Who cares wins? A comparative analysis of household waste medicines and batteries reverse logistics systems – the case of the NHS (UK).

Abstract

Purpose
The purpose of this paper is to determine how best to reduce, reuse and dispose of household waste medicines in the National Health Service (NHS) (UK).

Design/Methodology/Approach
Through a combination of literature review and empirical work, this research investigates the existing household waste medicines Reverse Logistics (RL) system, and makes recommendations for improvement by benchmarking it against household waste batteries RL system. The viability and feasibility of these recommendations are evaluated through in-depth interviews with healthcare professionals and end user surveys.

Findings
The batteries RL system appears to be a more structured and effective system with more active engagement from actors/stakeholders in instigating RL practices and for this very reason is an excellent comparator for waste medicines RL practices. Appropriate best practices are recommended to be incorporated into the waste medicines RL system, including recapturing product value, revised processing approaches, system co-operation and enforcement, drivers and motivations, and system design and facilitation.

Research implications/limitations
This study offers academics and professionals an improved insight into the current household waste medicines RL system, and provides a step towards reducing an existing gap in this under-researched area. A limitation is that only a small sample of healthcare professionals were involved in subjectively evaluating the feasibility of the recommendations, so the applicability of the recommendations needs to be tested in a wider context and the cost effectiveness of implementing the recommendations needs to be analysed.

Practical implications
Reducing, reusing and properly disposing of waste medicines contribute to economic sustainability, environmental protection and personal and community safety. The information retrieved from analysing returned medicines can be used to inform prescribing practice so as to reduce unnecessary medicine waste and meet the medicine optimisation agenda.

Originality/value
This paper advocates learning from best practices in batteries RL to improve the waste medicines RL design and execution, and it supports the current NHS agenda on medicine waste reduction (DoH, 2012). The recommendations made in the paper not only aim to reduce medicine waste, but also to use medicines effectively, placing the emphasis on improving health outcomes.

Key words
Waste medicines, NHS, benchmark, reverse logistics, and batteries reverse logistics.

Paper type
Research

1 Introduction

Research commissioned by the Department of Health (DoH) has found that NHS England prescription medicine waste cost £300 million a year in 2009, and about £90 million worth of medicines are stored in people's homes at any one time (DoH, 2011). The Department for Environment, Food & Rural Affairs (DEFRA) in the UK regulates that medicine waste produced at home is separated from mainstream household waste, and the recommended means of disposal is to return them to pharmacies. In this research, we refer to medicine waste residing within homes as household waste medicines. Such waste not only causes economic loss, but also has an adverse impact on the environment and on human health if the waste is ineffectively disposed of (Daughton and Ternes 1999). Safety is also paramount if medicines fall into the hands of children or individuals who wish to abuse the medicines themselves or support a 'grey' market for medicines exchange/sale for cash. Medicine waste is the result of a number of factors, encompassing: i) patients recovering before their dispensed medicines have all been taken; ii) therapies being stopped or changed because of ineffectiveness and/or unwanted side effects; iii) patients' deaths; and iv) factors relating to repeat prescribing and dispensing processes (DoH, 2011).

To protect the environment, reduce economic loss and increase the safety of medicine use, the DoH produced a series of guidance information on managing waste medicines, stating that community pharmacies are bound by contractual obligation to offer a return service for medication (DoH, 2011). However, the predominant method of disposal of household waste medicines in the UK is via household waste, and the disposal habit becomes an obstacle to developing effective healthcare waste management practice/systems in community Pharmaceutical Supply Chains (PSC) (Bound and Voulvoulis, 2005). The national public survey conducted in 2009 (DoH, 2011) found that the return rate to pharmacies is 40%, attributed to the fact that the sample included relatively high numbers of individuals with an above average interest in the subject and who might be comparatively careful medicines users.

In December 2012, the NHS (UK) launched an action plan to reduce medicine waste. The plan aimed to determine how best practice can be shared to improve the use of medicines and address medicine wastage within the NHS (DoH, 2012). Whilst this study was not involved in this analysis, it runs parallel to it and has the same aim: to determine how best to reduce waste medicines in the NHS (UK). The contracts governing the collection and disposal of waste medicines are organised regionally by Clinical Commissioning Groups (CCGs), a consortium of General Practitioner (GP[1]) groups. Prior to April 2013 these were known as Primary Care Trusts (PCT) and there will be reference to PCTs in the findings of this study as data was sourced from PCT professionals.

On a commercial level, medication is a product, and it enters the Reverse Logistics (RL) channel once it is retrieved from the end users. The focus of the research was on medicines prescribed by a doctor or other healthcare professionals rather than medicines bought over the counter, therefore end users are used to replace customers and refer to patients in a PSC. The RL system facilitates material reduction, reuse of products, refurbishment, repair,

[1] GP is a medical practitioner who treats, and provides preventive care and health education to patients.

remanufacturing, recycling of materials, and waste disposal (Stock, 1998; Van Hoek, 1999). Medication retrieved from end users cannot be reused and must be denatured and disposed of, although there are proposals to reuse expensive medication (Pomerantz, 2004) or to donate some medicines (InterCare, 2012). As there is no commercial value left in the medicines returned, RL of waste medicines gains very little attention (Xie and Breen, 2012; Ritchie et al., 2000), in comparison with research in other sectors where RL aims to recapture value from returned products and direct them towards a second market. The first research objective hence originates at this point; to investigate the existing RL system for household waste medicines in NHS community pharmacies. Although returned medicines are regarded as waste, they are also special types of End-of Life (EoL) or End-of-Use (EoU) returns of consumer goods, and initially source reduction strategies should be considered and developed to minimise waste production (Marien, 1998). The EoL returns are defined as "the returns taken back from the market to avoid environmental or commercial damage" Krikke et al. (2004, pp.26), and they are either returned to the original equipment manufacturer because of legal take back obligations, or other companies for value-added recovery, or environmental agencies for landfill or incineration. InterCare redistribute returned medicines to underdeveloped countries for free, and these medicines are regarded as EoU returns, i.e., products "returned after some period of operations due to the end of leasing, trade-in or product replacement" but still preserving functionality intact and capable of being reused (Krikke et al., 2004, pp.26). Greater contributions can be made if an effective and well-designed RL system is in place to reduce avoidable waste medicines (Xie and Breen, 2012), and reuse EoU medicines (InterCare, 2012), and properly dispose of EoL medicines, thereby reducing impacts on the environment and the risk of accidental injury or planned product abuse.

Previous research on RL has focused on improving business performance in various non-pharmaceutical industrial sectors, for example, household batteries (Kannan 2009, Zhou et al., 2007, Bartels, 1998). There are similarities between these two RL systems; for example, both waste medicines and batteries contain hazardous components and need separate collection and reprocessing. However, the lifecycles of some battery components are extended by reusing or recycling; whereas the majority of waste medicines are disposed of, and only a very limited portion of returned medicines are reused if they are intact, in good condition and in date. The RL system for household waste batteries is studied as the second research objective and, based on examination of its content and application, it appears to be more structured and effective in engaging actors and achieving customer buy-in and uptake. Therefore, the third research objective is to compare the operational practices within these two industries, and recommending best practices.

In summary there are 3 research objectives for this study which will be addressed and delivered to in the following discussion:

I. To study the current RL system for household waste medicines
II. To study the existing RL system for household waste batteries
III. To compare both systems above, identify gaps and best operational practices and deliver grounded recommendations for future design and practice.

The remainder of this paper is organised as follows: a literature review on RL is presented in Section 2, followed by theoretical underpinning and propositions in Section 3. The research methodologies are justified in Section 4. In Section 5, the existing RL systems are identified for household waste medicine and batteries, respectively. A benchmarking process is applied. Discussions and managerial implications of the findings are presented in Section 6. Finally, conclusions and future work are presented in Section 7.

2 Literature review

The literature on RL is broad and diverse, but there is little research that focuses on developing theory for RL. Literature in related fields secondarily adds to the theoretical growth of RL, and have been summarised and classified by Dowlatshahi (2000) in five categories: i) basic concepts and a summary of RL; ii) quantitative models on RL; iii) research dealing with more specific logistical issues; iv) the critical roles of manufacturing technologies and their impacts on RL performances; and v) the applications of RL in different industrial sectors. In addition, the recent literature investigated: vi) the capability, effectiveness and performance of a RL system; (vii) the motivators and the barriers of a RL system; and (viii) how information technology influences and facilitates the operation of a RL system. De Brito and Dekker (2004) developed a framework for understanding RL under four dimensions (see Table 1): “What”, “How”, “Who” and “Why and Why not”, and illustrated that the issues arising from RL system can be orchestrated by the four dimensions. To obtain theoretically grounded and holistic views on RL, this framework is adapted in the research and named as the RL framework, by adding another dimension “Where” (see Table 1) to address specific RL issues such as locations of collection points in a physical RL network.

Insert Table 1 here.

As shown in Table 2, the literature can be placed within the context of the RL framework, addressing one or more dimensions.

Insert Table 2 here.

Although industries have various levels of involvement with RL, applications of RL practices are regarded as difficult, as they complicate the traditional forward SC (Li and Olorunniwo, 2008). RL for waste medicines is more challenging and difficult to implement for the following reasons: *a) Lack of motivation:* There is less commercial motivation for actors in PSC to return or collect waste medicines, nor has the legislation been enacted requiring actors to do so. *b) Challenge of change:* Revising and improving the existing household waste medicines RL system will inevitably incur cost to NHS CCGs. However, reducing and managing medicine waste is a more cost effective way to increase the overall health and wellbeing of heath service users by directly and effectively contributing to improving care quality and health outcomes (DoH, 2010).

Research on RL in pharmaceutical industries has been conducted for B2B returns from entities within the PSC (Kumar et al., 2009), or for by-products within the manufacturing plant (Teunter et al., 2005). This research focuses on the household waste medicines returned by end users.

3 Theoretical underpinning and propositions

There are no established references on designing an RL system and the integral practices within it, so we use related literature to underpin practices proposed for a generic household waste system (Table 3) and then as applied to both batteries and waste medicines RL systems (Table 6). Dowlatshahi (2000) described a holistic view of RL by developing 11 factors for successful design and implementation of RL. The strategic factors consist of strategic costs, overall quality, customer service, environmental concerns, and legislative concerns. The operational factors consist of cost-benefit analysis, transportation, warehousing, supply management, remanufacturing and recycling, and packaging. These factors are framed as testable propositions for a household waste RL, and we use the RL framework (see Table 1) to discuss and complement the propositions (see Table 3).

Insert Table 3 here

3.1 Propositions under the RL framework

We propose that products with residual value are more likely to enter the reverse flows of a RL system, where returned products are reprocessed to recover value. Household waste counted as EoU returns can be directly reused or resold, while there is an order of favourable resource recovery options for those counted as EoL returns: reuse, remanufacturing, parts retrieval and material recycling. Actors in a RL system are made more active and engaged in RL activities due to legislation, economic drivers, corporate social responsibility and environmental concerns. Engagement can also be stimulated if the convenience of returning/collection is improved. However, the success of a RL requires total involvement and effort from every actor in the RL system.

What

The aspect "what" considers what is actually being discarded or returned, and four intrinsic product characteristics are discussed here as they are influential on the RL activities: composition, deterioration (De Brito and Dekker, 2004), dimensional size (Goggin and Browne, 2000) and packaging solution (Silvenius et al., 2013).

Product composition in terms of components, of materials and the number of components, affects the ease of returning/collecting, and reprocessing them and, the associated values recovered from them (Goggin and Browne, 2000).

A further characteristic is deterioration, which determines whether there is enough functionality left within a product to make further use or recapture of residual value from its parts/components viable. In addition, residual value depends on other factors: legislation that regulates the usability of the returned product; the existence of a secondary market (Gobbi, 2011) and the cost of the recovery process (Stock and Mulki, 2009). This deterioration characteristic strongly affects the recovery option, as well as actors' engagement in RL activities. Products may become obsolete because of replacement by a new product, ageing and expiry, or a product may become "obsolete" because of legislation restricting reuse of the returned products, as is the case with medicines. In both cases, reuse or resale of product is not an option; instead, parts retrieval can be considered if some components or packaging have not deteriorated. The findings from Gobbi (2011) indicate that knowing the residual value of the returned product can enhance actors' engagement in the recycling processes.

The dimensional size of the product is also an important factor affecting RL activities (Goggin and Browne, 2000). Small products tend to be discarded or stored rather than returned, while big products are more challenging to be transported and handled if returned.

Package solution of a product can have an influence on a RL that is required to process package related waste, and it concerns package sizes, shapes, materials used and so on. The waste is caused by the following: packaging that is too big for consumer needs or packaging that is too difficult to empty. Silvenius et al. (2013) claim that packaging solutions that minimise waste generation in households as well as in the forward chain will lead to the lowest environmental impacts. Therefore, it is important to design packaging that protects products properly and allows the customers to use the product completely.

The above characteristics have impacts on all other aspects of a RL system, and the impacts are discussed accordingly in the following sections. To best manage household waste, we propose informed practices in Section A of Table 3, under the "What" aspect.

How

The "how" aspect is at the heart of RL, and investigates how value is recovered from returned products. Activities that constitute the most common procedures of RL include return/collection, inspection/selection/sorting, and defining reprocessing strategies which are distinguished as (Thierry et al., 1995): 1) direct reuse (and re-sale); 2) product recovery management (repair; refurbishing; remanufacturing; parts retrieval; materials recycling); and 3) waste management (incineration and land filling).

The choice of collection methods is dependent on reprocessing strategies, cost of recovery, type of product, population of users, location of users, collection routes, transportation modes, etc. (Hanafi et al., 2008). Typical collection methods include manufacturer collection from consumer, retailer collection from consumer and third party collection from consumer (Savaskan et al., 2004). Collection methods are further classified by whether the initial transport is performed by the consumer, or by a waste management company (Jahre, 1995). In the UK, household waste is usually collected by local authorities via a weekly kerbside collection service, or returned to local recycling centers by residents. Products containing hazardous materials need special collection methods.

The definition of reprocessing strategies depends on the type of returns, the design of the remanufactured product or the type of recovered materials/energy, current manufacturing processes and capabilities, as well as the cost-benefit analysis (De Brito and Dekker, 2004). The outcomes of RL activities affect supply management in companies, which concerns the reuse of retrieved parts and materials to reduce the consumption and costs of raw materials (Dowlatshahi, 2000; Thierry et al., 1995). Through cost-benefit analysis, the benefits gained from reprocessing returned products should outweigh associated operational costs, landfill and contingent liability costs (Stock 1998). Environmental concern is also a factor affecting the choice of reprocessing strategy. Lansink's ladder offers an order of preference for recovery options for returned products (Figure 1). Those which reuse more of the functional contents of a product are claimed to be more environmentally friendly (Duflou et al., 2008).

Recovery options are simpler and more straightforward for EoU returns compared with EoL returns. EoU returns have the potential of generating monetary benefits through resale or reuse (Ravi et al., 2005), whilst there is an order of favourable resource recovery options for EoL returns, as proposed by European Commission: reuse of an EoL product, remanufacturing, parts retrieval and material recycling (Goggin and Browne 2000).

Value can not only be recovered from returned products, but also from the packaging materials (Dowlatshahi, 2000), which becomes an economic driver to actors in engaging RL activities. To reduce waste generation, cost and resource consumption, the European Directive 94/62/EC on packaging and industrial waste materials requires manufacturers to recover part of the packaging and waste related to marketed products (Gonzalez-Torre et al., 2004).

The literature reviewed above underpins our proposition on the reprocessing strategies for household waste, as summarised in Section B in Table 3.

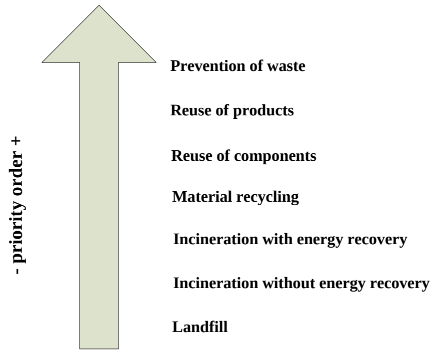

Figure 1 Lansink's ladder of recovery options

Who

The aspect of "who" concerns actors and their roles in a RL system. Actors can be distinguished as (Fuller and Allen, 1997): actors in the forward chain (supplier, manufacturer, wholesaler and retailer); specialised players in the reverse chain (third party RL service provider, organisation responsible for compliance scheme); opportunistic player (charity organisation); and sender or giver (customers who return products). Actors have different objectives and roles (De Brito and Dekker, 2004); some actors organise activities in the reverse chain, some execute tasks in the chain, and some do both. For example, manufacturers from the forward chain may be voluntarily responsible for recycling components or materials from returned products in order to reduce the cost of supply; they can also be made responsible by legislation for taking back returns to reduce waste and protect the environment. Third party organisations launch compliance schemes to generate awareness, as well as to help manufacturers and retailers complete RL operations. Customers are usually the sources or senders of product returns, as well as being the clients of remanufactured products (Srivastava, 2008).

Actors' compliance in fulfilling their duties is essential to RL operation and success. On the other hand, designing a return-friendly RL system will stimulate and enhance actors' compliance in this process (Xie and Breen, 2012). This, coupled with encouraging customers to proactively reduce waste, should achieve a high return on the investment of a newly designed RL system.

Good cooperation and relationships among the actors facilitate RL implementation, and a higher level of coordination between the actors will, in turn, lead to increased performance in a RL system (Flygansvær et al., 2008). Therefore, total involvement and cross-sector collaboration from all the actors in the RL system are needed to minimise the total environmental impact of a business (Van Hoek, 1999). To improve engagement and stimulate cooperation from actors, we make propositions in Section C of Table 3 as to "who" should take specific roles in managing household waste.

Where

The "where" aspect is about the physical network structure where the actors are located and the products are collected and processed. The locations of actors have an impact on the collection and flow of returned products. Modeling aspects relevant for RL network designs have been well studied in quantitative RL literature, with the aim of minimising the total cost (such as investment, processing, transportation, disposal and penalty costs) (Fleischmann et al., 1997; Srivastava 2008; Yu and Wu, 2010). Constrained by time and availability of data, our research presents preliminary analysis as to how the number and location of collection centers help to enhance the convenience of collection and maximise the return rate of household waste (Biehl et al., 2007).

Mechanisms and facilities provided to individuals influence the convenience of, and effort put into, recycling, which ultimately has an impact on household recycling behavior (including properly disposing of waste) (Barr et al., 2001). Furthermore, the location, the number of collection points, the average transport distance for the customer and the number of households covered by one collection point are more precise criteria that affect the service level of a collection scheme and household recycling behaviour (Jahre, 1995). The Environment Agency in the UK requires local authorities to be responsible for household waste collection and recycling. To increase recycling rate of household waste, local authorities in the UK provide weekly kerbside collection service and operate household waste recycling centers (HWRCs). A nationwide RL system with widely spread collection points encourages residents to be more engaged with recycling (Erol et al., 2010).

However, it is worth pointing out that operating collection centers accounts for a large share of total costs (Jahre, 1995), and the effectiveness of collection centers is influenced by the locations, the number of centers, the capacities, and the actors who are responsible for the centers. In this aspect, the lack of funding and increment of responsibilities prevent companies from taking ownership of collection centers (Rogers and Tibben-Lembke, 2001).

Instead of making heavy investment in dedicated resources, companies may wish to : 1) outsource the RL activities to the third party providers (Min and Ko, 2008) who set up nationwide collection networks, or 2) use existing HWRCs to shift the risk and save significant equipment and infrastructure costs (Erol et al., 2010).

Based on the discussions above, in Section D of Table 3, we recommend good practices in setting up collection centers to manage household waste.

Why

The aspect of "why" is about the driving forces behind companies or individuals to become active in RL. There is a distinction between incentives used to influence the return of products and incentives used to influence the acceptance of products. Drivers for receivers include economic factors (Stock, 1998; Andel 1997), legislation (Rogers and Tibben-Lembke, 2001; Carter and Ellram 1998), Corporate citizenship (Alvarez-Gil et al., 2007) and environmental and green concerns (Rogers and Tibben-Lembke, 2001; Dowlatshahi, 2000), while reasons as to why senders return vary between manufacturing returns, distribution returns and customer returns (De Brito and Dekker, 2004).

Household waste is classified as EoU or EoL customer return. Customers' expectations on receivers accepting these returns form an important noneconomic aspect of customer service (Dowlatshahi 2000; Andel 1997). Customers can be less engaged in EoU or EoL returns as they are not required to be engaged or do not get enough benefit from it. Research findings suggest that enhancing public awareness of environmental protection and conservation can have a significant influence on increasing product returns from consumers (Erol et al., 2010; Prahinski and Kocabasoglu, 2006), thus pushing the implementation of a RL system and achieving both economies of scale and sustainable development. Setting up an approved compliance scheme has also proven to be successful in enhancing public awareness of the necessity of reducing and recycling household waste.

Based on the literature review above, we propose incentives in Section E of Table 3 to enhance actors' engagement in RL activities for household waste.

3.2 Benchmarking process

The RL of batteries recycling (including household batteries) has received great attention from academic researchers, practitioners and governments. Bartels (1998) describes the setup and organisation of the Dutch nationwide system for recycling batteries. Faria de Almeida and Robertson (1995) investigate how a German battery manufacturer manages returned batteries in the UK by paying disposer fees for return to a collection point, while Kannan (2009) proposes a structured model for selecting the best third party RL provider for the battery industry. Zhou et al. (2007) analyses battery recycling practices in China and identifies obstacles and weaknesses in performance. They recommend adopting a better and more practical approach by benchmarking the Chinese battery recycling system against those in USA and European countries, and advocate focusing on reviewing legislative action, technical guidance and improved RL infrastructure.

The EU Directive 2006/66/EC on batteries came into force in 2006 requiring producers to take responsibility for the collection, treatment and recycling of batteries. Producers include manufacturers, wholesalers, retailers and those who import products for sale in the EU. The UK is required to achieve a battery recycling rate of over 45% by 2016; to achieve this target, compliance schemes have been launched to raise awareness of the need to recycle batteries and to publicise collection arrangements. The directive and regulations enforce responsibilities on all entities, and a well-developed RL system has been established for recycling and reusing waste batteries, which has resulted in a battery recycling rate of 42% (ERP, 2010).

Reducing, reusing and properly disposing of waste medicines require an increase in awareness of this issue, and an associated increase in activity and support. The aim of both RL systems is to recover and dispose effectively of waste material. However the practice by which this is achieved differs. The batteries RL system appears to be more structured and effective in engaging actors and achieving customer buy-in and uptake. One way of improving the operational efficiency and effectiveness of a RL system is to benchmark return operations with functional leaders (Blumberg, 1999), and identify and incorporate best practices into operational action plan to improve competence (Min and Joo, 2006).

A comparison under the RL framework reveals that similarities exist between the two systems (Table 4). Considering that research on RL processes for household waste medicine is limited, and best practices in the industry are not well identified, the waste medicines RL system is benchmarked against a more established battery RL system.

Insert Table 4 here

4 Research methodology

The research was conducted by combining a thorough literature review with empirical work, benchmarking method, survey and interviews, in seven steps (Figure 2):

1. The RL system for household batteries was constructed based on literature review.
2. The first round of interviews was conducted with 16 interviewees listed in Table 5.
3. The results from the first round of interviews were triangulated by observations at pharmacy sites and analysis of secondary resources. The triangulated findings provided the backbone for the construction of the RL system for household waste medicines.
4. The testable propositions developed in Table 3 are compared with the practices of the two RL systems constructed in Steps 1 and 3, to determine their generalisability and applicability.
5. A benchmarking exercise was conducted for the two RL systems, exploring the gaps in best practices; propositions verified by the batteries RL systems are recommended to bridge the gaps.
6. The survey results provided by Dynamic Group were used to assess the impacts of some recommended practices.
7. To assess the viability of other recommended practices identified from benchmarking process, a second round of interviews was conducted with 13 interviewees (as listed in Table 5) and a personal street intercept survey was conducted with end users of medicines.

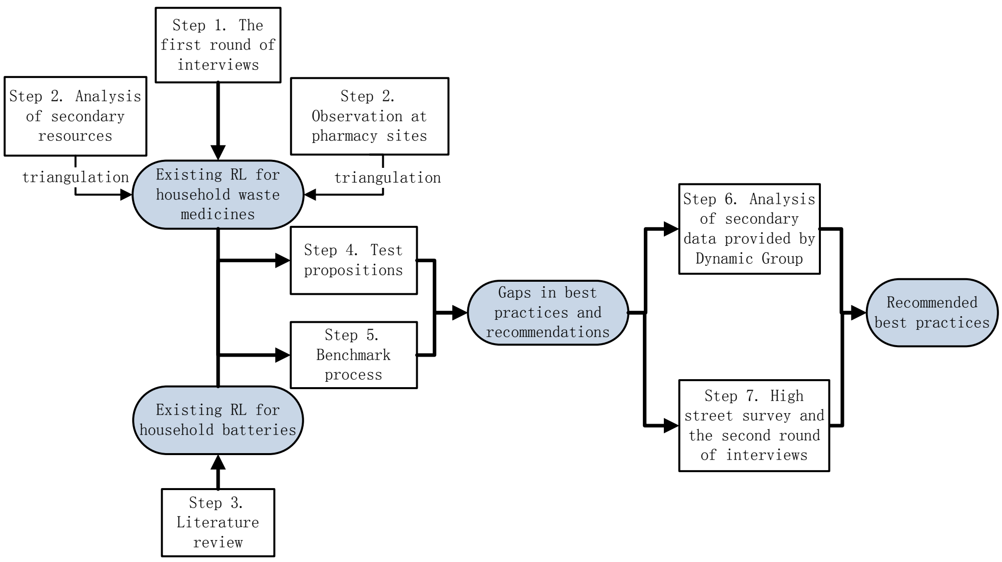

Figure 2: Research design and processes

4.1 The first round of interviews

The first round of interviews were undertaken with 9 community pharmacists working in UK pharmacies including nationwide pharmacy multiples, regional chains and independent pharmacies, supplemented by data from one PCT (as was in operation in 2012) committee representative, 3 General Practitioners, 1 NHS procurement manager, 1 product manager in a pharmaceutical manufacturing company, and a director in Dynamic Group, a social marketing company that has an interest in reducing waste medicines (see Table 5).

Insert Table 5 here.

A semi-structured interview guide was constructed under the RL framework in Table 1. The questions posed to participants aim to determine the current practice of product returns and disposal and the causes of waste generation. The information reported in this research is seen by the interviewees as a true reflection of the RL system in operation in NHS community pharmacies, considering that community pharmacies are managed and regulated centrally by CCGs who follow the same national guidance and regulations.

4.2 Benchmarking method

There is no single benchmarking process that has been universally adopted, but a typical benchmarking process consists of four phases: planning, analysis, integration and action (Camp, 1995). The first three phases were investigated in this research:

i) **Planning:** the process to be benchmarked is the household waste medicines RL system, defined by the RL framework in Table 1. The performance metrics are defined as the awareness of the necessity, importance of reducing, reusing and properly disposing in the selected industry sector, the availability of the RL service, and the level of engagement and compliance from actors. Similarities between waste medicine RL system and batteries RL systems act as grounds on which batteries RL is chosen as the benchmarking partner (Table 4).
ii) **Analysis:** the main purpose of this phase is to identify the gaps between the two systems, the causes of gaps in the initiator company (waste medicines), and the enablers of best practices in the benchmarking partner (waste batteries). Under the RL framework (see Table 1), the operational practices of the two RL systems selected in phase i) are compared with the testable propositions , and propositions verified by the two systems are compared again to identify gaps under each dimension of the RL framework. For each gap, the causes are explored through in depth interviews, and enablers for the good practices in battery RL are identified from the literature review.
iii) **Integration**: the gaps, causes and enablers obtained in phase ii) are communicated to gain acceptance. In line with the research aim, the best practices are identified from the household batteries RL and: i) are compared with the survey results obtained from Dynamic Group, checking if best practices such as publicity campaigns have an impact on changing end user behaviour of ordering medicines and disposing of waste medicines; ii) are communicated with a sample of end users through a survey, checking if they could be driven to be more compliant in returning waste medicines if the best practices are implemented; and iii) are repurposed as thought-starters and consulted with healthcare professionals in the second round of interviews, who rate the practices in terms of viability measured by effectiveness and likelihood of implementation.

4.3 The second round of interviews and high street survey

The viability and feasibility of the recommendations are evaluated through in-depth interviews with healthcare professional and surveys with end users of medicines.

4.3.1 The second round of interviews

To obtain experts' views on the recommended practices, and screen out the practices that are deemed to be inappropriate, such as directly reusing returned medicines in the UK, the second round of interviews were conducted with 13 interviewees; 5 are new and the others are from the first round of interviews (see Table 5). Constrained by distance and availability of interviewees, e-mail interviews were undertaken with the PCT committee representative (Interviewee 21) and the staff from councils (Interviewees 19-20). Face to face interviews were conducted with the other interviewees.

4.3.2 High street survey with end users of medicines

The recommended practices outlined from the first round of interview were used to construct a survey instrument to assess the influences on end users' intentions of dealing with waste medicines. The survey instrument consisted of three sections of questions that were completed by yes/no response statements, and coded box items. The first section focused on respondents' demographic information, the second section identified respondents' current practices of dealing with waste medicines, while the third section assessed respondents' attitudes towards the recommended practices.

A pilot study was conducted with 15 respondents in South East London and some minor changes were made in wording before launching the main study. A total of 300 individuals in Greater London were approached for the survey, from which 300 questionnaires were collected with 279 valid responses, a high response rate of 93%. All the 279 respondents have been medicine users and are primarily of relevance to the research, which increased the value of the survey.

5 Findings

This section presents RL systems constructed from Steps 1-3. Both systems are further reviewed to highlight synergies and disparities.

Under the RL framework, the waste medicines RL system is benchmarked against a battery RL system, and the practices within these two systems are compared in Table 6. The benchmarking analysis reveals that the RL system for batteries is a more 'caring' and more effective system. It is 'caring' in the sense that it has more supporting legislation to encourage higher levels of engaged actors with higher awareness of the necessity and importance of recycling batteries, and effective as it has a higher return rate of used batteries. Based on this premise, gaps in the waste medicines RL system are identified (Table 6). The best practices are recommended, provided that they are verfied by the waste batteries RL system and supported by the participants in the high street surveys or the second round interviews.

Insert Table 6 here.

To ensure continuity in this discussion, the analysis undertaken is based on the RL framework presented in Table 1.

5.1 Existing RL system for household batteries

The exiting RL for household batteries is constructed through literature review and shown in Figure 3:

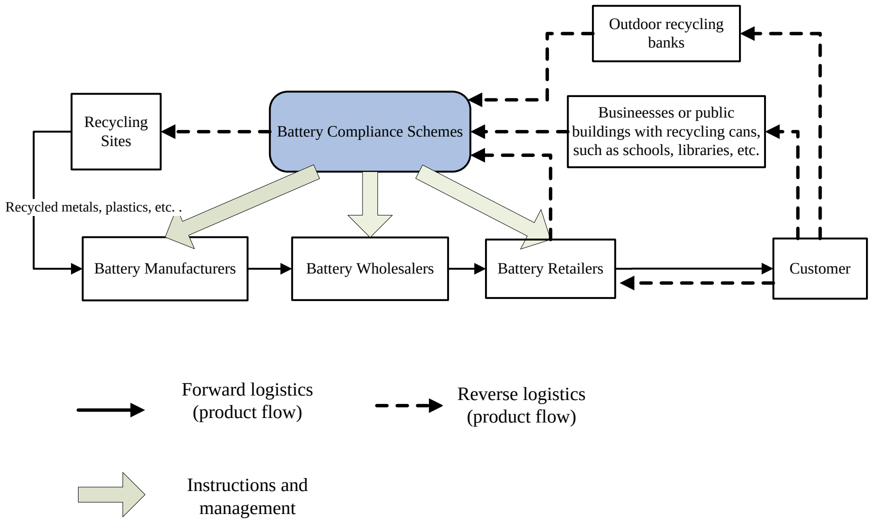

Figure 3: Existing reverse logistics system for household waste batteries

Propositions presented in Table 3 are well established in the exising household waste battery RL system (see Table 6), driven by the EU directive on waste batteries (EU Directive 2006/66/EC).

5.1.1 What: product

In this aspect, propositions A1-5 presented in Table 5 are verified (see Table 6). A1) Waste batteries contain components such as metals (Lithium, Zinc, Lead), chemicals (Mercury Oxide etc.) and plastics. A2) Waste batteries have residual value left, and are more likely to enter the RL processes (Zhou et al., 2007), where thousands of tonnes of metals, and components of the "black mass" can be recovered, and plastics are reprocessed. A3) Due to the presence of hazardous components, waste batteries need separate collection and treatment. A4) Waste batteries are of small sizes and easy to store at home. A5) Multiple package sizes are available for sale ranging from 2 to 50 batteries in a pack, and can meet different consumer needs; economic loss resulting from unused batteries can, therefore, be reduced. The overall recycling rate is at least 55% of the gross weight of the batteries treated, which reduces the need to mine new materials, cuts CO2 emissions and saves resources (BatteryBack, 2013).

5.1.2 How: processes and activities

Returning batteries is easy, as propositions B1-2 have been implemented: B1) A nationwide battery RL system has been set up providing more widely spread collection points. B2) Returned batteries are sent to sites to recycle the metal parts and the different components of the "black mass", and reprocess the plastics.

5.1.3 Who: actors

Propositions C1-3 have been implemented to engage every actor in the batteries RL system. C2) Five compliance schemes have been approved for battery recycling, and they not only provide complete collection, gate-keeping and disposition operations, but are also responsible for publicity campaigns (Environment Agency, 2013). C1) The producers register with the schemes as members and pay them to fulfil their obligations. C3) Many organisations like schools are also involved in the scheme, and they not only offer drop off bins, but also deliver education on battery recycling to pupils in schools, who then educate parents to be compliant in recycling batteries.

5.1.4 Where: network structure

To achieve the target recycling rate for batteries, propositions D1-2 have been implemented to improve recycling convenience. D1) A RL network has been set up with easily accessible collection points throughout UK. The Batteryback compliance scheme should provide 50,000 collection points by the end of 2013 (Batteryback, 2013). D2) Together with recycling points provided by other compliance schemes and HWRCs operated by local authorities, the RL network for waste batteries recycling should soon have more than 100,000 collection points. Having outdoor collection points removes the limitation imposed by opening hours.

5.1.5 Why: drivers

All the seven proposed drivers E1-7 are identified in the batteries RL system. E1 and E7) The UK government could face fines of millions of pounds if the target recycling rate (over 45%) is not met by 2016; these fines will be passed to battery manufacturers which, in time, will raise the price of batteries to customers. E2 and E5) Therefore, the directive and regulations enforce certain responsibilities on all the actors in the battery RL system except individual customers, requiring producers to incorporate waste management practice at the three levels: reduce, reuse and recycle. E1, E3, E4 and E6) The five battery compliance schemes in the UK are working together to achieve the target recycling rate (Environment Agency, 2013), and they have launched publicity campaigns, which aim to educate the public reducing resource costs and protecting the environment, while facilitating producers setting up corporate green images. E4) The success of the publicity campaigns is proved by significant behaviour change in the recycling of household batteries, with two in five people (42%) having recycled a battery (ERP, 2010).

Communication on battery recycling is rich and diverse, and there has been a comprehensive and continuing information campaign to increase the battery recycling rate. Information on battery recycling can be found in 83% (368 out of 445) of local authorities' websites, on television, in the premises of retailers, and on outdoor recycling banks.

5.2 Existing and recommended RL system for household waste medicines

The results from Steps 2 and 3 provide an insight into the RL system in community pharmacies, as shown in Figure 4:

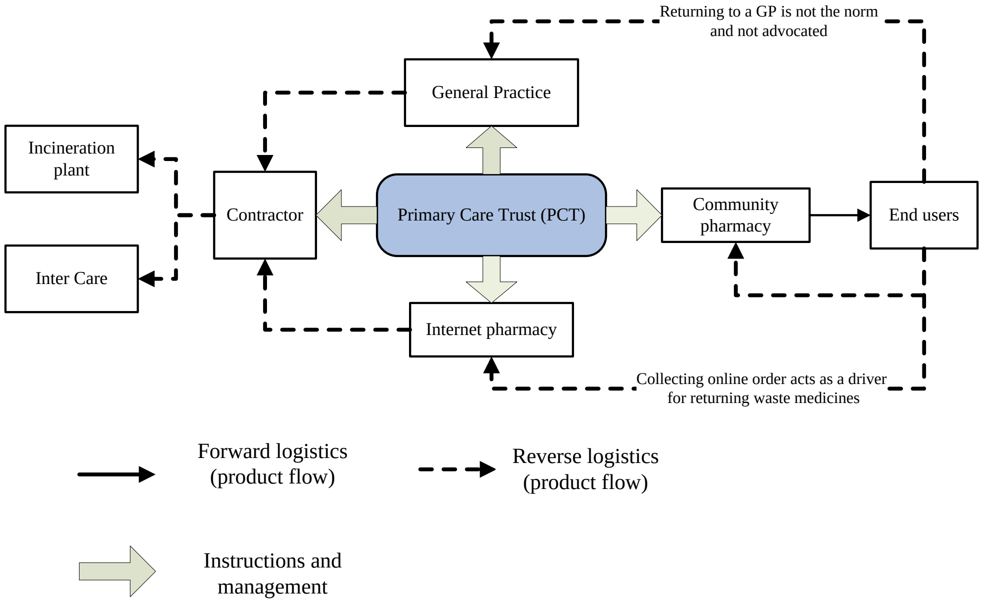

Figure 4: Existing reverse logistics system for household waste medicines

Propositions in Table 3 are less well implemented in the household waste medicines RL system, when compared with the waste batteries RL, and gaps are identified (see Table 6).

5.2.1 What: product

Existing practices

As a product, propositions A1, A3 and A4 are verified in waste medicine. A1 and A3) Waste medicines contain chemicals that are harmful to the environment if not properly disposed of, and require separate collection and treatment. The medicines may still have functionality if the expiry date is not passed. A4) Due to the small sizes, waste medicines are easy to store in a cupboard or be disposed of inappropriately (for example, flushed into the sewage system). Most medicine packs contain 28, 30 or 31 days medication, which will lead to medicine waste since the majority of NHS prescription periods are 28 days. Strict policies in the UK regulate that all returned medicine must be destroyed and cannot be re-used, which means no commercial value can be recaptured from the RL for household waste medicine.

The proposal of reusing waste medicine has been controversial (DoH, 2010). A majority of interviewees in the first round (54%, 7 out of 13) argued that returned medicines should require permission for reuse if they are intact, in good condition and in date. InterCare is a UK registered charity which collects unused medications from General Practitioner (GP) surgeries in the UK and then delivers them free of charge to over 100 health centres in 7 countries in sub-Saharan Africa (InterCare, 2012). According to the interviewed pharmaceutical product manager (Interviewee 15), some pharmaceutical industries in France are responsible for collection and reuse of waste medicines. However, other interviewees, especially pharmacists, strongly object to the idea of reusing dispensed medicines due to quality and safety concerns.

Gaps and recommended practices

Statistics from the high street survey and BBC News Health (2012) indicate that there is a secondary market for returned medicines in the UK as over half of people would be likely to take returned pills (see Table 7). The technology is available to scan returned medicines electronically and verify that they are still in good condition (Mackridge and Marriott, 2007). Therefore, it would be possible to propose A2, i.e., reusing at least some of these medicines.

The product manager in the second interview recommended that "medication pack sizes can be synchronised, based on the advice from the National Prescribing Centre", to enable smaller but more frequent doses to be dispensed by pharmacies, thus reducing the amount of unnecessary medication in circulation. This practice is our proposition A5, which is evident in other countries, e.g. shorter prescription periods (7-14 days) have been trialled in Canada (Paterson and Anderson, 2002).

Insert Table 7 here.

5.2.2 How: processes and activities

Existing practices

The findings indicate that none of the propositions in this dimension has been implemented. Medicines returned to pharmacies are disposed of with the obsolete medicines generated from pharmacy stock (quoted as 0.05% by Interviewee 3), using the same waste bins provided by the PCT. PCTs utilise a contractor to dispose of waste. The waste medicines are made safe by clinical waste incineration at an authorised incinerator.

An outlier to the main stream activity is the internet pharmacy. A pharmacist respondent, Interviewee 4, stipulated that as a pharmacy provider accessed via the internet, "….patients cannot access our premises. Our website does however outline the procedure for arranging collection of waste medicines from patients should that be required".

Gaps and recommended practices

In both waste medicines and batteries RL systems, reverse flows rely on end users' returns rather than collection by contractors, which influences the return rate and quantity. A more proactive approach would be to use the existing domestic waste service to collect waste medicines, facilitated by a compliance scheme (Interviewees 19 and 20). Since 1974, InterCare have sent nearly £11 million worth of surplus medicines as aid to Africa, and the donated medicines have treated millions of people who otherwise not have access to medical treatment (InterCare, 2012). Proposition B2 is therefore recommended, i.e., donating surplus medicines to under-developed countries as long as the medicines comply with the World Health Organisation guidelines on medicine donations.

Materials recycling and component reuse are the recovery options in the batteries RL system, while the recovery option for household waste medicine is incineration, making it less environmentally friendly or economically efficient. Proposition B3 "recycling packaging materials from waste medicines will certainly enhance the environmental friendliness" of the recovery option (Interviewees 14). Respondents in the second interviews acknowledged the potential positive impacts of proposition B1, i.e., investigating and initiating a compliance scheme which collects and treats waste medicines on behalf of CCGs and manufacturers.

5.2.3 Who: actors

Existing practices

Proposition C1 has been less well implemented in the existing household waste medicines RL system, as not everyone is fully engaged in the reverse activities they are assigned to. The DoH is responsible for regulations and policies on waste medicines management; the CCG is coordinated by GP practices and is responsible for arranging for contractors to collect waste medicines from pharmacies; and pharmacies accept waste medicines returned by end users. Although pharmacies do this as part of their contract, they "do not have economic incentives to do so" (Interviewee 13). The same sentiment could be applied to end users concerning their lack of activity in returning waste medicines as they are not obliged or motivated to do so.

Gaps and recommended practices

Medicine Waste campaigns organised by the Dynamic Group in 11 UK regions led to positive changes in end users' behaviour relating to ordering repeated medicines and disposing of waste medicines. The findings from the survey of medicine users also verify that they are likely to change their behaviour due to direct communication and education from healthcare professionals (see Q.2 in Table 7).

In addition to the end users, we propose the implementation of C1, i.e., every producer of waste "should work together so that we collectively reduce waste" (Interviewee 16). Implementing propositions C2 and C3 by performing RL activities under the responsibility of a consortium, for example the CCG, along with a few leading companies, such as companies that run a compliance scheme, could make it more cost effective to implement the RL system.

5.2.4 Where: network structure

Existing practices

At present, only community pharmacies and GP surgeries take back waste medicines, and none of the propositions to improve convenience of returning/collection has been implemented. There are around 12,175 community pharmacies in the UK, and 10,112 GP practices (British Medical Association (BMA), 2012). The provision for returning waste medicine is constrained by the numbers of collection points (22,287 in total), the locations (99% of population get to a pharmacy within 20 minutes by car and 96% by walking or using public transport), and the opening time (pharmacies open 40 hours/week or 100 hours/week under exemption, while 77.1% of GP surgeries open 53 hours/week). The constraints have a significant impact on the behavior of the 35-54 age group who contribute most to the generation of waste medicines.

Gaps and recommended practices

The findings from the survey prove that there is a significant level of inconvenience due to inadequate access to collection points (see Q.3 in Table 7), which, to a large extent, prohibits or reduces end users' compliance in returning waste medicines. A full clinical waste collection service is offered by the two councils where Interviewees 19 and 20 serve, at no cost to the residents. As summarised in Table 6, the design and provision of optimal collection could enhance end users' compliance in returning (propositions D1 and D2).

5.2.5 Why and why not: drivers

Existing practices

None of the proposed drivers has been identified in the existing waste medicines RL system. In the UK there are formal rules and guidance governing pharmacies or GPs accepting pharmaceutical waste, but not stimulating or enforcing them to actively take action. There is no regulation or directive on implementing an end user return system. Communication on managing household waste medicines is limited. Although governmental websites (for example, Directgov) list information on how to dispose of waste medicine, only 84 out of 445 (i.e., 19%) councils classify waste medicine as hazardous waste and advise residents to return them to pharmacies. The interviewed pharmacists indicated that communication between end users and community pharmacists concerning returning medicines waste is not consistent. Some respondents stipulated that they are informed of returns on completing a transaction but some are not, and the same comments were made by participants in the high street survey.

According to the DoH (2011), approximately £1 in every £25 spent on NHS medicines is wasted, but this message has not been passed to the public for their attention. The interviewed GPs claimed that there is a lack of financial awareness or incentives to encourage end users to return medicine waste. Community pharmacies are paid via their GP/CCG contract to accept returns but not paid to analyse reasons for return or find ways to reduce waste, so they are less incentivised to encourage returns. Although community pharmacies attempt to influence end users to return waste to prevent stockpiling or health and safety issues arising, the approach to this is not standardised across all pharmacies but is at the discretion of the pharmacy staff member.

Gaps and recommended practices
In both household waste medicines and batteries RL systems, end users need to be motivated to return waste products, while the other actors in the system need to be stimulated or enforced to take them back.

As shown in Table 6, gaps between the two RL systems are identified in the aspects of legislation/directive, compliance scheme, communication and financial incentives.

Although proposition E2 has been used as an impetus for establishing a RL network and driving companies to implement RL activities (Rogers and Tibben-Lembke, 2001), introducing new legislation or a directive requiring end users to return waste medicines is deemed to be impractical in the short term. In the waste medicines RL system, the situation can be improved by implementing E4, i.e., by enhancing public awareness or by healthcare professionals or government educating end users on the need for, and ways of, waste medicines reduction and proper disposal. As a result of the campaigns launched by Dynamic Group, at least 25% of 7022 respondents to the survey now claim to have changed how they order their repeat prescriptions, i.e., only order what they need. A similar proportion of respondents claim returning unwanted medicines to pharmacies because of the campaigns.

The findings from the high street survey reveal that direct communication with GPs or pharmacists work more effectively than leaflets or posters in encouraging end users to return waste medicines to pharmacies (see Q.4 in Table 7). The GPs and pharmacists in the second round of interviews support incentivising closer professional management of medicine supply at the point of dispensing to achieve lower waste targets.

Lack of economic incentives are also emphasised as a barrier to actors engaging in RL activities (Blumberg, 1999). Reusing returned medicines generates monetary benefits and could act as a strong driver, incentivising all the actors engage in the reverse activities (proposition E1). The interviewed pharmacists (Interviewees 1-2 and 7) recommended proposition E5, i.e., retrieving medicines to determine waste levels and instigate waste management strategies at three levels: reduce, reuse and properly dispose of. Targets may be put in place aligned with national or regional waste medicines reduction figures. This activity can be outsourced to a third party company, e.g., via compliance schemes coordinated by the

Environmental Agency (proposition E6). The interviewed GPs and Pharmacists indicate that they would be more cost conscious in prescribing and dispensing should a financial fine be introduced if waste medicines were above the predetermined target (proposition E7); they would also be more active in educating end users about waste medicines.

Proposition E7 can also be implemented by introducing a limited charge to all prescription items, or having a label attached showing the full cost of medicine is also suggested in order to reduce the likelihood of waste (Australian Government, Department of Health and Ageing, 2012). The high street survey further verifies the likely impact of raising cost awareness (see Q.5 in Table 7).

6 Discussions and managerial implications

The propositions presented in Table 6 have proved to be successful in creating a more 'caring' and more effective waste batteries RL system. How this has impacted on higher levels of engagement, more awareness of the necessity and importance of reducing and recycling, and a higher return rate in this RL system is unclear. Significant opportunities do seem to exist for a waste medicines RL system that seeks to reduce waste and cost, including product value, processing approaches, system co-operation and enforcement, drivers and motivations, and system design and facilitation.

The findings of this study indicate that there are key outputs which impact on RL system design and delivery. These are presented as follows:

Product value: - the residual value left in a returned product has a direct and positive impact on actors' engagement in RL. Since no commercial value can be recaptured from waste medicines, this causes hesitation and reluctance from the actors in the PSC to implement the RL processes (Prahinski and Kocabasoglu, 2006). This is a quite a significant finding since it in turn inhibits initiatives to invest in RL infrastructure and information systems, and limits the scope for collaboration among actors. Apart from recycling packing materials, it seems to be difficult to "create" residual value in returned medicines, due to strict regulations and health and safety concerns. Reuse of good condition medicines is encouraged since it not only reduces material wastage, but also acts as an incentive, motivating actors to engage in the reverse activities. However, the impact of actual cost savings per returned product for the NHS could be small. Sorting and separating processes for returned medicines can be complex in practice, and often only a minority of products are intact, in good condition and in date (DoH, 2011). This means that the extent to which reuse of medicines could affordably reduce the cost of NHS medicines wastage is likely to be very small. More effective savings would be generated from greater standardisation on medicine pack sizes, improved prescribing patterns (product type and quantity), and inventory management within pharmacies. All of which would reduce avoidable waste in a cost effective manner.

Processing approaches: - Both household waste medicines and household batteries are EoU or EoL returns initiated by end users, and are classified as public recycling which is oriented at avoiding waste and leads to a net positive benefit for the environment (De Brito and Dekker, 2004). The main way of processing returned waste medicines is incineration, which is less economically efficient or environmentally friendly than other recovery options. It is not possible to change the processing strategy for waste medicine; however, it is reasonable to reduce the amount of avoidable waste and reuse or properly dispose of more of the unavoidable waste (e.g. out of date, or opened packets/products). Launching a compliance scheme would make it easier to return or manage waste medicines, therefore encouraging actors to become more engaged.

System co-operation and enforcement: - The success of a RL system requires cross-boundary cooperation among the actors within the whole reverse chain (Xie and Green, 2012). Benchmarking against the batteries RL system found that the superior performance is attributed to the higher levels of engagement from all the actors. In contrast, the attention and interest in reducing and properly disposing of household waste medicine decreases substantially from top management (DoH) to the end users.

Discussions with healthcare professionals found that the lower levels of engagement are mainly due to the lack of obligations or financial incentives. Legislation and economic factors together determine the conduct of actors in the RL system, but these two factors are missing from the existing waste medicines RL system. In some countries, customers are required by law to return unused medication. For example, in Jefferson County USA, prescription medication should be separated from household pharmaceutical waste when being returned, and medication accumulated from more than one resource should be disposed of under national regulations (Grabow and Brachman, 2007). Imposed environmental protection regulations usually result in increased cost of products or services, as well as generating unwillingness to cooperate. Therefore, introducing new legislation or a directive requiring customers to return waste medicines is deemed to be impractical in the short term. Furthermore, not all the regulatory mandates have a substantive impact on the environmental disposal of the pharmaceuticals (Daughton, 2003).

If enforcement cannot be applied through legislation, communication and education are found to be the key mechanisms to enhance public awareness, as well as to encourage positive and heightened environmental behaviour with regard to waste medicines (Erol et al., 2010; Prahinski and Kocabasoglu; 2006). Our survey shows that greater personal or direct contacts with end users will be more effective in encouraging their engagement in recycling activities than just disseminating information on recycling. These findings are in agreement with literature that argue that direct communication are more effective in order to gain 'buy-in' from customers in recycling schemes (Tucker and Speirs, 2002). If vigilance concerning wasted medicines is to be raised, then there is scope for wider publication of this issue, e.g. not only from NHS providers but also local authorities. For long-term sustainable development and competitiveness, regulations need to be set up to promote, control and standardise practices on reducing and properly disposing of waste medicines (Erol et al., 2010); for example, standard practices on how pharmacies and GPs educate end users to return waste. The ultimate objective of communication and education is to encourage end users to voluntarily become stewards in promoting and performing better social and environmental practice, which is a more favoured approach than employing regulations and legislations (Daughton, 2003).

Drivers and motivation: economic benefit has been identified as one of the main drivers that motivates companies to adopt RL (de Brito et al., 2004). Business incentives, such as tax incentives and capital incentives, have resulted in environmental improvements (GEMI, 2006). Since there is no residual value left in the waste medicines, an indirect financial incentive is proposed, i.e., setting up a statutory target for the amount of waste medicines to be produced and imposing fines on producers and, ultimately, on end users if the target is not achieved. This incentive has been proven to work effectively in enhancing engagement and return rates in the waste battery RL system, but is hard to estimate the size of the effects achievable in the waste medicines system given that actors in the system, such as CCGs, are non-profit organisations and funded by central government. GP respondents also argued that the waste target should not become a barrier to improving the overall health and wellbeing of health service users. The role of the CCG is to commission services within a given geographic area and includes all GPs in this area. Where once PCTs commissioned services and GPs adhered to this decision, GPs now determine what is best for their patient population and select their provider of choice. CCGs in April 2013 replaced PCTs as commissioners and now control a large proportion of the NHS budget. As such GPs within this group will oversee contracts for medicines disposal in community pharmacy and may be involved in designing returns channels to promote medicines return and retrieval for safe disposal. Another community based by-product of the CCG formation is the need to have GP surgery/practice representation at CCG forums to feedback on the content and deployment of policy and practice to patients. Funds are provided to all GP practices to develop and support patient groups. Such groups could be used to trial newly designed educational materials/systems to promote end users' medicines returns.

Compliance from individual customers can also be stimulated by proper incentive schemes (Deci et al., 1999). Our findings advocate putting the price on every NHS medicine pack in order to raise awareness of costs, and thus encouraging reduction of wastage. This is a better supported proposal than direct charging since 80% of NHS patients do not pay for prescriptions and the latter proposal is thought to be unfeasible. The option of sending unused medicines to underdeveloped countries is also found to an incentive stimulating customers properly disposing of medicines. If it were thought that some form of reuse might be possible for expensive medicines, customers are more likely to take waste medicines to pharmacies (DoH, 2011). On the contrary, if customers know waste medicines are only incinerated, they tend not to take them back. The impetus appears therefore to be cost/economical (despite the fact that there is no value for this product at this stage in its life cycle) and less about safety in the home and relies heavily on Individual Social Responsibility (ISR). As purported by Bénabou and Tirole (2010) when exploring ISR and Corporate and Social Responsibility (CSR) people are driven by genuine instinctive altruism, respond to materials incentives and are also driven by social and self-esteem concerns. This observation is significant and important and needs to be maximised to increase the return of waste medicines.

System design and facilitation: system inadequacy (Rogers and Tibben-Lembke, 2001; Erol et al., 2010), such as inadequate collection points, is also a barrier, making end users less engaged in the returns process. Some local authorities have begun to offer waste medicines collection services through HWRCs, and the wider development of this service across the UK is encouraged in order to increase volumes (the economics of collection, segregation, transportation and processing), and ultimately increase the degree of involvement in reverse SCs (Prahinski and Kocabasoglu, 2006).

The findings under the five perspectives of the RL framework not only give context to a new waste medicines RL system, but their combination determines to a large extent the kind of issues that arise in implementing, monitoring and managing such a system.

7 Conclusion and future work

For a number of years, the NHS (UK) has been working under a Quality, Innovation, Productivity and Performance (QIPP) agenda (DoH, 2010). "During 2011/12, the NHS made a total of £5.8 billion of QIPP savings, with £700 million associated with medicines use and prescribing. The QIPP medicines use and procurement work stream aims to ensure that value for money is further enhanced while quality of care is maintained or improved, by optimising the use of medicines" (NICE online , 2013). Cutting the amount of medicine waste has therefore been a priority for the DoH and associated governmental and professional bodies e.g. Royal Pharmaceutical Society, as it potentially could save millions of pounds that could be invested elsewhere. However, the interest in reducing and properly disposing of waste medicine deteriorates significantly from top management levels to individual customers and actors in the existing waste medicine RL.

Similarities exist between the household waste medicine RL system and battery RL system, in terms of product, processes, actors, network structure and drivers. However, this research shows that awareness and return rates of battery waste are higher than those of waste medicines, and most importantly, the engagement from actors in battery RL is much greater and more active than those in waste medicine RL. The key cause for the differences is the support and enforcement from top management and regulatory authorities. EU directives place responsibilities on the actors in the battery RL to work together to achieve the target return rate, otherwise fines would be passed to producers and, finally, to customers. To improve the existing RL system for waste medicines, this paper benchmarks the household waste medicines RL system against the batteries RL system, and generates a profile of recommendations under the RL framework based on the best practices in battery RL. Strategically, critical drivers are identified to encourage and compel actors to participate in the waste medicine RL system, including incorporating practices at three levels, a compliance scheme, improved communication, and financial incentives. Operationally, improvement can be made within the PSC to proactively reduce waste (by professionals via more prudent clinical prescribing and end users when reordering repeat prescriptions), improve product management (synchronising medication pack sizes), enhance health and safety within the home (by encouraging and facilitating more effective waste returns), and recapture commercial value where possible (such as reusing good condition medicines and recycling packaging materials). Total involvement and cross-sector collaboration are needed from all actors in the system, which can be promoted by the drivers and a user-friendly RL network structure. Such results as presented by NICE online (2013) can only be delivered by a uniform, orchestrated and strategic approach which has not only government and regulatory support, but also customer engagement and delivery.

RL in pharmaceutical industries has been studied for B2B returns from participants within a PSC, or for by-products within the manufacturing plant. The academic research community would benefit from this research as it is focused on the under-researched area which is enhancing actors' compliance in reducing, reusing and properly disposing of medicine waste and the systems/practices to achieve it. The research findings provide a step towards reducing an existing gap in pharmaceutical RL research to influence best practice. The recommendations made in the paper not only aim to motivate actors to reduce medicine waste, but also use medicines effectively, placing an emphasis on improving health outcomes and meeting the medicines optimisation agenda in the NHS (NICE online, 2013). With the current restructuring of the NHS, there is even more need now than ever for GPs to take a more proactive stance in medical prescribing, as they are now responsible for pharmaceutical spend and spending their funds in an efficient manner. The information gathered via the recommended practices can offer valuable inputs to inform prescribing practice and encourage more sustainable green decision making in the forward logistics, helping the PSC to become 'greener' in terms of procurement, operational management and distribution. External to the PSC, an improved household waste medicine RL system will facilitate the development of a safer community and domestic residences, free of unnecessary pharmaceutical waste and potential hazardous materials. This in itself makes the case for this system and the crucial role of engagement from all actors within it.

The research limitations lie in how feasible it would be to implement the recommended practices, although they have gained acceptance from the interviewed pharmacists. While the interviewees in this study represent a wide and diverse range of relevant actors in the household waste medicine RL system, the sample remains relatively small in the context of the total number of healthcare professionals in the UK. The high street survey was only conducted in London, and relied on self-reporting, which may lead to some under-reporting, and also some inaccuracies. Further interest will focus on the cost effectiveness of implementing the recommendations, i.e., whether or not the recommended practices can be addressed in a cost effective manner; that is, could the savings made from reduced medicine costs outweigh the costs of the practices.

Future developments will measure performance and evaluate the appropriateness of recommended practices, and investigate practices that are less intensive or costly, but which can raise awareness of the importance of compliance in the waste medicine RL system.

The outputs of this study indicate that that the operational design and practice of the household battery RL is more structured and effective in achieving its purpose (meeting targets for returned products) than the medicine RL system. If 'caring' (having the resources, support and incentive to instigate change) leads to winning, then the battery RL system currently wins every time. This paper highlights this issue and advocates learning from best practice in battery RL to improve the medicine RL design and execution and supports the current NHS agenda on medicine waste reduction (DoH, 2012).

Figures and tables:

Table 1: RL framework (adapted from De Brito and Dekker 2004)

Dimensions	Definitions
What (Products)	The products entering the RL network (product-in's) and the products leaving the RL network (product-out's),
How (Activities and Processes)	The RL activities, including returning, collection, and main recovery processes (such as resale, reuse, redistribution, repair, refurbishing, remanufacturing, recycling, incineration, or proper disposal).
Who (Actors)	The actors and their roles in the RL network (supplier (the owners/users of the product-in's), collector, processor, customer and initiator).
Where (Network Structure)	The physical network structure where the actors are located and the products are collected and processed.
Why and Why not (Drivers, Return reasons, Barriers)	The drivers for the suppliers of the product-in's and the initiator of the RL activities, and the barriers for those who do not take RL activities.

Table 2 Literature classification under the RL framework

Literature classification	Dimensions of the framework				
	What (Products)	**How (Activities and Processes)**	**Who (Actors)**	**Where (Network Structure)**	**Why and Why not (Drivers, Return reasons, Barriers)**
i) Basic concepts and summary of RL					
- *De Brito and Dekker, 2004; Rogers and Tibben-Lembke, 2001; Stock, 1998;*	√	√	√		√
ii) Enhance RL system and its performance					
- *Quantitative models for RL (Fleischmann et al., 1997; Giuntini and Andel, 1995; Yu and Wu, 2010)*	√	√	√	√	√
- *Improving RL system performance using manufacturing technologies (Giuntini and Andel, 1995), information technologies (Li and Olorunniwo, 2010; Daugherty et al.2005), resource commitment (Daugherty et al., 2005), or network design (Qin and Ji, 2010)*		√		√	
- *Frameworks (Genchev et al., 2011), decision making models (Tan and Kumar,2006), and formalisation processes (Autry 2005)for managing RL systems*		√	√		
iii) Applications of RL in various sectors					
- *packaging material (Gonzalez-Torre et al. 2004), bottling or glass (González-Torre and Adenso-Díaz, 2006)*	√	√	√		√
- *non hazardous products, such as paper (Pati et al., 2008), clothes (De Brito and Dekker, 2004)*	√	√	√		√
- *Hazardous products, such as electrical waste(Lau and Wang, 2009), automobile(Daugherty et al., 2003),batteries (Kannan, 2009; Zhou et al., 2007; Faria de Almeida and Robertson, 1995, medicines (Xie and Breen, 2011)*	√	√	√		√
iv) Drivers and barriers of RL					
- *Drivers: Alvarez-Gil et al., 2007; De Brito and Dekker 2004;*					√
- *Barriers: (Ravi and Shankar, 2005)*					
v) Specific issues in RL					
- *distribution and warehousing (Andel 1997, Giuntini and Andel, 1995),*		√		√	
- *remanufacturing, repair, reconfiguration and recycling (Clendenin 1997)*		√			
- *transportation (Jahre, 1995);*		√		√	

Table 3 Testable propositions for a household waste RL

Dimensions	Factors identified by Dowlatshahi (2000)	Testable propositions
A. What	Overall quality Packaging	1. Household waste differs in four characteristics: composition, deterioration, dimensional size and packaging solution. 2. The four characteristics determine the residual value of a product. Products with residual value are more likely to be returned to and reprocessed in a RL system. It is proposed to find ways to “create” residual value in household waste, for example, use new technologies to retrieve materials. 3. Household waste containing hazardous components need to be handled separately and properly. 4. Small household waste tend to be stored or disposed through sewage system; while big household waste tends to be returned but are more challenging to be transported or handled. 5. Waste can be generated if package size is larger than consumer needs, or package is difficult to empty. It is proposed to reduce waste by synchronising package size with consumer needs.
B. How	Cost-benefit analysis Transportation Warehousing Supply management Remanufacturing Recycling	1. Organise an effective return and collection process through nationwide RL network. 2. Choose a cost effective and environmental friendly reprocessing strategy to recapture value from household waste. Reuse EoU returns if appropriate, and choose recover option for EoL returns according to options proposed by European Commission. 3. Recycle packaging materials.
C. Who		1. Total involvement and cross-sector collaboration are needed from all the actors in the RL systems. 2. Appoint a third party organisation to launch compliance scheme for publicity campaigns, and help other actors to fulfil RL duties. 3. Involve organisations and businesses to educate and encourage waste holders to reduce and recycle household waste.
D. Where		1. Outsource RL activities to a third party provider who setup nationwide collection network 2. Utilise the network of existing household waste recycling centres (HWRCs) and deploy local collection systems
E. Why and Why not	Overall costs Customer service Environmental concerns Legislative concerns	1. Encourage actors to reuse or recycle household waste for economic gains (Economic factors). 2. Enforce directives on reducing and recycling household waste (Legislation). 3. Encourage organisations to participate in household waste management therefore to improve corporate image (Corporate citizenship). 4. Enhance public awareness on the environmental impacts imposed by household waste (environmental and green concerns, public awareness). 5. Incorporate waste management practice into contracts of organisations at three levels: reduce, reuse and recycle (or properly dispose of if no component can be recycled). 6. Set up compliance schemes. 7. Apply financial incentives, i.e., sharing the cost of waste management among all the actors, or enhance financial awareness on full cost.

Table 4 Similarities between the RL for household waste medicines and household batteries

Dimensions	RL for household waste medicine and household battery
What	• both contain hazardous components, and need separate collection and treatment. • both are easy to be store at home, and easy to be disposed of inappropriately.
How	• separate collection and treatment.
Who	• end users, retailers, contractors, and professional and regulatory bodies need to become involved in both RL processes.
Where	• kerbside collection cannot be used, and end users need to return waste to the collection points.
Why and Why not	• motivate manufacturers, distributors and retailers to participate in the RL processes. • campaigns need to be launched to motivate the public to participate in the RL processes.

Table 5: Interviewee details

Interviewees in the first round	Role	Location
1-2	Qualified pharmacist	Kent
3-6	Qualified pharmacist	Yorkshire
7-9	Qualified pharmacist	Essex
10	PCT committee representative	Kent
11-12	General Practitioner	Yorkshire
13	General Practitioner	Greater London
14	NHS procurement manager	Greater London
15	Product Manager in a pharmaceutical manufacturer	Kent
16	Director of the Dynamic Group	Scotland
Interviewees in the second round	**Role**	**Location**
17	Environment planner in borough council	Cambridgeshire
18	Environment planner in borough council	Greater London
19	Waste management contracts manager in borough council	Yorkshire
20	Waste management contracts manager in borough council	Yorkshire
21	PCT committee representative	Cambridgeshire
1-2	Qualified pharmacist	Kent
7-9	Qualified pharmacist	Essex
10	PCT committee representative	Kent
13	General Practitioner	Greater London
16	Director of the Dynamic Group	Scotland

Table 6 Benchmarking household waste medicine RL against household battery RL

Dimensions	Propositions implemented in household waste batteries RL	Propositions implemented in household waste medicines RL	Gaps identified in waste medicine RL	Best practices recommended
A. What	A 1-5	• A1, 3-4	A 2. No commercial value is left in the returned waste medicines, so there is no product generated from RL. A 5. Waste is generated as prescribed amount exceeds end users' needs.	A.2 Recapture commercial value from waste medicines by reusing approved medicines, e.g. donating them to underdeveloped countries. A.5 Reduce economic loss by synchronising medicine pack size and reducing unnecessary medication in circulation (reducing waste generated).
B. How	B 1-2	• None	B.1 Returning is more difficult as collection points are not widespread. B.2 Returned medicines are incinerated.	B.1 Launch compliance scheme collect and treat waste medicines on behalf of CCGs and manufacturers. B.2 Reuse approved medicines, e.g., donating them to underdeveloped countries. B.3 Recycle the packaging materials of waste medicines.
C. Who	C 1-3	C.1	C.1 Not everyone is engaged. C.2 There is no organisation that launch compliance scheme. C.3 GP surgeries and pharmacies do not educate end users to return waste medicines.	C.1 Total involvement and cross-sector collaboration are needed from all the actors in the RL systems. End users become actors to reduce waste medicines. C.2 Appoint a third party to launch compliance scheme. C.3 GP surgeries and pharmacies not only offer a return service, but also educate end users to reduce and return waste medicines.
D. Where	D 1-2	None	The return of waste is limited by the number, locations and opening times of collection points. Collection is only available in GP practices and pharmacies, which are 22,287 collection points in total. .	D.1 Appoint a third party to setup a nationwide collection network, providing outdoor recycling banks and bins in pharmacies. D.2 A wider collection network needs to be configured utilising the network of existing household waste recycling centres (HWRCs) and deploying localised collection systems.
E. Why and Why not	E 1-7	None	E.1 No residual value is left in waste medicines. E.2 No directives or legislation exist to compel actors to participate RL system. E.4 Communication on waste medicines	E.1 Recapture commercial value from waste medicines by reusing approved medicines, e.g. donating them to underdeveloped countries. E.4 Improved communications on waste medicine, at every level between end users and health professionals is

			is limited, only available on government websites. E.5 waste management practices are not incorporated in the RL system. E.6 No compliance scheme is approved. E.7. Financial incentives are not applied.	encouraged. Local councils liaise with NHS to improve communication on waste medicines. For example, educate residents on how to reduce and return medicine waste via council websites; or launch open events to take back and reduce medicine waste. E.5 PCTs (or new Clinical Commissioning Groups) incorporate waste management practice into community pharmacy contracts at three levels: reduce, reuse and properly dispose of. E.6 Set up compliance schemes. E.7 Apply financial incentives, i.e., sharing the cost of waste among all the actors by introducing charges to all prescription items, or enhance financial awareness by labelling medicines with information on full cost.

Table 7 Results of the high street survey

Total respondents	**Q1. Will you take returned pills?**		**Q2. Will you become motivated to return waste medicines if educated by GPs or pharmacists?**		**Q3. Do you find it difficult to return waste medicines?**		**Q4. Why did you return waste medicines to pharmacies**			**Q5. Will you become motivated to return waste medicines if you are made aware of cost?**
	Y	N	Y	N	Y	N	Receiving education or direct communication from GPs or pharmacists	Seeing posters, leaflets, etc.	I don't return waste medicines	
279	140 (50%)	139 (50%)	237 (85%)	42 (15%)	228 (81.7%)	51 (18.3%)	89 (31.9%)	51(18.1%)	140 (50%)	237 (85%)

References:

Alvarez-Gil M.J., Berrone P., Husillos F.J., and Lado N. (2007), "Reverse logistics, stakeholders' influence, organisational slack and managers' posture", *Journal of Business Research*, Vol.60, pp.463-473.

Andel T. (1997), "Reverse logistics: a second chance to profit", *Transportation and Distribution*, Vol.38, No.7, pp.61.

Autry C.U. (2005), "Formalisation of reverse logistics programs: A strategy for managing liberalized returns", *Industrial Marketing Management*, Vol.34, pp.749-757.

Australian Government, Department of Health and Ageing (2012), "New Labels for PBS", available at: http://www.health.gov.au/internet/main/publishing.nsf/Content/health-pbs-general-labels.htm, (accessed 9 November, 2012).

Bartels J.J.C. (1998) au/ilection and processing of batteries in The Netherlands - the Stibat execution scheme. In: Goor A.R. van, Flapper S.D.P., Clement C. (Eds) *Handbook Reverse Logistics*. Kluwer B.V., Deventer, The Netherlands.

Barr S., Gilg A.W. and Ford N.J. (2001), "A conceptual framework for understanding and analyzing attitudes towards household-waste management", *Environment and Planning A*, Vol. 33, pp. 2025-2048.

BatteryBack (2013), "About BatteryBack", available at http://www.batteryback.org/about.html, (accessed 23 November, 2013).

BBC News Health (2012), "Are you willing to swallow a recycled pill?", available at: http://www.bbc.co.uk/news/health-17219584, (accessed 08 April, 2013).

Bénabou, R. And Tirole, J. (2010), "Individual and Corporate Social Responsibility", Working Paper Series, Fondazione Eni Enrico Mattei (FEEM), http://www.feem.it/getpage.aspx?id=2802&sez=Publications&padre=73. (accessed 16 December 2013).

Blumberg D.F. (1999), "Strategic examination of reverse logistics and repair service requirements, need, market size, and opportunities", *Journal of Business Logistics*, Vol. 20, pp. 141-59.

Biehl M., Prater M. and Realff, M. J. (2007), "Assessing performance and uncertainty in developing carpet reverse logistics systems", *Computers and Operations Research*, Vol.34, pp. 443 – 463.

Bound J.P. and Voulvoulis N. (2005), "Household disposal of pharmaceuticals as a pathway for aquatic contamination in the United Kindom", *Environmental Health Perspectives*, Vol.113, No.12, 1705-1711.

British Medical Association (BMA) (2012), "General Practitioners", available at: http://www.bma.org.uk/press_centre/pressgps.jsp, accessed on 3rd Feb, 2012.

Carter, C. R. and Ellram, L. M. (1998), "Reverse logistics: A review of the literature and framework for future investigation," *Journal of Business Logistics*, Vol. 19, No. 1, pp. 85-102.

Camp R.C. (1995), “Business process benchmarking: finding and implementing best practice”, ASQ Quality Press, Milwaukee.

Clendenin, J.A. (1997), “Closing the supply chain loop: reengineering the returns channel process”, *International Journal of Logistics Management*, Vol. 8 No. 1, pp. 75-85.

Daugherty P.J., Richey R.G., Hudgens B.J. and Autry C.W. (2003), “Reverse logistics in the automobile aftermarket industry aftermarket industry”, *International Journal Logistics Management*, Vol.14, No.1, pp.49 – 62.

Daugherty P.J., Richey R.G., Genchev S.E. and Chen, H. (2005), “Reverse logistics: superior performance through focused resource commitments to information technology”, *Transportation Research Part E*, Vol. 41 No. 2, pp. 77-92.

Daughton C.G. and Ternes T.A. (1999), “Pharmaceuticals and personal care products in the environment: agents of subtle change?”, *Environmental Health Perspectives*, Vol.107, pp.907-938.

Daughton C.G. (2003), “Cradle-to-cradle stewardship of drugs for minimizing their environmental disposition while promoting human health -Part I Rationale for and avenues toward a green pharmacy”, *Environmental Health Perspectives*, Vol.111, pp.757–774.

De Brito M.P. and Dekker R. (2004), “A framework for reverse logistics” In: Dekker R., Fleischmann M, Inderfurth K. and van Wassenhove L.N., (Ed.) *Reverse logistics, quantitative models for closed-loop supply chains*. Springer; Berlin, pp3-28.

Deci E.L.. Koestner R. and Ryan R.M. (1999), “A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation”, *Psychological Bulletin*, Vol.125, pp.627–668.

Department of Health (DoH) (2011), “Evaluation of the Scale, Causes and Costs of Waste Medicines”, available at: https://www.gov.uk/government/publications/making-best-use-of-medicines-report-of-a-department-of-health-roundtable-event-hosted-by-the-king-s-fund (accessed 30 November 2013).

Department of Health (DoH) (2012), “Improving the use of medicines for better outcomes and reduced waste: an action plan, available at: https://www.gov.uk/government/publications/action-plan-for-improving-the-use-of-medicines-and-reducing-waste (accessed 30 May 2013).

Duflou, J.R., Seliger, G., Kara, S., Umeda, Y., Ometto, A. and Willems, B. (2008), “Efficiency and feasibility of product disassembly: a case-based study”, *CIRP Annals – Manufacturing Technology*, Vol. 57 No. 2, pp. 583-600.

Dowlatshahi S. (2000), "Developing a theory of reverse logistics", *Interfaces*, Vol. 30, No. 3, pp.143–55.

Environment Agency (2013), "Public Register of Batteries Compliance Schemes", available at:http://npwd.environment-agency.gov.uk/PublicRegisterBatteriesSchemes.aspx?ReturnUrl=%2fBatteriesPublicRegisterLinks.aspx%3fReturnUrl%3d%252fdefault.aspx (accessed 23rd November 2013)

Erol I., Velioglu M.N., Serifoglu F.S., Büyüközkan G., Aras N., Çakar N.D. and Korugan A. (2010) "Exploring reverse supply chain management practices in Turkey", *Supply Chain Management: An International Journal*, Vol. 15, Iss.1, pp.43 – 54.

Faria de Almeida A. and Robertson A. (1995), "Logistics and the Environment: A Life-Cycle Approach to Consumer Electronic Products", *Proceedings of International Conference Clean Electronics Products & Technology (concept)*, Edinburgh, Scotland, pp.162-167.

Fleischmann M, Bloemhof-Ruwaard J.M, Dekker R., van der Laan E., van Nunen J.A, VanWassenhove L.N. (1997), "Quantitative models for reverse logistics: a review", *European Journal Operational Research*, Vol.103, No.1, pp.1–17.

Flygansvær B.M., Gadde L.E., and Haugland S.A., (2008) "Coordinated action in reverse distribution systems", *International Journal of Physical Distribution & Logistics Management*, Vol. 38 Iss: 1, pp.5 – 20.

Fuller D.A. and Allen J. (1997), " A typology of reverse channel systems for post-consumer recyclables", In Polonsky J. and Mintu-Winsatt A. T.(Eds), *Environmental marketing: strategies, practice, theory and research*. Haworth Press, Binghamton, NY.

GEMI (Global Environmental Management Initiative) (2006), *Environmental improvement through business incentives, Business helping business achieve environmental, health and safety excellence*, First Edition, Washington DC.

Genchev S.E., Richey R.G. and Gabler C.B. (2011), "Evaluating reverse logistics programs: a suggested process formalization", *The International Journal of Logistics Management*, Vol.22 No.2, pp.242-263.

Giuntini R. and Andel T. (1995), "Advance with reverse logistics", *Transportation and Distribution*, Vol. 36 No. 2, pp. 73-4, 77.

Gobbi C. (2011) "Designing the reverse supply chain: the impact of the product residual value", *International Journal of Physical Distribution & Logistics Management*, Vol. 41 Iss: 8, pp.768 – 796.

Goggin K. and Browne J. (2000), "Towards a taxonomy of resource recovery from end-of-life products", *Computers in Industry*, Vol. 42, Iss. 2-3, pp.177–191.

Gonzalez-Torre, P.L., Adenso-Diaz, B. and Artiba, H. (2004), "Environmental and reverse logistics policies in European bottling and packaging firms", *International Journal of Production Economics*, Vol. 88, No.1, pp. 95-104

Gonzalez-Torre, P.L. and Adenso-Díaz, B. (2006), “Reverse logistics practices in the glass sector in Spain and Belgium”, *International Business Review*, Vol. 15 No.5, pp.527-546.

InterCare (2012), “Medical Aid for Africa”, available at: http://www.intercare.org.uk/ (accessed 19 Jan, 2012)

Grabow S. and Brachman S. (2007), “Addressing pharmaceutical waste in Jefferson County-planned response”, *Proceedings report of educational programs and workshop results*.

Hanafi J., Kara S. and Kaebernick H., (2008) "Reverse logistics strategies for end-of-life products", *International Journal of Logistics Management*, Vol. 19 Iss: 3, pp.367 – 388.

Jahre M. (1995), “Household waste collection as a reverse channel – a theoretical perspective”, International *Journal of Physical Distribution and Logistics Management*, Vol.25, Iss.2, pp.39 – 55.

Kannan G., (2009) "Fuzzy approach for the selection of third party reverse logistics provider", *Asia Pacific Journal of Marketing and Logistics*, Vol. 21 Iss. 3, pp.397 - 416

Krikke H., le Blanc I. and van de Velde, S. (2004), “Product modularity and the design of closed-loop supply chains”, *California Management Review*, Vol. 46 No. 2, pp. 23-39.

Kumar S., Dieveney E., and Dieveney A. (2009) "Reverse logistic process control measures for the pharmaceutical industry supply chain", *International Journal of Productivity and Performance Management*, Vol. 58, No.2, pp.188 – 204

Lau, K.W. and Wang, Y. (2009), “Reverse logistics in the electronic industry of China: a case study”, *Supply Chain Management: An International Journal*, Vol.14, Iss.6, pp. 447-465.

Li, X. and Olorunniwo, F. (2008), “An exploration of reverse logistics practices in three companies”, *Supply Chain Management: An International Journal*, Vol. 13, Iss. 5, pp. 381-386.

Li X. and Olorunniwo F.O. (2010), “Information sharing and collaboration practices in reverse logistics”, *Supply Chain Management: An International Journal*, Vol.15, Iss.6, pp.454-462.

Mackridge A. J. and Marriott J. F. (2007). “Returned medicines: waste or a wasted opportunity?” *Journal of Public Health*, Vol. 29, No.3, pp.258-62.

Marien E. J. (1998), “Reverse logistics as competitive strategy”, *Supply Chain Management Review*, Vol.34, No.2, pp.43–52.

Min H. and Joo S.J., (2006) "Benchmarking the operational efficiency of third party logistics providers using data envelopment analysis", *Supply Chain Management: An International Journal*, Vol. 11, Iss.3, pp.259 – 265.

Min H. and Ko H.J. (2008), "The dynamic design of a reverse logistics network from the perspective of third-party logistics service providers", *International Journal of Production Economics*, Vol.113, Iss.1, pp.176-192.

National Institute of Clinical Effectiveness (NICE) online (2013). "QIPP medicines use and procurement work stream support", available at http://www.nice.org.uk/mpc/keytherapeutictopics/home.jsp (accessed 30th May 2013).

Paterson, J.M. and Anderson, G.M. (2002), "Trial prescriptions to reduce drugs wastage: results from a Canadian program and a community demonstration project", *American Journal of Managed Care,* Vol. 8 No. 2, pp. 151-8.

Pati, R.K., Vrat, P. and Kumar, P. (2008), "A goal programming model for paper recycling system", *OMEGA: International Journal of Management Science*, Vol. 36 No.3, pp. 405-417.

Pomerantz J.M. (2004), "Recycling Expensive Medication: Why Not?" *Medscape General Medicine*, Vol. 6, No. 2, pp.4, available at:
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1395800/ (accessed 22 March 2011)

Prahinski, C. and Kocabasoglu, C. (2006), "Empirical research opportunities in reverse supply chains", *Omega*, Vol. 34 No. 6, pp. 519-32.

Qin Z. and Ji X. (2010), "Logistics network design for product recovery in fuzzy environment", *European Journal of Operational Research*, Vol.202, pp.479-490.

Ravi V. and Shankar R. (2005), "Analysis of interactions among the barriers of reverse logistics", *Technological Forecasting & Social Change*, Vol.72, pp.1011-1029.

Ritchie L., Burnes, B., Whittle, P. and Hey, R. (2000), "The benefits of reverse logistics: the case of the Manchester Royal Infirmary Pharmacy", *Supply Chain Management: An International Journal*, Vol. 5, Iss. 5, pp. 226-233.

Rogers D.S. and Tibben-Lembke, R. (2001), "An examination of reverse logistics practices", *Journal of Business Logistics*, Vol. 22 No. 2, pp. 129-148.

Savaskan R.C., Bhattacharya S., and VanWassenhove Luk N. (2004), "Closed-loop supply chain models with product remanufacturing*", Management Science* Vol.50, Iss. (2), pp. 239 – 252.

Silvenius F., Grönman K., Katajajuuri J.M., Soukka R., Koivupuro H.K. and Virtanen Y. (2013), "The Role of Household Food Waste in Comparing Environmental Impacts of Packaging Alternatives", *Packaging Technology and Science: An International Journal,* DOI: 10.1002/pts.2032, pp.

Srivastava S.K. (2008), "Network design for reverse logistics", *Omega*, Vol.36, Iss.4, pp.535-548.

Stock, J.R (1998), *Development and Implementation of Reverse Logistics Programs*, Council of Logis-tics Management, Oak Brook, IL.

Stock, J. and Mulki, J. (2009), “Products returns processing: an examination of practices of manufactures, wholesales/distributors, and retailers”, *Journal of Business Logistics*, Vol. 30, No. 1, pp. 33-62.

Thierry M., Salomon M., van Nunen J.A.E.E., and van Wassenhove L.N., (1995), “Strategic issues in product recovery management”, *California Management Review*, Vol.37, No.2, pp.114–135.

Teunter R., Inderfurth K., Minner S. and Kleber R. (2005), “Reverse logistic process control measures for the pharmaceutical industry supply chain”, in Flapper S., Van Nunen J. and Wassenhove L.V. (Eds.) *Managing Closed-Loop Supply Chains*, pp.21-32.

Tucker, P. and Speirs, D. (2002) “Model forecasts of recycling participation rates and material capture rates”, *London: Strategy Unit.*

Van Hoek R. I., (1999), “From reversed logistics to green supply chains”, *Supply Chain Management, An International Journal*, Vol. 4, Iss.3, pp. 129-135.

Xie Y. and Breen L. (2012) "Greening community pharmaceutical supply chain in UK: a cross boundary approach", *Supply Chain Management: An International Journal*, Vol. 17 Iss: 1, pp.40 - 53.

Yu M.C. and Wu P.S. (2010), “A simulation study of the factors influencing the design of a waste collection channel in Taiwan”, *International Journal of Logistics: Research and Applications*, Vol. 13, No. 4, pp.257–27.

Zhou, L., Naim, M.M. and Wang, Y. (2007), “Soft systems analysis of reverse logistics battery recycling in China”, *International Journal of Logistics: Research and Applications*, Vol.10, No.1, pp. 57-70.