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Green Community Pharmaceutical Supply Chain in UK: Reducing and Recycling Pharmaceutical Waste

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Abstract
The Pharmaceutical Supply Chain (PSC) is a SC where pharmaceutical medications are produced, transported and consumed. Disposal of the medication waste is harmful to the environment and costly, therefore, greening the PSC by properly managing the medication waste is investigated. A Cross Boundary Green PSC (XGPSC) approach is proposed to design a green PSC that results in fewer preventable medication waste
and more recycling of inevitable medication waste, therefore improved environmental, economic and safety performances. This study focuses on the community PSC in UK where patients get medication from local community pharmacies. To green the PSC, every producer of waste is duty bound to ensure the safe handling and disposal of waste. This duty of care spans throughout the chain and includes all participants. This approach is drawn from the contemporary literature and our collaborative research, and can be used as a guidance to establish a waste management network in community PSC.

**Keywords:**
Green supply chain, pharmaceutical supply chain, environmental practices

1. **Introduction**

There has been increased consciousness of the environment in the last few decades. More people realise the world’s environmental issues such as global warming, carbon emissions, toxic substance usage, and resources scarcity. There is global advocation for going green, and many organizations respond to this by applying green principles to their company. In addition to the mandatory regulation driven programmes, numerous environmental programmes are introduced by organisations voluntarily. The British supermarket chain Sainsbury’s has expanded its trials running vehicles on biogas made from landfilled waste, with an order for five more of its vehicles to be converted (Navarro, 2009). Pepsi-Cola saved $44 million by switching from corrugated to reusable plastic shipping containers for one litre and 20-ounce bottles, conserving 196 million pounds of corrugated material. Wu and Dunn (1995) designed an environmental friendly chain for a single organisation where greening starts from procurement and work its way through to storage, distribution
and to end-consumers. However, the chain does not include the cross company activities. In fact, not only within a single organization, the green principles are extended to the whole supply chain (SC). Printing industries like Hewlett-Packard, IBM, Xerox and Digital Equipment Corporation have made their SC green via integrating suppliers, distributors and relocating facilities (Ashley, 1993; Bergstrom, 1993; Gillett, 1993 and Maxie, 1994). Green SC Management (GSCM) emerged in late 1990s, and it ranges from reactive monitoring of general environmental management programs to more proactive practices, such as the recycling, reclamation, remanufacturing, reverse logistics of environmental management and incorporating innovations (Zhu and Sarkis, 2004). For over 10 years, GSCM has become an important environmental practice for companies to achieve profit and increase market share in such a way that environmental risks are lowered and ecological efficiency are raised (Van Hok and Erasms, 2000). Realising the significance of the GSCM implemented by the organisations, Sarkis (2003) developed a strategic decision framework that aids managerial decision making in selecting GSCM alternatives, and product life cycle, operational life cycle (including procurement, production, distribution and reverse logistics (RL)), organisational performance measurements and environmentally conscious business practices serve as the foundations for the decision framework. Considering the previous literature that addressed various elements of GSCM (Carter et al., 1998; Walton et al., 1998; Zsidosin and Hendrick, 1998), Zhu and Sarkis (2004) developed four categories of GSCM practices (internal environmental management, external GSCM, investment recovery, and eco-design or design for environment practices), and examined the relationship between these practices and environmental and economic performance through empirical studies in the Chinese manufacturers.
The Pharmaceutical SC (PSC) is a special SC in which medications are produced, transported and consumed. Academic researchers and practitioners believe that “pharmaceuticals are different; they cannot be treated like other commodities” (Savage et al, 2006). The reasons for this sentiment were the high cost and long duration for research and development and the repercussions of the product not being available, hence again its criticality. Other unsupported perception-based factors that appear to make this supply chain distinctive include; the level of regulation in the product production, storage, distribution, consumption and the complexity of the fabric of this supply chain (Knight, 2005). Disposal of medication can be very harmful to the environment and costly. Vast arrays of drugs are entering 41 million Americans’ drinking water from people disposing the unused/expired drugs in the domestic rubbish or waste water (USATODAY, 2009). Globally, in 2003 at least £0.56 billion worth of unused drugs are flushed down the toilet (Van Eijken, et al., 2003). From an economic point of view, efficiencies can be made in the form of potential savings in the pulling back of stock from patients. Medication retrieved from patients cannot be re-used and must be disposed. It does however provide vital information and can encourage more prudent prescribing. Safety is also paramount when broaching pharmaceutical management and storage. Accidents can happen if products fall into the hands of children or individuals who wish to abuse the product themselves or support a ‘grey’ market for product exchange/sales. Global and domestic pressures on environmental, economic and safety considerations (Breen and Xie, 2009) drive us to manage PSC greening, i.e., improve the PSC economic and environmental performance by recycling the unused/unwanted medications and reducing medications that need disposal As a result of greening processes, the PSC will become safer when hazardous medications are removed from the supply chain.
and be kept away from vulnerable people, like children. However, there is very little research and practice on drug recycling (Ritchie et al., 2000) or green PSC (GPSC). As explained above, it is vitally important to properly dispose expired medication because of its hazardous nature, and it is even more critical for every producer of medication to take actions on reducing waste. The fate of unused consumer pharmaceuticals is an issue that has reached public consciousness more recently. There is emerging concern about the potential impact of medicine that reaches lakes and rivers via sewage plants and other sources (New Hampshire Department of Environmental Services, 2009).

This research aims to design a green PSC that results in fewer preventable drug waste and more recycling of inevitable drug waste, using a cross boundary green PSC (XGPSC) approach that requires every participant in the PSC to take environmental practices to improve the economic and environmental performances of the chain. In order to achieve the aim, the research framework and objectives are established in Section 2, then a community PSC with reverse logistics is designed in Section 3; and the XGPSC approach is proposed in Section 4 where participants are recommended to take environmental practices and actions to green PSC. Section 5 concludes the paper summarising the findings and potential for future research.

2. Research framework and methodology

The objectives to meet the research aim are: i) design a physical network for community PSC with RL built in; ii) develop a XGPSC approach, in which the environmental practices playing important roles in greening PSC are identified from a broad perspective; iii) under the environmental practices identified in ii), the specific the actions to be taken by each participant in the PSC are addressed from a detail
The research framework is shown in Figure 1, illustrating that each participant in the PSC network is recommended to adopt the XGPSC approach and take necessary environmental practices to green the PSC. The environmental practices to be conducted by the participants in the PSC are complex, collaborative, costly and different from other business sectors provided that PSC is a special SC, it would be impossible to conduct any empirical study to test any practice prior to a systematic conceptual approach is formulated. Therefore, the XGPSC approach is developed from the literature that identified the practices in the area of environmentally conscious business practices and from the authors’ collaborative research in the area of pharmaceutical supply chain. The recommended practices are made by the authors after consultation with academic experts, medication users, pharmacists, and professional and regulatory bodies like Royal Pharmacy Societies of Great Britain (RPSGB), Department of Health, and London National Health Service (NHS) London Procurement Programme (LPP). The authors also reviewed the regulations, guidance, audit results and other publications from the RPSGB and NHS to understand the current progress and expectations for medication waste management, and developed the environmental practices incorporating with the good experiences from other countries.

The drivers of green PSC are summarized as the environmental, economic and safety considerations and it is expected that the environmental, economic and safety performances of the chain can be improved when it is becoming green. It has been argued that new opportunities of competition (Hansmann and Kroger, 2001) and many benefits can be brought to the organisations if environmental protection activities are taken (Alvarez Gil et al., 2001), including improved organisational reputation.
(Welford, 1995), reduced cost, improved organisational efficiency, increased market share, getting ahead of competitors and legislation, access to new markets, and increased employee motivations (Porter and van der Linde, 1995; Shrivastava, 1995; Beaumont et al., 1993; Guimaraes and Liska, 1995). Using empirical results from 186 respondents on GSCM practice in Chinese manufacturing enterprises, Zhu and Sarkis (2004), found that an organization’s environmental and economic performances are improved if they take the four GSCM practices, i.e., internal environmental management, external GSCM, investment recovery, and eco-design or design for environment practices. The internal environment management requires commitment and support from senior managers in the organisation, as well as total quality environmental management (TQEM) and audit programme to be set up. The external GSCM practices focus on cooperation between suppliers and customers for environmental objectives, e.g., communication on product design, clean production and green packaging. The investment recovery is a traditional business practice in which excess inventories/materials are resold, or the scrap/used materials are resold. The eco-design requires the organisations involved in manufacturing processes to design products for reduced consumption of materials by adopting reusable or recyclable materials, and reducing use of hazardous components. The investment recovery practice is not applicable to the PSC as returned medication cannot be reused or resold. So the three GSCM practices except investment recovery will be used as foundations to develop a XGPSC approach, in which the environmental practices and specific actions are recommended to be taken by PSC participants in order to green PSC with improved environmental and economic performances. Considering the hazards that the out-of-date and unused medicines pose on the children and other vulnerable people, the green PSC reduce the excess medicines in households and
therefore reduce the propensity for these groups to take the out-of-date or unused medications which ultimately lead to improved safety performance of PSC.

3. A community PSC network with reverse logistics

As identified in Sarkis (2003), RL is one of the most important but least developed operational functions that serve as a foundation for GSCM practices. RL is defined as “the process of planning, implementing and controlling the efficient, cost-effective flow of raw materials, in process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing or creating value or for proper disposal” (Rogers and Tibben-Lembke, 1999, pp2). RL facilitates return of products for recycling in many sectors, like automobile (Lebreton and Tuma, 2006), electronic waste (Lau and Wang, 2009; Nagurney and Toyasaki, 2005), computer (Shih, 2001), paper (Pati et al., 2008), packaging material (González-Torre et al. 2004), bottling or glass (González-Torre and Adenso-Díaz, 2006) and batteries (Zhou et al., 2007); this can be both for re-use or disposal. As one of the few research applying RL in the medical area, Breen and Xie (2009) proposed an integrative customer relationship management (CRM) facilitated RL system in UK community pharmacy for environmental, economic and safety reasons.

Considering the operations of a community PSC in UK, a preliminary community
PSC network is designed and presented in Figure 2, where a forward logistics network is depicted in which medications are produced by the pharmaceutical manufacturer, transported by the logistics providers community pharmacies, and finally consumed by the customers who can be the patients or the buyers; also a RL network is designed for the unused/unwanted medications to be returned to the manufacturer. The unused/unwanted medications are encouraged to be returned for two reasons (Breen and Xie, 2009): i) it removes the product from circulation and from the domestic environment therefore reducing the risk of accidental injury or planned product abuse; ii) it provides valuable information which can be used to assess the efficiency of the prescribing process (who the prescriber is, the nature of the product and the quantity dispensed).

As shown in Figure 2, a RL network is one of the key resources needed by the customer, pharmacy, GP and manufacturer to conduct recycling behaviour. A channel must be available for the expired drugs to be sent back to manufacturers, and can be built in a number of ways: i) customers return the unused/unwanted medication to the pharmacies or the GPs in person, and the pharmacies or the GPs return them back to manufacturer via the logistics providers; ii) the pharmacies return the unsold or expired medications to manufacturer when appropriate; and iii) logistics providers or wholesalers get involved in the system acting as either independent operators such as collection, sorting, recycling and disposal or cooperating with other actors in the system (de la Fuente et al., 2007; Krumwiede and Sheu, 2002). The dashed line in Figure 2 represents the recycling channel for the expired drugs. In the process of recycling, logistics providers or wholesalers take the role of collection from the community pharmacy and transport to manufacturers or suitable places for disposal. The manufacturers, logistics providers/wholesalers, GPs and community pharmacies
are classified as direct participants in the PSC because their roles and activities have direct impact on the performance of the PSC, while the professional and regulatory bodies influence PSC indirectly via giving suggestions to the direct participants. In the middle of the figure (Figure 2), guidance and instructions from professional and regulatory bodies (like Royal Pharmacy Societies of Great Britain (RPSGB), Department of Health, or waste management agencies etc.) will be given to the direct participants in the PSC, and have a peripheral influence on the actions taken by direct participants.

Although RL has a great influence in greening the SC, recycling behaviours are classified as proactive green approaches, and the most far-reaching approach is value-seeking in which companies have the strategic initiative to integrate environmental practices into the business strategy and operate the company to reduce impact on the environment (Kopicki et al., 1993). Community pharmacies are bound by contractual obligation to offer a returns service for medication; this action is therefore built into their service provision (Department of Health, 2008; Bellingham, 2004). The strategic aim of which is to facilitate safe disposal, remove excessive storage of medicines in the home and to reduce the environmental damage from inappropriate disposal methods (Primary Care Commissioning, 2009). Also, medications once returned by customers cannot be re-used and must be disposed therefore they have no residual value. Strategically action must be taken to reduce the medication waste entry to the PSC for environmental protection, economic savings and safety considerations. As illustrated in the shaded boxes, the participants in the PSC are expected to reduce the medication waste by integrating environmental practices in their main activities. The specific actions to be taken by the participants to reduce waste will be discussed in the next section.
Figure 2: A community pharmaceutical supply chain with reverse logistics

4. A Cross Boundary Green PSC (XGPSC) approach

To green the community PSC, not only a physical PSC network needs to be constructed in Figure 2, but also GSCM practices should be implemented by all participants in the chain from the holistic system perspective, which is the far-reaching approach that will minimise the total environmental impact of a business (Van Hoek, 1999).

A cross boundary green PSC (XGPSC) approach is proposed in this section (as shown in Figure 3) to propose environmental practices to be adopted by participants in the PSC, in order to convert the community PSC in Figure 2 to be a green PSC. Based on the three categories of GSCM practices in Zhu and Sarkis (2004), the XGPSC approach recommend the four environmental practices in Table 1: i) top management commitment: each participant in the PSC make commitment to GSCM from top management team and setup environmental management system; ii) supplier certification and cooperation: each participant should evaluate his suppliers’ environmental practices and cooperate with suppliers for environmental
objectives; iii) **customer cooperation**: each participant cooperate with customers or support them for eco-design, cleaner production, green packaging and proper recycling or disposal; and iv) **eco-design**: the participant should become involved in the manufacturing process, designing products for reduced materials/energy, for reuse, recycle, recovery of materials, and for reduced use of hazardous components. The recommendation i) and iv) are classified as internal environmental management that take place inside an organisation and plays key roles in improving the performance of individual organisations (Carter et al., 1998). The ii) and iii) are external environmental practices that are more difficult to be implemented and require the information, support and collaboration from other participants. However, to successful green the PSC, the recommended practices are integrative and need cross-functional cooperation rather than oriented towards a single department or organisation (Xie, 2009).

Under the environmental practices recommended above, the specific actions to be taken by each participant vary along the chain and are illustrated in Figure 3.

Table 1: environmental practices recommended in XGPSC approach

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<th>XGPSC approach</th>
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<td><strong>Internal Environmental practices</strong></td>
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4.1 The Manufacturer
i) **Top management support:** As the producer and designer of the pharmaceutical products, the manufacturer can contribute to the green PSC through innovative and environment friendly medication designs, so the commitment of GSCM from the management team are essential to realise and ensure total green operational processes ranging from procurement, production, distribution and reverse logistics. It is also recommended that an environmental management system should be designed to improve the TQEM and make the ISO 14000 certification the target of the organisation and its suppliers (GEMI, 2001). To monitor and evaluate the organisation and its supplier’s practices, a series of environmental compliance and auditing programmes should be set up (Zhu and Sarkis, 2004).

ii) **Supplier certification and cooperation:** Florida (1996) claimed that close bonds with suppliers facilitate cleaner production. The supplier selections and procurement decisions have an impact on the GPSC through purchase of materials that are hazardous or non-hazardous, recyclable or reusable, or have already been recycled (Sarkis, 2003). The manufacturers are encouraged to add environmental, health and safety elements to their strategic sourcing initiatives, and provides practical resource for procurement staff to understand and pursue opportunities that will add business value to their companies (GEMI, 2001). The suppliers who have ISO 14000 certification are recommended to be selected to lessen the environmental risks associated with the materials procurement.

iii) **Customer cooperation:** By collaborating with the customers (the wholesalers or the pharmacies in this research) and communicating for design specifications and recycle feasibility of products, the manufacturers can contribute to innovative medication designs, cleaner production and green packaging (Zhu and Sarkis, 2004).
A strong relationship with wholesalers and pharmacies will encourage the returnable packaging adopted by them provided that reverse logistics channel is available.

iv) **Eco-design:** According to (Kreisberg, 2007), medications can be designed to be more ecologically sensitive, e.g., biodegraded more quickly, more efficient for lower doses, or less harmful. The shelf life of medication can be brought into closer alignment with real time by refining the expiration dates. It is also recommended in (Breen and Xie, 2009) that medication product life cycle can be maximised so that customers will feel it is worth returning them back for economic benefits.

In terms of medication packaging, recyclable materials can be used; the package can be designed by adding more complete/direct information about proper ways of disposal; and the package shapes and sizes can be designed for easy returning and transportation (e.g., mail back returning). In addition, multiple choice of the packaging size can be made available for the GPs or pharmacists to minimise the unused portion of prescriptions.

**4.2 The wholesaler and logistics providers**

The development of a RL system has enabled pharmacies to transport all unsold or expired drugs as products go back through these firms for the purpose of returning them to the manufacturer for credit. The activities of transportation in the RL system can be implemented by the wholesaler, or the logistics providers including the third party logistics (3PL) company. Any expired items that do not meet the manufacturers’ return policy become waste at the RL which becomes the waste generator, since this is where the decision to discard the item is made (Smith, 2002). Waste need to be properly dealt with by the wholesalers and logistics providers in collaboration with manufacturers and community pharmacies, for the purpose of greening PSC.
i) **Customer cooperation**: The role of the wholesaler is to support manufacturing operations through warehousing and distributing stock to community and hospital pharmacies. They have an established logistics network and so are well placed to enhance their service package through RL activities. They provide such a service for their own products (manufactured by their company or their customers) in retrieving defective products e.g. short-dated or incorrect items. The role of a 3PL has been investigated in hospital pharmacy in consolidating deliveries. Wholesalers can provide such a service in their current position in the PSC (Breen, 2004).

The service provided by the wholesaler and logistics providers can go beyond transportation, and include classification, storage, manifest, destruction, and disposal of medications. If the wholesalers or the logistics companies act as the waste management brokers, they are expected to classify and segregate the medication according to the hazardous or non-hazardous characteristics, then manage them under appropriate streams (Smith, 2002). Employing them in the RL network can reduce the amount of pharmaceutical waste generated and disposed improperly. But it is important to select a wholesaler or logistics provider that complies with environmental regulations, and acquires the licenses for these services before they are contracted in the RL network.

### 4.3 General Practitioner

i) **Customer cooperation**: A General Practitioner (GP) plays an important role in the community PSC, as s/he is the first point the patient (customer) contacts in the chain, and it is an ideal time point to educate the patient how to properly dispose or return the unused medications when the GP prescribes the medications.
According to waste audit conducted by Rowlands Pharmacy (2009), GPs might prescribe medication for a longer period than customers’ need, which results in unused medication accumulating in household. Therefore, GPs need to consider the timeframe needed for prescriptions prior to dispensing. Shorter periods of prescriptions have been trialed in Canada based on 7-14 days (Paterson and Anderson, 2002). GPs should also be consulted regarding patients involved, and an efficient Management Information System (MIS) is proposed to facilitate GPs to monitor patients’ progresses and remind them to return pharmaceuticals via text, call or email. In the MIS, patients’ consultation and personal details will be recorded, together with Medicines Use Reviews (MUR) results.

ii) Supplier certification and cooperation: The GPs should evaluate their pharmacy suppliers’ environment friendly practices and make proper suggestions or support to help them go green. Medication Use Reviews (MURs) are thought to have a vital role to play in medication management (Lammy, 2007), and Dispensed Review of the Use of Medicines (DRUMs) are regularly conducted by GPs and community pharmacies (as part of NHS contract obligations) to improve the way that medications are used, to reduce unnecessary medication in circulation and to make informed decisions regarding pack sizes and synchronization as advised by the National Prescribing Centre etc (NHS Cumbria, 2009). The DRUM can be conducted based on the medication information recorded in the GPs’ MIS which are appropriately shared with pharmacies to facilitate the whole process.

4.4 Community Pharmacies

Community pharmacies play different roles in the process of green PSC: i) they are customers of the pharmaceutical manufacturers, and are responsible for communicating with manufacturers or wholesalers regarding product information; ii)
they are a communication point with customers for advice and education on proper disposal of medication; iii) they act as an accessible site for customers returning back unwanted/unused medication; iv) and they act as a site where pharmacists conduct repeating or supplementary prescription to reduce unnecessary medication entering the PSC. So the environmental practices to be taken by community pharmacies will be:

i) **Supplier certification and cooperation:** The pharmacies are supposed to evaluate suppliers’ environmental practices and choose the one with ISO14000 certification or higher environmental compliance. In addition, they can manage their inventory with manufacturers, and launch collaborative planning, forecasting and replenishment (CPFR) to minimise the amount of expired medication. They also should collaborate with manufacturers for ecological medication design, and feedback manufacturers on the package sizes and labelling information on recycling, etc. Efforts can be made to introduce supplier development initiatives which would encourage interaction between suppliers and customers and facilitate knowledge exchange (Breen, 2004b). It could also allow for development opportunities such as vendor managed inventory services where pharmaceutical companies can share their supply chain management expertise.

ii) **Customer cooperation:** As seen in Figure 2 it is clear that community pharmacy is closer to the customer so has greater opportunity to build relationships with these parties. They act as a site to communicate with customers about proper disposal of unused/unwanted medication, and provide facilities for customers to drop off those medications. According to the research, 95% of pharmacies in British Columbia have recycle bins, which allow consumers to bring their unused/expired medicines back (Kreisberg, 2007). While in UK, there is no figure showing the percentage of
pharmacies providing drop in/recycle boxes, and it is recommended the pharmacies acting on the provisions. In addition, open events for returning medications can be organised by the pharmacies in collaboration with local councils, to launch a public campaign on reducing medication waste and protecting the environment e.g. Calderdale Primary Care Trust Wasted and Dangerous Campaign (2006).

The information obtained from pharmacist-led and GP-collaborated MURs can be sent to GP for proper description and manufacturers for medication design and it also can be used by pharmacies to identify the reasons of returning and take appropriate actions to reduce waste. MURs completed in Huntingdonshire for 100 patients indicated that 49% of patients were found to have medicines that could be stopped and 430 interventions were made to reduce wasting these no longer needed medicines (Lammy, 2007).

Similar conclusions regarding medication reviews were raised by Braybrook et al (1999) and Boivin (1997). Effective MURs in community pharmacy have also been linked to a reduction in hospital admission for asthma patients (Jerram, 2009).

More advanced systems are being launched in the NHS medication management system, such as repeating dispensing (Department of Health, 2007) and supplementary prescribing (PSNC, 2005; RPSGB, 2006), and these services are treated as essential steps in green PSC.

Repeat dispensing in community pharmacies allows patients to collect their repeat medication directly from their chosen pharmacy without consulting with a GP each time (Department of Health, 2007). Supplementary prescribing revolutionised the way medicine management was traditionally organised allowing more flexible team working. Supplementary prescribing allows pharmacists to prescribe drugs within the context of a Clinical Management Plan which is signed and agreed with a patient’s GP prior to the consultation (PSNC, 2005; RPSGB, 2006). The two systems allow
patients improved access to medicines and is seen as an important advance in the management of patient’s long term conditions. The service offered by the two systems allows community pharmacists to engage in a two way conversation with patients to ascertain that they are taking their medication as they should be and/or if they are experiencing any side effects (concurrs with Jesson et al’s findings, 2005). It also increases the patient convenience and will help develop good links between pharmacies and GPs. If designed in this way, this will reduce unnecessary medications entering into the RL pharmaceutical system.

### 4.5 Professional and regulatory bodies and waste management companies

The professional and regulatory bodies and waste management companies are treated as indirect participants and have peripheral influences on the direct participants in the PSC. Public awareness on the importance and necessity of drug recycling can be raised, and advice, instructions and support from professional and regulatory bodies given to individual organisations will have positive impact on greening the PSC, and these practices have been conducted in the United States (Practice Greenhealth, 2009). The waste management companies can make suggestions and advice. In this case, the PSC participants who are guided and instructed are treated as the customers, and the prior communications and cooperation with them are essential to define the guidance and instructions.

i) **Customer cooperation:** In 2006, the Department of Health and Royal Pharmacy Society of Great Britain (RPSGB) in UK produced guidance on best practice pharmaceutical waste management (Department of Health, 2006) and regulations on hazardous waste (RPSGB, 2005), which provide practical advice and guidance for waste producers in the healthcare system. The pharmacists in the PSC are required to understand and ensure their compliance with the guidance and regulations. However,
legislations are also required to oblige manufactures to make compliance on environmental protection in terms of procurement, production, distribution, reverse logistics and packaging. The rules defining customer compliance in returning the unused/unwanted medication will also facilitate the success of green PSC.

Waste management companies are providing services and advice to their customers on secure disposal of medication waste and compliance with legislations (Phs management, 2007; Veolia environmental services, 2007). It is expected that waste management companies propose reasonable suggestions that would reduce medicines waste.

The data collated from MURs and DRUMs can be fed back into the PSC via professional bodies and associations e.g. RPSGB and Association of the British Pharmaceutical Industry (ABPI), and they can make suggestions to manufacturers on medication design and package or to GPs on prescription period or further medication monitoring.

4.6 Customers

To green the PSC, the role of the customer is not only a consumer of medication/healthcare service, but also an actor to reduce unneeded medication and return the unused medication. They need to be educated to manage unwanted medication differently e.g. rather than dispose of medication into water or domestic waste systems, bring the medication to a collection site or hazardous waste facility. They can also buy smaller quantities of medication if possible, and buy products with recyclable packaging. There is a need therefore to raise awareness of the impact of medication and effective disposal methods.

i) **Supplier cooperation:** The management of returned medication cannot happen unless the customer is compliant and becomes involved, e.g., corporately or
proactively return the unused/unwanted medication to the suppliers (either GPs or pharmacies). Breen and Xie (2009) recognise that the customer operating in this new role is the only party in the PSC who pays for a product but is then expected to act altruistically for the good of PSC by initiating product recycling. Any guidance and support infrastructure put in place by the government and regulatory bodies will not ensure success in this area, unless the customer participates. Unlike the traditional model of recycling, e.g. where goods can be recovered and reused, pharmaceutical products take a different recycling pathway, that is, final disposal by a third party. The customer, as an existing patient, can also hold a strong position on an individual basis, as determined by the potential risk attached to the medication that is returned. The value in this case is based on the reduction of risk due to the product being taken out of circulation and no longer a hazard to patients or extended family etc.

Besides this, the patient engagement with the service is sometimes purely on a transactional basis or if there has been a length of servitude, it can result in something akin to loyalty. It is this element that community pharmacy management needs to secure and build upon to ensure the success and sustainability of returning medication in the PSC. This can be facilitated by a CRM system which places customer involvement at the forefront of this system, but also prompts and supports customer involvement by the use of information systems and technology (Breen and Xie, 2009).

4.7 A Green PSC

The cost of recycling medication in the PSC is difficult to quantify. The cost of final disposal is easy to identify but the cost of retrieval is a different matter. What is the price of an effective RL system which facilitates effective customer management and ensures recycling behaviour? How much does it cost to raise awareness and educate/energise customers to want to bring back unwanted medication? Regardless
of cost, the message is clear. For economic, environmental, and safety considerations, medication within the PSC needs to be reduced in order to reduce the quantity of stock destined for final disposal. The effective delivery of this objective requires the efforts of the complete PSC. Successful contribution of all participants will lead to a greener and more sustainable PSC.
Figure 3: The cross boundary green PSC (XGPSC) approach
5. Conclusion

There are increasing concerns regarding the adverse environmental consequences of inappropriately disposed medications, the economic loss caused by the preventable medication waste, and the safety problems caused by the expired or hazardous medications. To address these concerns, proper medication waste management becomes a new frontier in health care system and are investigated in this paper limited to community PSC in UK, which is one of the most frequently participated SC by the patients and the medication buyers. The medication waste management requires the involvement of the entire supply chain, from manufacturers, through wholesalers/logistics providers, to GPs, community pharmacies and finally to customers to green the PSC that results in fewer preventable drug waste and more recycling of inevitable drug waste.

To provide a channel for taking back the unused/expired medication, a PSC network is designed encompassing the RL to enable community pharmacies and customers to recycle medication. However, the recycling behaviour is only counted as a proactive environmental practice, and a XGPSC approach is designed as a far-reaching approach to integrate environmental practices into the business strategy and operate the companies in the PSC to reduce impact on the environment. The environmental practices and actions to be taken by the participants in the PSC are identified in the XGPSC approach that requires total involvement and cross-sector collaborations from participants. Four environmental practices are recommended: top management commitment, supplier certification and cooperation, customer
cooperation and eco-design. Under these environmental practices, specific actions are addressed for direct participants including manufacturers, wholesalers/logistics providers, GPs, community pharmacies, and customers. The key actions include making commitment to environmental objectives, evaluate and select suppliers with ISO14000 certificate, educate patients for proper disposal of medication, collaborate with customers for medication use review, change prescription period, and ecologically sensitive medication design. Indirect contribution is also recognised from peripheral influences from the professional and regulatory bodies and waste management agencies.

The proposed XGPSC approach can act as the guidance for all those involved in the management of medication waste, and provides practical advice and guidance for waste producers. With a firm commitment to take actions reducing and recycling medication waste, like changing habits, becoming stewards of medication rather than only consumers, the PSC will become greener in the future. Professional bodies or government may use it as a reference to define regulations and instructions for best practice of medication waste management.

The research work is built on the contemporary literature review and the collaborative research, so the proposed XGPSC approach needs to be further validated and improved in the future through empirical study.
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