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Saving Lives and Saving the Planet: The Readiness of Ireland's Healthcare Manufacturing Sector for the Circular Economy

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Abstract. Healthcare manufacturing is one of the leading creators of single use products in Ireland and accounts for 11% of waste generated. Industry and businesses can play a significant role in tackling unsustainable production and consumption levels. Circular Economy (CE) practices could play a major role in the sustainability of healthcare and medical device manufacturing. This study aimed to develop an understanding of the current state of these company's readiness for the Circular Economy. An online survey was carried out with key employees in this industry to understand their perception of CE and what might drive more circular models. This study found that there was very little knowledge of CE within this industry. Despite this, some aspects of CE had been implemented, driven by cost saving initiatives. The barriers to implementation identified included a lack of prioritization and funding to develop more sustainable models of production. It was also found that financial assistance (e.g. grants) together with policy and legislation could unlock opportunities to develop a more circular model. This study adds to the limited empirical literature on CE barriers and opportunities to manufacturing organisations operating in Ireland.

Keywords: Circular Economy, Sustainable Manufacturing, Eco-innovation, Industrial symbiosis, Healthcare manufacturing

1 Introduction

1.1 Background

Worldwide, natural resources are being used beyond planetary supply, primarily due to unsustainable production and consumption patterns including products being discarded after one use [1]. Ireland is contributing to this problem. In 2018, around 426,500 tons of municipal waste were accepted into Irish landfills [2]. Over 300 million tons of plastic is produced in Ireland every year, half of which comprises single use items. 11% of Ireland's waste [3] comes from healthcare manufacturing, an industry very important to the Irish economy [4] but which is one of the leading creators of single use products such as gloves, gowns, catheters or surgical instruments.

Single use products were not always seen as a negative. Disposable/single use business models emerged in the 1980s and 1990s, and were initially developed in healthcare for infection control, convenience and cost savings [5]. However, given the amount of waste produced by single use products and the subsequent impacts, it is imperative that industry works towards reversing environmental damage and reducing levels of production and consumption [6] [7]. As an unintended but advantageous consequence, such a move may also lead to companies realizing greater economic revenues [8].

One way for industry to approach this problem is to embrace a Circular Economy model(CE) which aims to eliminate the inefficiencies inherent in a traditional linear model of take, make and waste [1]. It is based on the three principles of: designing out waste and pollution; keeping products and materials in use for as long as possible; and regenerating natural systems [9]. Business needs to be part of the solution to reverse damaging environmental practices [10]. CE offers many opportunities to manage and reduce waste in healthcare and has been successfully used to implement sustainable procurement [11] [12] [13] [14], effective waste minimization, safe reuse, reprocessing and recycling [11] and new business models [9]. Studies have shown that CE adoption could also reduce cycle time in production and improve customer lead times, in turn increasing incomes and attracting new customers related to more sustainable processes and products [15]. Finally, it could also lead to developing closer relationships with customers and suppliers, opening new markets and generating higher profits. This is despite the reported challenges in recovering value from reusable devices caused by a lack of communication between various stakeholders such as employees, waste management staff, procurement and the end markets.

The current literature indicates that there are various eco-innovations already developed such as Design for the Environment (DfE), Waste to Energy (WtE) and Product Service Systems (PSS) that could be implemented by the medical manufacturing industry to incorporate circular elements. However, their implementation is mixed. Design for the Environment in the medical industry lags in its performance, despite this being the best place to address the issues, as most of the environmental impact is decided at this stage [3] [16]. Optimizing the traditional waste cycle by adopting Waste to Energy is used as one way of diverting waste from landfills and reduce environmental impacts somewhat [17]. Product Service Systems is an instrument that could support CE models and manage resources effectively [18] if the systems are well designed to reduce environmental impacts [1]. However, the opportunities would need to change the business model significantly, and it may only be suitable for larger medical equipment rather than other products [1] [15].

Industrial symbiosis could play a significant role in adopting many of the eco-innovations mentioned above. Industrial Symbiosis is the process by which waste or by-products of an industry or industrial process become the raw materials for another [19]. Cross-sector collaborations and innovation are needed to operationalize a symbiotic system, but limitations are reported, in particular among small and medium enterprises [20]. There are also particular challenges in the Medical industry compared with other sectors due to it being a high-risk field (which could endanger health or lives) and there are strict regulations in place [21]. Nonetheless, there has been a recent emergence of a

small number of companies managing the reprocessing of single-use devices (such as Siemens, Philips, GE and Stryker Sustainability Solutions) [21].

Despite the small pockets of reported activity, overall, there is a lack of research in the area of the Circular Economy and the healthcare manufacturing sector [15]. Hence this paper aims to assess Ireland's healthcare manufacturing companies' readiness for the Circular Economy. It looks at their current environmental management-practices and attitudes to the Circular Economy. It examines the main drivers, motivators and barriers, while also looking into future opportunities for the industry. This research contributes to the unique perspective of this highly regulated sector and helps to develop an understanding of how these companies could prepare for the opportunities of circular manufacturing models.

2 Methodology

This paper presents the views of people working in the healthcare manufacturing industry on the Circular Economy in Ireland. It asks specific questions on the environmental management practices within their organizations, their views on aspects related to the circular economy, and what would motivate them and their companies to become more circular.

2.1 The approach

This study seeks insights into practices and readiness of companies for the Circular Economy in Ireland, while taking into account the realities of their highly regulated manufacturing environment. It considers differing views across various levels of employees, from CEO and senior management to production operatives. The theoretical perspective is post-positivist because it involves investigating the perspectives of employees as well as measuring, for example, the environmental management practices related to the Circular Economy readiness.

The methods of analysis used were a literature review followed by a quantitative questionnaire, which was adapted from earlier studies conducted in Denmark and the UK. [20] [15].

2.2 The survey instrument

The survey instrument posed questions in the following key areas:

1. The profile of the respondent and the company
2. Familiarity with the Circular Economy (CE), eco-innovation and industrial symbiosis and current activities and opportunities
3. Personal and perceived company attitudes to CE opportunities
4. Drivers, motivators and barriers of CE

The questionnaire was carried out online. It employed a non-probability convenience sampling method as it was distributed through regional business support organizations.

The questionnaire comprised 26 questions, a mixture of multiple choice and a scale rating to ensure the reliability and validity. Likert scales were mainly used to quantify opinions, interest or perceived efficacy [22]. A Likert-scale rating was used to allow for qualitative data on a nominal scale and allowed for comparison between companies and respondents. The scales consist of one 7-point scale with the rest being a 5-point scale. As the Circular Economy is a relatively new concept to most people much of the questions are subjective. As the survey seeks opinions, it may lead to some qualitative data or inconsistencies in the data.

2.3 Limitations

The main limitation of this study was the relatively low sample size of twenty-nine, despite it being distributed to hundreds of company contacts. Response bias is also a factor, in that only persons with an interest in the area may have responded to the questionnaire.

3 Results and discussion

3.1 Respondent profile

A total of 29 respondents completed the survey, almost half (48%) were OEMs, 38% were contract manufacturers and the remainder comprised pharmaceutical, consultancy, diagnostic and R&D companies. Most of the respondents (79%) represented large companies employing over 500 people. The professional profile included some senior management perspectives (14%), but the majority of respondents were middle tier occupations such as Engineers and Specialists (72%). The majority of respondents worked in manufacturing/operations and quality/regulatory departments.

3.2 Familiarity with the Circular Economy

Thirty four percent of respondents had never heard of the concept of CE when initially asked. Thirty eight percent who had heard of CE were not sure what it was. Only two of respondents claimed to be very familiar with the concept and indicated that their companies were working towards it. Only one person in a senior management position knew what CE was. Most of the 'Do not know' answers came from lower tier employees, such as product builders and technicians. After the initial question about familiarity of the concept, a simple definition was provided. This was to ensure that they understood the concept sufficiently to be able to provide meaningful answers to the survey.

3.3 Opportunities and current activities in the Circular Economy

While there was an initial lack of familiarity of the Circular Economy, after reading the definition, 63% of respondents claimed that their understanding of the Circular Economy had improved by a significant amount. Most of respondents (76%) believed there could be opportunities in their companies and over half (55%) of respondents

recognized that their company was actively exploring CE opportunities. Almost half (45%) of respondents were personally interested in getting involved in CE activities, but only 31% perceived that their companies were interested.

When asked what the company is currently doing, 90% reported recycling 'Waste reduction through procurement' featured highly with 62% of companies active in this area which indicates a deeper commitment to sustainability. Despite so few respondents having knowledge of the CE concept at the outset of the questionnaire, 52% reported activities related to 'design or redesign of products to reduce waste' and 'refurbishment'. This was higher than expected, but many manufacturing companies implement lean manufacturing and continuously strive to eliminate waste in its products and processes. Engineers/Specialist selected the highest number of answers claiming their companies currently practice 8 out of 9 possible processes. Senior Management/Director had the next highest with Product builders only selecting 1 possible process.

Almost half (48%) of respondents believed CE opportunities could be realized through 'recycling', whereas 'using different raw materials' (e.g. recyclable) in their packaging and manufacturing of products came in second highest (45%). 'Product or service design' and 'reuse' of materials or products was seen as an opportunity by many (41%) and 'refurbishment of fixtures and machinery' was selected by almost a third (31%). When it came to higher level strategies, 38% of respondents saw 'Business Strategy change' and 'Procurement & Supply chain' as a viable opportunity. Better use or implementation of ERP systems was suggested as a support towards CE. No current or future opportunity could be seen by 10% of respondents (all of which were OEMs). When presented with the range of opportunities, those in senior roles could envisage all of them as potential opportunities within their company. This is to be expected as respondents at this level would be used to looking for high level opportunities for saving money and improving process efficiency.

3.4 Drivers, motivators and barriers of CE in healthcare manufacturing

Responses related to main drivers to company CE adoption highlight a significant link to *cost savings* (72%), which was expected. 'New business opportunities' and 'supply chain' ranked the second and fourth drivers of adoption, which are both linked to cost savings and/or increased revenues. However, 'government legislation' ranked third, which was not surprising in such a highly regulated industry. A quarter of respondents believed CE was 'always part of our business model'. However only one respondent (in senior management) connected CE to 'part of future vision for growth and competitive advantage'.

When asked what would motivate them to change their business to a CE approach in future, 'reducing waste', 'driving increased future profits' and 'having a sustainable business strategy' ranked top motivators with 69% of respondents in agreement. Although 'Supply chain' was cited by 41% as a main driver for current actions, a 'constrained resource supply' or 'resource price fluctuation' was not seen as a significant future motivator (only 14% selected this option).

'Customers actively seeking our products', 'social conscience' and 'seen as part of future vision for growth and competitive advantage' were additional responses entered

by the senior management. This cohort also recognized all options to adopt the Circular Economy approach, did not see the supply chain as a barrier. It is unclear if this was because future education is needed on the importance of this aspect or whether they consider their supply chains to be mature enough and ready for CE.

Internal factors are the main barriers hindering these companies' approach to CE. Over half (52 %) of respondents selected '*Internal prioritization*' and 41% choose '*internal funding and resources*'. Employees at technician level report external barriers, feeling '*customer perception*' and '*policy and legislation*' acting as a hinderance. This is possibly because they are aware of the process level restrictions and rules constraining their daily tasks and assume they are insurmountable barriers at a higher level. It is interesting they think customer perception would be a hinderance given that reducing waste and supporting the environment are seen by many customers as positive company behaviours. It is possible that this view will change over time as sustainability and CE become an order qualifier or an order winner in this sector.

3.5 Unlocking CE opportunities, eco innovation and CE readiness.

Unlocking CE opportunities.

This survey indicates that '*Enabling policy & legislation*' is the biggest contributing factor to help unlock Circular Economy opportunities for the respondents, followed by '*financial assistance*'. Senior employees recognized all options presented to them as helpful to unlock CE opportunity, whereas production staff have a limited perspective that relate only to the products they are building. Better '*design for disassembly*' and '*collaborations within industry*' was recognized by many (37%) . To a lesser degree '*viable take back mechanisms*' and '*greater collaboration with other industries*'. These both feed into the 24 % of respondents that thought R&D knowhow with a more knowledgeable technical team and a higher value for remanufactured goods and materials would be of assistance. '*Senior management buy in*' was chosen by 34% of respondents but interestingly not by many senior managers, perhaps showing they do not consider their opinion will influence measures. Once again both senior management, directors, engineers and specialist have selected all options. Product builders and lower tier employees have selected options to do with products themselves, as opposed to any external factors.

Eco-innovation.

Respondents rated their readiness to change towards eco-innovation as medium-highly ready to change their business model towards eco-innovation. This was a uniform response over all tiers of employees within companies. However, they are unsure of their potential to minimize resource consumption or to change raw materials for recycled ones or to use by-products as raw materials. There is a clear trend in a higher rating of lower tier occupations and a significant decrease in rating as you move up the tiers of employment to top tier employees.

Industrial Symbiosis

The opportunity for investment in eco-innovation and/or industrial symbiosis was in the middle at a rating of 2.5 overall. However, senior management, directors, managers and supervisors all rated the opportunity at a lower than average rating. The ratings for a company's readiness to change its business model towards industrial symbiosis showed very mixed opinion. However, results show a willingness to cooperate and communicate, particularly among senior management

4 Conclusion

The concept of the Circular Economy is not well known in the healthcare manufacturing industry in Ireland. However, when it is explained to them, the majority of respondents could see its potential. Many respondents are personally driven to move towards CE, but not all believed their companies were. It is interesting to note that the difference between the companies' attitude and personal attitudes when it came to the Circular economy. All senior management respondents claimed to already be exploring opportunities or interested in exploration of these opportunities both personally and professionally. Middle tier respondents were the only ones to be negative towards their company's attitude. This may represent a top management idealistic view of what is happening as opposed to ordinary workers for whom it not a priority. The opportunities identified align with Witjes and Lozano's [12] belief that '*Collaboration between procurers and suppliers throughout the procurement process can lead to reductions in raw material utilisation and waste generation, whilst promoting the development of new, more sustainable, business model.*' Results also correlate to Moultrie *et al's* [5] ideas when they say, despite this the medical device industry faces sustainability concerns common to the design process in many commercial areas, such as waste and consumption of scarce materials. It is a concern that OEMs were less likely to envisage opportunities, perhaps due to the likelihood that they have a longer history of being rigidly regulated which the company culture may struggle to see beyond. As with any business, managing costs is the biggest driver and motivator (rather than as environmentally conscious decisions) which is in agreement with many previous studies [5].

The main barriers to CE were seen as internal, which was surprising and a cause for concern, especially because chosen by senior management. It was encouraging to see that all respondents in senior positions could see potential for eco-innovations, including industrial symbiosis. It was surprising however to see senior management rate so highly their ability to exchange information with other companies. This may just be due to the locality of healthcare manufacturing companies to each other, as Ireland is a very small country and this industry is clustered together in industrial parks or they can see the benefits that this could bring to the business as well as the environment around it.

Education on the benefits of the Circular Economy needs to be given to show that in the long term it is good for the environment, whilst also leading to business benefits. Respondents are aware that there are Circular Economy opportunities in all companies, but being able to see these opportunities and exploiting them are very different things.

There are no disputes that single-use items need to be replaced but without any incentives to implement change, such as packaging to recyclable materials, the associated costs involved will make this prohibitive. Better design for disassembly or even higher value put on remanufactured goods would all be simple steps to unlocking Circular Economy opportunities within the Irish healthcare manufacturing industry. More research into suitable materials for reuse and reprocessing needs to be undertaken to show companies the benefits and cost saving that can be had from these processes. Responsibility for implementing change lies with government and companies alike. Attitudes need to change away from purely cost based incentives and look towards sustainability. Government and companies need more communication to develop realistic plans to meet Circular Economy goals.

It is clear from this study that more communication is needed within companies themselves to develop a consensus between all tiers within the company. All employees no matter their status need to be working towards a common goal. Internal barriers need to be broken and offering incentives to employees regardless of their role to come up with innovative ideas to help the business, gives them a sense of pride and appreciation. Readiness and potential towards eco-innovation and industrial symbiosis ideas can be subjective. They do not directly correlate to willingness or even want for companies to implement these ideas. Industrial symbiosis can help companies work together to spread costs of research into innovative ways to reduce waste and make the most out of the resources they have. Working together can benefit smaller as well as larger companies due to the shared investment and intellectual benefits of working with other like-minded companies.

In summary Irelands healthcare manufacturing companies are far from being ready for the Circular Economy. The opportunities are there, but more work is needed to find the best ways to exploit these opportunities within this industry. Until education is given as to the major benefits of implementing these concepts, they will not be done from an environmentally conscious decision standpoint. Legislation and incentives need to be introduced to motivate companies into adopting more Circular Economy concepts, to safeguard our planets resources for future generations to come.

This study adds to the limited empirical literature on CE barriers and opportunities to manufacturing organisations operating in Ireland. Further research into this field needs to be done to explore in depth how to make the most out of the opportunities presented. Research also needs to be undertaken to discover the best materials to be used to make it safer for reprocessing devices and instruments, along with biodegradable or recyclable packaging of such devices as well as design for ease of disassembly.

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