Where are you? A preliminary examination of the track and trace mechanisms in place to facilitate effective closed-loop medical equipment retrieval in the National Health Service (NHS) (UK).

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Abstract

The National Health Service (UK) is wholly accountable and heavily scrutinised for its strategy, activity, performance and spending (Appleby, 2016; NHS Confederation, 2016; Parliament UK, 2010), and much research has been undertaken as to its effectiveness at managing its operations and its competency in doing so (Gov.Uk, 2016; National Audit Office, 1999)). The impact of not performing adequately combined with threats such as funding cuts (King's Fund, 2016), government intervention and private sector competition; has led to uncertainty and disillusion with the sustainability of the service (Hunter, 2016). Based on current economic concerns, this paper chooses to focus on the area of Medical Equipment Loans Services where products are released to patients to aid therapeutic rehabilitation and physical mobility. The aim of this study is to examine the process of product retrieval in a multi-case study analysis and consider how value-added technologies can be used to improve retrieval success rates.

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Introduction

As reported by the NHS Confederation (2016) the NHS net expenditure has increased from £64.173 billion in 2003/04 to £113.300bn in 2014/15. Planned expenditure has also been reported for 2015/16 as £116.574bn. In reviewing health expenditure per capita in England (medical services, health research, central and other health services) this has risen from £1,841 in 2009/10 to £1,994 in 2013/14 (NHS Confederation, 2016). According to the National Information Board (NIB) (2014) the health and care system faces unprecedented financial constraint at a time of rising demand for its services. *"Technology can help people use care services less by supporting healthier lives; and it can transform the cost of services when they are needed. It is key to helping our NHS meet the efficiency, as well as quality, challenges it faces"* (NIB 3:2014). The National Audit Office in 1999 reported that NHS Trusts spent £120 million on new and £97 million on replacement medical equipment in 1996-97. NHS trusts spent £20.6 billion in 2011-12 on goods and services of which £4.5 billion was on clinical supplies and services which includes medical devices and occupational therapy resources (Department of Health/NHS England, 2013). "*Medical equipment includes all medical devices connected to patients as part of their treatment and care in hospital, and medical devices used for diagnostic and laboratory purposes. Medical equipment therefore represents a substantial asset for the NHS that needs to be managed efficiently". (National Audit Office, 1:1999).*

The NHS is known for its outward service provision but also it is needs to focus on the effective management of physical goods like pharmaceuticals, medical devices and health aids as well as the flow of patients (Beier, 1995). Such efforts can thus support the agenda as outlined by the NIB and the Department of Health, through waste reduction and asset management in a fiscally challenged era. To date in the academic and professional arena, there is limited analysis of the mechanisms by which medical equipment is managed and returned as assets into the system and how this can be improved. This study aims through its findings provide some intelligence on the process of asset management of medical equipment within this closed loop supply chain and explore the use of facilitating technologies in asset retrieval.

Reverse Logistics in action

There is a wealth of supply chain (SC) management (SCM) research undertaken within health care sector, which indicates that the health care sector not only relates to medical service provision, but also needs effective management of physical goods like pharmaceuticals, medical devices and equipment. In healthcare SC physical goods are provided to facilitate the medical service delivery or enhance the effect of such a service. As a service cannot be returned, the "recovery" of resources is considered to be the terminating return process (Giannakis, 2011). The management of medical equipment is a closed-loop supply chain which in essence is a system in which returned products or components are recycled. The focus therein is to add value through product reuse or recovery or parts from the product through refurbishment/repair (Guide and Van Wassenhove, 2009).When a given medical service provision reaches its natural end and patients are rehabilitated, the recovery is the return of some physical goods and reuse of them for the next patient. The aforementioned process is an emerging field in healthcare that concerns the reverse flows of physical goods from downstream customers to upstream providers. A systematic approach to investigate this phenomenon is the reverse logistics (RL) system, which retrieves the product from the end user for the purposes of capturing value or proper disposal (Van Hoek, 1999). RL brings economic benefits of cost minimisation and increasing productivity and revenue through promoting alternate uses of resources that are

environment friendly and economically effective (Stock *et al*., 2002). By adopting RL practices, organisations can achieve Corporate Social Responsibility and Sustainability by reducing waste and adverse impacts on environment (Alvarez-Gil *et al*., 2007).

In the NHS, designated coordinators are usually appointed and trained to take responsibility for key asset management of medical devices. Such coordinators can range from specialised teams within hospitals to community and district nursing staff, private healthcare providers and carers. Within a busy hospital environment, high volumes of mobile medical devices move between medical departments, theatres and hospital Medical Equipment Libraries, which makes management of mobile devices a challenge. Loss or of medical devices lead to significant unnecessary costs relating to staff time spent on tracking the devices, procurement or renting cost of new devices. Asset management of medical devices within the NHS has come under increasing scrutiny as the belief is that there is a lack of asset management strategy and discipline, leading to waste (Moore, 2014).

From the perspectives of both economics and safety, there is a need to collect devices from end users within hospital, when they are no longer needed or when they need maintenance or repair. In the case where a faulty device is returned, a replacement one is issued to the same end user. Regardless of the type of reverse activity, the medical device needs to enter the RL system. Research undertaken by Dapiran and Kam (2014) asserted the need to focus on the concept of value creation in relation to product returns management. The authors recognised the financial impact of effective product management and its contribution to an organisations financial position. Their literature review asserted that firms can benefit from the information released from a well-designed and an effectively executed product returns system, e.g. this information offers greater transparency of product location, arrival time, condition to plan for refurbishment and redeployment when needed. This effectively links the closed-loop returns practice with forward planning and replenishment e.g. Continuous Planning Forecasting and Replenishment (CPFR), which is critical when supply chains depend on product returns for reuse as the standard service offering (Ketzenberg, 2009). Other benefits highlighted by Dapiran and Kam (2014) include optimisation of storage space and possible reductions of costs relating to reduced storage, deficiencies in product design/functionality (after repeated use), and the ability to reduce lead times to deliver products which can lead to improved customer satisfaction (Dapiran and Kam, 2011).

The healthcare sector's focuses are medical treatment and forward logistics, and RL is in an exception-driven process in healthcare SC, thus not designed or implemented with great attention or effort. A recent study from Jalil *et al*. (2016) identified significant interactions between situational and personal factors, in particular demographic factors, impacting on household recycling behaviour pertaining to RL. The key factors are identified as engagement, convenience, availability and accessibility. With enhanced engagement in RL from healthcare professionals, healthcare sectors could see an increase in availability and accessibility of well-maintained medical devices, and an increment in savings by eliminating waste. Healthcare RL involves the mapping of the return flow, setting standard lead times for returns, defining the cost of returns, establishing the physical inventory locations and reprocessing the returns. Transportation needs to be arranged that will handle the flow of the reverse chain effectively. At present, data for items entering the RL are often of poor quality (limited in its quantity, value and use). Thus, a different overall perspective is needed for managing RL systems in the healthcare sectors (Rogers and Tibben-Lembke, 1999).

RL in healthcare supply chains is beginning to gain attention from academics and practitioners (Xie *et al.*, 2016; Xie and Breen, 2014; Xie and Breen, 2012; Breen, 2006), but there is little research that has been conducted to investigate returns in healthcare sectors in the UK.

Medical Equipment services within NHS Operations

As defined above (National Audit Office, 1999) medical equipment comes in various forms and is generally used to encourage patient mobility and rehabilitation and diagnostics. According to the MHRA (2014), a medical device is a device or instrument manufactured for i) diagnosis or treatment of disease (such as X-ray machines, Magnetic Resonance Imaging (MRI) scanners); ii) monitoring of patients (ECG, pulse oximeter), iii) critical care (blood-gas analysers, defibrillators); iv) improving function and independence of people with physical impairments (hoists, walking aids); v) community based healthcare (urine drainage systems); and vi) emergency services (stretchers, trolleys). For the purpose of this study, the medical equipment examined focuses on rehabilitation and mobility as opposed to diagnostics/laboratory use. Medical equipment and associated devices are managed by stores, central pools or libraries, which have the obligation to ensure all devices are clean and fit for use. The device stores, pools or libraries are either located in hospitals as separate units or in the form of community stores, such as Integrated Community Equipment Services (ICES), and they have the ownership of the devices and are responsible for issuing devices to patients/carers as required (Xie *et al.,* 2016).

Once a patient's health status has changed (improved or worsened) these products/devices are deemed as of end of use items and so need to be returned for maintenance and reuse. Should this retrieval practice not be in place, NHS operations will have to procure additional medical equipment increasing the strain on NHS purse and budgets unnecessarily. More specifically the mechanisms involved in instigating product retrieval and how this can be improved upon to deliver enhanced performance and savings for the NHS as a whole.

The NHS, as stated above, use medical device as part of their core and extended service provision. At times this has led to equipment loss and shrinkage through non-returns, damage and theft, examples of which have been seen in the community (non-return of crutches, Lomax, 2011), and in hospital (non-return of pyjamas, Donnelly, 2014). Breen when examining returnable transit container (RTC) shrinkage in industry (2006) asserted that customers not returning RTCs which were key inputs into, and facilitators of, service delivery e.g. pallets, tote boxes, roll cages etc could cost some industries up to £140 billion. The variation and disparity in NHS spend on medical equipment (National Audit Office, 1999) has brought this area under scrutiny as a high percentage of costs are attributed to equipment and inventory generally (Baffo et al., 2009; Oliveira and Nightingale, 2007; Aptel and Pourjalali, 2001).

The MHRA (Medicines and Healthcare Products Regulatory Agency) in 2014 published a report on Managing Medical Devices, asserting that *"The purpose of this document is to outline a systematic approach to the acquisition, deployment, maintenance (preventive maintenance and performance assurance), repair and disposal of medical devices. We also give guidance on medical device training"* (4: 2014). Whilst this is a comprehensive document, it does not discuss the implications of stock shrinkage and retention by patients or offer solutions to prevent/respond to this issue.

Currently there is no legislation which specifically covers the resale or reuse of medical devices or equipment. However, should products be surplus to requirements and risk assessed as safe to use and working according to specification, it can be resold but all relevant documentation e.g. service history etc must be presented and the device has to be compliant with other legislation e.g. Consumer

Protection Act (Consumer Safety and Product Liability); Sale and Supply of Goods Act; Health and Safety at Work Act (MHRA, 2014).

Managing assets and inventory – now and the future.

The Carter Review into operational productivity and performance in NHS acute hospitals (Gov.UK, 2016) emphasised that implementing digital platforms alongside improved inventory management and staff organisational practices could yield savings of up to £5 billion per annum, with the introduction of GS1 standards alone across every NHS hospital accounting for £3 million in potential savings. The role that technology could play in tracking and managing inventory was emphasised in an analysis of 22 trusts undertaken as part of the review which suggested that 30,000 suppliers were used yielding 20,000 product brands with more than 400,000 manufacturer product codes ordered by over 7000 NHS employees. Few trusts could demonstrate basic visibility of their inventory and purchase order compliance and with this in mind, the NHS National Information Board's digital roadmaps is now driving the introduction of paper-free clinical care by 2020 across trusts (National Information Board, 2014). This envisages that by October 2018, the NHS will have seen the widespread introduction of ICT systems for e-rostering, e-prescribing, e-cataloguing, costing at the individual patient level and inventory management including the tracking and management of stock and assets using tagging technologies. The aim of NIB *" is to put data and technology safely to work for patients, service users, citizens and the caring professionals who serve them, to help ensure that health and care in this country is improving and sustainable"* (3:2014).

There are many technologies capable of realising this vision within healthcare operations which aid the management of inventory and reduce wastage as part of existing Continuous Planning Forecasting and Replenishment (CPFR), Electronic Data Management (EDI) and Vendor Managed Inventory (VMI) systems (Kumar *et al*., 2008; Guimarães *et al*., 2011; Dumoulin *et al*., 2012). Information Communications Technologies (ICT) such as barcoding, QR coding and RFID tagging (Towill and Christopher, 2005; Parnaby and Towill, 2008; Parnaby and Towill, 2009) are being used to not only automate stock management and handling processes, but also enhance the visibility of who is interacting with inventory in time and space to improve understanding of usage rates.

The adoption of technologies such as Quick Response (QR) codes has seen a cost-effective way of delivering and retrieving digital information facilitating a higher level of engagement in operational spaces in B-2-C and B-2-B operations. Examples of application include the use of QR codes in: 1) service environments e.g. in museums (Pérez-Sanagustín *et al*., 2016); schools (Reffstrup Christensen *et al.,* 2015); researcher recruitment (Gua *et al.,* 2016); 2) in supply chain/logistics e.g. medication compliance (Mira *et al*., 2015); freight logistics (Chang *et al.,* 2015); and 3) manufacturing e.g. bulk metallic glass replication (Vella *et al*., 2015); information sharing in SMEs (Park, 2015).

Intelligent storage solutions are becoming a key part of electronic prescribing and medicines administration (EMPA) where hospitals reduce medication errors and save time through automating central pharmacy tasks and inventory management (IPSA, 2016; Omnicell, 2011). Such technological approaches have helped better integrate the clinical decision support system with the patients' passage through the system from admission to discharge, and have enable staff time to be better utilised with the removal of paper-based records processes. Trusts such as Cambridge, Royal Cornwall and University Hospital Birmingham have all implemented such systems and are realising benefits. The Royal Wolverhampton NHS Trust has used real-time locating software along with infra-red and RFID

tagging to locate patients, equipment and staff in real-time. This has been primarily used to monitor staff cleanliness compliance as part of their SafeHands programme but the system also allows the trust to monitor and evaluate staff-to-patient contact time (National Health Executive, 2016).

A study undertaken by Bendavid *et al*. (2010) implemented an e-kanban RFID solution but the success of this within the hospital was the introduction of this resource in conjunction with the redesign of the ward floor and of the roles and functions. The authors purported that *" The most important benefits for the hospital are derived from the time saved from non-value-added activities that can be transferred to patient care activities and the significant reduction of on-hand inventory at distributed storage locations*" (1:2010). Other authors have focused on the introduction of RFID in medical supply chains (Swartz *et al.,* 2010; Katz, 2009)

Smart technologies appear to have filtered through into various pockets of healthcare services and due to their level of efficiency and success their uptake and use appears to be spreading. In a study conducted by Buttigieg and Mamo (2012) the authors found that the use of smart technology in the community was an attractive and efficient proposition which were user-friendly and had relatively low running costs. The challenges faced with transferring these technologies to the health care setting are the initial high cost of implementation/installation (Ustundag and Tanyas, 2009) and security maintenance. Another challenge which can presents a barriers to effective implementation and continued use of asset management technologies is the customer reaction to the use of track and trace solutions. Customers may have an adverse reaction relating to data capture using technology such as RFID. Boeck and Wamba (2007) examined this issue and their findings highlight the need for eight key dimensions to be considered and addressed in supply chain relationships to support RFID success such as: communication and information sharing, cooperation, trust, commitment, relationship value, power imbalance and interdependence, adaptation, and conflict.

Methodology

A multi-case study approach was adopted for this study as case study analysis focuses on 'how' and 'why' rather than just the 'what?' (Smart *et al*. 2009:492). Single case research provides depth of study whilst multiple cases augment external validity (Maxwell, 2002). The data was collected from NHS operations within the North of England and Scotland. The locations were chosen based purely on the proximity of the researcher to the respondent sites to encourage response rates. Participants were contacted at random by the researcher via e-mail or telephone or personnel referral (from colleagues within the NHS operation) to source a purposive sample of respondents. The purposive targeting of individuals (Hair *et al*., 2007) was a critical ingredient of this study as the participants needed to be experts in the phenomenon under examination (Creswell and Plano Clark, 2011). The respondents all held a key functional role in of the management of medical equipment. As a comparator Respondent A was also included, a Physiotherapy department involved in the loan medical equipment e.g. crutches. In total 10 operations were approached and 5 agreed to complete the questionnaire and contribute to this study.

A questionnaire was chosen as the most appropriate method of collating data from the respondents. The questionnaire was deployment via e-mail as a Word document that could be edited/respondents could input into, save and return. The line of questioning delivered during the interview was informed by the extant literature on Reverse Logistics practices and specifically asset management/track and trace mechanisms. Where necessary a telephone call was made to a respondent to supplement the data collected via the questionnaire (only applicable to Respondent D). The data was analysed using thematic analysis with the identification of key words and phrases.

Table 1 Respondent Profile

Respondent	Position in NHS Operation	Service provider	Location	Access route
A	Head of Therapy/Physiotherapy	NHS hospital Trust	North England	Personal referral
B	Medical Devices Coordinator	NHS hospital Trust	North England	Personal referral
C	Medical Devices Manager	Integrated Community Equipment Service	Scotland	E-mail
D	Joint Equipment Loans Service Manager	Community Services/Joint Equipment Loans Service (JELS)	North England	E-mail and Telephone
E	Service Manager	Integrated Community Equipment Service	North England	Personal referral

Results

Based on the extant literature reviewed and the participant responses, the process of product release and retrieval can be summarised as follows. Products once 'loaned' to patients are returned for a variety of reasons as shown, and are processed accordingly. Many equipment items are deemed fit for re-use immediately upon return, others need maintenance and repair prior for re-distribution, whilst others are disposed of having come to the end of life use.

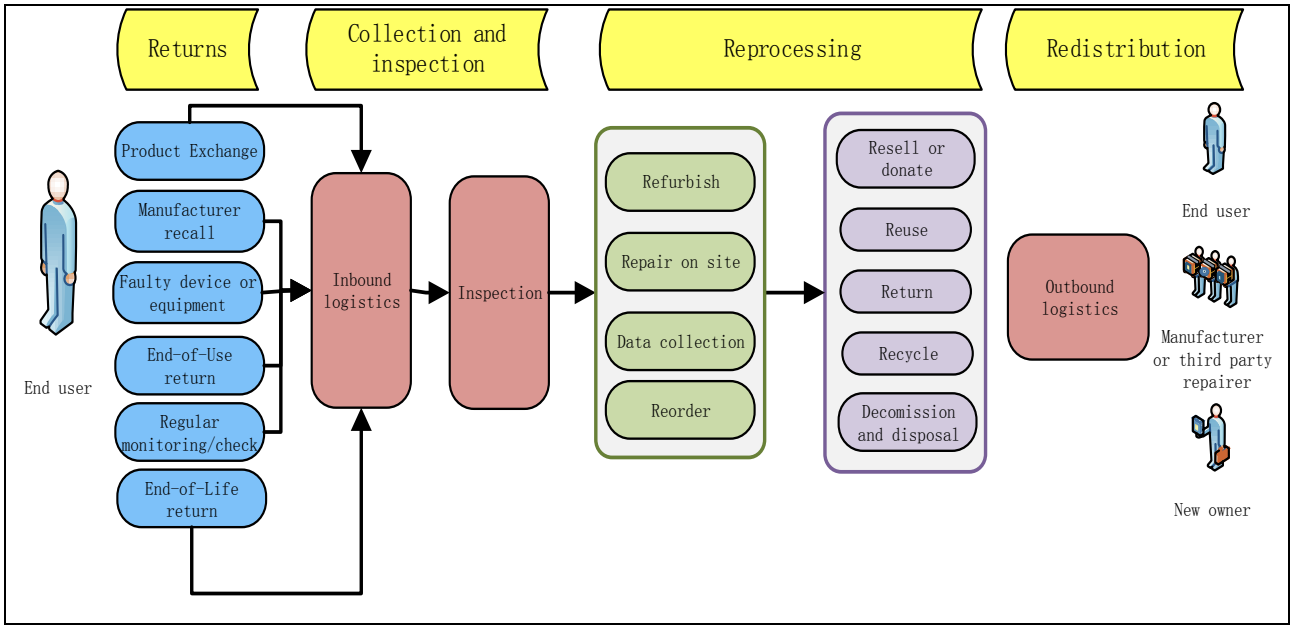

Figure 1 Product retrieval and processing in the healthcare sector.

The general response from equipment service providers was that systems were in place to manage reverse exchanges but some were less developed and effective than others. The sophistication of systems presented indicates a bi-polar split between system design and ICT integration in the simple versus highly developed systems. As stated by Interviewee A, the main problem associated with her simple reverse exchange system was the over reliance on the manual tracking of product, where a staff member would 'remember' who had been allocated what product and so would track this. This system however constantly led to stock shrinkage and loss due to inadequacies in this type of track and trace mechanism. Even though this system at times was supplemented by patients or relatives returning stock, the ICT use was very low and products were not tagged or marked up so retrieval was problematic.

More sophisticated systems adopted an integrated systems approach, e.g. Interviewee C who could issue, track and trace products using an asset management system for stock ordering and control (Equipment Loan Management System (ELMS)) and also link to external community systems e.g. the council's death register. Despite the level of sophistication demonstrated the respondent wanted to extend the use of ICT within the service to enhance the service offering by improving their response time, user engagement and overall quality.

This system also currently had the capability to place orders on iPads in the patient's home and send them through to Headquarters/stores. The iPad allowed the staff member to connect to the NHS system, and then provide access into the ELMS system, history, online catalogue, and ordering system. This facilitates a quicker stock turnaround for the user and ensures that high quality information is always available to the service provider on and off site.

Process Enhancements through facilitating technologies

The interviewees had varied views as to the potential use of smart technologies to automate and enhance the reverse exchange of equipment and medical devices. Interviewee C wanted to adopt a type of 'Facetime' (Apple application) but a more robust version of this. His equipment service had a

wide geographic spread and the manager wanted to harness ICT solutions to provide real time communications between himself and staff members to provide expert advice from the office to support equipment installations and user queries. The limiting factor was the internet capability and connectivity at the present time in this area. This restricted how he could develop his service and what applications he could employ. .The lead time for product delivery was very short; *"The current schedule is if a patient request is made before 3pm then the order has a guaranteed delivery time of the following day".* This being the case, the more automated key activities in the process were the greater the success rate for on time delivery.

Interviewee C also wanted to maximise the time his staff spent with users in their homes, by having pre-loaded patient information on the IPad ready for use. This could speed up the ordering process but this had confidentiality and security issues which had yet to be resolved.

Interviewees within the equipment departments/services were invited to speculate as to the use of 'common' (as informed by the extant literature) smart applications/technologies (Texts, smart applications (Apps), RFID, dedicated websites for track and trace and QR codes) and how they could be employed within their services. Their responses are collated in Table 2.

Table 2 Process improvement options as suggested by interviewees

Improvement option	**Interviewee**				
	A	**B**	**C**	**D**	**E**
Smart phone application	Not sure	Yes	Yes	No	No
Text service	Yes	Yes	Yes	No	Yes
Dedicated website with track and trace functionality	Yes	No	Yes	Possibly	No
RFID chipping	Yes	Yes	No	No	No
QR codes	Not sure	No	Yes	No	No

Smart applications to support the reverse exchange of products were not popular within this group. One interviewee (Interviewee C) already used an app which was a 'lite' version of the full ELMs asset management system, so he could appreciate the current and potential value of smart applications. The same interviewee had commented on the proposed use of a 'Facetime' application to support service provision.

The use of the text service appeared to be the favoured choice of contact for stock retrieval – this may be due to the fact that text systems are already in place in hospitals for appointment reminders etc. It was suggested that the use of text to instigate equipment recovery could 'piggy-back' onto this existing system as this was entirely feasible by using the current infrastructure. Some respondents had

this in place already for equipment reminders for collection whilst others were considering introducing it.

Dedicated track and trace websites are used by logistics providers and allow customers to log into a dedicated site to gauge the status of their order/delivery. The interviewees did think that there was merit in the use of such technology but did not know of any in use or what they would look like/how they would perform in their service. This was one of the more elusive options (in that they could not relate to its use as easy as others).

RFID was considered by the majority of services as useful but too expensive. Equipment circulated to patients was generally marked or tagged in some manner but not electronically using RFID tags. Interviewee C stated that their products were tagged with barcodes and indelible markings are used on products. Interviewee E concurred with the RFID cost issue and indicated that her service practice was as follows: *"Currently all products owned and released from this service have red vinyl address labels and barcodes. The driver scans the code to sign out the product using a hand held scanner, the data is uploaded via a cradle day end and the product allocation/stock levels updated on the system. The same occurs when a piece of equipment is collected. Thus the product is booked back into the system".* Yet whilst this system appeared very effective in retrieving products it only worked if the product was presented for return. She also commented that pieces of equipment marked up for this NHS trust had been found in second hand sales shops, which indicates that marking of property may not be a robust mechanism for product recovery.

QR codes appeared to be less well known within this group of Respondents. The participants did not appear to know much about or what they could offer from an information sharing functionality. Once explained they thought that QR codes would be useful on literature provided to patients supporting the equipment service (e.g. delivery notes Interviewee C).

Interviewee A stated that equipment provided in their service (physio/OT) had no identifiable markings. She stated that a lot of stock is lost due to patients not returning it and it having no markings to be identified and returned by honest people. The practice of marking up of stock would be too costly and a lot of time and money is wasted trying to chase stock held by patients, so it is not undertaken anymore.

Discussion

The findings of this study indicate a number of key results that warrant analysis.

Process Design and execution

The most obvious finding was the variety in the design and execution of product return processes within each respondent site. Technologies to support product management within a healthcare operation (Bendavid *et al*., 2010) can affect process redesign to deliver enhanced service outputs. Based on the sophistication of the process and the level of technology employed to facilitate returns, Interviewee C had the most advance process and Interviewee A the most basic. The variation in both sites appeared to be based on a number of variables including; impetus to retrieve the products, resources to facilitate product returns, tracking mechanisms, time and overall management of the entire process. Interviewee C managed the process in a very controlled manner and was keen to

enhance the process further whereas Interviewee A managed this process as well as delivering clinical care.

The majority of respondents had good practice in place where the returns process was triggered by the patient when a product was no longer needed. In this instance the product was collected from the patient, in the exception of Interviewee A whereby this mechanism was not in place and the patient had to actively return the product. Jalil *et al*. (2016) asserted that the key factors in domestic product returns were engagement, convenience, availability and accessibility. Xie and Breen (2012) also propose adopting a cross boundary green approach when managing the pharmaceutical supply chain Both studies encourages education and awareness amongst all stakeholders and a collaborative approach to an effective RL systems design. The same principles as reported by both sources should be applied to the design and execution of medical equipment retrieval.

Economic contribution and value-add

As a closed loop supply chain the retrieval of products facilitates the sustainability of service provision, very much a critical element of closed loop supply chains to initiate outward logistics (Dapiran and Kam, 2014; Dapiran and Kam, 2011; Ketzenberg, 2009; Guide and Van Wassenhove, 2009).The economic impact of products being delayed or lost within this supply chain leads to longer lead times for product loan/delivery, delays in patient treatment (e.g. where crutches or walking frames are needed for rehabilitation), higher procurement costs in sourcing new equipment (National Audit Office, 1999), and loss of confidence in the healthcare system. From a sustainability perspective it is desirable for patients to return products so that the product loan service can be delivered and products are value-adding in that they are reused where applicable; thus reducing the overall impact on the public sector purse. Interviewee A was strong in her convictions that time was wasted chasing patients and stock held by them so it was a fruitless exercise.

The respondents stated that the normal 'loan' period was open ended with only a few designated items on fixed term loans e.g. beds released to care homes for 6 weeks and then retrieved or equipment used for elective surgery was generally loaned to patients for 12 weeks. The decision to stop using equipment was generally made by the healthcare professional who contacted the ICES or advised the patient to return the product to their provider. Whilst there does appear to be some consistency in the pushing out and pulling in of equipment items, it does provide less reliable transparency of product return times and thus less capacity to use this information for CPFR activity (Dapiran and Kam, 2011; Bendavid *et al*., 2010; Ketzenberg, 2009) which is needed in closed-loop supply chains. The use of technology to monitor this activity has obvious benefits and providing a speedy response to product recovery and re-distribution once it has been retrieved.

ICT choice and engagement

The cost of ICT solutions was considered a barrier (Ustundag and Tanyas, 2009) and this was mentioned by a number of respondents as well as the issue of process secure information securely between disparate smart applications and organisational IT systems (Fisher and Monaghan, 2008). For some (Interviewee A) this coupled with lack of resources to effectively retrieve products meant that this process was not supported by technology of any sort (other than a more manual checking system using an Excel spreadsheet for product tracking). The majority of respondents (80%) had a designated system in place which facilitated equipment management. The Equipment Loan Management System (ELMS) was the most comprehensive package and this was used on 2 sites. This system had the capacity to have smart applications to support the main package (ELMS lite) and was

used by one respondent. As part of the government's healthcare agenda (National Information Board, 2015) more technology will be introduced into all aspects of the NHS to support service delivery and patient care. The findings from this study indicate that technological adoption in this close loop supply chain is more advanced on some sites than others. A possible reason for this in the case of Interviewee C is the geographical position and catchment of this service. The area covered in vast so technology is used to manage remote service support and increase service response. For example orders are placed on I pads and transferred to ICES before staff have left the patients house. This is an excellent use of the technology and also delivers high levels of customer satisfaction.

There was a very mixed response to the adoption of proposed technologies to support asset management. The use of QR codes received a limited response due to lack of knowledge about this product and its functionality. The studies that have shown benefits of the use of QR codes are cross-sector however some research does elude to acceptance of engagement with this technology being higher with a younger generation (Gua *et al*., 2016). However from a cost perspective this technology is less expensive than others such as RFID (Ustundag and Tanyas, 2009). Texting as a process enhancement was seen as a more plausible option. Automate texts could be sent to patients as reminders for equipment returns/collections. As a precedent already exists in NHS hospitals this would not be too challenging to adopt, yet these sites did not use it for this purpose. Whilst RFID has a clear track record in product manufacturing and logistics its functionality and benefits have still to be fully realised in service environments but this is clearly underway (National Health Executive, 2016, Bendavid *et al*., 2010).

Impact

The results indicate that the success of this closed loop supply chain is the continuity of service; products once returned are considered viable for repair, refurbishment and redistribution. This sustains the service provision (Ketzenberg, 2009; Guide and Van Wassenhove, 2009). The role of both well designed systems and processes facilitate this cycle of activity and technology designed into this has to be well considered and appropriate but also progressive. The ultimate impact of technology on this service provision is difficult to identify as it is supported/undermined by other variables such as; 1) patient education and social consciousness (in wanting to be a good citizen and proactively return products and hence do not need to be 'chased'); 2) people supporting infrastructure (health professionals and other facilitating staff who may remind patients or take equipment from them); 3) technology supporting infrastructure (other technologies that link to an asset management system e.g. the council death register as reported by Interviewee C); 4) resource availability (to manage the system effectively, to determine the viability of new technologies) and 5) technology readiness (a willingness and time to explore new options to improve the service design and delivery).

Conclusions and Recommendations

The aim of this study was to examine the process of product retrieval in a multi-case study analysis and consider how value-added technologies can be used to improve retrieval success rates. As stated previously, RL in healthcare supply chains is beginning to gain attention from academics and practitioners (Xie *et al*., 2016: Xie and Breen, 2014), and this study aims to supplement this body of knowledge.

As purported by Bendavid *et al*. (1:2010) *"The most important benefits for the hospital are derived from the time saved from non-value-added activities that can be transferred to patient care*

activities". The outputs of this study indicate that the interviewees strived to deliver a service where they had ICT solutions in place to effectively retrieve stock which reduced the amount of non-value-activity that they had to undertake. At least one department however who distributed medical equipment appeared to concur with the view expressed by Moore (2014) that asset management strategy and practice is not being effectively practiced leading to waste. However this was a clinical department distributing medical equipment for therapeutic needs and so their focus was split between distributing of such assets and treating patients. It does raise the question of the proportion of operations which are so overwhelmed by undertaking non-value added activities, such as writing letters to patients requesting equipment returns, that they stop managing their equipment and inevitably lose stock which challenges the sustainability of service provision.

The results also indicate a strong willingness to improve service provision by the introduction of enhanced asset management technologies, to promote value add activities, to work with patients in managing their equipment needs, to offer a quicker response to patients and to deliver customer satisfaction.

Boeck and Wamba (2007) when discussing RFID success within and between organisations suggest the need for eight key dimensions to be considered: *communication and information sharing, cooperation, trust, commitment, relationship value, power imbalance and interdependence, adaptation, and conflict.* All eight dimensions are critical to the success of any transactional or partnership relationship within the supply chain, including B-2-C relationships. All eight should be considered in the design and redesign of asset management of medical equipment in NHS operations.

This study highlights practice in place across multiple NHS operations regarding asset management and medical equipment retrieval. In doing so it highlights the disparity in practice which can lead to stock shrinkage and variation in stock holding, the operational repercussions of which are a) unavailability of stock; b) increased procurement costs and c) funds tied up in assets and d) delays in therapy and customer dissatisfaction. Due to the magnitude of this issue and the costs attributed to its mismanagement it is under investigation currently within the NHS and wider governmental bodies e.g. the Carter Review (Gov.Uk, 2016).

This study raises awareness of the need to effectively management assets such as medical equipment through well designed RL systems and robust technology and for healthcare professionals to become gatekeepers to this closed loop system, educating patients as critical inputs into this system and providing the channels which facilitate product returns. Whilst the outputs of this study are small scale and thus difficult to generalise upon, we provide an insight into the medical equipment returns process and believe that there is more scope for further research in this area. The economic concerns raised in current governmental literature alone indicate a need for this research to be undertaken. Further analysis can focus specifically on key types of equipment (High volume/low variety and high variety/low volume) and specific providers of this service on a larger scale.

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