satellite pharmacies, at the heart of the NHS GG&C Acute Pharmacy Redesign Program is the Pharmacy Distribution Centre (PDC). The PDC is an integrated facility that takes over many of the functions previously carried out autonomously at each hospital site. The primary rationale behind the PDC is that orders from the various sites can be consolidated, hence giving NHS GG&C greater bargaining and procurement economies, whilst simultaneously greater control can be exercised over stock and inventory processes. Streamlining of the end-to-end process is intended to reduce duplication across each of the sites, and the PDC concentrates a specialist knowledge base around all aspects of the pharmaceutical supply chain in one centralised location.

The most significant innovation in the NHS GC&C supply chain is the use of robotic technology to pick and distribute hospital orders. This comes in the shape of 8 picking robots supplied by ARx, who customized the robotic system for the specific

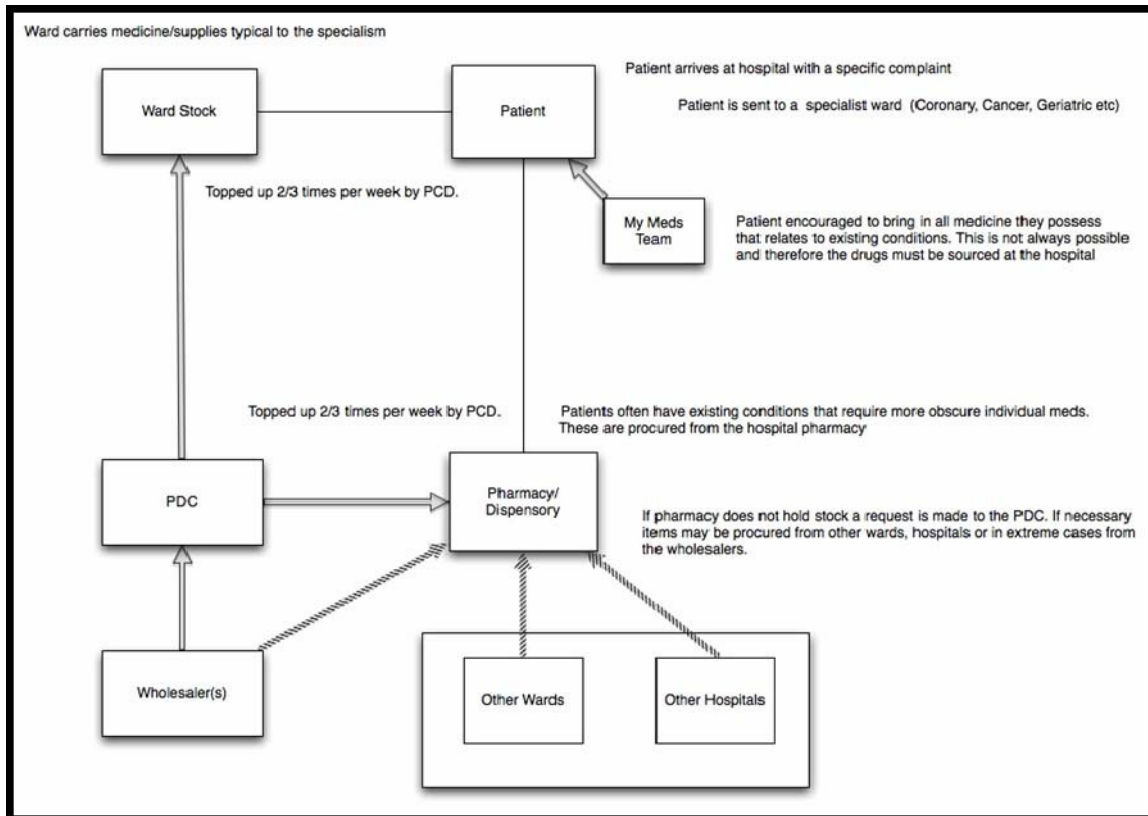
needs of NHS GG&C. This in itself was a major challenge to engineers – although the technology is proven on a smaller scale, the PDC implementation is thought to be the largest-scale use of such an IT system in the world. This, inevitably, poses some unique technical problems discussed later, and has undoubtedly had a major impact on the eventual rollout and perception of the whole PDC project.

The other significant innovation in the redesign is that NHS GG&C seek to change the way end users interact with the distribution service. They do this by bringing the patient into the supply chain via the 'Making the Most of your Medicine' (MMyM) scheme, which encourages individuals to bring their own medicines to hospital with them whenever possible. This is particularly important for patients suffering from an array of conditions, each of which may require medicines not commonly stocked in specialist ward cupboards. This attempts to engage the patient in a positive and constructive manner, and when fully operational, should result in significant reductions in medicine wastage.

The redesigned supply chain, illustrated below in figure 4, can be described relatively simply:

Each ward in the hospital has a list of stock that should be maintained at an agreed level. This stock is checked at regular intervals and any requirements are requested from the PDC. The order is sent electronically to the PDC who in turn process it before dispatching goods back to the ward. There are occasions when a ward may urgently need a particular medicine that is not in stock. In this instance the ward should seek the drugs at the local hospital dispensary, from another ward or from another hospital. If they still cannot source the drugs, a mechanism allows them to send an emergency indent to the PDC for urgent processing. In some instances, when items are out-of-stock at the PDC, the hospital may take delivery of goods directly from the wholesaler.

Figure 4: Overview of PDC Supply Chain



5.1.5 Supply Chain Technology

The primary driver of the pharmacy distribution redesign is reducing costs and increasing quality by harnessing cutting edge advances in technology. This takes place in two ways: the robotic hardware provided by ARx and the 3rd party software that interacts with it.

5.1.6 Robotic System

The PDC robot, or more accurately robots (as there are eight sitting side by side) form the nerve centre of the redesigned system. Located in a specially adapted warehouse, these impressively large robots, together approximately the length of one bus and the width of two, dominate the space. Each robot has adjustable internal shelving that holds stock, a picking head and a chute that allows goods to flow down to the relevant order 'tote' box. The robots are air-conditioned and have sufficient space for a person to enter via a front door if necessary. The picking head is also equipped with a video camera that constantly records activity. This footage can be used to help PDC staff and engineers understand why any problems arise

with the robot picking, such as certain types of drug boxes being incompatible with the machine.

Each of the eight robots has a conveyor belt that effectively 'feeds' the shelves with stock. Staff can place large volumes of unsorted stock onto the belt and the robot will shelve the items in a specific location using a barcode, which it will remember for future picking. This is a particularly clever system as stock will be allocated amongst all eight robots, meaning therefore that if one robot breaks down, *all* stock of a particular item will be dispersed and not 'trapped' in any single machine. This function also means that the robot can make the most optimal use of space when putting away stock - an important consideration if the system is required to take on added capacity in the future.

The robot has a control console that sits at the side of the machine. This allows a trained user to monitor the system for any blockages or messages, and provides an interface for staff to view the orders that have been picked and are ready to be moved to the next stage in the supply chain.

The unprecedented scale of the robotic system has created some significant technical challenges for ARx. The conveyor belt feeding the system has been prone to problems as has the chute linking the robots to the order boxes. This problem in particular has led to stock becoming jammed in the system and causing a backup that spills goods on the floor. In many cases the system alarm has failed to trigger with staff remaining unaware of the problem, subsequently allowing the problem to build up in the background. Recovery time is significant in these instances, and can in extreme circumstances be up to 45 minutes, disrupting the supply chain for several days. Another persistent problem experienced during the implementation period occurred when the belt that transported products to their order boxes fell out-of-synchronisation with the robot. This led to single orders being split between two separate orders resulting in wards receiving either the wrong or only partially complete orders. This was a difficult problem to detect for PDC staff, as they will normally only know an order is wrong when the end user follows quality assessment procedures and contacts the PDC. This wrong order normally triggers an emergency order, further adding to the workload of the PDC.

The PDC project team remained in constant dialogue with ARx during the implementation and worked together in an attempt to overcome these issues. In general staff adapted to the frequent system breakdowns resiliently, though understandably frustration grew at times. Despite these technical difficulties, the robot has demonstrated impressive capabilities and staff look forward to the teething problems being rectified.

5.1.7 Software

Unusually for such a large and complex supply chain, there is no significantly coordinated Enterprise Resource Planning (ERP) system in place. This can perhaps be attributed to the use of the industry specific ASCRIBE software for managing stock and ordering throughout the system. This system was used pre-PDC to manage inventory and continues to be used as part of the redesigned supply chain. Software engineers have developed an interface allowing ASCRIBE and the ARx robot to communicate with each other and this is essentially what drives the automated system.

Perhaps inevitably, given that ASCRIBE is not a bespoke software solution for the ARx robot, problems have been encountered at various points in the supply chain during the rollout. Firstly, a software update (from version 8 to version 10) caused systems to repeatedly crash and led to significant labour wastage and frustration amongst site-based users of ASCRIBE. The origin of this problem took some time to locate, and a solution, even longer to develop. The net impact of this problem was that confidence in the new system was shaken at an early stage and it took significant effort from the project team to overcome.

Other unanticipated problems stem from a lack of functionality in the ASCRIBE system. For instance, orders placed through ASCRIBE by wards and hospitals have no time stamp attached to them and thus PDC staff cannot effectively prioritize them. Again, the impact of this kind of system failure cannot be underestimated – late orders that have not been prioritized properly trigger a call to customer services who in turn, contact warehouse staff to find out why an order has not been fulfilled, ultimately leading to resource wastage at all points of the supply chain.

These issues have prevented the PDC from fulfilling accurate timely orders and contribute to a negative perception of the redesign amongst the service users. It has also created tension within the PDC as staff understandably felt that the IT is *hampering* rather than *helping* them in their duties – unfortunately it was these staff members who received much of the ire for inaccurate orders from hospital based colleagues when, in fact, it was largely out of their hands.

Given that the robustness and integrity of the pharmacy supply chain and medicine distribution is paramount, these observations have critical importance for any software upgrades in the future. More diligence must be used when testing or piloting any changes in order to eliminate any bugs *before* they have the opportunity to impact the performance of the supply chain. It would also be advisable to involve front-line staff in the piloting phase so that any changes that may affect the work-flow of staff (such as the time-stamp problem) are picked up and amended pre-implementation.

Attention must also be paid to existing resources in the PDC such as Gemini and Business Objects. Though not comprehensively used at present, it is anticipated that Gemini could be an important tool for collating and analyzing data about the supply chain for deeper interrogation. Similarly, Business Objects is a powerful tool that, if used effectively, can provide a detailed insight into the supply chain, particularly after the system has bedded in properly.

Finally, there are particular functional areas within the PDC that are still using outdated paper-based systems, leading to inefficiencies and at times, service consequences. For example, the Vaccinations Department records all deliveries manually and have no shareable digital record of output. This leads to multiple time-consuming calls to the department each day from hospitals and GP surgeries querying deliveries. If an electronic record were maintained, then the customer services department in the PDC would be able to field these repetitive and non-technical calls without interrupting the workflow of the pharmacy technicians at the PDC.

5.1.8 Supply Chain Communication

Given the considerable structural changes that have taken place during the course of the pharmacy distribution redesign, an area of interest and potentially significant importance are the communication channels between elements of the supply chain.

Formal channels and processes have been established to facilitate most systems that support the supply chain. Centralised customer services and procurement departments provide a standard mechanism for reporting and logging any complaints or queries. High-level communications are also cascaded through local site managers. Additionally, attempts have been made to bring different parts of the supply chain to the PDC for site visits, primarily to break down any communication barriers that may naturally arise with such a change.

There also exists a dense network of informal communication networks that the supply chain relies on for information and guidance on the strategic and operational issues. The reason these networks remain so strong and powerful, is principally due to the way labour was dispersed during the formation of the new PDC. Workers at the PDC, who have moved from the sites that they are now supplying, remain in contact with their former colleagues and share information about daily issues. The effect of this is double edged; on one hand, when the PDC is performing below expectations, the enormous goodwill between ex-colleagues creates a buffer zone that prevents the system from declining further; on the downside, negative messages can filter between the sites and the PDC – often no more than everyday workplace grievances - are deemed to carry more weight, and hence serve to ‘confirm’ negative information about the project implementation. With so much of the redesign’s success being dependant on buy-in and cooperation from the hundreds of staff who are forming the supply chain, negativity and loss of trust between management and workers is extremely damaging.

This problem is compounded by the way official communications are diluted and interpreted differently across the various sites. Since there is no centralised source of information that staff can access or interact with, there is an element of Chinese whispers across the supply chain (a problem also discussed by Coleman (22)). This was evidenced at several project working group meetings where staff at different sites denied knowledge of instructions that should have been implemented several

months prior. Without the confidence that all messages and actions will be received and acted upon at the farthest points in the supply chain, it is difficult to implement change.

Case Study:

The project implementation team, midway through the rollout of the pharmacy distribution redesign, became concerned that some users of the service did not understand some of the basic standard operating procedures (SOPs) relating to PDC ordering. This was having a significant effect on the system as, on a daily basis, hundreds of orders came through to the PDC that should not have.

It appeared that, despite a clear vision and articulation of the new procedures from the project board, senior management and staff at the PDC, the communication disintegrated beyond this point. Some sites adapted to the new procedures without incident, while others appeared to have misunderstood. A failure to ensure local management were confident and motivated in selling the new practices to staff added acute strain to the rollout.

Every attempt possible should be made to objectify information, making it readily accessible to staff at all times via information systems, and at the same time, tighter control should be kept of briefings registers so that senior management have evidence that instructions have been received.

A further observation from the implementation phase of the project was that members of the project working group played a crucial role in communicating the ongoing vision and supporting local managers. Given the impact that the redesign had on many employees – sometimes resulting in a change of role and/or location – it proved important for the project leader, and others on the board, to remain the ‘face’ of change. This involved taking considerable time to visit each of the sites to update progress, congratulate the effort employees were making and to answer questions. Though these meetings could often be difficult, with the board members taking considerable flak for some of the technological difficulties being experienced,

it nonetheless sent out a symbolically important message that the board were willing to listen and valued their colleague's contributions.

5.1.9 Management Information

Perhaps one of the most underdeveloped aspects of the PDC project relates to information management. Information is a critical resource that is required to measure performance, support decision-making and identify problem areas. Public Sector information systems are however littered with examples of failure and extreme risk (31).

In a dynamic and complex environment such as a large pharmaceutical supply chain, timely, accurate and comparable information is a fundamental requirement. At present, it is questionable whether enough information is being systematically collected. Because of technical issues associated with the implementation, attention has been very much focussed towards 'fire fighting' operational problems. This has been at the expense of routine data collection and analysis. With each site previously being responsible for its own medicines procurement, there is no cohesion with regards to reporting in the redesigned system.

Case Study:

The PDC received frequent complaints from sites concerning wrong or incorrectly delivered items. While it is true that many orders had been shipped incorrectly, almost none of the sites systematically checked their orders, and therefore nobody had a true picture of how the supply chain was operating.

Staff at The Western Infirmary used their initiative and started recording all discrepancies in a diary that provided key information for staff at the PDC regarding inaccuracies. This idea was shared with other sites and provided a first attempt at sharing management information in the new system.

The negative effect of this is that, in the vacuum of actual management information concerning order accuracy and timeliness, anecdotal and often exaggerated information has taken prominence. There is, to date, little robust data to prove the system is improving, and rich seams of existing secondary data such as robot

downtime, staff sickness rates and driver delivery scheduling have not been queried to quantify impact on the supply chain. It would be a worthwhile and perhaps critical step to identify the key sources of data that will need to be collected in order to benchmark and then continuously evaluate the system.

It is also crucial to normalise all methods of reporting across the system – at the moment there are many local idiosyncrasies that obfuscate any meaningful comparisons.

5.2 Process Analysis

As part of this report into the Pharmacy Distribution Redesign, close attention was paid to several of the key processes, both in the PDC and beyond. This was an important exercise as it enabled PDC staff to reflect on some of their everyday practices and it facilitated a deeper understanding of how the system dynamics can be negatively or positively affected by seemingly minor actions. For the project working group, this was particularly valuable information as they sought to make explicit the linkages between weak processes and defective orders further down the supply chain. Given that many of the processes had evolved in an ad-hoc manner and were significantly different to the processes initially planned, this activity helped managers to retain control of the overall system.

Jin, Switzer et al. (17) comment that 'Six Sigma' and 'Lean,' despite being almost ubiquitous in other industries, has received little attention in healthcare. Of the few examples where Six Sigma has been implemented, the Hospitals in question saved €2.9 million in 3 years (32) and €3 million per annum (33), indicating the impressive tangible benefits that can be achieved by building the approach into operational activities. Six Sigma works on the DMAIC methodology (Define, Measure, Analyse, Improve and Control) and uses statistical tools to optimize the process.

Though it was not possible to map and analyze all of the relevant processes due to resource constraints, a representative sample of the most important processes were considered.

They included:

1. Manual Order Picking
2. Hospital/Ward Ordering, and
3. Delivery Drivers,

5.2.1 Process Analysis – Manual Order Picking

Purpose of the process: To combine the stock picked by the robot with goods that the robot cannot process (either due to size, packaging or absence of a barcode) for delivery to hospital sites.

Overview: The robots fill around 20 tote boxes at a time when operational. As these orders are completed, a signal tells the manual picking staff that they need to either supplement the order with non-robot goods or seal the order and put it on the relevant outgoing delivery cage. For orders that need to be supplemented, the picker takes the tote box to the shelves of non-robot stock and works from a picking list. Once complete, another picker must check the goods for accuracy, before initialling the picking sheet and then taking the goods to the relevant outgoing dock.

This process presents many instances in which the output quality of the PDC may be sacrificed, primarily in terms of speed and accuracy. Firstly, many of the goods need to be over-labelled before they can be distributed. The non-labelled goods sit in the corner of the warehouse unorganized, and are over-labelled when PDC staff have spare time. If the over-labelling is not completed, it can add up to 3 or 4 minutes to the average picking time per order, as staff must rummage through a large pile of goods to get what they require.

Suggested Improvements: Though the PDC makes effective use of staff time by reallocating them to new duties when they have finished their own work, a clearer line must be drawn over the tasks that are considered critical and non-critical to the supply chain. Although over-labelling appears to be a good task to work on during down time, the observations from the manual picking process show that failure to fully complete this task can have a disproportionately negative impact on another part of the supply chain.

It is also important to streamline and rationalise the work-flow of staff following this particular process. Concentration is necessary for sustained periods when picking, yet at the moment, workers are being asked to check other colleagues' orders for accuracy. This means dropping everything to complete this request as the other picker cannot move on to the next order until signed off.

There are also, at times, queues of pickers waiting to have orders checked at the small desk on the warehouse floor. When considered on a larger scale, the time lost because of this bottleneck has the potential to be considerable. It is worth exploring ways of streamlining this area and looking at more 'production-line' techniques that would perhaps divide activities more, rotating tasks every few hours to ensure maximum concentration.

5.2.2 Process Analysis - Hospital/Ward Ordering

Purpose of the process: Hospital wards replenish stock via the online ordering system.

Overview: In order to ensure that the PDC can operate effectively, each hospital has particular days allocated for placing orders. It has been observed on many occasions however, that wards ignore this and place what are generally considered inappropriate orders out with this slot. This puts an incredible resource strain on the PDC as they may be required to fill another 20 – 30 orders that are completely unanticipated. It is also clear that some being received are for single items which, firstly should either be in stock or sourced at the local site (in one instance a common skin cream was requested for a dermatology department) or secondly, could be consolidated into the site's bulk order that would arrive within a day or two. Putting through this request however takes a comparable amount of time and cost to process as a much larger bulk order. These ad-hoc requests eat into precious labour time in the PDC, and have a domino effect on other activities – in particular tasks such as the aforementioned over-labelling are put aside to deal with what is perceived to be a more urgent task. It is also demoralising for PDC staff who, after scheduling their tasks for the day, return from lunch to find another batch of orders.

Suggested Improvements: The observations suggest there is either a problem communicating how the PDC should be used or there are elements of resistance

amongst staff who have not adapted or bought-in to the new system. The patient-focussed ethos amongst front-line NHS staff, while one of the service's greatest assets, can cloud the more rational nature of an effective supply chain system. Conveying the message that staff cannot always have the medication they require at that exact point in time, within agreed parameters of patient safety, will be a significant cultural hurdle to overcome. For the future success of the PDC though, it is an important consideration; a consideration that may possibly require more stringent systems of control, in order to limit the range of possible actions from the sites.

5.2.3 Process Analysis - Delivery Drivers

Purpose of the Process: NHS drivers are responsible for transporting goods from the PDC to the various hospital sites.

Overview: Although this is a very straightforward process, it presents several significant opportunities to optimize the supply chain. On several occasions drivers were observed waiting for considerable long time periods because of delays in the PDC. After some time waiting the drivers gradually started assisting with some non-technical tasks such as loading stock into the robot. While this is a good example of reducing wastage, it seemed as if there was a slight impasse and uncertainty before the drivers began helping.

Similarly, in the Vaccines Department, drivers bring back cool packs each day at the start of their shift. These cool packs must be unpacked and refrigerated for a set period of time before they can be used again. Unpacking the cool boxes for each hospital takes one of the vaccination staff a considerable amount of time which could be more effectively utilised. If drivers were to take responsibility for their own cool boxes, it would be a more effective utilisation of resource. It would be damaging for the supply chain if people are only able and willing to perform extremely limited tasks – successful supply chains benefit from flexibility and adaptability.

Suggested Improvements: Consider carefully the system-wide impact of delays and resource allocation. If delivery drivers, or any other functional group for that matter, think of themselves in isolation and not as part of a bigger system, then the synergetic benefits of an effective supply chain will not be realized. This is an ethos

that must be fostered from senior management and must be rewarded and continuously reinforced. If some elements of the supply chain are viewed by other elements as not fairly contributing to the supply chain activities, there is a risk of goodwill and co-operation being lost.

5.3 Inventory Management

The healthcare sector has long lagged behind other industries with regards to inventory management innovations such as Just in Time (JIT) logistics or “Lean” thinking (34). This is despite enormous pressures on the healthcare system to reduce cost against a backdrop of increasingly expensive medicines and political pressure to maintain service levels. Wastage is a common problem in healthcare systems, and the problem is particularly acute due to the nature of some medicines being extremely perishable and requiring controlled storage conditions. There is also an instinct amongst healthcare professionals to hold as much stock as possible in order to mitigate any distribution breakdowns (35). Jarrett (16, 36) claims that fear of a patient dying due to unavailability of critical supplies has hindered supply-chain progress for years.

It would appear then, that JIT and ‘Lean’ are both operationally and philosophically at odds with the traditional inventory management paradigm in the NHS which is to hoard stock. Some have suggested that approaches such as JIT, in their purest form, cannot be implemented in healthcare as “production capacity and scheduling cannot always be predicted” (36) (pg 750), however there is a strong case for adapted versions to be used. Costantino, Dotoli et al.(37) agree that it is necessary to have particular drugs on stock at all times, however, in some cases absence of medicine does not “compromise the patient life” and is therefore suitable for lean or JIT logistics.

The ethos behind “Lean” and “JIT logistics,” is that wastage should be eliminated wherever possible and quality should remain high at all times. In terms of inventory management, JIT is of interest as it aims to hold as little stock as possible, possibly even reaching ‘zero inventory.’ This means that suppliers only ship *enough* inventory at the agreed time it is required. As Srinivasan (38) notes “less inventory in the supply chain makes an organization more agile and more responsive to ever-changing customer demands” (pg 21). In order to operate properly however, this

may involve in many cases, suppliers making many small deliveries in any given day. There must also be high levels of trust between suppliers and distributors, as each cog in the supply chain must fulfil their duty correctly and to an agreed standard each time.

5.3.1 Methods of Inventory Management

Di Martinelly (39) provides a comprehensive overview of inventory management approaches in healthcare systems. From this review, it is found that most hospitals operate on a ROP/EOQ (Reorder point/Economic order quantity) basis, due in part to the simplicity of the model. Rackoff, Wiseman et al. (40) however, find that there is often a conflict between *actual* inventory needed and *desired* inventory. Inventory is also constrained by available storage space, and over/under-stocking can occur because of local organisational issues. The issue of demand uncertainty is another common theme touched upon by authors. Models of stochastic demand and service level have been proposed by Dellart and van de Poel (41) and Nicholson, Vakharia et al. (42) though there is no widely diffused optimized model available to date.

A successful inventory management approach involves balancing the cost of inventory and the benefits of inventory. The consideration to increase the inventory turnover while maintaining the service levels can be an example of such an approach. An effective inventory system will greatly help to ensure the level of service that will consistently meet customers order without the risk of shortage.

Two of the simplest and common tools in inventory management are the Economic Order Quantity (EOQ) model, which is particularly useful for 'independent demand' items, such as medicines, and the ABC classification. Two main types of EOQ models are presented here; namely, the continuous-review (or 'ROQ-ROL') system and the periodic-review system.

5.3.2 Continuous-review system

The EOQ approach is used to identify how much to order when the stock needs replenishing. This decision is more complicated, when the system is faced with uncertain demand, which then brings the need for safety stocks to avoid stock-outs(43). The continuous review system assumes demand is variable, but that it follows a (relatively) predictable pattern and that the ordering lead time is (more or less) constant. In line with its name, this system needs a process to review the

stock level continuously and to place an order of a fixed size (the Re-Order Quantity, or ROQ), whenever the stock reaches the predetermined Re-Order Level (ROL). Although the drawbacks of this model are the irregular timing of orders and also that inventory checking could be time-consuming, the order size is constant and can be set as an optimal economic order quantity (44) (p386). However, if all inventory data are computerized, the effort required to check inventory continuously would not be such a problem. For example, a bar coding system can track inventory balances continuously to generate orders when stock goes below the ROL (42).

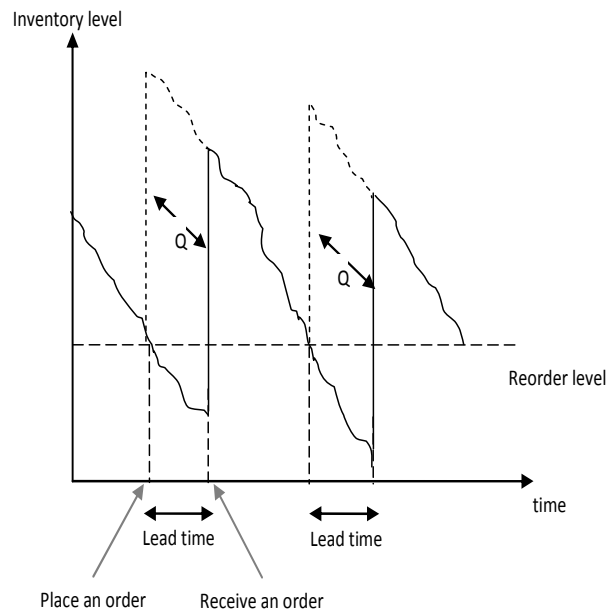


FIGURE6: CONTINUOUS-REVIEW MODEL

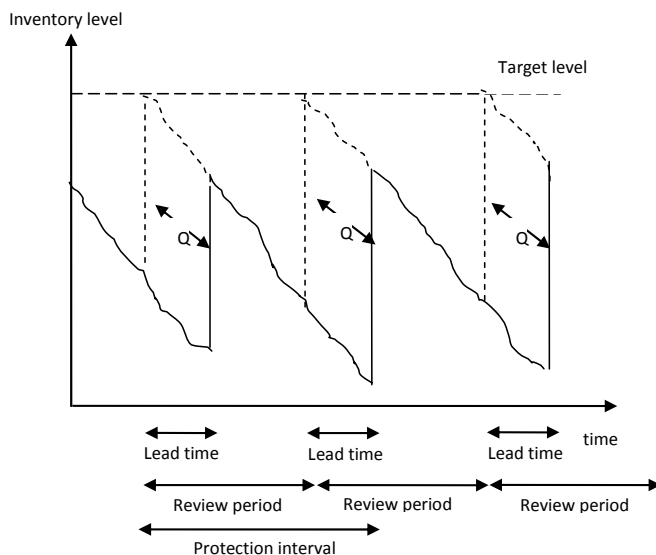


FIGURE 7: PERIODIC-REVIEW MODEL

5.3.3 Periodic-review system

On the other hand, the periodic review model could be simpler and more practical in inventory management terms. In this system, the order is placed at a fixed and regular time intervals (42) (pg386). The size of the order is equal to the difference between the current inventory level and a predetermined target level.

However, this target level needs to be

adequate to cover demand during the 'protection interval' (which is equal to the ordering lead time plus the time interval between successive reviews). Therefore, this model will incur more stock-holding expense than the continuous review system since it requires safety stock to cover a longer period before the next order (45). However, Satir and Cengiz (46) argued that the periodic review system maybe more effective than continuous review in medicine inventory control, especially in detecting spoilage of slow-moving medicines since there is at least an occasional review of stock status.

5.3.4 ABC Classification

Another inventory tool helps to classify items into more finely-grained groups and to treat these with appropriate methodologies; this is called ABC analysis. Stock categorization into ABC classes, using the Pareto rule, allows appropriate management effort and inventory policies to be applied to different stock characteristics. The ABC system assumes that the majority of a pharmacy's financial expenditures are concentrated in a relatively few line items (47). According to the past study by the NHS Logistics Authority on the pharmacy supply chain at Royal Bournemouth & Christchurch hospitals, products were classified based on their criticality, availability, turnover or value. It was found that stockholding and unnecessary scrutiny of orders had been reduced. Moreover, more attention could

be paid to those exceptional products that are critical to patient care or require manual intervention from specialists (48).

According to Hotelling (as cited in Salamie (49)), ABC inventory predicts that, as a rough guide, 70% of pharmacy purchase costs are for 10% of items A, 20% for 20% of items B, and 10% for 70% of items C. The total purchase cost is simply equal to the annual quantity purchased multiplied by the unit price. Once the inventory has been subdivided into its classes, an appropriate inventory management policy – for instance, re-order quantity (ROQ) and re-order level (ROL) for the high-expense items (category A) – can be determined (47). A study by Kaur *et. al*(50) also shows that only items in category “A” were considered for VEN analysis¹ and other inventory measures such as EOQ, ROL and safety stock, and that a more simple ‘min-max’ basis was used for items “B” and “C” (51). Further, ABC analysis can also discover spending on non-essential drugs and show that this unnecessary expense could be reduced accordingly (50).

5.3.5 Inventory management in the context of the PDC

In the pharmacy distribution system centered on the PDC, there appear to be two different inventory management approaches in operation. Each hospital site uses a (not necessarily standardized) type of periodic review system, whereas the PDC itself manages its inventory on the basis of a continuous review (ROQ-ROL) system. A good picture of the inventory management issues raised at hospital site/ward level was gained from a study of the system in use at the Southern General Hospital.

The Southern General Hospital (SGH) is the second largest hospital in NHS GG&C. Despite the teething problems with the new distribution system documented elsewhere in this report, the SGH has appeared to cope relatively well.

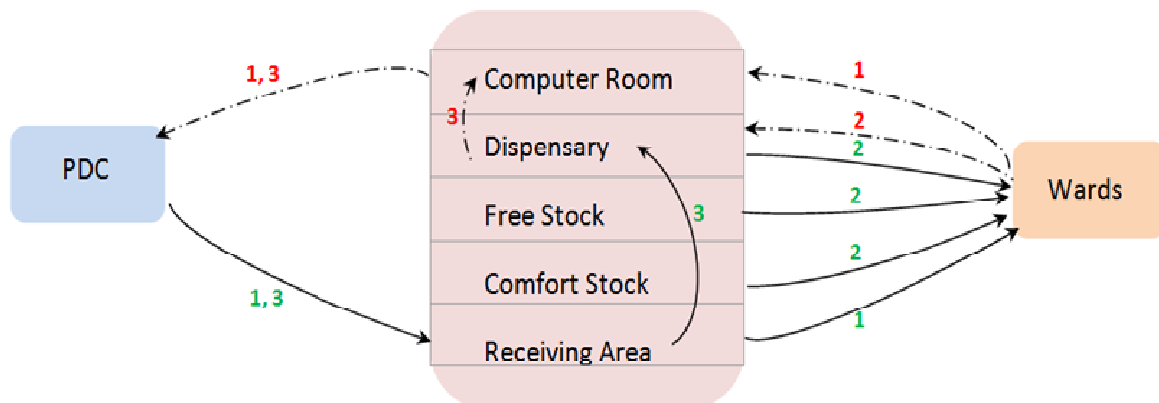
¹ VEN Analysis is a practical exercise that categorizes drugs and supplies into three types according to their health impact. They are Vital (V), Essential (E) and Non essential (N). Available from www.poracom.net/intepharm/workshop/who_july_2006/Session%25209--Financial%2520Management.ppt+ven+analysis&cd=10&hl=en&ct=clnk&gl=uk&client=firefox-a

5.3.6 Orders and Drugs Flow – Southern General Hospital

The hospital pharmacy at the SGH can be divided into a number of sections. As represented in Figure 8, the pharmacy has 5 prime areas of interest.

- Computer Room: the majority of the orders for any kind of requirement are placed from this section in the pharmacy, which is known as the computer room. In this room, a small number of pharmacy technicians process all the orders received from wards and pharmacies.
- Dispensary: discharge medicines are issued from this area.
- 'Free Stock': ward returns are kept in this stock.
- 'Comfort Stock': this is the stock that SGH had before the PDC was established. This stock is being used for the weekend requirements, when the PDC does not supply.
- Receiving Area: all orders sent by the PDC are received in this area.

FIGURE 8: ORDER AND MEDICINE FLOW DIAGRAM FOR SGH



*Dotted line shows orders and dark lines show medicine flow.

5.3.7 The ordering process at site level

For most of the wards, inventory is managed by the pharmacy. At regular time intervals, a pharmacy technician goes to the wards and takes a manual count of the available medicines (Figure 9). The orders for any medicines that do not match the target stock level are ordered using a hand-held device. For a few wards, ward nurses complete a paper-based stock control list, through which they perform similar checks on stock availability.



FIGURE 9:
PHARMACY STAFF CHECKING WARD'S STOCK MANUALLY

New orders from both the hand-held devices and the paper-based stock control lists are taken to the computer room, where orders are transferred to ASCRIBE and sent to the PDC (these orders are labelled “1” in Figure 8). The frequency of stock reviews depends on the type of wards. As mentioned earlier, pharmacy’s internal orders are also sent through the computer room. (These orders are labelled “3”.) The orders labelled “2” in Figure 8 are indents or requests sent by wards to the hospital pharmacy. The pharmacy tries to fulfil these specific requirements from its free stock or its comfort stock. If it can not supply the required medicines, then the request is forwarded to the PDC.

5.3.8 The distribution process at site level

The medicines supplied by the PDC (using ‘tote’ boxes) are received in a secure receiving area. From here, the orders for each particular ward are sent to that ward. The orders destined for the hospital pharmacy are checked for accuracy and stored in the pharmacy.

5.3.9 Some comments on current inventory management problems

It is clear from the description that the SGH’s inventory management approach conforms to a periodic review model. This also appears to be the case at the other hospital sites.

A periodic review system has certain advantages. Perhaps the main one is that the implementation of this kind of system can be relatively straightforward. In particular, it can be operated without the need for barcoding or similar technology, which would be required for continuous stock checking. However, for this system to be fully effective, the review intervals should be neither too short nor too long. Short review periods tend to result in many small orders, which may put excessive strain on the distribution system. On the other hand, long review periods require high safety stock levels in order to prevent excessive stockout risks. In addition, target inventory levels need to be carefully determined, based on the expected demand during the 'protection interval' (which is equal to the review period plus the expected lead time for replenishment orders). In other words, the correct stock review periods and target stock levels should be set in a consistent manner, based on a careful analysis of relevant cost and demand data, and should not rely too much on personal judgements of individual members of ward staff.

The impression that the PDC has been receiving numerous small replenishment orders from the various hospital sites in its first few months of operation suggests that the current review periods could generally be too short and target stock levels too low. If, in addition, ward stock lists were not fully up-to-date, then that would only exacerbate the problem by generating excessive amounts of indents. Besides reviewing all ward stock lists based on current (and expected) demand data (which may also alleviate to some extent the problem of having to source non-stock items from other hospital sites, as described below), a potential solution might be a general lengthening of the review periods for ward stocks (except where directly indicated to the contrary) and increases in target stock levels. Of course, for the latter suggestion to be generally feasible, sufficient storage space would have to be available on the wards.

A compounding factor in all this would appear to be a certain lack of trust from staff at the hospital sites in the capability of the PDC-centered distribution system to deliver orders in a speedy and reliable manner. Many of the issues affecting the operation of the PDC are reviewed elsewhere in this report. But it is useful to note at this point that the PDC appears to be operating a continuous review (or ROQ-ROL) system of inventory management. The effectiveness of this kind of system relies heavily on determining the correct values of the re-order quantity (ROQ) and – from

a risk perspective, even more importantly – the re-order level (ROL). Unfortunately, the Ascribe software does not seem to provide much assistance in setting these values.

Additionally, the actual lead times experienced by the PDC in replenishing its medicine stocks from its suppliers would appear, at times, to be greatly in excess of the normally expected lead times. In fact, a sudden and unexpected failure on the part of a supplier to deliver some key medicine to the PDC does not appear to be wholly uncommon. Such occurrences, even if largely out of the control of PDC staff, tend to reduce trust in the effectiveness of the new distribution system among hospital staff.

Unfortunately, a loss of trust in the capability of an inventory management system tends to induce adverse changes in behaviour among system users. By illustration, for fear of running out, staff placing stock replenishment orders from the various hospital sites may order sooner than would normally be considered optimal; and even more seriously, site orders to the PDC may be unnecessarily duplicated while the original orders are still being processed. In this respect, the practices adopted at the SGH – where small ward orders are filled first of all from the hospital pharmacy's own stock and where computer room staff put a lot of effort into spotting duplicated orders (despite the lack of functionality offered by the Ascribe software for this task) – would appear to be helpful in the current situation. Even so, SGH pharmacy staff noted the lack of standard procedures for these kinds of activities, which seem to result more from local improvisation rather than formal guidance.

Finally, any lack of confidence among hospital pharmacy staff is not helped by the inability of the Ascribe system to indicate clearly the relative urgency of different site orders to the PDC. The generally accepted procedure is for site orders received by the PDC by a specific cut-off time to qualify for same-day delivery. However, not all of these orders are necessarily equally pressing and, on the other hand, particularly urgent requirements may emerge later in the day at any given hospital. But the "Print Picking Tickets" screen in Ascribe does not seem to be capable of showing either the relative urgency of any order, nor even the exact time when it was placed.

The following brief sections describe in more detail some specific issues discussed at various hospital sites (not just the SGH).

5.3.10 Sourcing Non-Stock Items

Staff at some sites commented that having to source non-stock items from other sites was time consuming and sometimes unsuccessful. Each ward has a stock list consisting of common items used on that ward. Non-stock items are those which are not on the list and are required on a per-patient basis. As the PDC is not designed to deal with individual patient needs, staff who are looking for a particular non-stock item have to source it from another location.

For example, an elderly person when entering a cardiac ward will be able to access cardiac medications supplied by that ward while they are hospitalised. However, this individual may also be on a particular anti-inflammatory medication for arthritis, insulin for diabetes, etc. If the cardiac ward does not stock these specific items, they have to source them from elsewhere, the first ports of call normally being surrounding wards and the local pharmacy. If the item is not available at these points, the ward then requires the pharmacy dispensary to contact other sites in order to locate. The site then has to organise transport, in the form of taxi or courier, to collect the item and bring it to the pharmacy to dispense to the cardiac ward. Staff explained during interviews that before they went live with the PDC, *'all required items were ordered from the same location'* which was a *'simpler'* and *'more reliable'* system. Staff expressed that because the PDC is not designed for individual patient needs, sourcing non-stock items can be *'really time consuming'* and difficult, particularly when it is for a rare item.

5.3.11 Returns

The term 'returns' refers to items either distributed in error by the PDC or ordered in error by the site. Many participants spoke of how the amount of wrong items received from the PDC was *'really difficult to manage'* and at times they were unable to cope with them as stock would *'be lying about everywhere'*. As items cannot be returned to the PDC, it was observed that many sites were left with storage facilities full of returns, unorganised and unused. This problem relates back to the issue of order errors, as if there were no errors of this nature then there would be fewer returns.

Case Study

To illustrate this issue, the pharmacy staff at the Southern General were presented with a problem when the PDC highlighted that they would not be accepting returns. Staff commented that a few months prior to data collection, they were aware that returns were causing problems as they were accumulating quickly and there was no place to store them. Staff then came up with a solution to resolve this problem by organising, thoroughly checking and storing all returned items in alphabetical order, and consulting this store when doing indents before sourcing from elsewhere. Although staff recognised that this was not a system that should be recommended for long-term use, they have solved their current returns issue through this system. Members of Management highlighted however, that the system setup was only made possible through the appropriate staffing level at the time of action, and that this setup would not have been possible if their team had been one or two members fewer.

5.4 Section 2 - Organisational Change

This section moves the focus of analysis towards the human and cultural aspects of the pharmacy redesign project. As can reasonably be expected in such a significant change project, the effect on some employees has been profound. This section builds on the case studies and quotes from staff illustrated throughout section 1, and moves to capture some of the positive and negative experiences associated with the redesign.

5.4.1 Literature Overview

The previous literature on organisational change is presented mainly in case study form. Recent studies have shown that sudden organisation change is quite typical, with a more continuous level of change being less common and less practical (52-54). Interestingly, Dawson (55, 56), and Pettigrew & Whipp's (57) view that examining the process of change, that is - how change occurs - is just as important as examining the actual changes themselves.

Nelson (58) conducted a case study on the organisational change occurring in the electricity company PowerCo during the 1990s. The main source of data collection was through interviews with those in senior management positions, as well as former senior managers and CEOs at the time of change. These interviews were tape recorded and later transcribed, then processed using the NUDIST system (59). Nelson also made use of organisational documents such as annual reports and company records to aid the investigation. Zhao & Liu's(60) case study on the Anhui Telecom Company in China also made use of interview and questionnaire data, combining both qualitative and quantitative research for a fuller picture

Organisational change in the healthcare setting has been well covered in the previous literature. Nettleton *et al* (61) documented the consequences of NHS modernisation for doctors using interview data. This modernisation took the form of increased regulation and audit of medical professionals, which impacted their everyday working lives, as well as other procedures under the guise of clinical governance (pg 334). One of the main queries in Nettleton *et al*'s (61) study is whether the concept of tacit/embodied knowledge is still valid given the current regulatory environment? The term 'tacit knowledge' refers to Gordon's (62) (pg 269) observation that 'clinical and practical knowledge is embodied knowledge - knowledge sensed through and with the body'. This concern is supported by Shilling & Mellor (63), who argue that the rise of the regulated culture is associated with a loss of embodied learning. Nettleton *et al* (61) found that the importance of tacit knowledge was a dominant theme in their research, with participants often commenting on how experiential learning such as training, practice and adequate learning time through 'doing' is essential for good practice, and that regulation and modernisation can threaten this (64).

Drainoni *et al* (65) investigated issues for health policy makers when going through staff redeployment and commented that transitions from environment A to environment B, the role of Trade Unions, wages & benefits, and retraining are all important considerations when moving staff from one industry to another within the same organisation. Baumann *et al* (66) investigated how redeployment and job change affected the working conditions of nursing personnel in the NHS. By using questionnaires, they found that nurses who moved location showed less job commitment, perceived negative changes in patient care, workload and work-related

injuries, as well as taking longer to integrate as part of a team than nurses who changed role but not location. Other studies have found similar results in America and Canada (67-69).

McDonald *et al* (64) discussed the demonization of modernising the healthcare system, and how a sense of nostalgia further fuelled this aversion among employees. Through interviews with surgeons and anaesthetists from a large teaching hospital in the North of England, McDonald and colleagues found that participants commented more favourably on the 'good old days', where they felt resources were more plentiful, where management appreciated staff more, and where the work was more enjoyable. Participants also felt that their profession had been downgraded in the sense that their position had become a contractual obligation ruled by protocol, targets and financial gain. On the other hand, employees also felt that modernisation posed potential risks in terms of new technological equipment and procedures due to lack of experience. Although not all staff actively disagreed with the modernisations that had occurred in the surgical environment (a small minority welcomed change), it was evident that the introduction of policies and new procedures had resulted in a more negative view of medicine, meaning staff were feeling very nostalgic towards the past. This nostalgia then in turn fed the aversion to modernisation and therefore demonised it.

5.4.2 Analysis of the GG&C Pharmacy Redesign

5.4.3 PPSU Work Positive Survey

The NHS GG&C Project Board commissioned a Pharmacy Prescribing Support Unit (PPSU) Work Positive Survey to be conducted at set time periods during the redesign program. This survey comprised a series of questions which staff from all affected sites were asked to complete. The PPSU graphs were analysed in terms of selecting which statements elicited the most 'High Risk' responses. If any statement had the two highest risk responses collectively chosen by 40% or more of respondents (at either time points) then this statement was then considered as a High Risk factor in the workplace. The percentages from both the October 2008 and May 2009 surveys are shown in table 3.

Table 3: PPSU Work Positive Survey Statements Eliciting 40% or Over Highest Risk Responses at Either or Both Survey Times Periods

(October 2008 & May 2009)

Statements with 40% or over respondents choosing either of the two Highest Risk Responses	% that were Highest Risk Responses (Oct 2008 / May 2009)
Morale is low in this organisation	70% / 72%
I feel I am fairly paid for the work I do	50% / 43%
Staff are always consulted about change at work	45% / 47%
When changes are made at work, I am clear how they will work out in practice	40% / 45%
I am given supportive feedback on the work I do	44% / 44%
My working time can be flexible	50% / 46%
I am consulted about organisational policies and decisions	50% / 51%
I have to work very intensely	60% / 63%
The welfare facilities are adequate	42% / 36%

The researcher used this data as a useful step in preparing for the interviewing and shadowing of pharmacy staff during the site visits.

The 'High Risk' responses relating to involvement in decision making, change, and control at work were clearly marbled throughout the interview and observation data, as staff spoke mainly of how they felt uninvolved and dismissed when it came to the changes made in their workplace.

Through observation (as well as interview data) it was clear that staff were working intensely and very quickly, as often they could not keep up with the demand and level of work to be completed. One member of management commented that staff have had to stay later than they are contracted at work, without extra pay, as they felt obliged to ensure all orders going in and going out were completed before they went home. During observation periods, staff were often short for time, were

sometimes late going on breaks, had little time to speak to the investigator (or were often pulled away by other staff members during interviews) and appeared stressed and harassed.

The general move to the PDC system clearly contributed to the low morale reported, as this has been a source of great pressure at work for all participants. Every staff member interviewed commented that the new system had caused them some sort of professional (and sometimes personal) anxiety, whether that was relating to specific incidences or on a more long-term day-to-day basis.

Additionally, some staff explained that the more specific example of a recent clinical incident had caused them to experience either direct or indirect pressure as well as low morale. Comments related to worrying about orders arriving on time, the correct orders arriving and errors in ordering behaviours as being a sources of pressure, which may all affect in some form or another the chance of a patient receiving their correct medication at the right time.

The following sections provide a more detailed commentary around specific themes.

5.4.4 Staffing

Observations & Commentary: When discussing staffing levels with each site, most agreed that they were struggling in terms of staff numbers. Members of Bank Staff were present and interviewed in all sites, and according to some staff, offered some alleviation when it came to the new way of working. Bank staff are a pool of temporary staff who are deployed by the NHS to various sites for a short period of time before they are moved on to another site or to the PDC. Sites do not always have vacancies for new Bank staff when pre-existing ones move on. This was highlighted as an issue for many participants, mainly by senior members, as they were struggling to cope once Bank staff had been removed from their site or had their hours reduced in some cases. Staff commented that they '*really relied*' on Bank Staff and valued them more when they '*had experience and knew what they were doing*'. One staff member described the skills and presence of one particular Bank staff as '*really great*'.

Additionally, staff explained that the extra workload involved in locating non-stock items has put pressure on staff. This is an extra process which was not involved in

the old system, and thus according to those interviewed requires extra staffing resources.

Case Study:

Staff at the Victoria Infirmary gave a specific example of how staffing levels were not suitable for the department's daily processes. One of the consequences reported as a result of low staff numbers was inaccurate stock levels. As order errors were frequent (and therefore so were returns), the log of what stock the Pharmacy actually held was wrong. Staff felt that they required resources to be allocated to the upkeep of this, including the running of regular stock takes. As regular stock takes had ceased due to reduced staff numbers and increased workload, during one interview it was highlighted that staff felt they could not run down their stock levels to the recommended quantity and range as they did not have the staff to oversee this.

5.4.5 Perception of the PDC Role

Observations & Commentary: During individual interviews at the Western Infirmary, and during one group interview at the Victoria Infirmary, it was said that the exact role of the PDC was vague and unclear to staff, with some staff saying that they '*don't even know what it looks like*', and that they would have appreciated more information on how exactly the PDC should be used and should function. Some staff commented that different sites had their own ways of working, and processes even differed between staff members. This relates to the general issue of there being few introductions of common SOPs across all sites which affects all aspects of the system, from ordering behaviours, to dealing with returns, and inevitably, to the time it takes for a patient to receive their medication. During project working group meetings, the flow-chart illustration of how the system should operate was explained fully, yet it appeared in practice that it was not suitable to meet staff needs. Staff commented that they felt that the illustration was '*too simplistic*' and was not applicable to a real-life working environment. This led staff to work the system in a way which was not entirely suitable as they often felt that they did not understand exactly what processes to go through in every ordering scenario. This

misunderstanding was observed in several forms, for example, in that staff spent a great deal of time calling other sites for non-stock items before consulting other wards on some sites.

Case Study:

One example is the issue surrounding hand-written codes on order documentation. During one group interview, it was highlighted that when staff looked at the documentation which came with an order, items that had not arrived had a varying degree of lettering written next to them. Often whole words were used, but staff were often confused as to what each letter represented. During this session, staff explained that they had no idea whether to re-order these items or not as the coding did not indicate the availability of the items.

It was also found that staff often asked members of management about individual or unusual cases where there were no SOPs in place to direct them. Staff explained that they required full knowledge of how the PDC should be used, how ordering should be completed and how the departments should run. It was also observed that every department in every site had a different way of operating on a day-to-day basis. Although it could be argued that there are positives to this, as it is encouraging staff to think conscientiously, staff expressed that they would have preferred there to be SOPs in place as a means of education and professional support; they felt that when they knew what they were doing, they were happy.

5.4.6 Communications

Observations & Commentary: All participants interviewed commented that the communication levels between the sites and the PDC were poor. This problem was experienced in a number of contexts, one example being missing orders. Staff often found it hard to get a hold of a customer services member of staff, and felt that their concerns and complaints were not being processed adequately. Staff on-site also felt that their complaints and the stress associated with them were often not taken seriously by customer services at the PDC, and they felt that this may be down to high stress levels at the PDC. Staff on site were sympathetic towards the PDC staff and identified with them in many ways, stating that they *'totally understood how they*

felt' and sometimes '*felt quite sorry for them*'. During a group interview at the Royal Infirmary, staff complained that to-follows were being deleted by the PDC without informing the staff at site; hence individuals were waiting on items arriving that had been cancelled.

Many staff members at the sites were also curious and unaware of how the PDC worked. They asked many questions about how things worked and commented that they would have appreciated some members of the Project Team to visiting the sites occasionally. Staff commented on feeling low about this, as they felt uninvolved with the changes that were occurring; they felt changes were happening to them and not with them.

In contrast, during an individual interview at the Victoria Infirmary, one staff member pointed out that when there was a pharmacy-experienced staff member on the Customer Services line that the service was improved greatly, stating that they '*knew exactly what you needed*'. Staff understood fully the urgency and issue with each call as they were familiar with the item names and staff at the sites felt that their queries and complaints were dealt with much more efficiently when the Customer Services Advisor has experience with medicines. Staff at the GRI, when questioned on this matter, also agreed that this was the case.

Actions Taken: These findings were presented to the project team and validated previous discussions on how best to improve communications between all parties involved. The project team then helped to develop and release a regular e-newsletter to all sites, with stories of successes, challenges and future plans for the PDC. Details of particular SOPs or new procedures were also detailed in the e-newsletter. This served the function of keeping staff at all sites well informed not only of the changes and struggles involved in going live, but also the successes. The e-newsletter material was contributed to greatly by members of staff at the sites, with them reporting back their experiences.

5.4.7 Staff Morale

Observations & Commentary: All sites were struggling with low morale levels, however the Western Infirmary and the Victoria Infirmary commented most on this. During a large group interview at the Victoria Infirmary, staff spoke of how they felt

that they could no longer maintain the high standard of work that they had before PDC implementation, and that they were feeling under pressure and were struggling with the new system, morale was low and staff were feeling disheartened and sad about this. Some staff said that working with the PDC was '*soul destroying*' and '*heartbreaking*'. It was evident each team had a great sense of pride in their work, and that the introduction of (and current problems with) the new system were '*giving Pharmacy a bad name*'. During the group session, it was also explained that when the initial vision of the PDC was presented to them, staff felt that their concerns over the seemingly simplistic and flawed vision of how the PDC should work were not listened to or dealt with adequately. Staff also expressed concerns that confidence levels were low as staff had gone from a place where they were highly familiar with their job role and with their duties, very quickly to a place where their job role was completely new and full of uncertainty. In particular, staff who had previously been in the same (or similar) working environments for many years commented that they were now very unsure of what their job was and how they had to do it at times since the introduction of the PDC.

Complimenting this however, was the observed sense of unity and teamwork among all staff in all sites. When exploring issues of morale, staff attributed their progress through the difficult stage of transition to there being adequate support among the teams, and this was supported during observation times, as the level of humour and camaraderie in the departments was often high, even in moments of high anxiety and stress. Some staff also stated that they felt that '*good nature was being played upon*' which made them feel pressured to work harder and longer every day. Staff explained that through everyone's hard work and determination, they were able to pull through, yet this approach was not solving any problems, but only maintaining the system at what they felt was a '*just-operable*' level. One staff member likened this to '*putting a plaster on to cover a deep cut*'. The staff who were interviewed all shared a very patient-focused view of their role within the pharmacy, and attributed this attitude to their perseverance and willingness to make the system work. On many occasions during all visits, staff expressed a strong desire for the system to be a success and claimed to be working harder in aid of this goal.

6.0 Summary

The implementation of the new pharmacy distribution system has been an incredibly challenging and rewarding experience for those involved. When fully operational, the system will represent a considerable innovation in the pharmaceutical distribution community, and will be a model for other health organisations around the world. This is not to underplay some of the difficulties that were experienced during the implementation, some of which could be considered unfortunate, others - with hindsight - perhaps avoidable.

Arguably the most significant problems experienced during the rollout have been technological. The ARx robot has experienced a myriad of faults, leading directly or indirectly to most of the resource wastage and errors that have been reported. This is perhaps one of the dangers inherent in attempting such a radical and forward thinking program, though admittedly this offers little consolation to the employees who have been at the frontline of these problems.

The new supply chain is theoretically sound and well planned, though it is clear that the cultural change of moving to a centralised model has been underestimated in planning activities. This can be evidenced by the different practices witnessed at each of the hospital sites regarding stock ordering and inventory management – system wide benefits cannot be realised unless there is uniformity across the supply chain. Similarly, the difficulties communicating with some areas of the supply chain, and the difficulties in supporting employees through significant change have been challenging.

By far the greatest hurdle for the project team now is to overcome standardising processes and practices across all hospital sites. As the case study evidence shows, most sites are operating on procedures that are a legacy of the pre-PDC days. Though this may indeed work on an individual basis at each site, it negates any potential inventory savings and will not allow for the comparison of sites.

A further benefit of standardisation will be effective process refinement using lean Six Sigma. At the moment, many processes have not fully bedded in as technological problems have forced workers to adapt their work-flow around different obstacles. When the system is approaching full strength, greater attention can be

paid to optimizing processes and sharing best practice across the supply chain. The implementation period was not the best time to do this critically important activity as the rapidly changing and dynamic environment would have made many of the suggestions obsolete after a short period of time.

The final benefit of standardisation will be the collection of management information data that can feed into a performance measurement tool such as a supply chain dashboard or a balanced score-card. The importance of this kind of management tool is well documented in the literature, and should be an urgent priority moving forward in the supply chain redesign.

7.0 Discussion & Recommendations

NHS Greater Glasgow and Clyde are in the midst of a major pharmacy redesign program which aims to maximise the application of technology within the medicines supply chain and release staff to deliver improved patient care through the Making the Most of My Medicines (MMyM) service.

The aims of the study were, first, to develop a suitable metrics framework for the new pharmacy distribution system and, second, to capture the organisational learning gained from the initial implementation phase of the PDC. However, as the project progressed it became clear that the primary focus would be on capturing organisational learning and providing expert advice to support implementation before a more effective performance measurement framework could be designed.

The suggestions for improving both the supply chain and human resource issues are presented in the following section, with the remaining section of the recommendations consisting of the proposed dashboard & BSC metrics and a further explanation of the rationale behind them. A phased plan of action, detailing estimates of how to implement these changes is also included for information.

7.1 Standardising Processes, Improving Quality and Sharing Best Practice

- Ensure that each site is following the same process for ordering, inventory management, recording data and reporting issues.
- Create a knowledge-base tool that can be used by all staff members to source information about operational aspects of the pharmacy distribution redesign.
- Nurture and maintain a culture of quality and continuous improvement. Implement mechanisms such as quality circles and Kaizen workshops to engage staff in the process.
- Remove opportunities for order defects. Find alternative approaches to using handwritten labels on Tote boxes. Despite efforts to reduce the errors in this area, it is clear that the failure to control the quality of manual labelling can have considerable impact.
- System Health Status. Consideration should be given to implementing a traffic light system that provides all parts of the supply chain with a

quick and unequivocal status update from the PDC. This would allow sites to adjust their activities accordingly and perhaps go into an alert mode (for example holding back on non-urgent orders to give the PDC time to recover from a breakdown).

There is broad agreement that one of the fundamental barriers to success in the PDC supply chain is a lack of standardisation in areas as diverse as inventory management, management reporting and stock ordering. This results in a dysfunctional supply chain that fails to fully capitalise on the benefits of the automated technology that has been installed.

It is perhaps unsurprising that in the absence of experience and clear instruction, the ambiguity and uncertainty that can be closely associated with significant change projects, encourages workers to revert to old habits and behaviours. As some of the examples given in this report illustrate however, even the slightest deviation from established processes and procedures can threaten system-wide progress.

It is suggested that a more detailed analysis is performed at each of the hospital sites to ascertain where deviations from SOPs are occurring and for what reason. From the empirical evidence collected for this report, it is suggested that deviations occurred primarily because supply chain issues led to situations that workers did not have any established set of operating procedures for. This in turn led to instinctive and 'selfish' behaviours which included stock hoarding and inappropriate ordering, and the result was a domino effect of negative behaviour throughout the remainder of the system. It is clear that this, and any other form of damaging behaviour must be controlled more efficiently, and the most effective way of achieving this would be to perform a full audit of certain key processes.

It would also be beneficial to create an online knowledge base (perhaps using the wiki framework or a decision tree tool) to provide a common objective point of contact for staff experiencing 'on the job' problems. If individuals, perhaps without immediate managerial support, find themselves unsure of how to deal with any particular situations that arise, then rather than rely on incomplete or incorrect information, a centralised, instantly accessible guide can be accessed to source the required knowledge. This also has the benefit of being a dynamic system, so staff

can amend and update content, ensuring that the knowledge base remains up to date and relevant.

The study can also report significant positives observed during research into the pharmacy redesign. In particular, a recurring theme that emerged from staff interviews and shadowing was that the best solutions to some of the seemingly intractable problems in the supply chain came from front-line staff. For example employees at the Southern General implemented an innovative method of recycling the stock that had built up during the redesign, with the result that waste was reduced and patient care improved, all with little resource expenditure.

The challenge for NHS GG&C lies in amplifying these examples of good practice to the farthest corners of the supply chain, and nurturing the conditions that compel staff to invest time and effort creating and sharing ideas that will continue to improve the supply chain. It was found that many employees contributed to the improvement of processes owing to a sense of ownership around particular activities; as problems started to mount in the PDC however, staff distanced themselves from failures, felt that their opinions were not valued and disengaged with the change process. This unfortunately led to a downward spiral in some departments where a sense of disenfranchisement from the whole project led to uncooperative employees.

To maintain and grow this sense of ownership, mechanisms should be established to encourage continuous quality improvement. Again, taking inspiration from Japanese manufacturing practices, the idea of regularly scheduled Kaizen workshops, or similar quality-based activities, would serve to both create buy-in from workers, and potentially lead to solutions that could be cascaded through the supply chain. It is also important for senior management to reinforce the culture of cooperation and innovation by formally recognising examples of good practice, either through a certificate or some kind of other non-pecuniary reward.

7.1.1 Improving Staff Morale

- Continue to hold well-structured staff meetings to feedback news about different parts of the supply chain, share new ideas and listen to feedback from employees.

- Continue use of the PPSU Work Positive Survey to identify any areas that need long-term attention.

The supply chain is only as strong as the individuals who perform the various supply chain roles, and by that reasoning, ensuring the morale of the staff is high should ensure a positive supply chain performance. To improve morale, it is suggested that staff are empowered to become part of the solution to the problems they are experiencing. This would involve the aforementioned series of quality improvement workshops where staff that choose to do so, can air their ideas and opinions. If individuals feel they can make a positive impact on their working environment, they are likely to be happier and more fulfilled in their job.

It is also important that regular team meetings continue to be held with all levels of staff. These gatherings provide an important mechanism for information to be shared, successes to be celebrated and most importantly, for team bonding to occur.

Finally, the PPSU Work Positive Survey is a good method of gauging morale and identifying problem areas. The use of this survey should be rolled out consistently over the coming years to gather longitudinal data about the impact of the pharmacy redesign, and it will also provide evidence to support the success of any staff morale initiatives.

7.1.2 Inventory Management

- Examine and, where necessary, adjust the parameters of the periodic review models applied by the various hospital sites for (top-up) replenishment orders
- Examine and, where necessary, adjust the parameters of the continuous review (ROQ-ROL) model applied by the PDC for its replenishment orders to its suppliers
- Investigate and, where possible, eliminate the causes of delays or failures to supply experienced by the PDC from its suppliers
- Critically review the functionality of the Ascribe software, and investigate the feasibility and costs of enhancements in software functionality

As noted in an earlier section of this report, the impression that the PDC has been receiving numerous small replenishment orders from the various hospital sites in its first few months of operation suggests that the current review periods could generally be too short and target stock levels too low. When examining these parameters, a careful balance must be struck between the need to avoid too many small replenishment orders and the pressures on storage space at the hospital wards. Keeping all ward stock lists fully up-to-date, based on current and – where feasible – expected demand, will be a vital ingredient of this exercise.

As far as inventory management at the PDC itself is concerned, the Ascribe software ought to be able to support the determination of the most appropriate re-order quantity (ROQ) and re-order level (ROL) parameters for each item stocked. However, although this functionality seems to be present in principle, it is not deemed by PDC staff to be effective in practice. This conforms to a general impression, not only from the PDC but also the various hospital sites, that the Ascribe software does not provide the quality of decision support that is required for inventory management purposes. Another example of this lack of Ascribe functionality is its apparent inability to show clearly the relative urgency of orders received by the PDC from the various hospital sites.

Any delays or failures to supply experienced by the PDC from its own suppliers negatively affect the confidence among hospital staff in the capabilities of the new distribution system. The performance of PDC suppliers in terms of delivery speed and dependability (as well other relevant objectives, such as cost, quality and general level of customer service) should be subject to regular review. In particular, suppliers should be instructed to provide timely warnings to the PDC of potential supply problems for any of their items. And, similarly, the effectiveness of the system whereby the PDC passes such warnings on to pharmacy staff at the hospital sites should be examined and, where possible, improved.

7.2 Towards a an Operational Dashboard and Balanced Score Card

In order to baseline the performance of the PDC supply chain, and to subsequently improve quality, a set of robust performance metrics are suggested. Firstly, a brief overview of the BSC and dashboard is offered with comments relating to some of the obstacles that must be surmounted for an effective implementation. This is followed

by a phased set of activities for the coming 12 months that will result in a robust and effective performance management tool.

7.2.1 Measuring Performance in the PDC Supply Chain

It is widely acknowledged that supply chain performance metrics must be captured effectively to allow for ongoing and continuous improvement. Hausman (70) draws attention to one of the most important pitfalls when measuring performance in a multifunctional environment; that is, taking a functional-specific, or, silo approach. Measuring, in isolation, the performance of a single business unit or functional unit can be misrepresentative, as the supply chain is only as strong as its weakest link. Instead, to fully understand how the chain is performing, metrics that examine the full system should be utilised.

A common approach to performance measurement involves using a balanced scorecard (BSC) approach. This tool, introduced by Kaplan and Norton (71), aims to capture more than the traditional financial metrics of business/organisational performance, by looking at customer satisfaction, internal processes and any other sector-specific variables. The authors suggest that the finished BSC should provide the same kind of information to the manager as a driver finds on their car dashboard. Continuing with this analogy, the supply chain manager can then make the most informed decisions about what direction to take the supply chain in the future, including how to avoid potential dangers that arise along the road. The scorecard approach has been utilised in the healthcare sector successfully, though special care must be taken to adapt the individual metrics so that they are aligned with the organizations strategy (72).

While the BSC is a high-level strategic tool that is reviewed on a monthly or quarterly basis, sitting underneath and directly feeding into this, is the more operationally-focused dashboard. The dashboard consists of data that is collected on a regular basis from across the supply chain, and can provide a timely insight into the variables that are affecting performance.

The pharmacy distribution system in the GG&C area would greatly benefit from this kind of holistic approach. It is clear, even from a cursory glance, that measuring individual functions is insufficient for capturing the system wide inventory savings

through automation to the improvements in patient experience through delivery of the MMyM service. A deeper understanding of the integrated performance of the full system must therefore be attained.

There are however two major obstacles that must be surmounted in order to implement such a system. Firstly, referring back to the management information section of this study, there is no cohesive data collected throughout the supply chain. As Zelmanet *al* (73) note, “health care organizations often have poor data warehousing and multiple information systems that are not integrated, making it difficult to obtain desired information in a timely manner”(pg6). Robust systems must be established for collecting data from each of the sites in order to populate the dashboard or BSC, and this must be done by working closely with staff to ensure the transparency and fairness of performance indicators.

Secondly, collecting data and producing the necessary reporting for the BSC and/or dashboard is a considerable resource commitment. It is estimated that this could possibly take the efforts of a full time member of staff to gather daily information on all of the metrics, interrogate the data and then present back in a suitable format to management. Cooperation with every member of the supply chain would be a necessity, as would greater use of existing IT systems.

It could be reasonably anticipated that savings made from improved managerial decision-making based on this data would outweigh the resource allocated for this task. At present, poor oversight of the entire system casts significant doubt over the ability of the supply-chain to fulfil the promised efficiencies outlined in the business case.

7.2.2 Integrating the Supply Chain into a Balanced Score Card

The BSC is valued as an important business tool as it does not simply focus on quantitative financial data. Instead, it is designed to consider softer factors that affect performance such as the interaction between business functions, customer data and internal quality. While supply chain management has a range of traditional logistics measures, they are deemed insufficient to measure the effectiveness of the whole chain (73).

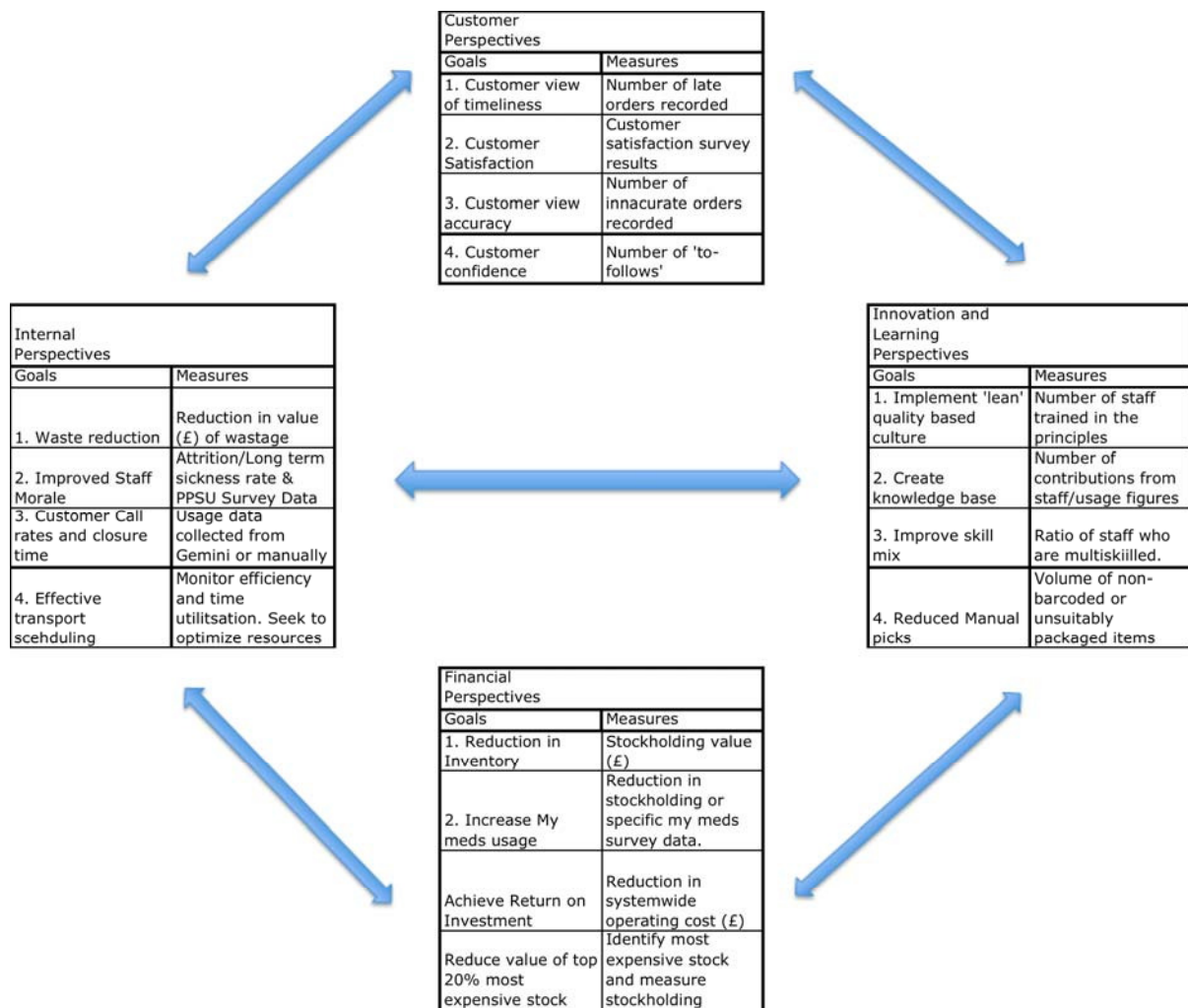
The supply chain has four main areas of performance measurement: customer perspective, internal business perspective, financial perspective and innovation and learning perspective. Brewer (73) breaks these areas down into several key questions:

Customer perspective:	how do customers see us?
Internal business processes:	what must we excel at?
Innovation and learning perspective:	can we continue to improve and create value?
Financial perspective:	how do we look to shareholders?

Integration is achieved by using measures that cross various functions as opposed to stand-alone units. For example, measuring the number of personnel qualified in lean management principles would reflect the strategic future direction of the supply chain as opposed to highlighting individual outlying pockets of innovation. Another example is the measurement of the number of beds covered by the MMyM service, resulting from staff release with role out of the PDC service to hospitals across GG&C. The concept is to promote integration between different elements of the supply chain and to encourage employees to start thinking about the whole supply chain rather than their own small part in it.

Figure 10 shows a first cut of metrics that may be effective in the PDC supply chain. These must firstly be debated and reviewed with senior management to ensure they complement the strategic aims of NHS GG&C, but nonetheless serve as a guide to potential metrics.

Figure 10: Potential Selection of BSC Supply Chain Metrics



7.3 Phased Actions

It is recommended that a phased approach is employed to stabilise and improve the GG&C pharmacy distribution system. Each phase will help build the necessary foundational processes that will facilitate the implementation of more advanced quality and efficiency measures.

7.4 Towards a BSC and dashboard for GG&C

7.4.1 Phase 1

Estimated timescale: Between 1 and 2 Month Prior to the Dashboard/BSC Implementation.

The initial step for the project team will be to review the suggested bucket of metrics in the outline PDC and Hospital dashboards (see Appendix 2-4) and assess the feasibility of collecting this data. This will involve assessing the capability of each ward/hospital to produce the required management information and then putting any actions in place that may assist these sites. Significant effort will be required at this stage to ensure reporting is consistent across hospitals, and that any process deviations are rectified promptly.

To populate some parts of the dashboard, computer (SQL) queries should be developed that can quickly produce the desired information (particularly for stockholding levels and system downtime).

During phase one, senior management must decide how often and in what format the dashboard is presented. It is recommended that someone is appointed to oversee the production of the dashboard/BSC on a daily basis, and that they write a short daily commentary that can be easily digested by stakeholders. This removes the need for many different people to spend time analyzing the same data in depth as only significant trends and exceptions are identified. Dashboards are often widely shared in commercial organisations as they can encourage competition between different business units. The same may be applicable to hospitals where an element of competition can be introduced to promote efficiency.

Where information is to be coded (such as customer complaints/enquiries), relevant categories must be agreed across the system.

Where appropriate, targets should be established for each of the metrics. These must be agreed upon with management and workers.

By the end of this phase, a full and robust dashboard should be complete. Processes to collect the data should be in place, and the supply chain workers should have a good understanding of the key metrics that have been implemented.

7.4.2 Phase 2

Estimated Timescale: Months 1-3

Dashboard introduced and data is collected

7.4.3 Phase 3

Estimated Timescale: Months 3-9

The dashboard should be implemented across the system. After a particular time period, perhaps 3 months, there should be enough data captured for detailed analysis. It is anticipated at this stage that techniques such as Six Sigma and FMEA can be used to investigate and improve some of the problematic areas. Lean management tools and principles will be introduced to employees, and quality improvement projects will be initiated wherever they may be required.

It is anticipated that different variables can be correlated to examine aspects of performance that are not immediately obvious. To give an illustrative example, a strong link may emerge between productivity and the usage of bank staff. Effective analysis of the data will highlight any of these trends to management and allow action to be taken accordingly.

It is important at this stage to start introducing and reinforcing a culture of continuous quality improvement into the system. This can be achieved by bringing together teams consisting of employees from across the supply chain to participate in these improvement projects. This creates buy-in and engagement from those involved and helps enforce the idea of the supply chain being more than a series of individual activities.

7.4.4 Phase 4

Estimated Timescale: Months 10-12

It is important after a full year of monitoring operations that some reflective activities are performed. A full review of metrics, targets and figures is necessary to evaluate the success of the supply chain and to identify strategic areas of improvement. This may involve examining the possibility of implementing bar-coding technology at the hospital side of the supply chain in order to increase accuracy and keep a real time record of inventory levels.

8.0 Appendix

Appendix 1- Initial Study Brief

Greater Glasgow and Clyde Acute Pharmacy Redesign Program

Procurement and Distribution Project

Professor Marion Bennie, Strathclyde Institute of Pharmacy and Biomedical Sciences

Dr Robert Van Der Meer, Strathclyde Business School

Final Proposal

1. Purpose: to present an outline proposal to support implementation of the procurement and distribution project in NHS Greater Glasgow and Clyde.

2. Background

- NHS Greater Glasgow and Clyde (GG&C) are engaged in a major redesign program
- One component of this program is the establishment of a Pharmacy Distribution Centre (PDC) for all distribution and procurement of medicines. This PDC will employ nine robots to support automatic storage and picking of medicines for issue of medicines to wards and departments to replenish routine stock and to hospital dispensaries to support individual patient dispensing.
- This site will enable NHS GG&C to move from 11 medicines stores to one single store
- There is a major IM&T redesign program to support this focused on all sites being on a single pharmacy stock control system (Ascribe version 10)

- The timetable for implementation is: installation of Robots Nov 2009; transfer of supply from 11 stores to central site January to March 2010.

3. Proposed Program of Work

Prof Norman Lannigan had an exploratory discussion with Prof Bennie and Dr Van Der Meer and it was agreed that an outline proposal be prepared and submitted for initial consideration by the Procurement and Distribution Re-Design Project Board.

It is proposed that two key areas of activity are taken forward:

- Area 1: Development of a metrics framework to enable measurement of benefits and inform the basis for a sustainable quality management system.
- Area 2: Capture of the learning generated from the project implementation to inform the next steps in the acute pharmacy design program

Area 1

This area would involve working with the project team to build on the initial identified key performance indicators*:

1. Bed numbers with access to “Making the Most of Your Medicines” in patient medicines management system now versus the bed numbers once staff have been re-deployed
2. Current picking error rate now versus future PDC model
3. Customer call rates and timescales to closure
4. Transport scheduling
5. Decrease in values of monthly stockholding
6. To follow rate

** we recognise that the project team may have undertaken further detailed work and expansion of these indicators beyond the background information shared with us to date.*

It is proposed that this work will focus on two key aspects.

First, although each KPI needs to be carefully monitored in its own right, taking a 'Lean Six Sigma' approach can provide the overall methodology for performance measurement, analysis and improvement. For instance, the principles of statistical process control – which is an integral part of the Lean Six Sigma approach – can be applied to develop control charts for rate-based performance indicators, such as error rates. Such tools can also support the process capability studies that are needed to track future performance improvements.

More generally, one of the first steps in the DMAIC (define; measure; analyse; improve; control) methodology underpinning Lean Six Sigma would be to develop a more detailed process map of the pharmacy distribution system as a whole, if not already available. This would provide a vital input to the second aspect of this work; namely the development of a structured framework for measuring and managing organisational performance in the form of a 'balanced scorecard'. With patient safety as an overriding priority, such a framework allows for a balanced view to be taken of wider customer service and resource utilisation objectives. As noted by Berg and Pantelides in their recent study of the pharmacy division within one of the largest Canadian healthcare regions:

“Any number of new technologies represent the opportunity to reduce costs, increase efficiency, and reduce medical errors, but deciding between them requires an understanding of cause and effect and the ability to make accurate measurements.” (Berg & Pantelides, 2006)

In short, this work aims to address both the issue of accurate measurement and the question of how to develop a correct understanding of the interactions between different performance indicators.

Once the metrics are developed and data collection systems established, the University team would support data analysis with the help of well-established quality tools. In particular, appropriate statistical software (SPSS or Minitab, both available at the University) can be used to identify trends and outliers, and – more generally – to identify emerging patterns in the data that may indicate the underlying

mechanisms. The results of this analysis can then be fed back to the identified forums in order to inform an iterative change process.

While we would not disagree with any of the six KPIs that have been identified, we have a number of questions on issues such as:

- a) Which key element of the overall process (i.e. the pharmacy distribution system) is each KPI intended to evaluate, and on what basis has this particular set of KPIs been selected?
- b) Which specific problems might be anticipated with the accurate measurement of key indicators such as error rates? If an accurate measurement system is not yet in place, how quickly could such a system be established, what would be the likely impediments, and how could these best be resolved?

An important issue is that some key elements of the process may not be captured. For an important investment of this type, our previous experience at Strathclyde would normally have us consider at least four key objectives:

- *Feasibility* (does the new technology actually perform its intended tasks – for instance, does the Ascribe Pharmacy software system communicate effectively with the robotic system supplied by ARx?)
- *Acceptability in financial terms* (does the new technology provide an acceptable return on investment?)
- *Risk* (what are the main areas of risk involved, and how effectively are these being monitored and managed?)
- *Support for the organisation's superordinate strategic goals* (how well does the new technology actually support the overall goals of the pharmacy services redesign project?)

With regard to the organisation's strategic goals, can these be captured accurately and comprehensively by the usual four perspectives of a public sector balanced scorecard? And if so, does the set of currently identified KPIs effectively address each of these different perspectives?

Area 2

The main purpose of this area of work is to capture the tacit learning that is embodied in the experiences of the various project participants, to make this learning more explicit, and to use it to develop an organisational memory in the form of shared causal maps and other suitable tools. This requires the application of qualitative research methods such as direct observation, interviews, questionnaires, and causal mapping workshops, as appropriate. The research data can then be analysed using suitable software packages for qualitative analysis, such as NVivo and Decision Explorer (both of which are available at the University), and the results fed back to the identified forums.

4. Benefits to NHS Greater Glasgow and Clyde

- Development of a structured framework for measuring and managing organisational performance in the form of a 'balanced scorecard'. This can be used to demonstrate acceptable return on investment, improvements in external and internal service capabilities, and the attainment of important learning objectives.
- Development of a sustainable quality management system for the service
- Identification, transfer and implementation of best practices relating to performance measurement in comparable supply chains.
- Documentation of the learning generated in introducing robotics into the medicine supply chain across a single health care system.
- Provision of timely feedback on metrics capture, staff learning/experience during implementation to inform project.
- Publication of findings to inform evidence base

5. Resources

It is proposed that this work be delivered over the timeframe January – June 2010.

University of Strathclyde Team

The program outlined would be jointly led by Prof Bennie and Dr Van Der Meer. It is proposed that the following resources would be aligned to support this initiative:

- Leadership and quality assurance of the project
 - Prof Bennie
 - Dr. Van Der Meer
- Researcher to support methodological development, data collection and analysis - 1 wte for study duration. (University post-doc band 7)
- Alignment of postgraduate students (subject to meeting student project timelines).

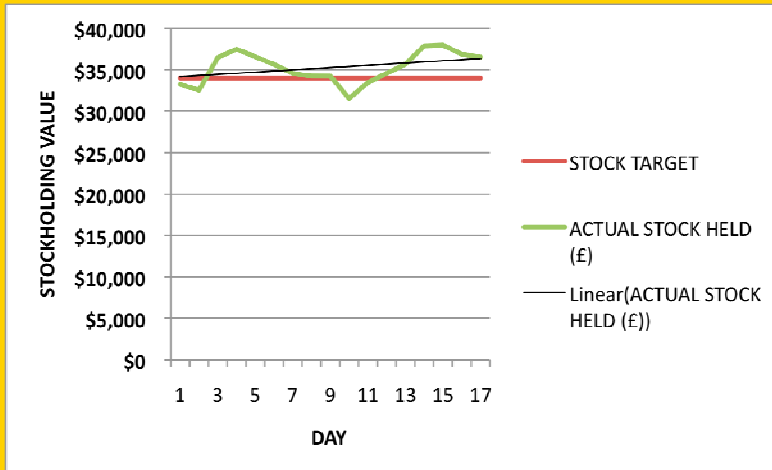
Appendix 2 – Sample PDC Dashboard

GREATER GLASGOW AND CLYDE

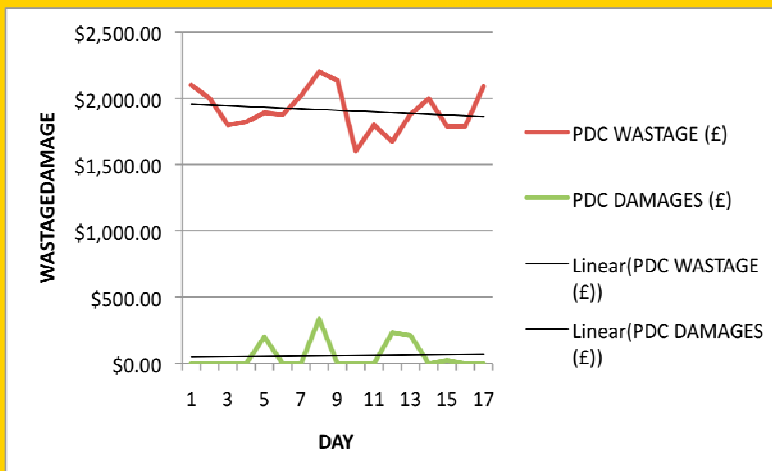
PDC DASHBOARD



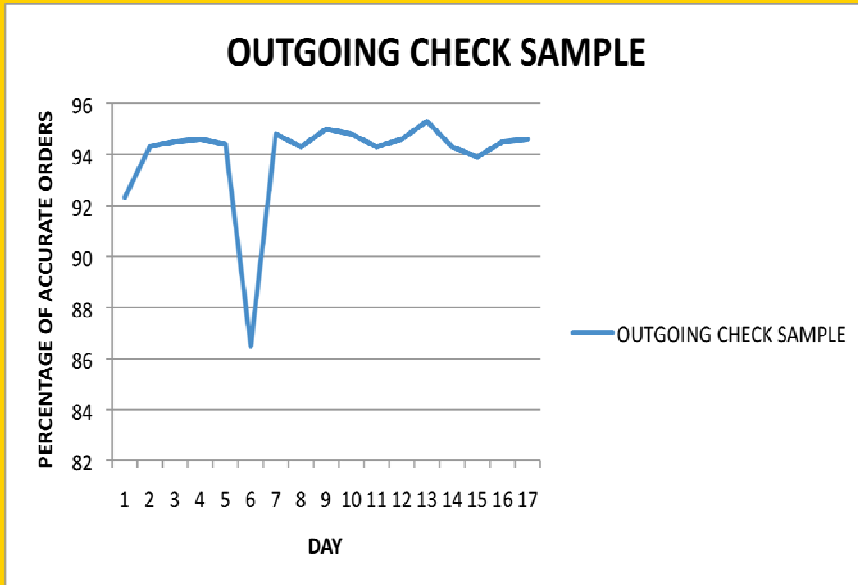
PDC STOCKHOLDING VALUE



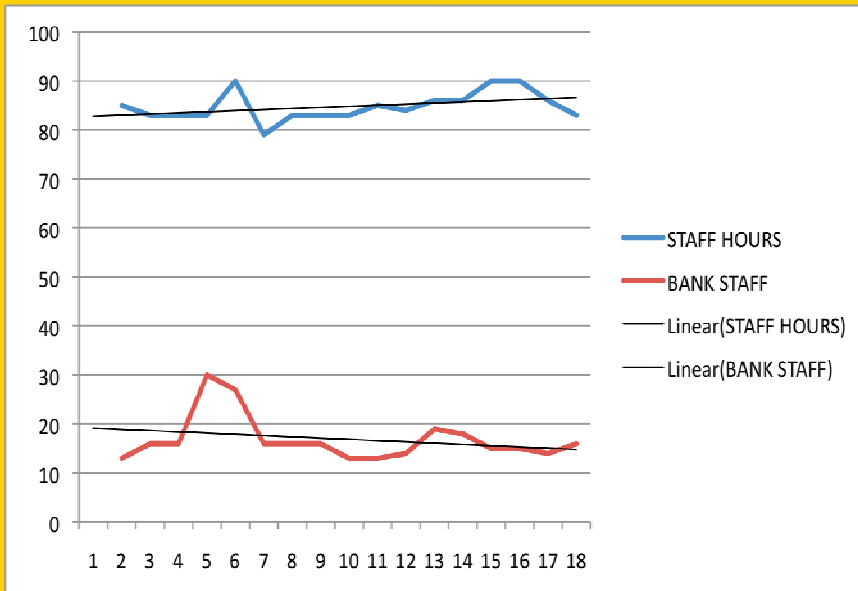
PDC WASTAGE REPORT



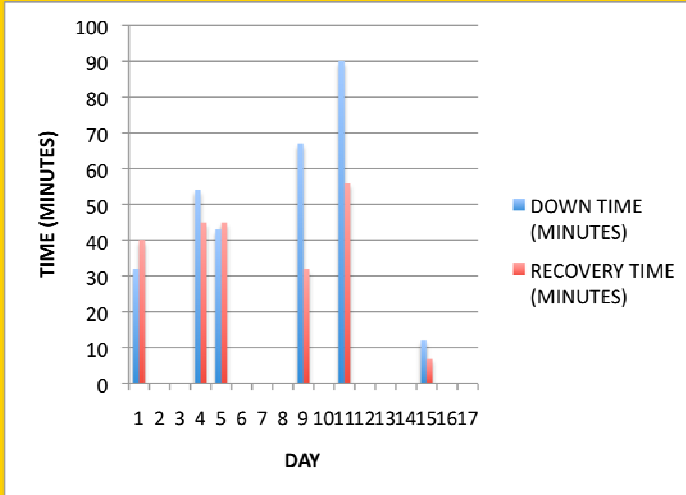
SUPPLY CHAIN ACCURACY CHECK (OUTGOING SAMPLE)



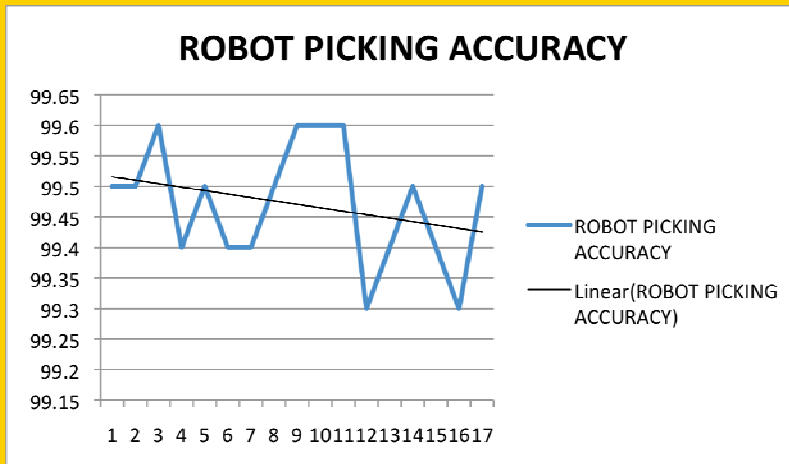
PDC STAFFING LEVELS



PDC DOWNTIME & RECOVERY TIME



ROBOT PICKING ACCURACY



Appendix 3 -Sample Hospital Dashboard

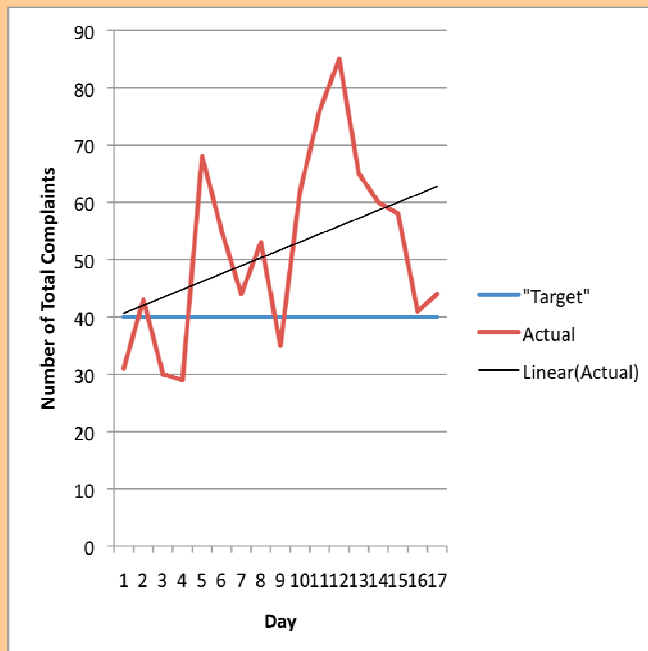
'GREATER GLASGOW CLYDE'

M.I DASHBOARD

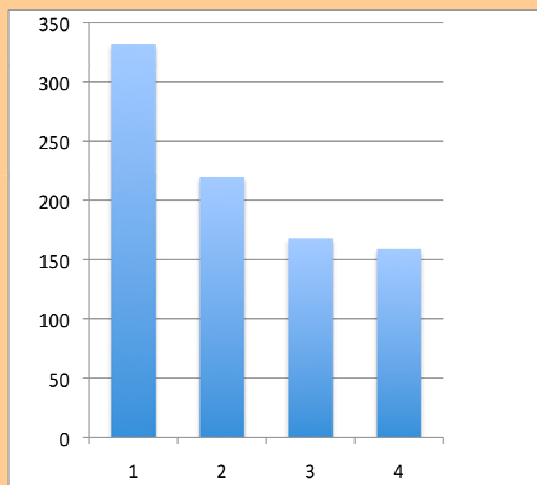


YEARLY CUMULATIVE INFORMATION

Year to date - Total Complaints



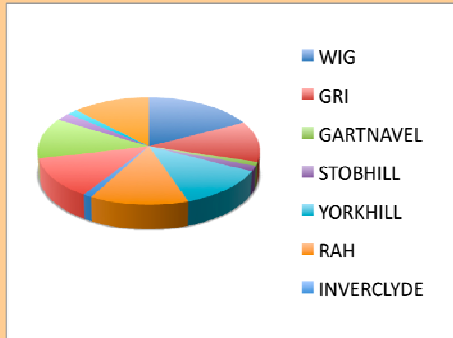
Year to date - Complaints by Code



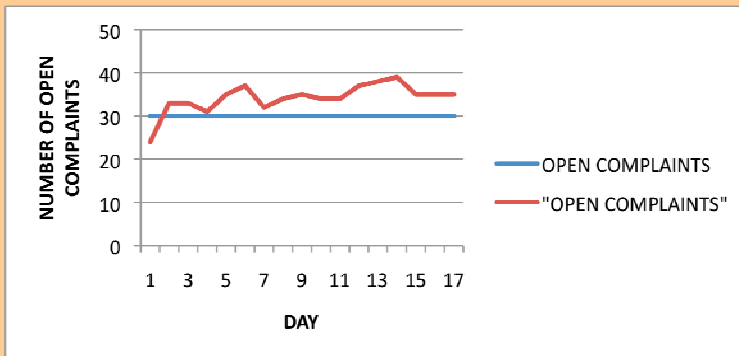
KEY	
1	Delivery Problem
2	Order Problem
3	Invoice Problem
4	

Complaints by Hospital

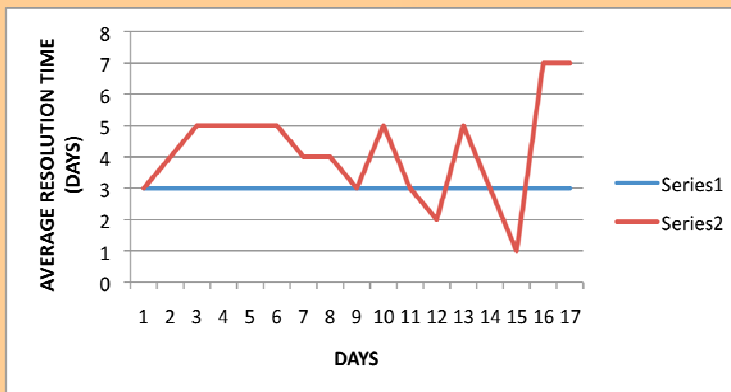
Hospital	No. of Complaints
WIG	332
GRI	234
GARTNAVEL	22
STOBHILL	32
YORKHILL	234
RAH	253
INVERCLYDE	23
LEVERNDALE	234
JUBILEE	235
DUMBARTON	45
DYKEBAR	32
HOMEPAH	234



Number of Open Complaints

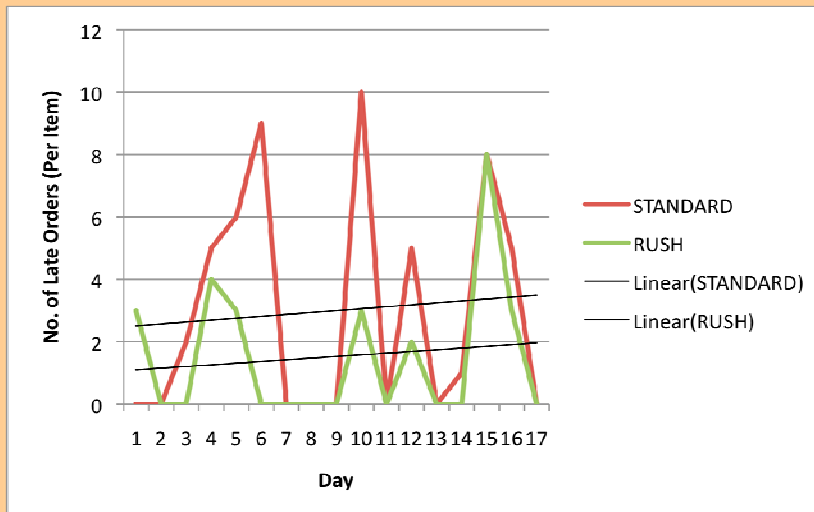


Average Resolution Time (in Days)

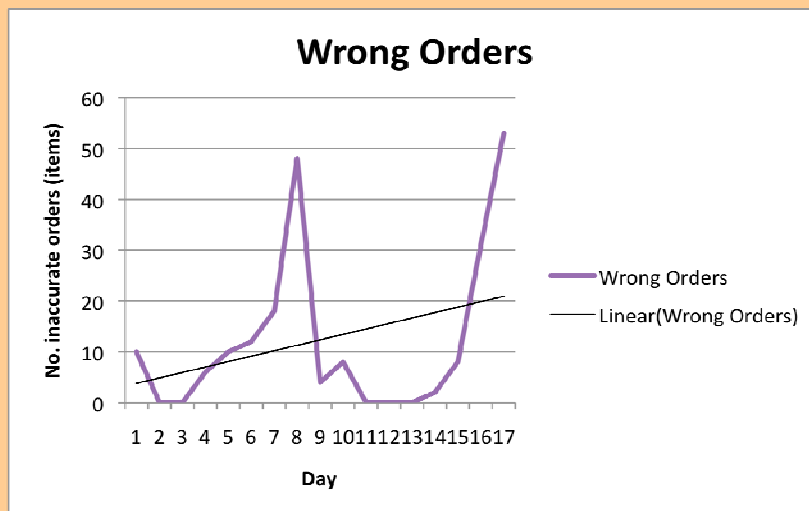


YEARLY CUMULATIVE INFORMATION

Late Orders (number of items)



Inaccurate Orders (Number of Individual Items)



Appendix 4 - Dashboard Metric and Rationale

The two dashboards would consist of daily, weekly and cumulative yearly statistics. Each hospital would have its own dashboard in addition to an aggregated dashboard for all hospitals.

Hospital Dashboard

Complaints

One of the significant shifts in the new NHS GG&C operational model is that the PDC now effectively has a supplier/customer relationship. This means that sites now expect a level of customer service commensurate with commercial distributors. This will ultimately involve the PDC being responsive to customer needs and complaints - taking action to minimize these problems where possible. The first step in this direction is to gather the following management information:

Complaints by Code

Complaints should be coded according to the *type* of problem being reported. This may involve delivery problems, order problems, invoice problems, or whatever categories are deemed most appropriate after consultation with customer service staff and management.

Complaints by Hospital

It is important to gather information detailing *where* the issues reported are arising. This data can quickly point to a high volume of problems relating to specific issues at a particular site. This can then be investigated and help management identify SOPs or personnel issues that are causing the problem.

Average Resolution time

As part of the performance measurement of customer service representatives, it is suggested that the time taken to resolve any particular issues be considered. This is important in private sector operations where suppliers are often interchangeable and customer focus is paramount. Because the same commercial pressures do not exist in the NHS GG&C, complacency from the PDC and customer service representatives is a very real danger.

Late Orders (Broken down by standard and non-standard orders)

The volume of late orders will be an important barometer for managers of the supply chain. This will help identify any bottlenecks or demand spikes or insufficient labour

Inaccurate Orders

Accuracy is of critical importance in the NHS GGC&C supply chain - perhaps more so than in any other industry - and therefore an accurate and detailed record of incorrect orders should be established. This data can then be analysed to ascertain whether the errors were manual or robotic.

PDC Dashboard

PDC Stockholding Value

As one of the goals of the redesign project was to realise a reduction in stockholding, it is important to monitor current stockholding values. More work will need to be done to establish how to operationalise this metric, as it may require creating some kind of SQL query being created. The stockholding value will be a useful figure to ensure that wastage or inefficiency creeps into the system over time.

PDC Wastage Report

It is inevitable that some stock will be either damaged or wasted in the PDC over time. This may include damages, controlled items being stored incorrectly or other miscellaneous forms of wastage. When implementing a total quality culture, tracking avoidable forms of wastage is necessary.

PDC Downtime & Recovery

The PDC Robot can provide information about downtime. What is also critical to report is the recovery time, or the time taken by the PDC to become fully operational following a breakdown. Given that downtime can be caused by an array of factors, it is not sufficient to assume a standard recovery time. For instance, some breakdowns have caused internal shelving and stock to crash to the floor, taking hours to recover from. Improving recovery time should be an important consideration for ensuring the stability of the system.

Robot Picking Accuracy

The ARx robot can produce a report that details the accuracy of picking. While it is not expected to deviate from the accuracy levels specified by the manufacturer, it is advisable to regularly monitor this so that problems can be quickly identified and reported to ARx engineers.

Outgoing Accuracy Check

It was identified during the study that, although the robot was claiming a picking accuracy of almost 100%, in reality the figure was far lower. This is because the errors were occurring after the items had been picked and instead when they were being separated into destination tote boxes.

There is also the possibility of human error causing inaccurate orders, primarily when manual pickers are filling orders. It is not feasible to check every outgoing order, but an agreeable sampling rate should be agreed to monitor the PDC output.

PDC Staffing Levels (Staff hours/Bank Staff hours)

A useful correlation to examine would be staffing hours compared with output, and accuracy. It would also be useful to examine the effect on output that differing levels of bank vs. permanent staff has – if any.

Bibliography

1. Crane J, Crane F. Preventing medication errors in hospitals through a systems approach and technological innovation: a prescription for 2010. *Hospital topics*. 2006;84(4):3-8.
2. Jindal k, Puangpee P. *Medicines Supply Chain - Examination of Robotic Systems for NHS Greater Glasgow & Clyde*. Glasgow: University of Strathclyde; 2010.
3. Bresler L. *The Quarterly Journal of Music Teaching and Learning*. 1995;6(3).
4. Fetterman. *Ethnography*. Thousand Oaks, CA: Sage Publications; 1998.
5. Van Maanen J. *Ethnography*. In: Kuper AKaJ, editor. *The Social Science Encyclopedia*. London: Routledge; 1996. p. 263-5.
6. Lewin K. Action research and minority problems. *Journal of Social Issues*. 1946;2:34-6.
7. Meyer J. Qualitative research in health care: using qualitative methods in health related action research. . *BMJ*. 2000;320:178-81.
8. O'Brien R. An overview of the methodological approach of action research. 1998.
9. Brydon-Miller M. Participatory action research: psychology and social change. . *Journal of Social Issues*. 1997;53(4):657-66.
10. Pope C, Mays N. Reaching the parts other methods cannot reach: an introduction to qualitative methods in health and health services research. *BMJ*. 1995;311:42-5.
11. Winter R. *Learning From experience: principles and Practice in Action-Research*. Philadelphia: The Falmer press; 1989.
12. East L, Robinson J. Change in process: bringing about change in health care through action research. . *Journal of Clinical Nursing*. 1994;3:57-61.
13. Simchi-Levi D, Kaminsky P, Simchi-Levi E. *Designing and managing the supply chain: concepts, strategies, and case studies*. London: McGraw-Hill/Irwin; 2003.
14. Anderson D, F Britt F, and Favre DJ. *The 7 Principles of Supply Chain Management*. *Supply Chain Management Review*. 1997(Spring).
15. van Bodegraven A, Ackerman KB. A lean, mean supply chain machin. 2007 [cited 2010 01/09/2010]; Available from: <http://www.dvelocity.com/articles/20071101basictraining/>.
16. Jarrett PG. An analysis of international health care logistics: The benefits and implications of implementing just-in-time systems in the health care industry. *Leadership in Health Services*. [doi:10.1108/13660750610643813]. 2006;19:1-10.
17. Jin M, Switzer M, Agirbas G. Six Sigma and Lean in healthcare logistics centre design and operation: a case at North Mississippi Health Services. *International Journal of Six Sigma and Competitive Advantage*. [doi:10.1504/IJSSCA.2008.021840]. 2008;4:270-88.
18. Bepko RJJ, Moore JR, Coleman JR. Implementation of a Pharmacy Automation System (Robotics) to Ensure Medication Safety at Norwalk Hospital. *Quality Management in Healthcare*. 2009;18(2):103-14 10.1097/QMH.0b013e3181a02771.
19. White L. Key success factors in the implementation of an automated dispensing system in a community pharmacy. *International Journal of Healthcare Technology and Management*. 2009;10(6):393-407.

20. Coleman B. hospital pharmacy staff attitudes towards automated dispensing before and after. hospital pharmacist. 2004;11(June):248.
21. White L. Key success factors in the implementation of an automated dispensing system in a community pharmacy. *International Journal of Healthcare Technology and Management*. 2009;10(6):393-407.
22. Coleman B. Hospital pharmacy staff attitudes towards automated dispensing before and after. *Hospital Pharmacist*. 2004 June;11:248.
23. Crane J, ., Crane F. Preventing medication errors in hospitals through a systems approach and technological innovation: a prescription for 2010. *Hospital topics*. 2006;84(4):3-8.
24. Leape LL, Bates DW, Cullen DJ, Cooper J, Demonaco HJ, Gallivan T, et al. Systems Analysis of Adverse Drug Events. *JAMA*. 1995 July 5, 1995;274(1):35-43.
25. Bonnabry P. Information Technologies for the Prevention of Medication Errors. *CHIMIA International Journal for Chemistry*. [doi:10.2533/000942905777676399]. 2005;59:359-61.
26. Hakk E, Walenbergh van-Veen M, . Pharmacy Drug Distribution Redesign. *EJHPP Practice*. 2006;12(5).
27. Bates DW. Using information technology to reduce rates of medication errors in hospitals. *BMJ*. 2000 March 18, 2000;320(7237):788-91.
28. Franklin BD, O'Grady K, Voncina L, Popoola J, Jacklin A. An evaluation of two automated dispensing machines in UK hospital pharmacy. *International Journal of Pharmacy Practice*. 2008;16(1):47-53.
29. Brinklow N. A report assessing the impact of an ADS at Kings College Hospital Trust. London: Kings College Hospital Trust NHS2006.
30. Rhule F, Braun R, Ostermann H. Impact of Robotic Dispensing Machines in German Pharmacies on Business Performance Indicators. *Libyan Journal of Medicine*. 2009;4(4).
31. Willcocks L. MANAGING INFORMATION SYSTEMS IN UK PUBLIC ADMINISTRATION: ISSUES AND PROSPECTS. *Public Administration*. 1994;72(1):13-32.
32. Scalise D. Six sigma. The quest for quality. *Hosp Health Netw*. 2001;75(12):41-6.
33. van den Heuvel J. Dutch Hospital Implements Six Sigma. *SIX SIGMA FORUM MAGAZINE*. 2005.
34. Saccomano A. GAXT prescriptions for JIT hospital supplies. *Traffic World*. 1996 January 29th 22-3.
35. Saccomano A. GAXT prescriptions for JIT hospital supplies *Traffic World*. 1996(Jan 29th):22-3.
36. Jarrett PG. Logistics in the health care industry. *International Journal of Physical Distribution and Logistics Management*. 1998;28:741-72.
37. Costantino N, Dotoli M, Falagario M, Fanti MP, Mangini AM, Sciancalepore F, et al., editors. A model for the optimal design of the Hospital Drug Distribution Chain. *Health Care Management (WHCM)*, 2010 IEEE Workshop on; 2010.
38. Srinivasan M, Srinivasan T, Choi E. The Lean Supply Chain. *Handbook of Global Supply*. London: Sagw; 2007.

39. Di Martinelly C. Proposition of a framework to reengineer and evaluate the hospital supply chain. Lyon: INSTITUT NATIONAL DES SCIENCES APPLIQUÉES 2008.
40. Rackoff N, Wiseman C, Ullrich WA. Information Systems for Competitive Advantage: Implementation of a Planning Process. *MIS Quarterly*. 1985;9(4):285-94.
41. Dellaert N, van de Poel E. Global inventory control in an academic hospital. *International Journal of Production Economics*. [doi: DOI: 10.1016/0925-5273(95)00110-7]. 1996;46-47:277-84.
42. Nicholson L, Vakharia AJ, Selcuk Erenguc S. Outsourcing inventory management decisions in healthcare: Models and application. *European Journal of Operational Research*. [doi: DOI: 10.1016/S0377-2217(02)00700-2]. 2004;154(1):271-90.
43. Fitzsimmons JA, J. FM. *Service Management*. 4th ed: Irwin/McGraw-Hill; 2003.
44. Slack N, Chambers S, Johnston R. *Operations Management*. 5th ed: Pearson Education Limited.; 2007.
45. Tagaras G, Vlachos D. A periodic review inventory system with emergency replenishments. *Management Science*. 2001;47(3):415-29.
46. Satir A, Cengiz D. Medicinal inventory control in a University Health Centre. *Journal of Operation Research Society*. 1987;38(5):387-95.
47. Noel MW. Quantitative measurements of inventory control. *American Journal of Hospital Pharmacy*. 1984;41(11):2378-83.
48. Authority NL. Report for NHS Pharmacy Supply Chain Best Practice Programme Board on Pharmacy Supply Chain Best Practice Pilot Study at Royal Bournemouth & Christchurch Hospitals NHS Foundation Trust 2005.
49. Salamie D. Modern inventory analysis techniques. *American Journal of Health-System Pharmacy* 2000;57(4):351-67.
50. Kaur J, Bapna JS, Bhoi N, Singh OP. Management of Hospital Pharmacy in Private Sector. *Journal of Health Management*. 2006;6(129-137).
51. Murphy J, Yemen S. Computer-assisted inventory control utilizing ABC inventory analysis and EOQ in a hospital pharmacy. *Canadian Journal of Hospital Pharmacy*. 1986;39(6):159-63.
52. Pettigrew A. *The Awakening Giant: Continuity in Change in ICI*. Oxford: Basil Blackwell; 1985.
53. Fombrun CJ. *Turning Points*. 1992.
54. Greenwood R, Hinnings CR. Organisational design types, tracks and the dynamics of strategic change. *Organization Studies*. 1988;9(3):293-316.
55. Dawson P. *Organisational Change: A Processual Approach*. London: Paul Chapman; 1994.
56. Dawson P. Beyond conventional change models: a processual prospective. *Asia Pacific Journal of Human Resources*. 1996;34(2):57-70.
57. Pettigrew A, Whipp R. *Managing Change for Competitive Success*. Cambridge: Blackwell; 1991.
58. Nelson L. A case study in organisational change: implications for theory. *The Learning Organisation*. 2003;10(1):18-30.

59. Richards TJ, Richards L. Using computers in qualitative research. Fielding NGR, M. L., editor. London: Sage Publications; 1994.
60. Zhao Y, Lui Y. Organisational change: a case study on Anhui Telecom Company. International Seminar on Business and Information Management 2008. p. 133-6.
61. Nettleton S, Burrow R, Watt I. Regulating medical bodies? The consequences of the 'modernisation' of the NHS and the disembodiment of clinical knowledge. *Sociology of Health & Illness*. 2008;30(3):333-48.
62. Gordon DR. Clinical science and clinical experience: changing boundaries between art and science in medicine. In: Lock MG, R. R. , editor. *Biomedicine examined*. Dordrecht: Kluwer; 1988. p. 257-95.
63. Shilling C, Mellor P. Cultures of embodied experience: technology, religion and body pedagogics. *Sociological Review*. 2007;55(3):531-49.
64. McDonald R, Waring J, Harrison S. At the cutting edge? Modernisation and nostalgia in a hospital operating theatre department. . *Sociology*. 2006;40:1097-115.
65. Drainoni ML, Strickler G, Omans J. Redeployment of staff from state institutions: issues for state health policy makers. *Administration and Policy in Mental Health*. 1995;22(5):226-562.
66. Baumann A, Giovannetti P, O'Brien-Pallas L, Mallette C, Deber R, Blythe J, et al. Healthcare restructuring: the impact of job change. *Nursing Leadership (CJNL)*. 2001;14(1):14-20.
67. Cameron S, Horsburgh ME, Armstrong-Stassen M. Job satisfaction, propensity to leave and burnout in RNs and RNAs: A multivariate perspective. *The Canadian Journal of Nursing Administration*. 1994;7(3):43-64.
68. Salmond SW. Models of care using unlicensed assistive personnel. Part I: Job scope, preparation and utilisation patterns. . *Orthopaedic Nursing*. 1995;14(5):20-30.
69. Shindul-Rothschild J, Berry D, Long-Middleton E. Where have all the nurses gone? Final results of our patient care survey. *American Journal of Nursing*. 1996;96(11):24-39.
70. Hausman W. *Supply Chain Performance Metrics*. 2002.
71. Kaplan R, Norton D. The balanced scorecard: measures that drive performance. *Harvard business review*. 1992;70:71-9.
72. Zelman W, Pink G, Matthias C. Use of the balanced scorecard in health care. *Health Care Finance*. 2003;29(4):1-16.
73. Brewer PCS, T. W. Using the Balanced Scorecard to Measure Supply Chain Performance. *JOURNAL OF BUSINESS LOGISTICS*. 2000;21(1):75-94.