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Developing Frameworks for Evaluation and Mitigation of Environmental Impact of Infant Feeding Decisions on Healthcare and Society

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Rialtas na hÉireann
Government of Ireland

ENVIRONMENTAL PROTECTION AGENCY

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- Office of Evidence and Assessment
- Office of Radiation Protection and Environmental Monitoring
- Office of Communications and Corporate Services

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EPA RESEARCH PROGRAMME 2014–2020

Developing Frameworks for Evaluation and Mitigation of the Environmental Impact of Infant Feeding Decisions on Healthcare and Society

(2014-SE-MS-2)

EPA Research Report

Prepared for the Environmental Protection Agency

by

University of Limerick

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DISCLAIMER

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Executive Summary

Substantial environmental costs result from infant feeding decisions, not only regarding milks, foods and equipment purchased, but also regarding disposal of plastics, packaging and food waste. In 2017, 62,053 infants were born in Ireland with between 787,057 and 946,220 bottles of ready-to-use (RTU) formula purchased for use in maternity units. These numbers are indicative of the scale of the issue of environmental impact related to infant feeding. Existing infant feeding policies and waste management guidance do not address the disposal and waste aspects.

The objectives of this study were to:

- develop assessment tools to establish the environmental impact related to infant feeding decisions in hospital maternity ward settings through interviews, reviews, audits and checklists;
- identify mitigating opportunities in the healthcare system and perpetuate these through identification and fulfilment of environmental education needs, best practice, guidance, etc.;
- develop methods to assess the environmental impact of infant feeding decisions and establish the real and potential environmental impacts based on these;
- develop appropriate guidance and policy recommendations.

The work was carried out in four phases: a literature review and framework for evaluation and mitigation were carried out; an environmental training module for healthcare professionals on guidance pertaining to resource efficiency was created; and a baseline of data surrounding infant feeding decisions was also established. The fourth phase was an analysis of single-use plastics and an in-depth case study of a waste management programme in a hospital setting were explored. This report provides policy recommendations.

Key findings that have emerged from this research, as of 2018:

- At present, there is no standard practice in hospitals relating to the disposal of waste infant formula.
- There is no standard regarding the collection of data, maintenance of records, monitoring or evaluation with different methods employed and variances in the type of data collected. This gave rise to the necessity of using defined assumptions for the purposes of this research.
- Of the three main brands of RTU formula examined, two were over three times and one five times a typical newborn infant's stomach capacity. This represents an excessive amount of formula provided, as up to 60% may go directly to waste.
- The identification marks on polymers used in components of RTU formula bottles are not standardised and are often missing. Education for and implementation of recycling practices surrounding RTU formula bottles could benefit hospital environments and raise awareness, including outside of the hospital setting.
- Improved waste management system in hospitals is needed and improved management of stock in maternity wards is needed to help prevent waste.
- In cooperation with healthcare facilities, the opportunity exists for manufacturers to take back end-of-life products, which could generate its own resource stream.
- The Sustainable Healthcare and Living Programme adopted by Cork University Hospital is an approach that could be replicated across the healthcare sector.
- For any of the recommendations outlined below to prove successful, management and staff buy-in is required. A behavioural shift at all levels, including inpatients, outpatients, suppliers and waste contractors, is needed.

This report makes the following recommendations for Ireland:

- Recommendation 1: for all healthcare facilities, relevant waste data regarding infant feeding decisions should be collected on an annual basis and made publicly available.
- Recommendation 2: to address the consumption of formula and associated waste, environmental and education awareness campaigns must be developed and resourced.

- Recommendation 3: healthcare providers should ensure that procurement policies and practices reflect waste reduction priorities.
- Recommendation 4: European Union and national policy is needed to bring about a standardised polymer labelling system for all recyclable (healthcare) plastics.
- Recommendation 5: initiatives to improve waste management through a collaborative approach, combining top-down and bottom-up actions, were found to be effective and should be implemented.
- Recommendation 6: causes of formula wastage are complex and relate to the presentation of products, infection and control policies, birth rates and infant feeding decisions, as well as to over purchasing. Application of the review tool developed here may aid in information collection and adoption of project recommendations, and can assist in encouraging awareness and behaviour change towards mitigating the environmental impact of infant feeding actions.

1 Research Context and Introduction

Substantial environmental costs result from infant feeding decisions, not only regarding milks, foods and equipment purchased, but also regarding disposal of plastics, packaging, food waste and end-of-life waste electrical and electronic equipment (WEEE). The situation is compounded by dwindling landfill space and Ireland's reliance on overseas treatment of recycling materials including plastics and WEEE wastes. Opportunities to prevent waste and increase resource efficiency are national policy priorities. Infant feeding decision-making represents an aspect of material consumption and waste generation that has hitherto attracted little attention. In addition, it serves as a case study, highlighting the complexity and challenge of achieving dematerialisation and waste management and the range of initiatives needed to make significant progress. Managing waste is complex, as it necessarily comprises a wide range of waste streams, which differ, for example, in toxicity, ease of recycling, size and composition.

In this report, a case study of waste management relevant to infant feeding is included for plastic bottles containing infant formula (as an example of plastic waste management). This report examines the environmentally significant effects of infant feeding decisions; it does so in relation to the 2009 World Health Organization (WHO) and United Nations Children's Fund (UNICEF) Baby-friendly Hospital Initiative (BFHI; WHO and UNICEF, 2009) and the WHO International Code of Marketing of Breast-milk Substitutes (henceforth "the International Code"; WHO, 1981), which promotes safe and adequate nutrition for infants by ensuring proper use of formulas, when these are necessary. The International Code also regulates the marketing of formulas and related products, such as infant formula, other milk products, foods and beverages, feeding bottles and teats. Environmental impacts of infant feeding actions can be most readily observed in a hospital maternity ward context, in terms of resource efficiency and the quantities and types of solid and liquid wastes generated. In the absence of published information, to identify and evaluate such impacts, researchers are required to engage with key stakeholders, who can explain both barriers to and opportunities for levered and sustained environmental gains. Examples of voluntary initiatives, codes of conduct, policies, behaviour change, education and awareness are investigated.

In addition to the BFHI and the International Code, the European Strategy for Plastics in a Circular Economy (EC, 2018) seeks to transform the way plastic products are designed, used, produced and recycled in the EU, in a bid to protect the environment by reducing marine litter, greenhouse gas emissions and the EU's dependence on imported fossil fuels (European Commission, 2018). A single-use plastics directive is under way to complement the EU Strategy for Plastics in a Circular Economy, highlighting the importance of plastic waste management.

Provision is made in all Irish maternity units to provide sustenance to all mothers and babies, meaning that human milk or substitutes (also known as "formula") are provided free of cost to mothers. Bottles are provided in a standard size, with the teat and bottle top separate. The stomach capacity of infants varies and these differences are perhaps most evident in neonatal units, in which the neonates consume relatively much smaller volumes. In the context of Cork University Hospital (CUH)'s overarching aim to maintain and enhance health, and to minimise risks from stale milk substitutes, these liquids cannot be decanted and unconsumed residues are disposed of, generally through the wastewater system. Thus, infant feeding actions are contributing to resource inefficiency and an increase in liquid waste. Recently, the last brand that was still using glass changed to plastic packaging. These bottles, including teats and bottle tops, are formed of many different plastic polymers.

Since the early 1990s, the Department of Health has had in place the National Breastfeeding Policy for Ireland. In 2015, the Health Service Executive (HSE) put in place the Breastfeeding Policy for Primary Care Teams and Community Healthcare Settings, which was followed in 2016 by the Breastfeeding in a Healthy Ireland – Health Service Breastfeeding Action Plan 2016–2021. However, these documents do not

deal with waste management associated with infant feeding. In relation to socio-economic aspects, the Economic and Social Research Institute (ESRI) has estimated that exclusively formula feeding costs the Irish healthcare system over €12 million per annum in the treatment of infections in infancy alone (ESRI, 2012). No equivalent Irish studies have been carried out on the environmental impacts of formula use. This is perhaps surprising, as widespread formula use has been evident for more than 60 years (Leone-Cava *et al*., 2002).

Although a majority of Irish infants are breastfed in hospital, the supplementation with formula rate was, until recently, very high in some maternity units (BFHI, 2013). Women who gave birth in a BFHI-accredited hospital were more likely to breastfeed than women who gave birth elsewhere, but after 1 month they were found to be no more likely to breastfeed (ESRI, 2012).

The International Code (WHO, 1981) and subsequent Irish legislation came into being to protect infants, parents and healthcare professionals from inappropriate marketing, which may influence attitudes and knowledge. It argues that increased marketing of formula to new parents may erode the environmental benefits associated with breastfeeding and increase environmental impacts associated with other infant feeding actions. The Food Safety Authority of Ireland (FSAI) is the designated monitoring body responsible for food standards and labelling. The FSAI also monitors and enforces the legislation related to infant formula marketing.

In this project it was anticipated that in the hospital setting, infant feeding actions would have direct environmental impacts in terms of materials used, unconsumed waste formula, bottles, teats, packaging, leaflets and product information, plus the costs of storage and obsolescence. Similarly, some direct consumption of goods associated with infant feeding in the home and community setting may include bottles, teats, cans and packaging, breast pumps, sterilisers and bottle re-heaters, and this may thus have environmental and socio-economic impacts. It has been stated that breastfeeding represents an environmentally friendly feeding solution, as it "generally requires no containers, no paper, no power to prepare, and no transportation to deliver" (US Department of Health and Human Services, 2011).

1.1 Infant Feeding in the Healthcare Setting

It has been recognised that hospitals and healthcare facilities contribute significantly to environmental damage. Healthcare is a major contributor to environmental pollution, contributing pathological, pharmaceutical, chemical, radioactive, as well as other wastes (WHO Europe, 2017), but retrofits of facilities, with new technologies and new-build hospitals, have resulted in fewer environmental impacts (Thiel *et al*., 2014). However, on account of economic constraints, refurbishments, new builds and technologies cannot be solely relied on to deliver the required environmental improvements (Huesemann, 2011), and existing facilities must act. There is a growing body of research comparing reusable and single-use medical instruments (Sørensen and Wenzel, 2014; Campion *et al*., 2015), water conservation and wastewater treatment (Verlicchi *et al*., 2010; energy efficiency (Teke and Timur, 2014), and the impacts of food choice, preparation and wastage (Sonnino and McWilliam, 2011; Vidal *et al*., 2015) in hospitals. Waste management continues to feature in sustainable healthcare research (Saad, 2013; Xin, 2015). This is hardly surprising, since Harhay *et al*. (2009) reported that approximately 50% of the world's population is likely to face public health, occupational and environmental risks due to inadequate public healthcare waste management.

It is argued that "greening" healthcare has largely relied on self-policing based on an assumed knowledge base among healthcare professionals, which in practice may be absent (McDiarmid, 2006). Although some have called for clearer regulation (McDiarmid, 2006; Vatovec *et al*., 2013), the main thrust of regulation in healthcare focuses on product development and manufacture as being distinct from procurement, distribution, use and decommission. Best practice guidance on sustainable healthcare tends to come from international bodies such as WHO and Health Care Without Harm; however, the ultimate realisation of measures is dependent on facilities, national regulations and local supports. Stakeholder behaviour contributes to the environmental performance of an organisation, especially in terms of waste management, for which regulations are in place in most countries (Porter-O'Grady and Malloch, 2010). Opportunities that are present which do not yet deliver direct financial benefits or contribute to

legislative compliance make a meaningful contribution to the environment and society, for example prioritising preventative care so that fewer health interventions are ultimately made reduces associated environmental impacts (Weisz *et al*., 2011).

Evaluation of the evidence presented by medical experts to explain the effects of infant feeding practices on health falls outside the scope of this study, but the effects are mentioned briefly in the context of waste reduction. This programme of research aims to provide further information and guidance in relation to several policy arenas, as set out in Table 1.1.

Through the Green Healthcare Programme (GHCP), part of the Irish National Waste Prevention Programme, which is led by the Environmental Protection Agency (EPA), about 100 healthcare facilities have been audited and guidance and best practice on reducing waste generation has been produced. This report provided additional information to contribute towards Greening Healthcare, also in relation to Green Home (EPA) and Green Communities (EPA) activities and Stop Food Waste and Prevent and Save initiatives. This additional information relates to the environmental impact of infant feeding decisions, which hitherto has received little attention internationally, and builds on previous work undertaken by an Irish hospital on food and water wastes.

1.2 Project Objectives

The project aims to provide a factual basis for current and future scenarios in relation to the environmental impacts of infant feeding decisions. The focus is on the development of behavioural changes that may be expected to result in resource efficiency, waste reduction and better management of wastes arising. Case studies are presented to enhance understanding of wider issues in waste reduction and reducing environmental impacts. Much of the factual information that was sought was not routinely collected by the relevant bodies or accessible to us. An important aspect of work reported here relates to the

Table 1.1. Role of this research project in relation to national policy in Ireland

National plan/policy	Role of this project
National Waste Prevention Programme: Towards a Resource Efficient Ireland. A National Strategy to 2020	• Evaluation and mitigation of wasteful consumption • Encouragement of behavioural change to enhance resource use efficiency
National Hazardous Waste Management Plan 2014–2020	• Identification of unreported WEEE waste and estimation of quantities • Identification of opportunities to prevent WEEE and hazardous waste arising • Better management of current wastes • Identification of producer and retailer responsibilities • Contribution to waste prevention strategies in healthcare in home settings
A Resource Opportunity: Waste Management Policy in Ireland	• Identification of possible resource efficiency and prevention strategies • Suggestion for a coordinated approach involving healthcare, community and home settings
Green Tenders: An Action Plan on Green Procurement	• Examination of the procurement of infant breast milk substitutes • Food procurement as one of eight priority topics • Development of training and best practice guidance
Our Sustainable Future: A Framework for Sustainable Development in Ireland	• Evaluation of sustainable consumption patterns • Education, communication and behavioural change • Meeting of measures under framework for sustainable public health service
Healthy Ireland: A Framework for Improved Health and Wellbeing 2013–2025	• Theme 2: partnerships and cross-sectoral work, contributing to EPA position on Health Advisory Committee

development of methods for information collection and evaluation.

The objectives were:

- to develop an assessment approach to establish environmental impacts related to infant feeding decisions in hospital maternity ward settings, through interviews, reviews, audits and checklists;
- to identify mitigating opportunities in the healthcare system and perpetuate these through identification and fulfilment of environmental education needs, best practice, guidance, etc.;
- to develop methods to assess the environmental impact of infant feeding decisions in society and establish the real and potential environmental impacts based on these;
- to develop appropriate guidance and policy recommendations.

1.3 Report Structure

Chapter 1 has set out the context for the research and the project objectives. Chapter 2 describes the baseline data for two hospital-based maternity units selected for the study, the data identified as relevant, the methods by which baseline data, ethics-related constraints on data collection; it also examines the data collected. This allowed characterisation of relevant policies and practices current in 2016. Chapter 3 identifies and evaluates mitigation measures within the management of waste arising from the consumption of ready-to-use (RTU) formulas in the hospitals selected for study. Chapter 4 analyses single-use plastic bottle waste used in packaging of formulas and explores opportunities to reduce such waste and constraints which create challenges in avoidance of this waste. Chapter 5 presents a case study in the roll-out of waste reduction measures throughout a hospital and the wider community, which provides a context for findings in Chapter 4, as waste management at the hospital scale may deliver an effective mechanism for managing multiple waste streams arising in hospitals. Chapter 6 provides a synthesis of findings and their implications and a set of recommendations to reduce waste arising in hospital maternity units.

2 Baseline Data Relevant to Infant Feeding Decisions in Irish Hospitals

2.1 Introduction

This chapter provides a literature review in relation to issues and concerns previously identified related to infant feeding decisions, ethics-related constraints on data collection in hospital settings, the development of a method for data collection and results from the application of this method. Food waste has especially been a major concern in healthcare systems, and has been the subject of many investigative research studies (Abd El-Salam, 2010; Barton *et al*., 2000; Halloran *et al*., 2014; Sonnino and McWilliam, 2011; Williams and Walton, 2011). Williams and Walton (2011) summarised the results from 32 hospital studies and these suggest a median food wastage rate of 30% by mass, with ranges varying between 6% and 65%. Various authors have argued that healthcare needs to shift to preventative and more demand-led measures, in terms of both demand for healthcare and demand for materials and energy required to deliver universal healthcare systems, in order to move towards sustainability (McGain and Naylor, 2014; NHS England, 2014; Watts *et al*., 2015; Ryan-Fogarty *et al*., 2016).

To date, research regarding the environmental impact of food has tended to focus on production and supply chain waste alleviation, rather than on addressing consumption and demand factors, which are more challenging in their identification and mitigation (Bajzelj *et al*., 2014). As humanity begins to focus on the effects of climate change and adaptation to decreased availability of agricultural land, attention has shifted to seeking optimal sources of nutrition, particularly protein sources, for human consumption. There is a growing consensus that in order to effectively curtail environmental impact and provide food security, society needs to address the significant impacts exerted through the cultivation, production, processing and transport of food; however, crucially, overall consumption patterns need to change through diet adaptation and food waste reduction (Wirsenius *et al*., 2010; Garnett, 2011; González *et al*., 2011; Bajzelj *et al*., 2014).

In hospital settings, infant feeding actions may have direct environmental impacts in terms of transport, materials used, unconsumed formula, bottles, teats, packaging, leaflets and product information as well as in terms of the costs of storage and obsolescence (American Academy of Paediatrics, 2012). Published works have attempted some quantification of the costs to health services of purchasing formulas and of the costs of exclusive formula feeding in terms of health impacts (Renfrew *et al*., 2003; Pokhrel *et al*., 2014; UNICEF UK, 2015). Cost reduction as a result of waste reduction may also serve as a useful incentive. Furthermore, money saved could be reinvested to support continual improvement. Publications have highlighted the impact of infant feeding practices on food security, women's health, consumption patterns and ethical considerations (Cassidy, 2012; Ryan *et al*., 2013; Salmon, 2015; UNICEF UK, 2015; Becker and Ryan-Fogarty, 2016). However, available data (as of 2016) suggest that the environmental impact of formula food and associated wastes have not been formally quantified, nor have measures been taken to mitigate impacts.

Ireland has five maternity hospitals and a further 14 general hospitals have maternity units or wards; these also include paediatric hospitals and wards for infants. Of these 19 maternity service providers, 9 hold the baby-friendly hospital designation and all other remaining hospitals are registered as participating in the initiative. For Irish acute hospitals, a study published in 2013 by the Irish EPA found that 0.73 kg of food waste was generated per patient bed-day (EPA, 2013). However, as was found in other studies (Costello *et al*., 2015), accounting for liquid food wastes, such as milk, which may be disposed of into wastewater, presents significant challenges. Waste milk and formulas have a high biological oxygen demand, are sources of nitrogen and phosphorus pollution and may cause operational issues, especially to on-site wastewater treatment plants, where dilution factors may be lower.

Of all the plastic waste generated in Europe in 2014, about 30% was claimed as being recycled. The same

percentage was going to landfill (PlasticsEurope, 2016), which may lead to severe environmental impacts, such as toxic components leaking into soils and aquifers. Up until 2018, national data for Ireland indicated that approximately 35% of plastic was recycled, with the bulk being transported to China. Infant feeding bottles contribute to this waste stream and thus provide a case study on how to reduce plastic pollution.

The national and international policy provides a basis for adoption of scenario analysis and backcasting and forecasting methods to provide a preliminary assessment of the environmental impact of infant feeding decisions and the potential environmental impact of policy development on infant feeding in healthcare, domestic and community settings. The World Health Assembly (WHA) resolution on infant feeding, as set out in the International Code, and the extent to which this influenced Irish government policy, provided a further starting point. It was necessary to first establish baseline information on policies and practices in Irish hospitals, which in turn required development of a method for capturing this information. The baseline year selected was the first year of the project, namely 2014.

2.2 Site Visits and Ethics Approval

Site visits were made to the Coombe Women & Infants University Hospital in Dublin in relation to the hospital's plan to reduce infant formula waste; similar site visits were made to maternity units in both Cork University Maternity Hospital (CUMH) and University Maternity Hospital Limerick (UMHL). This, in part, provided the information needed to design a data gathering tool, which formed part of an application to gain ethics approval for data gathering in hospitals.

Issues regarding requirements for ethics approval in performing the kind of research employed within this project are complex. First, the research team set about establishing the parameters of the research and the data required from the hospitals to perform the analyses. Second, the requirement for ethics approval was established; although quality assurance studies and audits may not require ethical committee approval, it does not imply that they are exempt and so an ethics committee consultation was sought.

The University of Limerick (UL) Chemical Sciences Department Research Ethics Committee was contacted for advice and a formal submission was subsequently made. This committee subsequently advised that approval should be sought from the UL Hospitals Ethics Committee. Contact with CUMH led to an application being made to the CUMH Ethics Committee and an additional application to the UL Ethics Committee. As a result, physical data collection commenced in September 2015 at UMHL and October 2015 at CUMH. The Green Healthcare team recommended that Dr Ryan-Fogarty visit Coombe Women & Infants University Hospital as one of the few stand-alone maternity hospitals participating in the EPA Green Healthcare Programme (EPA-GHCP). Ethics approval for the visit was not sought as no data were collected.

A clear advantage in pursuing ethics approval was the ability to "front load" the application form, that is, by outlining data required, the research team was in a strong position to acquire vital information which would not have been accessible without the support of ethics approval. An example of this was retrieving data on the costs incurred by hospitals because of procurement and waste disposal. Further advantages attributable to ethics approval processes were feedback and advice from expert panels, informing key influencers of the research proposal and maintenance of future options to further extend the research parameters and team through addenda to existing approvals. Ethical concerns were raised as to what benefit participation in the research would provide to the hospitals involved. Dr Ryan also wished to minimise the amount of time that data collection would require of hospital staff, as participation might have unanticipated knock-on effects in relation to jeopardising patient care. Thus, several visits were necessary to establish, for example, when lactation consultants were on duty. Ethics approval was granted for information collection in CUMH and UMHL.

2.3 Method – Development of Tool to Establish Baseline Data

As little was published about waste arising in Irish maternity wards, a necessary first step was to generate baseline data, which would permit characterisation of waste streams and, in turn, facilitate identification of opportunities to reduce waste.

No published method for such an audit was available; therefore, the research team designed the "Infant Feeding Waste Review Tool" (reproduced in Appendix 1). The goal was to gain as much information as possible while minimising time spent in the hospitals. The tool created a checklist of points of interest to be included by a member of the research team on a walk-through audit of the hospital and was completed in the presence of the medical and support staff facilitating the review to ensure, as far as possible, that the checklist was as complete as possible and clear.

2.4 Results of the Infant Feeding Waste Review Tool

2.4.1 Infant Feeding Waste Review Tool

The topics for which information were sought are outlined in the Infant Feeding Waste Review Tool in Appendix 1, together with relevant published sources of information, attributes of CUMH and UMHL, equipment available to mothers, estimated numbers of infants feeding and numbers of bottles used. Waste management responsibilities and methods for 2014 were also gathered.

Table 2.1 compares the key attributes of the CUMH and UMHL gathered from the audit using the Infant Feeding Waste Review Tool and online data. A large range of hospital staff members were consulted for input and follow-up emails and telephone calls were used to gather outstanding information (Table 2.2). Where information gaps existed, other published sources were utilised.

2.4.2 Infant feeding

Several types of feeding-related equipment are available to mothers at CUMH and UMHL (Table 2.3). The lactation consultants provided the numbers of infants being fed and by milk type at both hospitals for 2014 (Table 2.4). This information was maintained for the compilation of perinatal statistics, which were then reported annually in the form of perinatal statistics by the HSE Health Pricing Office. Data collected formed part of the European PeriStat reporting, which includes breastfeeding as a key indicator. The hospitals were planning on collecting fuller information on breastfeeding. In both hospitals, a small number of infants, in neonatal care, received donated human

Table 2.1. Attributes of hospitals gathered from audits and online data (2014)

Attribute	CUMH	UMHL
History of development	Opened in 2007 as a result of the amalgamation of three maternity service providers and gynaecology services of CUH	Opened in 1960
Site	Located at CUH	Stand-alone site
BFHI status	Participant	Awarded
Facilities management	On-site shared	Off-site shared
	Waste officers	Facilities manager
Links to University	Long established: Green-Campus Award (UCC in 2011 and CUHM in 2013)	More recent: Green-Campus Award (UL in 2015)
EPA Green Healthcare Programme status	Participant	Non-participant

Table 2.2. Hospital staff who provided information during audits from CUMH and UMHL (2014)

CUMH	UMHL
Waste officers	Porters
Midwives	Clinical midwife manager
Ward managers	Hospital manager and administrators
Healthcare assistants	Ward managers
Midwifery directorate	Midwifery directorate
Lactation consultant	Lactation consultants

Table 2.3. Feeding-related equipment available to mothers at CUMH and UMHL (2014)

Equipment provided by the hospital	CUMH	UMHL
Hand pump	Three per ward available	Demonstration only
Electric pump use	Twelve in neonatal (Medela) On loan from chemists on a monthly basis	Six pumps available (Medela)
Funnel/connection set for hospital electric pump	These can be sterilised and reused	These can be used 8 times in 24 hours Single-user but not single-use
Milk storage containers	Yes	Yes
Nipple shields	Yes	No
Nipple creams and ointments	No	No
Breast pads	No	No
Feeding pillows	About 10 of these for multiple births	Demonstration only
Feeding cups	No	Yes
Other feeding equipment	Syringes for infant feeding	Syringes Nasogastric tubes

Table 2.4. Estimations of numbers of infants feeding and by milk type at CUMH and UMHL (2014)

Milk type	CUMH	UMHL
Total infants feeding and percentage of total births in Ireland	8038 (12%)	4477 (7%)
Breastfed alone	2492 (31%)	2011 (45%)
Breastfed plus formula	1939 (24%)	328 (7%)
Formula alone	3607 (44%)	2138 (48%)
Some or all formula combined	5546 (69%)	2466 (55%)

breast milk and these numbers were not included in the data reported here.

There was considerable variation in formula types used, especially in neonatal wards. However, three brands were clearly most prevalent, and it was decided to examine the use of these. The research team sought data for individually bottled RTU formula and teats purchased for the year 2014. In CUMH, all infant formula went to a centralised storage facility from which wards requested supplies as required. As a rule, healthcare assistants ordered from the central store once per week and kept a supply in a general storage room on each ward. Wards maintained computerised records of orders. In UMHL, formula was ordered by porters, as required, from a pharmaceutical supplier and stored in a central storage area. Computerised records were not maintained, so records may not be fully accurate.

Hospitals were asked how many bottles were allocated per infant per day. In CUMH, eight were allocated daily, with none on the day of discharge. In UMHL, six were allocated daily, with two on the day of discharge.

Information was also supplied by hospital lactation consultants; however, estimations based on these data are subject to some uncertainty. CUMH had one full-time lactation consultant post, made up of two-part time positions; UMHL had the equivalent of 1.1 full-time consultants. Methods of data collection, and the person responsible for this, differed between hospitals.

To allow estimations to be made for UMHL, the number of exclusively breastfed infants was subtracted from the total number of infants being fed to estimate the number receiving formula. The number of infants being fed a combination of breast milk and formula was estimated by the consultants, and the number of infants exclusively fed formula was thus estimated.

Similar methods of estimation were adopted for CUMH (Table 2.4).

Differences occurred between information supplied by consultants and those responsible for ordering formula, and the direction of difference varied between hospitals. For CUMH, estimates based on consultants' responses were higher than purchasing records suggested, while the opposite is the case for the UMHL data. Similarly, divergences between estimated and recorded number of bottles used by infants during their stay in hospital were evident, especially in UMHL (Table 2.5). These highlight the uncertainties found for the 2014 data.

2.4.3 Waste management

Information on the waste management responsibilities and methods of CUMH and UMHL for 2014 was also sought (Table 2.6).

Table 2.5. Numbers of bottles used, purchase records and difference between estimates and records for CUMH and UMHL (2014)

Hospital record	CUMH	UMHL
Estimated number of bottles used – high waste level scenario	146,414	67,346
Recorded amounts of bottles of formula purchased	132,432	87,720
Recorded number of teats purchased	153,618	107,520
% difference between estimated bottle numbers and recorded bottle numbers	–10%	+30%
% difference between estimated number of teats needed and recorded teats	+5%	+60%

Table 2.6. Waste management responsibilities and methods for CUMH and UMHL (2014)

	CUMH	UMHL
Persons responsible for waste management	Waste manager/officer	Porters
	Porters	
Waste-to-sewer permit held	Yes, but in 2014 not monitored	No
Waste management facilities on site	Compactor	Compactor (for all non-hazardous waste)
	Glass recycling collection point	Glass recycling collection point
	Plastic segregated for recycling	Cardboard and wastepaper collection
	Cardboard and paper collection	WEEE collection
	Mixed dry recyclables	
	WEEE collection	
Waste infant formula disposal	Bottles into recycling	Waste formula disposed to general wastewater system
	Teats into general waste	
	Waste formula placed in compostable containers, which then went to general food waste	Plastic bottle and teat placed in recycling collection
	Removed 3–4 times per day from wards	
Persons collecting waste formula	Healthcare assistants	Healthcare assistants
Bottle rinsed before recycling	Yes	Yes
Glass recycling cost	€145 per tonne	N/A[a]
Formula disposal cost	€135 per tonne	N/A[a]
Plastic recycling cost	€97 per tonne	N/A[a]
WEEE recycling cost	Free	N/A[a]
Paper and cardboard cost	Free	N/A[a]

[a]**N/A, not available.**

2.5 Discussion and Conclusions

2.5.1 Audits

A broad range of hospital staff contributed to the provision of information that was sought through the Infant Feeding Waste Review Tool, as can be seen from the diversity of information required (Appendix 1). Hospitals varied in their attributes.

2.5.2 Infant feeding

A wide variety of feeding-related equipment is available to mothers, although, once again, this differed depending on the hospital. Because of this variation, waste quantities related to infant feeding differ at each hospital. UMHL had considerably fewer feeding infants than CUMH, but a higher percentage of both breastfed-only and formula-fed-only infants compared with CUMH. At UMHL, there was a greater divergence between estimated and recorded numbers of both bottles and teats.

2.5.3 Waste management

There was great variation in how waste infant formula was disposed of. CUMH recycled the bottles and the teats went to general waste, whereas at UMHL both plastic bottles and teats went to recycling. CUMH placed waste formula into compostable cups to be included in food waste, whereas UMHL disposed of the waste formula in the general wastewater system. Figure 2.1 outlines infant formula waste in Irish maternity hospitals and contributing factors using the data collected to scale up to national perinatal statistics. It is evident that there needs to be a standard practice relating to the disposal of waste infant formula or standard surrounding data collection.

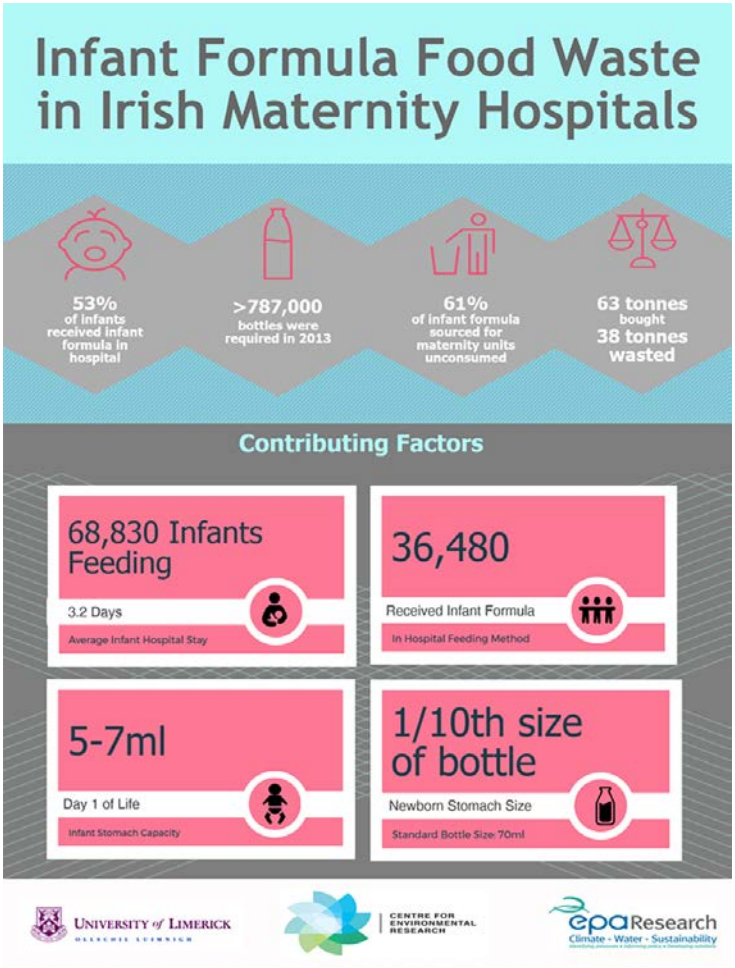

Figure 2.1. Poster quantifying infant formula waste in Irish maternity hospitals and contributing factors (Ryan-Fogarty and Becker, 2017a).

3 Mitigation and Management of Ready-to-use Formula Waste in Irish Hospitals

3.1 Introduction

This chapter reports on the adoption of a desk-based backcasting method to analyse food waste prevention, mitigation and management options within the Irish maternity service. Best practice in healthcare provision and waste management regulations are used to frame solutions.

Results presented here show that 61% of the volume of RTU formulas purchased by maternity services in 2014 remained unconsumed and was disposed of as waste. Significant opportunities exist to prevent waste and decrease food demand, leading to both positive health and environmental outcomes. Backcasting methods were selected as optimal in identifying food waste management strategies in healthcare settings, especially where evidenced-based best practice policies exist to inform solution-forming processes.

In terms of food waste prevention and management, difficulties arise in distinguishing between demand reduction, waste prevention and waste reduction measures under the waste management hierarchy (Directive 2008/98/EC; EU, 2008a) definitions. Ultimately, demand reduction at the source requires prioritisation, a strategy that in this case is complementary to health policy on infant feeding, to increase the exclusive breastfeeding rate, thus reducing the amount of infant formula used. Although an incremental approach is pragmatic, it should be based on a goal that has been agreed upon by the relevant stakeholders, taking a long-term view and cementing commitment from all levels (Alshuwaikhat and Abubakar, 2008; Wiek and Iwaniec, 2014). This would require a level of forward planning, where initiatives that might achieve much in the short term may not be the most appropriate in the long term.

3.2 Organisational and Regulatory Frameworks

The Irish Food Waste Regulations (Waste Management (Food Waste) Regulations 2009; Government of Ireland, 2009) list 11 classes of commercial or other activities that require source segregation and treatment of authorised food waste treatment plants. Several provisions in the legislation ensure that food waste is consigned to recycling instead of to disposal via sewage systems; for example, the use of in-sink macerators is prohibited by the Food Waste Regulations where a food waste collection service is available, even if a discharge licence allowing food effluent to the sewer has been issued. This provision strives to ensure that all food waste is recycled (DEHLG, 2010). However, it was estimated that up to 36 tonnes of waste food from catering operations enter the Irish drainage system per day through the use of macerators, leading to blockages and reduced effectiveness of grease traps and also leading to flooding and increased pressure on wastewater treatment plants (Creedon *et al*., 2010).

3.3 Methods

Systemic changes and transitions are required to enhance sustainability. Backcasting has been proposed as a means to achieve integrated approaches to combine:

- involvement of a range of stakeholders;
- incorporation of economic and social components in tandem with environmental components of sustainability;
- consideration of demand and supply chains as interconnected production and consumption systems.

Backcasting is an approach in which desirable, sustainable and future visions or “normative scenarios” are created, followed by an analysis of how to achieve these from a known baseline, as a foundation for describing strategies and follow-up activities to attain desirable futures (Holmberg and Robert, 2000; Jansen, 2003; Quist and Vergragt, 2006; Alcamo and Henrichs, 2008; Doyle and Davies, 2013). Scenarios may provide interdisciplinary frameworks in which solutions can be envisaged for complex environmental problems; these scenarios should also

be able to raise awareness, communicate complex information, facilitate policymakers in engagement with stakeholders and provide assistance in thinking big about an environmental issue (Alcamo, 2008). The complexity of future uncertainties and the "inherent ambiguity" of the different values and mental frameworks of stakeholders makes grasping the knowledge of what transitions are required difficult, and there exists a wide variety and diversity in approaches, topics, systems and scales (Quist and Vergragt, 2006; Vergragt and Quist, 2011).

As an iterative and reflexive method, it has been argued that backcasting does not propose a finalised version of the future; instead it assumes that vision and pathway developments employ higher learning processes and that participants learn about desired futures, barriers, contradictions, change agents, incentives and improvements to the future vision (Vergragt and Quist, 2011).

The Irish healthcare system offers an informative case study, as in recent years it has developed sustainability aims and has undertaken extensive waste prevention measures, especially with respect to food waste, under the Irish EPA Green Healthcare Programme (EPA-GHCP) (EPA, 2014a; Ryan-Fogarty *et al*., 2016). The maternity service, through established environmental and health initiative programmes, can provide a testbed for innovative solutions and can therefore be used to identify methods and strategies that have potential for application in other jurisdictions.

For this research, backcasting methods were utilised, as outlined in the FOR-LEARN Backcasting Online Foresight Guide (JRC, 2007), to develop normative scenarios for formula waste management. Steps in the backcasting method employed are shown in Figure 3.1.

3.3.1 Backcasting method steps

- Step 1: strategic problem orientation and definition. The sources and extent of RTU formula waste and implications were determined through literature reviews, using data from published papers, books, the 2013 national perinatal statistics, BFHI reports and HSE infant feeding policies. The research team also had access to additional knowledge through a project advisor who is familiar with practice in Irish hospitals and is active in reporting best practice in infant feeding through her work with the health services.
- Step 2: development of future vision. To overcome impacts associated with waste formulas, both

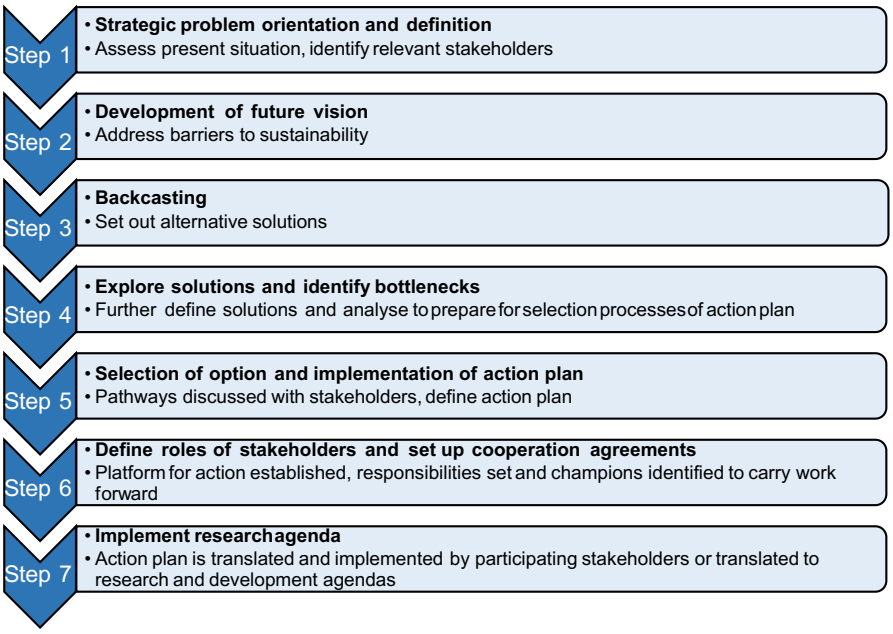

Figure 3.1. Steps required in adopting backcasting methods. Reprinted from *Waste Management*, Vol. 61, Ryan-Fogarty, Y., Becker, G., Moles, R. and O'Regan, B., Backcasting to identify food waste prevention and mitigation opportunities for infant feeding in maternity services, pp. 405–414, copyright 2017, with permission from Elsevier.

the waste management hierarchy (Directive 2008/98/EC; EU, 2008a) and the WHO Global Strategy on Infant and Young Child Feeding (WHO and UNICEF, 2003), as enacted through the BFHI, were used to develop the future scenarios and choices. It is not uncommon to have normative assumptions and goals predefined in backcasting approaches, as many have used pre-existing targets and goals, e.g. "Factor 20", in their approaches (Quist and Vergragt, 2006). EU policies and directives, such as the Water Framework and Nitrates Directives and Common Agricultural Policies, were used successfully as the basis of scenario analyses (Therond *et al*., 2009; Kok *et al*., 2011).

- Steps 3 and 4: backcasting. Setting out the alternative solutions, and Step 4: explore solutions and identify bottlenecks. Alternative solutions were developed by the research team, which consisted of persons with expertise in scenario assessments, environmental economics, environmental analysis, dietetics, human lactation and healthcare policy. The opportunities for and barriers to the implementation of the scenarios and potential effects on environment and health systems are presented and discussed in this report.

Backcasting method components, such as the implementation of action plans, definition of stakeholder roles and establishment of cooperation agreements (Fig 3.1 steps 5 and 6), fall outside the scope of this paper; however, the research team identified future research agendas and data gaps in this emergent multidisciplinary field (Fig 3.1 Step 7).

3.4 Results

3.4.1 Strategic problem orientation and definition

Where formula was required, it was provided free of cost to mothers and their babies; however, hospitals paid for the purchase of formulas as per the guidance established through Ireland's commitments as a signatory to the International Code.

Formula was purchased by the HSE for maternity units and for paediatric hospitals and neonatal and paediatric units in general hospitals on the following bases:

- as required from intermediate suppliers;
- as required by individual hospitals;
- from multiple sources, including different brands, volumes and types, for example, RTU formula, powdered infant formula (PIF), hypoallergenic and soya based;
- as a part of food and pharmaceutical budgets.

The cost to the HSE was reported to be approximately €1 per bottle and teat (BFHI, 2013), whereas the average cost to consumers through retailers was calculated by the research team to be, on average, €1.78 for the same items (pricing compiled in October 2015). In general, pre-portioned bottles of RTU formula were used, except where specialised formulas were required (FSAI, 2012a). Eight bottles of RTU formula were allocated per day to infants that were exclusively formula fed, based on advice that formula fed babies feed every 3–4 hours (HSE and Safefood, 2012). The advice provided with RTU formulas varied between manufacturers and storage conditions; in a clinical setting, once a bottle was opened and a teat attached, best practice was to discard the bottle after 1 hour (Macqueen *et al*., 2012).

Ireland's perinatal statistics from 2013 record formula-, breast- and combined feeding rates as 44%, 46% and 9% of 68,830 live births, respectively (HSE Healthcare Pricing Office, 2014); however, the point at which an infant received formula, or how much was provided, was not recorded. Babies gradually increase total daily milk intake from 30–60 ml/kg/day at day 1 to 60 ml/kg/day on day 2 and 90 ml/kg/day on day 4 of life over multiple feeding sessions (Sinha *et al*., 2012). In 2013, the average infant stay in hospital was 3.2 days (HSE Healthcare Pricing Office, 2014). As the bottles are pre-portioned with set volumes, the remaining formula post feeding becomes waste, as decanting of RTU formulas to share between infants does not routinely occur on account of infection control, labelling and storage requirements as well as staff time.

RTU formulas used in the Irish maternity service were procured from three manufacturers. Brand A supplied 100 ml bottles whereas brands B and C both supplied 70 ml bottles; these volumes are all considerably greater than a typical newborn infant's stomach capacity. The research team calculated the average requirements of formula-fed babies for days 1, 2 and 3 of life, based on the average stay and the average birth weight of 3.493 kg (HSE Healthcare Pricing

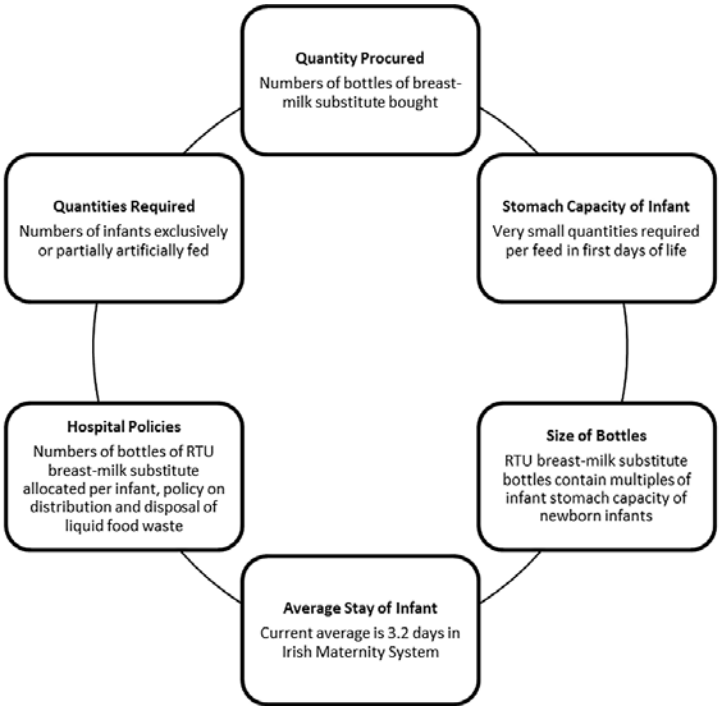

Figure 3.2. Factors contributing to liquid RTU formula waste. Reprinted from *Waste Management*, Vol. 61, Ryan-Fogarty, Y., Becker, G., Moles, R. and O'Regan, B., Backcasting to identify food waste prevention and mitigation opportunities for infant feeding in maternity services, pp. 405–414, copyright 2017, with permission from Elsevier.

Office, 2014). The factors leading to RTU formula food waste are summarised in Figure 3.2.

Neonatal and perinatal deaths were not subtracted from live births for 2013; the number of infants feeding was reported as 68,830. To move from the causation of RTU formula waste to an estimation of RTU formula procured and volumes of liquid waste arising, the following assumptions were made in the quantification of formula waste rates:

- Infants that were formula fed or partially breastfed received one of the three main brands of formulas purchased by the maternity services. Brand use was assumed to be evenly split across the three brands. Here, the average volume of the three brands – 80 ml – was assumed to be the RTU bottle capacity. Specialist or other milks and fortifiers were not included in these calculations.
- Only eight bottles allocated per infant were considered. Spilled, out-of-date and opened-but-unconsumed bottles (in addition to the allocated eight) were not included, as there were no available data on which to base a calculation.
- The low-use scenario assumed that those infants who received breastmilk but were not exclusively breastfed each received one bottle on day 1 of life.
- The high-use scenario assumed that those infants who received breastmilk but were not exclusively breastfed received as many bottles as exclusively formula fed infants did during the average hospital stay and that the rate of waste remained similar for high- and low-use models.
- The density of RTU formulas was assumed to be the same as water (1 g/ml).

The estimated national annual consumption, waste and cost levels during hospital days are given in Table 3.1.

3.4.2 Development of a future vision

In developing a future vision for the sustainable management of formula food waste, both the waste management hierarchy (Directive 2008/98/EC; EU, 2008a,b) and the WHO and UNICEF Global Strategy on Infant and Young Child Feeding (WHO and UNICEF, 2003), as applied through the BFHI and HSE Infant Feeding Policy for Maternity and Neonatal Units (HSE, 2015), were used to inform

Table 3.1. Annual RTU formula consumption and costs for high- and low-use scenarios based on 2014 data

Estimated use, waste and costs	Low use	High use
Number of bottles required: formula-fed infants	780,587	780,587
Number of bottles required: partly breastfed	6,470	165,633
Total number of bottles required	787,057	946,220
Low cost (cost of procurement to HSE) (€)	787,057	946,220
High cost (if retail prices paid) (€)	1,397,901	1,680,591
RTU formula volumes required (tonnes)	63	76
Average unconsumed (% per volume purchased)	61	61
Waste RTU formula (tonnes)	38	46

best practice. The EU Waste Framework Directive requires that EU Member States apply the waste management hierarchy in the following manner: prevention, preparing for reuse, recycling, recovery and disposal, with prevention of waste being the most favourable option and disposal the least favourable.

3.4.3 Backcasting: identification of alternative solutions and bottlenecks

By taking the future vision and pairing this with knowledge gained through the problem orientation (formula waste causation and quantification), alternative solutions and bottlenecks were identified. The following sections group and outline the potential solutions. Table 3.2 summarises and contextualises these with respect to the waste management hierarchy and compatibility with the WHO and UNICEF Global Strategy on Infant and Young Child Feeding and BFHI.

3.5 Discussion and Conclusions

3.5.1 Formula waste prevention measures

Arguments for the wider adoption of breastfeeding that relate to health and wellbeing fall outside of the scope of this study. Reducing waste at the source and waste prevention are the highest priorities within the waste management hierarchy. The backcasting model deployed here resulted in the identification of 13 potential solutions to prevent or reduce formula waste. Of these, only three have been identified as not compatible with best practice in infant feeding policies (Table 3.2). For ease of description, potential solutions were further grouped around interrelated issues.

3.5.2 Changes to procedures on provision of RTU formulas

An alternative option, other than breastfeeding or access to human breastmilk, is the use of milk substitutes. The first possibility identified by the research team is that mothers bring their own formula to the hospitals. This reduces the cost to hospitals of providing the formula, but unless parents are bringing home unused amounts from each feed, it does not reduce the waste to be disposed of within the hospital. The involvement of healthcare professionals in assisting new parents to identify infant feeding requirements and safe practices is crucial to the provision of safe infant care. Uncontrolled use of infant feeds brought into the hospital could pose a potential risk to infants. At present, this was determined to not be feasible.

The second possibility is to address the inappropriate sizing of bottles of RTU formulas (between 70 ml and 100 ml), which leads to waste. Strategic problem orientation suggested that 61% of the volume of RTU formula purchased by the Irish maternity service was unconsumed by infants and became waste. RTU bottle sizes have also been identified by healthcare professionals as causing mothers to assume that babies should finish the volume provided in the bottle at each feeding interval, leading to overfeeding (Sinha *et al.*, 2012). In recent times, some brands have reduced their bottle size from 100 ml to 70 ml,

Table 3.2. Waste management hierarchy and summary of potential solutions to formula waste and compatibility with the Global Strategy on Infant and Young Child Feeding and the BFHI

Potential solution	Rationale	Compatibility with Global Strategy on Infant and Young Child Feeding, BFHI and waste management hierarchy
Prevention		
Increase exclusive breastfeeding rates	Low rates of exclusive breastfeeding in Ireland Potential to increase	*Compatible:* in hospital, breastfeeding initiation rates of >80% have been achieved in other parts of the world. Irish hospital initiation rates ranged between 44% and 70% in 2013 (BFHI, 2014)
Increase use of human donor milk and reduce supplementation with formulas	Increase eligibility criteria, as only very premature and ill infants were eligible at the time of the study	*Compatible:* systems were already in place for premature/ill infants. Milk sharing and donations for term and non-risk neonates in early stages of development in Ireland
Wider range of bottle sizes	Newborn infant stomach capacity is small, resulting in large percentage of waste unconsumed formulas per feed	*Compatible:* Ireland is a small market; pressure from larger and international customers may be required
Decanting of bulk liquid formulas	Amounts that are more accurate can be decanted into bottles on-site as per need of infant	*Compatible:* if number of exclusively formula-fed infants fell, space and resources would not be limiting factors. However, infection control measures and bottle/teat requirements need to be established
Powdered formulas	Quantities can be prepared as demanded and stored for use as required	*Compatible:* guidelines available in hospital. If number of exclusively formula-fed infants fell, space and resources would not be limiting factors
Mothers to bring own formulas	Hospital provides first bottle if mother is not breastfeeding. Mother provides subsequent formula as RTU or powder	*Incompatible:* may result in mothers bringing own formulas into hospital just in case it is needed and may encourage use because it is already purchased Would take up space, equipment, risk in mothers preparing bottles in hospital, particularly when formula feeding rates are high Does not solve waste management issues
Guidelines regarding stand times in clinical settings	Disposal of formula 2 hours after opening according to manufacturers' guidelines, though after only 1 hour according to clinical guidelines.	*Compatible:* until further investigation is complete
Hospital practices regarding bottle distribution	Record and control number of bottles distributed per infant. No bottles on discharge	*Compatible:* ensure HSE National Infant Feeding Policy is fully implemented
Procurement of policy and prices of RTU formulas	Pricing of supplies to healthcare may mask cost to families when products are bought for home use	*Compatible:* however, it is contrary to normal procurement in seeking lowest cost. Paying retail cost of formulas may highlight high use as a result of greater visibility in cost reporting Adherence to Green Procurement Guidelines
Other recovery		
Potential animal feed product	Segregated formulas could be used for feed of certain animals (e.g. pets and fur animals)	*Incompatible:* increased focus on prevention make this option unlikely, as quantities would be too low for collection
On-site composting or anaerobic digestion	All hospitals would be required to ensure separate food waste collection	*Incompatible:* not feasible when waste prevention practices implemented
Off-site composting or anaerobic digestion	All hospitals would be required to ensure separate food waste collection	*Compatible:* add waste formulas to existing food waste collection on-site
Disposal		
Disposal of waste formulas to drain or waste collection is not permitted	Must abide by waste management hierarchy There is some evidence that not all hospitals believe waste formulas to be a food waste and requiring treatment as such	*Compatible:* formulas not to be disposed of in drainage system or general waste collection

but, as argued, these volumes are still too large for newborn infants. However, in the shorter term, feeding in response to an infant's needs ("demand feeding") may require more frequent feeds of smaller volumes, creating additional need for RTU bottles and thereby resulting in further waste.

Options to circumvent these issues include:

- requiring manufacturers to produce appropriately sized RTU bottles;
- decanting of bulk RTU formula or the reconstitution of PIF on site; and
- provision of bottles based on individual requirements of infants.

RTU is sterile and was recommended rather than PIF for infants with the highest risk of infection (WHO, 2007), but for healthy infants PIF was considered acceptable. The use of RTU means that hospital resources were not invested in provision of milk-preparation areas, sterilising equipment, water heating, containers, labelling equipment, refrigerators and staff time (Marino *et al*., 2013). Bulk preparation of PIF in healthcare settings requires cleaning and sterilisation of feeding and preparation equipment, as does it require heating of water to temperatures >70 °C (WHO, 2007), sterilising bottles and teats and dedication of additional staff time. There may be infection control issues for high-risk infants related to pouring of liquids from one container to another in a general ward environment. The safe use of PIFs for specialist formulations and formulas is normal practice in many maternity and paediatric units worldwide. Increased breastfeeding initiation rates, as prioritised by public health policy and recently observed, may lead to reduced overall demand for formula; therefore, decanting of bulk RTU or reconstitution of PIF on site may become a more feasible option for hospitals.

As identified as part of the problem orientation, mixed guidelines regarding stand times of bottles may contribute to increased waste and the variance between (a) clinical guidelines as taught to healthcare workers and (b) manufacturers' guidelines, which in turn may cause confusion. The revision and possible extension of stand times for opened formula bottles needs further investigation and is therefore considered here as a potential solution pending further investigation.

The Infant Feeding Policy for Maternity and Neonatal Services recommends that formula stocks should only be accessible by staff, stocks should not be on display and RTU formula or related products should not be provided to mothers on discharge (HSE, 2015). In theory, healthcare staff should be monitoring the infant's intake to help new parents understand intake and feeding patterns. Many hospitals have in-house policies that require the healthcare staff to receive back a bottle from the mother before a new bottle is dispensed to ensure that excessive amounts are not provided and the healthcare staff are monitoring the situation.

Tarrant *et al*. (2015) reported, in one Hong Kong maternity unit, that implementation of hospital policies to pay market prices for formula increased the rates of exclusive breastfeeding and breastfeeding duration and decreased in-hospital formula supplementation. Although formula is not provided to hospitals in the Irish healthcare system for free, its relatively low cost may encourage overconsumption. The payment of retail prices would increase the cost of RTU formula from approximately €0.8 million to €1.4 million in the low-use model alone.

Some medicines may be of strategic importance to suppliers, i.e. where the patient is prescribed the medication on discharge (Vogler *et al*., 2013). Vogler *et al*. (2013) suggest that branding of formulas in hospitals is of strategic importance to manufacturers. Studies have found that advice from paediatricians, brand loyalty and recognition of brands used in hospitals influenced brand choice by parents and, therefore, sales (Tshikovhi *et al*., 2015). Formula consumption may extend into toddlerhood and thus developing brand loyalty from birth is of strategic importance (Berry *et al*., 2012), as manufacturers of infant milk strive to generate growth in demand (Mohajan, 2015).

In terms of pricing and procurement policies, the cost of waste RTU formula does not appear to be calculated by health services and has not been considered in other formula cost comparison studies (Marino *et al*., 2013). Purchasing approximately 1 litre of RTU formula may have cost the Irish Health Service between €5.40 and €7.70 per litre. This study estimated that 61% of this becomes waste and, therefore, additional associated costs arise for disposal services and staff resources in managing waste exist.

3.5.3 Increasing use of breast-feeding, human donor milk and reducing supplementation with RTU formula

The WHO and UNICEF (2003) recommended that infants should be exclusively breastfed for the first 6 months of life and thereafter receive nutritionally adequate and safe complementary foods while breastfeeding continues for up to 2 years and beyond. When an infant cannot be breastfed, the WHO and UNICEF outlined alternatives in the following order of preference: expressed breastmilk from infant's own mother, human milk from a milk bank and, lastly, a suitable formula, fed by cup (WHO and UNICEF, 2003). The prevalence of exclusive breastfeeding has increased in Ireland over the past years; 56% of mothers recorded any breastfeeding in 2013, compared with 53% and 46% in 2009 and 2004, respectively, yet only 47% of mothers exclusively breastfed during their stay in hospital (ESRI, 2013). Women who gave birth in a BFHI hospital were more likely to breastfeed than women who gave birth in another hospital (Declercq *et al*., 2009; Becker, 2013); in Irish BFHI-accredited hospitals, women were found to be 11% more likely to breastfeed (ESRI, 2012). As of 2016, not all maternity units in Ireland were BFHI accredited and, therefore, significant scope exists to increase breastfeeding rates and decrease the demand for RTU formulas.

A multiplicity of reasons for in-hospital supplementation of breastfeeding with formulas have been suggested, ranging from maternal anxiety, breastfeeding problems, infant behaviour and maternal fatigue to maternal education with respect to infant feeding (Gagnon, 2005; Tender *et al*., 2009). Strategies to reduce in-hospital formula supplementation included following the WHO recommendations on infant feeding and ensuring all hospitals were BFHI compliant (Requejo and Black, 2014).

The FSAI's guidance in relation to milk sharing recommended that mothers with surplus milk be encouraged to donate to a registered milk bank (FSAI, 2015).The WHO recommends banked donor human milk as a suitable option where an infant cannot be breastfed or where the infant's own mother's breastmilk is unavailable. The use of banked donor human milk has been found to be cost effective in hospitals on account of reductions in disease incidences and consequential resource use (Kim and Unger, 2010; Renfrew *et al*., 2003; Holla-Bhar *et al*., 2015). At the time of writing, Ireland had one milk bank, located in County Fermanagh. In 2015, this milk bank issued approximately 1500 litres of milk to units around Ireland (Western Health and Social Care Trust, 2015). However, limited supply is a constraining factor. Increased donations of human milk would contribute to reduced formula milk waste by creating more opportunities for waste reduction.

As is routine practice in all Irish maternity and neonatal units, expressed milk is refrigerated if not used immediately and frozen if not used within 24 hours (G. Becker, 2018, personal communication).

3.5.4 Preparation for reuse, recycling and other recovery

Potential solutions pertaining to waste management of waste formulas:

- potential recovery as animal feed;
- on-site composting or anaerobic digestion;
- off-site composting or anaerobic digestion.

Reuse of waste formula is not possible on account of health and hygiene best practice. EU and Irish regulations ban the feeding of food waste to animals, except in the cases of certain pet and fur animals; the regulations make provision for those seeking to transport waste foodstuffs to apply for permits and licences. The enforcement of restrictions and ensuring that all waste streams are segregated places additional administration burdens on healthcare facilities since the quantities involved at individual sites may be insignificant, especially if more desirable waste prevention measures are implemented which further diminish available quantities. Recycling and recovery could potentially include on-site treatment; however, in 2016, transfer to authorised regional facilities (mainly composting or anaerobic digestion plants; EPA, 2016) by the hospital using a waste management contractor was standard practice for all wastes, including food waste. Many hospitals are small, located on confined sites and have neither space nor staff available to invest in on-site treatment options.

3.5.5 Disposal to the sewerage system

Disposal of formula waste directly to the sewerage system is not permitted under Irish legislation. Where

food waste producers have access to a separate food waste collection service, they must not allow food waste to enter residual waste collection or use macerators to discharge food waste to a sewer (Irish Statute Book, 2009).

3.5.6 Implications of findings for healthcare managers

The problem orientation aspect of the backcasting method revealed multiple causes of formula waste and quantified the food waste rate as 61% by volume of RTU purchased. Research on hospital plate waste reported a median rate of 30% in a range of 6% to 65% by mass (Williams and Walton, 2011). The wide range is probably due to differing methods being adopted to quantify food waste in hospitals where specific food waste streams were not isolated for investigation. Infant formula is a distinct food item of which the waste can be quantified; however, it is not known if infant formula waste is included in overall hospital food waste measured.

Findings presented here are particularly relevant for healthcare systems where in-hospital artificial feeding and formula supplementation rates are high. Significant opportunity exists for both waste prevention and reduction, which should be prioritised as health, economic and environmental priorities. For some measures, a direct relationship can be drawn between public health policy and waste prevention, that is, if 90% of infants were breastfed during the hospital stay, between 700,000 and 850,000 bottles, or between 57 and 68 tonnes of RTU formula, would not be required. More appropriate bottle sizing by manufacturers or preparation of PIF on demand may play a role in preventing a significant amount of waste. Our findings are therefore relevant in cases where hospitals are considering switching from PIF to RTU formulas. Hospitals must consider the broader cost implications, such as environmental costs, of such changes.

Collaboration between environmental and health sciences researchers determined that some proposed solutions were not feasible. Here it was decided to present both feasible and unfeasible solutions as part of the selection of solutions to facilitate cross-disciplinary knowledge development and ensure that staff, policymakers and hospital management were aware that some alternative solutions, although appealing from cost resource management perspectives, may incur undesirable outcomes in terms of patient care, staff time and/or environmental impact. Although analysis of unfeasible solutions is a deviation from traditional backcasting methods, it demonstrates an important point for consideration in the development of management strategies within the complex healthcare setting.

3.5.7 Implications of findings on healthcare sustainability research

The use of sustainability analysis tools to enhance the environmental performance of healthcare is growing, with substance/material flow analyses, life-cycle analyses, audits and checklists featured in recent literature. This chapter reports on the use of a backcasting method, although some have argued that in order to create future visions, experts need to disengage from present-day values, interests and societal constraints (Vergragt and Quist, 2011). Here it is proposed that for selected healthcare issues evidenced, best practice exists, yet it was not fully implemented and, in this case, backcasting provided evidence of further benefits of implementation of international protocol and best practices, and has identified pathways by which these can be achieved. In this case an expert-led backcasting exercise was used and backcasting has previously been demonstrated to be valuable in developing policy objectives (Vergragt and Quist, 2011). A limitation in conducting the problem orientation as a back-of-house exercise was that rates of formula waste due to obsolescence or other factors could not be considered. This led the research team to focus on demand reduction measures as opposed to management of current procurement practices. Alcamo and Henrichs (2008) stressed the importance of developing legitimate scenarios that involve researchers and data from relevant scientific disciplines. The use of recognised best practice and policy in both infant feeding and waste management analysed by researchers working in these fields adds legitimacy to the processes employed.

This study focused on a backcasting method solely for RTU formula waste. Backcasting may provide an insight into multiple research areas; for example, concerns have been raised regarding the commodification and commercialisation of human milk and breastfeeding (Cassidy, 2012; Ryan *et al*., 2013; UNICEF UK, 2015), and the environmental impacts of

breastfeeding as a mitigation measure in food demand and health protection has not been fully characterised. Solutions pertaining to formula procurement and hospital policies also require further attention. For example, improvements in bottle sizing may lead to increased production, thus perpetuating a rebound effect and, therefore, the producer responsibility of manufacturers warrants consideration.

In terms of recycling and reuse, food waste from clinical settings is not suitable for reuse as animal feed. Disposal to sewage systems was not permitted and, therefore, the feasible options for residual wastes are on- or off-site composting or anaerobic digestion. Not all potential scenarios may be feasible on account of waste management legislation and international policy on infant feeding, yet health services management requires an awareness of the broad impact of these to avoid undesirable effects. Attaining sustainable healthcare and food systems requires increased collaboration between medical and environmental practitioners. Without this synergy, outcomes are liable to be compromised. Further research is required based on the solutions presented herein.

4 Mitigation and Management of Single-use Plastics in the Irish Healthcare System

4.1 The Scale and Urgency of Actions Necessary to Reduce Plastic Waste Pollution

For some time, it has been recognised that plastic fulfils a great many useful functions and that for packaging its lightness and strength have proven to be of great advantage to manufacturers and retailers. Globally, it is calculated that more than half of all plastic is used once, then discarded. It has been estimated that 9% of plastic waste is recycled, 80% is landfilled and 11% is incinerated; of the 9% recycled, about 10% is recycled a second time (Brooks *et al*., 2018; Kosier, 2018, O'Hanlon *et al*., 2017). Plastic waste creates multiple threats to the environment and human health. Plastic is not homogenous, but rather is formed of a range of types of plastic, referred to as resins or polymers, here called polymers. Polymers are mostly derived from oil, but differ in their overall impact on the environment. For example, landfilled plastic may release toxins such as phthalates to groundwater (Pivnenko *et al*., 2016). Plastic in the sea does not degrade but instead breaks into ever-finer particles and micro-plastic particles then enter the food chain (Munir, 2018). Some plastic polymers in landfill release known toxins and endocrine disruptors (Beckman, 2018). In recent years, the scale of these threats has been recognised as being on a similar scale to stratospheric ozone depletion and climate change, in that they represent a significant perturbation of global scale environmental functioning, and require a similar action with equivalent ambition and urgency (Cornell *et al*., 2018).

Many publications have identified and evaluated policies designed to achieve significant reductions in plastic use and waste arising as a result, including its reclassification as hazardous waste on the grounds that it may contain many chemicals, some potentially hazardous (Pivnenko *et al*., 2016). Although a broad range of approaches have been adopted and evaluated (Rigamonti *et al*., 2014), it is not yet clear which management approaches and technologies provide optimal solutions (Garcia and Robertson, 2017).

Although some authors report evidence that recycling plastics reduces environmental impacts and results in cost savings (Al-Salem *et al*., 2017), an assessment of the feasibility of plastic recycling suggests that currently available technologies are limited in scope, as for some polymers, no technologies were available for effective recycling (Garcia and Robertson, 2017). A limiting factor in processing plastic waste is that the polymers used require different treatments. It is therefore necessary to identify the polymer type or types forming composite plastic products. In order to facilitate processing of waste, international classification systems are in place whereby plastic packaging manufacturers may identify the polymer forming each component or product (Beckman, 2018). However, because the market in plastic products is global, more than one system has been used in components forming a product or the polymer types are not identified. In addition, products may be made from a mix of polymers or may be formed of several components, each of different polymer type (Rigamonti *et al*., 2014). Collection and segregation of plastic waste before recycling is often costly and time intensive and for some polymers sorting by hand is employed. Processes in recycling plants may be energy intensive and, in some cases, the recyclates in the form of granules or pellets are found to be of low quality and unattractive to manufacturers (Garcia and Robertson, 2017). However, various additional technologies are being developed and tested, which may provide the means to readily identify and recycle a greater range of polymers (Al-Salem *et al*., 2017).

4.2 Plastic Waste Generation and Recycling in Ireland

Of the EU Member states, Ireland produces the greatest per capita quantity of plastic waste, which underlines the necessity that such waste be greatly reduced (Munir, 2018). Recent and probable future changes in opportunities to export plastic waste for treatment suggest that Ireland will have to expand and develop indigenous plastic waste processing, and although avoidance and reduction in use form

the preferable approaches, for the foreseeable future recycling and the reuse of recyclates are likely to play crucial roles in reducing consumption and environmental impacts of plastic (Walker, 2018). In relation to the island of Ireland, an Internet search found more than 50 currently active material recovery facilities where municipal and industrial waste can be segregated into separate streams for subsequent treatment or disposal. The search also found websites for 11 companies in Ireland which are engaged in processing plastic polymers into granules and pellets for use in the production of new goods. Information here was sourced from company websites. In comparison with the range of polymers in use globally (Beckman, 2018), relatively few were accepted for recycling by these Irish companies, but those polymers frequently used in packaging were accepted. Irish companies have access to technologies which allow identification of polymer types in wastes, including the use of spectrometers.

4.3 Packaging Components of RTU Infant Formula

For this study, a widely available brand of RTU formula for infants was selected and the bottle and other packaging were examined (March 2019). Milk contents were 70 ml. Empty, the bottle weighed 6 g, and the total weight of packaging was 18 g. Packaging was formed of eight components and made of polymers, paper, silicone and aluminium. A removable shrink-wrap covering displayed information about the product. A plastic bottle held the formula. An aluminium cap sealed the bottle. The teat was packaged in a separate plastic cone, sealed with waxed paper and a further component allowed the teat to be attached to the bottle. Plastic components were visually inspected for polymer identification marks and the availability of recycling estimated based on recycling company websites (Table 4.1).

4.4 Discussion and Conclusions

Major challenges associated with recycling plastic products, as identified above, that can act to complicate or prevent recycling include (1) problems in identifying the polymers used in manufactured products, (2) problems in placing products that are formed of components formed of different polymers into appropriate waste streams, (3) problems in developing technologies which allow recycling of products which contain non-plastic components and (4) problems in avoiding contamination of plastic waste by food. The packaging and contents of the bottle examined here exemplified all of these problems, potentially reducing the feasibility of recycling. A further consideration is that most of the components are very small, so that each bottle placed in a bin for recycling will provide very small quantities of material, as is the case, for example, with aluminium foil seals on bottles. Full recycling of such products is often contingent on recycling companies finding large and dependable sources of the discarded items. Achieving a critical mass of waste, thus gaining economies of scale in collection, transport processing and reuse, may be facilitated when institutions such as hospitals formulate clear policy on recycling, the necessary infrastructure is put in place and staff and visitors are active in both generating and implementing policy. At the same time, manufacturers might be asked to consider alternative packaging. Retail shops offer formula in both bottles and paper cartons. Although health and

Table 4.1. RTU formula bottle and packaging components and estimated likelihood of recycling in Ireland (March 2019)

Product component	Material	Polymer identification	Feasibility of recycling In Ireland
Shrink wrap	Plastic	None	Unknown
Bottle	Plastic	Polypropylene	Possible
Bottle lid	Plastic	High-density polypropylene	Possible
Fitting to attach teat to bottle	Plastic	None	Unknown
Cone to enclose teat	Plastic	None	Unknown
Bottle seal	Aluminium	Not applicable	Possible
Seal on teat packaging	Waxed paper	Not applicable	Not possible
Teat	Silicone rubber	Not applicable	Unknown

hygiene are critical concerns in hospitals, investigating further possibilities to reduce use of plastic in formula packaging might be explored. However, given the challenges to be faced in effectively recycling waste plastic, the most feasible solution may be, as far as possible, to stop creating plastic waste (Ryan-Fogarty *et al*., 2017b).

5 CUH: Case Study as Part of Dissemination for Wider Community

5.1 Introduction

CUH was selected as a best practice case study on account of its environmental education programme. In a systematic review of sustainable healthcare, McGain and Naylor (2014) identified a need to provide more information to guide decision-making as well as interdisciplinary coordination in research on sustainable healthcare. This chapter describes how CUH systematically applied an environmental education programme, designed for use originally with schools and subsequently with university campuses, as a framework to utilise both regulatory requirements and voluntary initiatives supported by government agencies and non-governmental organisations (NGOs). Descriptions of the framework and initiatives used with practical examples of technical and support measures employed are presented in this chapter. Energy and waste management are taken as examples to demonstrate how environmental programmes have been adapted on site. The environmental programme represents an example of an existing framework through which infant feeding decisions and associated environmental impacts may be addressed in the healthcare setting.

5.2 Implementing Waste Management Programmes at CUH

5.2.1 Programmes employed

CUH was the largest teaching hospital and only level one trauma centre in Ireland, containing over 40 medical and surgical specialities. Full-time equivalent staff and student numbers total 3297 and 408, respectively. During 2013, the hospital catered for 234,752 patient bed-days, 166,103 outpatient attendances and 8295 births. The hospital contained 18 buildings with a total floor area of 96,720 m^2.

CUH requested to join the Green-Campus Programme (GCP) (An Taisce, 2015) in 2010 and was accepted to participate as a teaching hospital. Its academic affiliate, University College Cork (UCC), was the first university to implement the GCP. The GCP is both an environmental education programme and award system based on the International Eco-Schools Programme. In Ireland, An Taisce, an environmental charity and NGO, coordinates the programme. The GCP does not reward specific environmental projects, implementation of technologies or capital investments. Instead, it acknowledges long-term commitment to continual improvement from the entire organisation and full implementation of a seven-step environmental management system. Participants are facilitated to determine which environmental targets to pursue; some organisations have extensive buildings and estates management whereas others do not. Green-Campus status stipulates that institutions be registered for a minimum of 1.5 academic years and have implemented all seven steps of the programme. Assessment is site specific and is based on a written application submitted to an assessment panel, followed by a site audit and interview. To retain GCP status, annual renewal reports must be submitted with full reassessments required every 3 years (An Taisce, 2013).

CUH enlisted in the EPA-GHCP in 2009 as a pilot site. Since then >100 surveys on healthcare facilities around Ireland have been conducted. The EPA-GHCP aims to improve resource efficiency, reduce waste and save costs through direct assistance via detailed waste surveys, follow-up reports, recommendations and customised advice. The two targets of the EPA-GHCP are waste reduction and water conservation, with an extensive benchmarking system for acute hospitals developed within the state (EPA, 2014a).

In 2013, CUH joined the Global Green and Healthy Hospitals Network (GGHHN) and the Public Sector Energy Efficiency Programme (PSEEP). The GGHHN is coordinated by Health Care Without Harm, a global network of healthcare systems that research and develop guidance on issues pertaining to healthcare and environmental sustainability (Health Care Without Harm, 2015). The Sustainable Energy

Authority of Ireland (SEAI) developed the PSEEP (SEAI, 2015), which consists of resources, training and peer support for energy management, to assist the public sector to meet national commitments to improve energy efficiency by 33% by 2020 (Department of Communications, Energy and Natural Resources, 2009). Because CUH is publicly funded, it is obliged to meet these targets; however, participation in the PSEEP is voluntary.

5.2.2 Sustainable healthcare environment steering group, green advocates and teams

Within CUH a Sustainable Healthcare Environment Steering Group (SHESG) was formed and a sustainable environment officer appointed in 2013. The role of the SHESG was to oversee the direction, coordination and implementation of the 2013–2017 HSE sustainability management strategies on hospital campuses (HSE and CUH, 2016). Previously, CUH had one part-time waste officer and no energy manager. The Irish public healthcare system is managed by the HSE, with buildings management shared at a regional scale rather than per site. The SHESG, appointed by the Senior Management Group for 2-year terms, includes representatives from hospital management, medical specialties, HSE and UCC representatives, including management and students.

The SHESG identified two significant challenges to be considered while striving to improve environmental performance:

- Resources: the implementation of environmental programmes, as it is a voluntary undertaking within the hospital. Workload demands, staffing and funding levels provide significant constraints.
- Staff engagement: the engagement of frontline staff, particularly clinical staff, whose main priority is delivery of patient care in an acute healthcare setting and the myriad of competing commitments in a public institution.

To address these issues, the SHESG established a Green Advocates Network, following the advocacy model in healthcare. The advocacy role is a voluntary one and the steering committee aimed to have green advocates and teams in every ward and department.

5.2.3 Environmental review

CUH undertook extensive environmental reviews for two targets: waste generation and energy consumption. Nascent reviews and action plans were developed for water, travel, air quality, biodiversity, sustainable procurement and future building design. Suggestions and feedback from the Green Advocate Network and stakeholders were logged into the Register of Opportunities for discussion and action. Here, findings associated with waste management are reported. Initial waste characterisation including detailed analysis of food and healthcare risk waste, together with reports containing specific recommendations, were provided by the EPA-GHCP in 2009. Additional surveys, undertaken by the SHESG, reviewed implementation of recommendations made by the EPA-GHCP and identified additional targets such as litter and general waste management practices, as inspired by additional environmental programmes input and staff suggestions. Key findings of the waste review are presented in Table 5.1.

5.2.4 Actions taken

Detailed action plans were formulated using environmental review outputs with key additional information brought to the attention of the SHESG through green advocates, events and other feedback mechanisms. The plans were goal orientated, using key performance targets, task owners and schedules to incorporate GCP step requirements, namely monitoring and evaluation, informing and involving, linking to learning on site and the Green Charter. The action plan remains a live document to guide implementation of environmental performance targets on site.

In terms of waste reduction measures, all issues identified in Table 5.1 were included in the action plan. As of 2016, there were no public sector targets pertaining to waste management; however, CUH wished to at least meet the benchmarks set by the EPA-GCHP.

Surveys of departments and wards showed that although frontline staff knew what actions could conserve resources, their behaviour did not reflect this knowledge. It was ascertained that their main priority was safe delivery of patient care and staffing constraints affected daily workload. The SHESG formed the action plan using "back-of-house" technical

Table 5.1. Key findings of the CUH waste review

Method/description	Key findings
1. General waste management: overview. 2. An overview of waste management practice, ensuring compliance with legislation.	• All waste disposal and collection were in compliance with national legislation. • Waste services contracts were managed centrally by the HSE through Service Level Agreements. CUH had input into tender specifications. • Contract caterers and other contractors working in the hospital were obliged to remove their waste. • Identified over 20 separate waste collection streams on-site. • Waste was benchmarked against Green Healthcare indicators although there is a need for internal waste metrics.
1. Food waste survey. 2. Portion size and composition of food reviewed.	• All patients received similar sized portions, bread included with all meals, condiments disposed of unused. • Potential for reuse of unserved food e.g. meats in salad and vegetables in soup.
1. Hazardous waste management: laboratories. 2. Review of microbiology, pathology, histology, haematology, clinical biochemistry.	• Identified and quantified hazardous wastes. • Best practice requirements identified for prevention, storage, recording and management.
1. General and healthcare risk waste. 2. Categorised and quantified wastes arising in every part of the hospital.	• Potential for increased waste prevention, better segregation and waste management costs reductions across all departments. • Some wards were not recycling glass and RTU formula disposed to wastewater. • Polystyrene and non-reusable cups were in use. • Some offices were not recycling or preventing paper waste. • Inadequate numbers of recycling bins to meet demand.
1. External litter survey. 2. Review of good practice.	• 25 external bins. • No records of quantities collected. • Litter black spots identified.
1. Identified waste prevention, minimisation, recycling and reuse practices to ensure continuity and further enhancement.	• Prevention measures included food waste prevention measures, non-toxic cleaning solutions, refill toners and inks, reduced packaging in purchasing contracts. • Minimisation included printing instructions, use of rechargeable batteries, durable equipment covered by warranties, daily deliveries in reusable containers. • Reuse and Recycling included cooking oil, paper used internally, interoffice envelopes, ceramic cups and glasses in addition to paper-based versions.

initiatives and "front-of-house" actions to address awareness and behavioural change. As part of the GCP, awareness campaigns focused on achievable actions that could be realised on site and in the wider community through CUH links with educational institutions and opportunities available to educate staff, patients and visitors.

5.2.5 Technical initiatives

Management initiatives refer to engagement with specific systems or key staff and can be described as technical and process driven in nature, as opposed to the wider hospital community involvement described in the front-of-house initiatives. Technical initiatives to increase energy efficiency – both implemented and planned – are listed in Table 5.2.

5.2.6 Informing and involving

As Ireland's largest teaching hospital and a significant economic and social presence in Cork City, the SHESG recognised that a broad range of approaches to environmental action was required

Table 5.2. Implemented and planned technical initiatives to increase energy efficiency in CUH

Waste management	Solutions
Procurement.	• All purchasing contracts have a requirement to reduce packaging. • Reusable packaging for daily deliveries. • Source food locally where possible. • Durable equipment to increase life of product. • Products procured that are guaranteed by warranty where appropriate. • Procure rechargeable batteries where possible.
Waste receptacles.	• Detailed location guidelines. • Bin-less offices pilot scheme. • Clear waste signage and guidance on all bins. • Installation of more waste recycling bins to capture recyclables. • Identified litter black spots, signage and litter receptacles installed.
Departmental waste.	• Departmental green teams examine waste specific to department. • Detailed monitoring of waste streams and comparison with available benchmarks. • Checklists ensuring bins are located, labelled and used correctly.
Food waste.	• Reuse of unserved food where appropriate. • Training programme for staff. • Patient menus with portion size, sides and condiment options. • Notification of patient discharges to kitchen. • Periodic review of food waste to identify trends and remedial action. • Smaller portion options in canteens. • Segregation of milk and waste RTU formula food waste. • Ceramic instead of disposable cups and removal of polystyrene cups.
Waste best practice: cleaning and administration.	• Building on best practice and dissemination to other departments. • Non-toxic cleaning products to avoid hazardous waste. • Data stored electronically, memos sent via e-mail. • Paperless meetings. • Refill toner cartridges for print equipment. • Avoid colour printing. • Instructions at print equipment for paper and ink reduction. • Recycled photocopier paper, reuse scrap paper for internal notes, confidential paper shredded and recycled. • Reuse of interoffice envelopes, file folders and boxes.

and that stakeholders within the hospital and outside in the wider community needed to participate to fully embrace the changes and actions required. Over time, the SHESG engaged with numerous stakeholders and a diversity of initiatives. Concerns arose that the number of environmental initiatives on-site may confuse stakeholders. Uniform branding of all sustainability initiatives under one banner "CUH SEECO" (representing Social, Environmental and Economic sustainable change) was viewed as a means to unify and simplify initiatives. As well as environmental management, CUH interpret sustainable healthcare to include service delivery adaptation, health and wellbeing promotion and corporate social responsibility. Table 5.3 lists informing and involving actions.

Table 5.3. Informing and involving initiatives and actions at CUH

Informing and involving initiatives	Specific actions
Communications plan.	• Standardisation of environmental messages. • Monthly newsletters. • Hospital radio slots. • Messages on public TV display screens. • Notice boards. • Newspaper articles. • Website pages. • Messages on staff payslips. • Environmental data shared on internal servers accessible to staff.
Waste reporting.	• Detailed waste monitoring. • Specific actions communicated to staff. • Developed best practice checklists for wards, offices and laboratories.
Environmental events.	• Green Home Hub established for staff to utilise sustainability principles at home. • Waste exhibitions, information stands and experts on hand to meet staff and visitors.
Cross-departmental cooperation.	• Green advocates network allows staff across the hospital to communicate. • Green teams within departments develop targeted solutions. • Providing behind the scenes views of departments e.g. canteen "what happens to your waste" exhibition. • Suggestions logged to the register of opportunities.
Involving the local community.	• SHESG are members of the Cork Food Policy Council. • Link with UCC and local schools. • National Spring Clean in locality.
Engagement with national and international peer institutions.	• Facilitation of National HSE Training Day on-site. • Presentation at HSE National Sustainability Office Events. • Linking with GCP and GGHHN participants nationally and internationally.

5.2.7 Linking to learning

The Sustainable Healthcare Environment Steering Group, as part of the "linking to learning" step in the GCP, developed environmental education strategies for all stakeholders. Specific initiatives were established for current and future staff, students, patients, visitors, higher education partners and local schools. These are presented in Table 5.4.

5.2.8 Sustainability indicators

The SHESG developed an indicator set to establish a baseline and monitor progress made in the years 2012 to 2014. Relevant data are presented in Table 5.5.

Despite increased hospital activity and building size, over the 3-year monitoring period, energy and waste management were trending to target. Adjusted energy consumption shows a downwards trend of 14% on the 2012 patient bed-day. However, the 2020 targets laid down by the Irish Government are absolute, based on 2009 as the default baseline year (SEAI, 2014); therefore, further significant investment and energy management measures are required. The EPA-GHCP developed benchmarks based on kilograms waste generated per inpatient bed-day (EPA, 2014b). CUH falls below the benchmarks in all areas, except healthcare risk waste, indicating that further opportunities need to be investigated. The higher rate of healthcare risk waste might be

Table 5.4. Environmental education strategies for stakeholders in CUH

Target group	Initiatives	Details
Current and future staff.	Staff induction.	• Induction process updated to include sustainable healthcare briefing and orientation.
	Green Advocates.	• Green Advocate Training programme developed: includes initiatives undertaken within CUH plus practical sustainability tools and applications that can be taken back to the advocate's department/ward.
	On-site lecture series.	• Sustainability measures lecture series presented in on-site auditorium at grand rounds events.
	Training opportunities.	• Professional training and development opportunities for members of the SHESG and Green Advocates, internally from the HSE and external training bodies. • Integration of environmental protection into staff/student training.
Students.	Training.	• All placement students receive induction training where information on the CUH sustainability healthcare programme is provided.
	Invitation to become involved.	• Students invited to join both the SHESG and Green Advocate Network. • Acknowledgement and feedback provided to students contributing suggestions for improvements.
Maternity: new parents.	Maternity Green Guide.	• A factsheet hand-out for parents on green parenting, cost and waste saving opportunities.
Children's ward.	CUH School: Green-School.	• CUH School for children in hospital developed environmental lesson plans guided by Green-Schools.
	Intervarsity BioBlitz.	• "Skulduggery", a game which identifies animals by skeletal remains led by UCC students.
Visitors.	Communications plan and public events.	• Daily foot fall of ~4,000 people (excluding admissions) on-site, presenting environmental education opportunities.
Educational institutions.	UCC.	• UCC have held the Green-Flag since 2010 and are ranked 2nd in the world in UI Green Metric 2014 (Lauder *et al*., 2015). • Formal link between both environmental committees: UCC representatives on SHESG. • UCC taught module on Environmental Sustainability available to all students including those attending CUH. • A Liaison Group to develop policy and manage operational links between both organisations to support clinical research and professional health education and training.
	Cork Institute of Technology.	• Nursing students complete academic training in CIT and work placement in CUH. • SEECO Branding created by final year students as part of competition organised by CUH.
	Local schools.	• Local Green-Schools visited CUH and link on shared targets e.g. food waste.
Sustainable healthcare environment steering group (shesg).	Group learning.	• Learn from hospital community, feedback logged in register of opportunity. • Examination of best practice e.g. training, inviting speakers and linking with national and international peer groups.

Table 5.5. Sustainability indicators developed by the Sustainable Healthcare Environment Steering Group

	Indicator/unit	Baseline 2012	Performance 2013	Performance 2014	% Change 2012–2014
Hospital activity	Patient contact	597,382	608,650	660,650	+11
	Patient bed-day	222,907	234,752	244,949	+10
	Floor area (m²)	—	92,989	96,720	+4
Waste management Total waste	Total waste generated (tonnes)	1,813.45	1,678.62	1,601.20	–11
	Total waste (kg/patient bed-day)	8.14	7.15	6.54	–20
Breakdown of overall waste quantities	Mixed recyclable waste (tonnes)	225.66	272.97	298.01	+32
	Mixed recyclable waste (tonnes/patient bed-day)	1.01	1.16	1.22	+20
	Healthcare risk waste (tonnes)	596.79	589.18	575.87	–4
	Healthcare risk waste (kg/patient bed-day)	2.68	2.51	2.35	–12
	Food waste (tonnes)	70.46	67.04	74.43	+6
	Food waste (kg/patient bed-day)	0.32	0.29	0.30	–4
	Landfill waste (tonnes)	920.54	749.45	652.89	–29
	Landfill waste (kg/ patient bed-day)	4.13	3.19	2.67	–35
Waste recovered, recycled and composted	Total waste recovered (tonnes)	296.26	340.01	372.44	+26
	% waste recovered from total waste	16	20	23	+30

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explained by the structure of the hospital as a level one trauma centre with a higher surgical caseload (Xin, 2015). The environmental review revealed that over 20 separate waste streams are collected in CUH; however, for ease of reporting these are aggregated into four sub-grouped categories. Further opportunities exist to develop waste prevention techniques, given that separate collections are established, e.g. milk waste is collected separately in wards. Healthcare risk waste, comprising six categories, is collected in accordance with EU and Irish legislation but is reported collectively here for ease of comparison. Within departments, targets and monitoring exist, yet the lack of published verifiable data and clear case studies demonstrates the need for further research. The indicator set includes patient bed-days, which facilitates comparison with similar type hospitals, and the inclusion of total quantities allows for deeper trend analysis and identification of future targets.

Departments and wards within the hospital vary in autonomy in procurement. Some are limited to national procurement policy, others are limited by size in purchasing power, while others again have full control. This implies that there are many more opportunities for waste prevention strategies at national, hospital and departmental levels. Technical initiatives, particularly in energy conservation (Table 5.2), are relatively easy to assess, for example a lagged boiler versus an unlagged system. Savings attributable to increased staff awareness and front-of-house activities are more complex to verify and quantify. Records were not kept of savings arising from waste prevention measures. Record keeping is improving at the department level; however, centralised waste collection may perpetuate a lack of awareness of waste prevention opportunities. The SHESG maintain records of informing and involving (Table 5.3) and linking to learning (Table 5.4) events and initiatives on site as required by the

GCP. To date, CUH has over 110 green advocates and several departmental green teams.

5.3 Discussion and Conclusions

This work successfully applied a novel method for organising waste management in a hospital campus setting, with agreed and mutually re-enforcing bottom-up and top-down actions, based on a systemic view of campus functioning. It represents a model which may be adapted for a great number of large institutions and is expected to significantly increase the effectiveness of waste management in waste types currently not well managed. This programme presents an immense opportunity for CUH and other healthcare facilities to address waste related to infant feeding in a holistic way, and it is expected to result in better outcomes regarding waste management. The use of backcasting to address specific environmental problems within a healthcare setting shows significant promise as a means of unifying diverse stakeholders. Such techniques are particularly useful where international and national policies exist for desirable health and environmental outcomes.

5.3.1 Ensuring continuity and expansion of current initiatives

CUH began work on greening the organisation through two voluntary initiatives: EPA-GHCP and GCP. CUH has been working with the EPA-GHCP on water conservation measures. The GCP programme culminates in a Green Flag Award, based on the successful implementation of a seven-step process and a commitment to long-term continuation of the programme on site. As part of the assessment process for the GCP, in addition to demonstrating completion of the seven steps, CUH developed a continuity plan containing short-and long-term targets. The plan was reviewed by the GCP assessment panel, consisting of environmental specialists, and additional future targets and directions were negotiated. A formal assessment is made every 3 years to retain Green-Campus status. CUH renewed the Green Flag in June 2018 (CUH, 2018). By these means, CUH's engagement in a voluntary environmental accreditation has secured the development of targeted and realistic continuity plans and has ensured that initiatives are documented and that progress towards targets is continually assessed. The "CUH Green Charter" was developed and displayed publicly on websites, notice boards and hospital documentation.

5.3.2 Supports, support bodies and voluntary initiatives

Concerns regarding the use of voluntary initiatives and standards in industry and organisations have stemmed from their potential use to circumvent legislation, gain unwarranted positive publicity, reach marketing targets or bow to pressure from peers (Labatt and Maclaren, 1998). In this case, voluntary initiatives benefited public healthcare, where regulations and benchmarks are available for some targets (waste) but not for others (water, biodiversity, travel, a broader environmental agenda and preventative care to protect the environment). Notwithstanding, the importance of targets and the role of legislation should not be understated. However, engaging all members of staff is essential and this is where voluntary initiatives, when used in conjunction with regulation and strong peer group supports, can deliver positive results and innovation on unregulated but environmentally significant targets. Suitably qualified NGOs and other peer groups have proved to be trusted vectors to deliver environmental programmes in a non-judgemental framework. Both the EPA-GHCP and the GCP do not chastise the participants but rather assist them in developing better practice. The GCP is not based on a defined target and instead focuses on a process; the GCP programme supports the site throughout this. The focus on the process allows creativity and engagement with others, but, crucially, it ensures that decisions are made that are environmentally beneficial in the long term. Because it is both a programme and an award system, the focus on achieving and maintaining the award facilitates sustained change. The recognition of achievements is important since many of the efforts made by CUH drive environmental benefits that are far reaching but do not necessarily return revenue; for example, the removal of litter at the source prevents contamination of water courses, which protects marine biodiversity. The programme is led by a national environmental NGO, allowing CUH to become involved in further national sustainability initiatives (examples included in Table 5.3). Health Care Without Harm and GGHN are led by healthcare professionals and form a

suitable peer group for CUH, providing information on best practice and green medical research internationally (Karliner and Guenther, 2011; Boone, 2012).

5.3.3 Environmental education

Teaching hospitals offer unique opportunities to foster environmental education, as described in Table 5.4. Graduates move to other healthcare facilities, to other countries or into private practice. Delivering environmental education to healthcare practitioners creates a ripple effect that filters through the hospital, the wider healthcare system and, ultimately, society. A recurrent theme in healthcare and environment literature is that healthcare workers are undertrained and uninformed (Harhay *et al*., 2009; Ozder *et al*., 2013). Evidence from this case suggests that for most healthcare practitioners, patient safety takes priority and so a wider understanding of how unpolluted environments support patient safety is required. Green advocates were offered environmental training, which counted towards continuing professional development. Opportunities that hospitals can exploit as visible presences in cities may promote society scale environmental sustainability. Footfall of visitors and staff is high, so public engagement was included in CUH action plans. Some patients were receptive to environmental education (Table 5.4), green guides were developed for mothers in the maternity unit and the CUH school is enrolled in the Green-Schools programme. Informing and involving the local community increases environmental knowledge and action.

Disposal of waste with no associated environmental impacts is difficult to accomplish and it is challenging to identify contemporary examples where a waste stream is managed to focus entirely on reuse and recycling. Avoidance is often problematic as contemporary western lifestyles support an economy based on behaviours, which result in relatively high levels of consumption. Of course, continual consumption at this level supports economic activity, jobs and government tax income, so it is intricately linked to the wider organisation of society, which falls outside the scope of this study. However, it has been argued that to change behaviours to reduce the waste arising, disruptive and innovatory alternatives must be implemented.

5.3.4 Implications of case study to project and wider application

Although this project focuses on reducing waste arising in one aspect of healthcare, it also aims to provide a case study with wider application to other behaviours and other forms of consumption that support these. Here, the overall strategy adopted is summarised and it is this overall strategy which might have a wider application. The strategy may be characterised as a set of precepts. The first was to recognise that waste avoidance is often the most practical option. Once waste is created, there are often no clear paths to impact-free disposal. The second was that little can be achieved without the active involvement of consumers. Their behaviours are to be understood and they need to be more aware of both the impacts of the waste that they produce and the alternatives available to them. This underlines the need for guidance and education strategies that stress the need for innovative and sometimes disruptive actions, but which at the same time gives consumers clear understanding of issues. The third precept was that disruptive actions must be assessed carefully to avoid solving one problem by causing another. Managing this supply is complex because there are important health and hygiene issues, which are of paramount importance in a hospital setting. Changes to the way formula is provided and stored cannot compromise infant health and certain candidate disruptive actions may carry unacceptable risks to both infants and mothers

The fourth precept addressed the complexity of these issues, and states that, to be effective, finding holistic approaches to waste management requires the active participation of all major stakeholders. This is demonstrated here using the case study of the whole hospital approach, which allows a range of actions to be taken in a coordinated way, to maximise gain and avoid potentially risky consequences. In relation to RTU formula, this included assessment of procurement methods and the safe storage of unused milk, including expressed milk, through to the disposal of bottles and teats. Difficulties were identified: formula manufacturers operate in a competitive market and seek to hold or gain their market share. The recent switch from glass to bottle packaging by one company and the international sourcing of plastic bottles create difficulties for recycling in a situation where

avoidance and reuse are not easily achievable. On the basis of online search results, Ireland, in 2018, was found to have nine plants related to plastic recycling; however, of these only two appeared to produce new products and the plants recycled only two polymers. However, better management of partly used bottles was identified as an initial option, which is expected to reduce waste. Many waste streams operate even at the hospital scale; the fifth precept recognised that these streams require individual solutions, with different sets of stakeholders involved. The relatively small economy of Ireland is constrained by the sea; it faces the dual difficulties of a market too small to benefit from economies of scale and relatively expensive transport costs. Some waste streams are clearly more problematic than others. The final precept focused on the need for mainstreaming acceptance of the need for radical change in our behaviours. One route may be to have institutions such as hospitals educating their stakeholders through application of new practices, who in turn would disseminate these novel practices to their family and social contacts.

6 Key Findings and Recommendations from the Project

6.1 Summary and Evaluation of Findings

The development of enhanced waste management in hospitals is challenging. Gaseous, solid and liquid waste streams are generated, some of which are hazardous. Waste management strategies adopted clearly should not in any way compromise patient care. Hospitals are very busy organisations, with front-line staff under time pressure; strategies to enhance waste management are unlikely to be successful if additional and time-intensive duties are imposed on these staff. Recommendations included in the report are designed to be feasible within this challenging context.

This report provides a case study in the development of an approach to reduce the impact of healthcare on the environment. The identification of gaps in information, the methods adopted in data collection and analysis, the identification of the range of staff involved in taking action and the explanation of the types of actions that may be taken to reduce environmental impacts are all applicable to other waste streams. As such, they may be adopted or adapted in future studies focused on the larger impacts of healthcare on the environment and they are perhaps most likely to be successful in the context of a whole-hospital approach to waste management, as described in the report.

Within maternity units, the need to avoid food contamination is of crucial importance. In this context, food takes the form of milk, sourced either through breastfeeding, a breastmilk bank or bottled formulas or a combination of these. Utilising any of these sources of milk will create a waste stream and thus also the potential for environmental impacts.

Greater reliance on breastfeeding was found to reduce the maternity unit consumption of bottled formula and hence increased the complete or partial avoidance of gaseous, liquid and solid wastes arising from the manufacture, distribution and storage of both the product and its packaging, and the final disposal of unwanted product and the packaging. Avoidance is widely acknowledged as being the most advantageous waste management strategy. Breastfeeding creates a waste stream associated with end-of-life disposal of electrical and manual breast pumps and the storage of breastmilk. Few data were captured in relation to the frequency of use of different types of pumps in the maternity units, but observation suggested that, where possible, faulty pumps were repaired and in other case the end-of-life disposal followed current best practice.

Information gathered in the maternity hospitals allowed identification of a range of actions that, if implemented, would lead to a reduction in environmental impacts associated with the purchase and storage of formula; these are itemised in the report recommendations. Of significance, the report shows that when breastmilk is selected as infant food, advantages accrue in both healthcare (as identified by the WHO) and waste management. The report shows how this commonality may be used in raising awareness of the environmental implications of infant feeding decisions.

Plastic waste streams are complex and difficult to manage effectively and so the reduction in the use of plastic polymers in packaging is widely seen as a significant goal. The packaging of formulas is typically formed of a variety of polymers (types of plastic), many of which are not labelled clearly so as to be identifiable for recycling. As of 2019, only a few polymer types were recycled in Ireland and, to allow most efficient and feasible recycling, plastic packaging should be formed of these. Provision of bottle sizes more appropriate for neonates and the evaluation of the option of using paper rather than plastic packaging are further examples of recommendations made in the report.

Waste management within maternity units was considered to be more likely to be fully effective if carried out as part of a hospital-wide action plan to identify sources and mitigation measures to avoid or reduce waste arising.

Breastfeeding is likely to result in financial savings for maternity units and parents, resulting from the reduction in consumption of bottled products, but in this study it was not possible to establish the extent to which these financial savings have resulted in a reduction in overall environmental impacts.

Authors of this report work within sustainability science and are not qualified to offer advice or recommendations in relation to infant nutrition or to undertake ideographic research. In relation to information on nutrition, the report relied on literature published by international authorities, other organisations and journals and from expertise available through the project steering committee.

This report is based on evidence collected in 2014–2016 in two Irish hospital-based maternity units and it is acknowledged that waste management practices may be different in other maternity units and that the units may also have developed in effectiveness over time since then.

6.2 Key Findings

The research has evaluated the environmental impact of infant feeding decisions on healthcare and society, updating understanding of an area that little consideration had previously been given to in terms of waste reduction.

Key findings:

- At present, there is no standard practice in hospitals relating to the disposal of waste infant formula, suggesting that it is not yet viewed as a significant issue.
- There is no standard regarding the collection of data, maintenance of records, monitoring or evaluation. It was found that different methods were employed and that there were variances in the type of data collected. This gave rise to the necessity of estimating numbers for the purposes of this research.
- Of the three main brands of RTU formula, the bottle capacity of two were over triple, and one was five times the typical newborn infant's stomach capacity. This may result in up to 60% of the formula going directly to waste.
- The identification of materials used in the RTU formula bottles is not standardised. This is a global issue and makes it almost impossible for everyday users of the products to know how to dispose of them correctly, as the components cannot be readily identified.
- Education for, and implementation of, recycling practices surrounding RTU formula bottles could benefit hospital environments and raise awareness, including outside the hospital setting.
- An improved waste management system in hospitals is needed; this could be based on the ISO system.
- In cooperation with healthcare facilities, the opportunity exists for manufacturers to take back end-of-life products, which could generate its own resource stream.
- The strategy adopted by CUH to implement GCP and GHP could be replicated across the healthcare sector.
- For any of the recommendations outlined below, successful implementation requires buy-in by management and staff. A behavioural shift at all levels is needed, including in- and outpatients, suppliers and waste contractors.

6.3 Recommendations

In making recommendations, the research team are fully aware of the paramount need to maintain baby and mother health through rigorous hygiene, the provision of sterile products and the safe storage of perishable food. The research team are fully aware of financial and staffing constraints currently experienced in many hospitals. Given these considerations, the following recommendations are proposed.

6.3.1 Recommendation 1

For all healthcare facilities, relevant waste data regarding infant feeding decisions should be collected on an annual basis and made publicly available.

Hospitals already collect a wide range of healthcare data. For the collection of waste data to be successful and not to jeopardise patient care through additional workloads, hospitals might consider the appointment of a waste officer or sustainability officer. Data collection will require management support and resources. This research created the Infant Feeding Waste Review Tool, which is available to be used to establish baseline data regarding waste arising in Irish maternity wards. This tool could be utilised as a starting point for hospitals in waste management surrounding infant feeding. To aid in the collection and reporting of data, it is recommended that:

- a standardised core set of indicators for the sector, where relevant, is adopted and accepted, for which the Infant Feeding Waste Review Tool may act as a reference point;

- collection and publication of sustainability data takes place;
- an assessment framework for monitoring, reporting and evaluation is established;
- records of these data are maintained.

This collection of data would allow healthcare facilities to monitor their progress and to identify possible opportunities surrounding waste reduction. It would also standardise data collected across healthcare facilities. Furthermore, with a reduction in waste generated, there would be a reduction in associated costs. The money saved would create an opportunity for reinvestment in a process of ongoing improvement in waste management.

Recommendation 2

To address the consumption of formula and associated waste, environmental and education awareness campaigns must be developed and resourced.

Food waste is of major concern, especially in healthcare systems. Although ongoing actions to encourage mothers to breastfeed relate to health care, and thus fall outside the scope of this study, consideration might be given to include environmental benefits in future awareness-raising campaigns, which may aid in awareness raising in the wider public. This could help reduce waste through more informed choices in relation to infant feeding and increase the likelihood of RTU bottles being disposed of correctly in line with the waste management hierarchy, supporting the National Waste Prevention Programme. Hospital management will be pivotal in this success, as it will require resources.

Recommendation 3

Healthcare providers should ensure that procurement policies and practices reflect waste reduction priorities. Plastic waste is now generally regarded as a major environmental challenge and will require, among many actions, step changes, for example in packaging to address growing plastic waste quantities.

- In this context, hospitals and formula manufacturers might consider the reuse of glass bottles. However, a study of the environmental impact of glass and plastic in this setting would be needed to determine if a return to glass would be environmentally beneficial.
- Formula bottles were available in one size and contained too much liquid for smaller babies and neonates; consideration might be given to packaging formula in smaller bottles, in addition to current sized bottles, to reduce wastage.
- Hospitals and manufacturers should consider the possibility of delivering formula in larger containers to wards and dispensing this when and in the quantities required.
- There is potential scope for change in design of plastic bottles to allow for easy disassembly.
- Changes to hospital procurement procedures and formula management policies would help facilitate waste prevention and reduction.

Recommendation 4

EU and national policy is needed to bring about a standardised labelling system for all recyclable (healthcare) plastics.

The European Strategy for Plastics in a Circular Economy (EC, 2018) aims for all plastics packaging placed on the EU market to be either reusable or easily recyclable by 2030. For this to be achieved, the polymers used in all plastics packaging will need to be identifiable. RTU formula is currently packaged in plastic bottles formed of components of various polymer types, which complicates recycling. This highlights the need for a standardised EU labelling system and for manufacturers to comply with this coding for products for the EU market. Although policies and strategies at the EU level are in place regarding plastic use, more effort is needed to address plastic use in the hospital and healthcare settings. Currently, with respect to infant formula, EU regulations are based on food safety and relate to health claims in advertising. The regulations do not specifically address formula or formula packaging as waste products. Hospitals and manufacturers might consider redesigned bottles formed of polyethylene terephthalate (PET) or other polymers which are more readily recycled in Ireland.

Recommendation 5

Implementation of an improved waste management system in the healthcare setting is needed. Audits and assessments should support continual improvement.

Based on the experience reported here, across the healthcare sector standard practice regarding waste formula, bottle and breast pump disposal would result in benefits to the environment and society and it would also reduce associated economic costs. Experience suggests that waste management may be most effective in the context of a whole-hospital approach to reduction in environmental impacts. CUH adopted both the GCP and the EPA-GHCP. Consideration might be given to the development of a more comprehensive environmental programme that encompasses the areas covered by the GCP and the EPA-GHCP specifically for hospitals. Hospitals might consider developing and facilitating structures to spread awareness of environmental impacts and actions that can be taken. Consideration might be given to the appointment of waste management officers to initiate and coordinate actions. To facilitate whole-hospital actions to reduce environmental impacts, including greenhouse gas emissions resulting from consumption of energy and materials, hospitals might consider appointment and training of sustainability officers. This will require management commitment and resources for it be successful. Hospitals, where appropriate, might consider centralising and formalising the methods by which formula is purchased, stored and dispensed, to minimise unused bottles going to waste. As in the case of WEEE waste, cooperation with manufacturers for bottle take-back programmes would help to decrease the overall need for new materials and resources.

To date, the main thrust of regulation in healthcare has focused on product development and manufacture as distinct from use and decommission. For waste management to be successful, a comprehensive approach needs to be adopted with consideration given to stakeholder behaviour. This research represents an opportunity for the Irish EPA to support further studies to ensure all opportunities for waste management are identified and pursued.

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Abbreviations

BFHI	Baby-friendly Hospital Initiative
CUH	Cork University Hospital
CUMH	Cork University Maternity Hospital
EPA	Environmental Protection Agency
EPA-GHCP	Environmental Protection Agency Green Healthcare Programme
ESRI	Economic and Social Research Institute
FSAI	Food Safety Authority of Ireland
GCP	Green-Campus Programme
GGHHN	Global Green and Healthy Hospitals Network
HSE	Health Service Executive
NGO	Non-governmental organisation
PIF	Powdered infant formula
PSEEP	Public Sector Energy Efficiency Programme
RTU	Ready to use
SEAI	Sustainable Energy Authority of Ireland
SEECO	Social, environmental and economic sustainable change
SHESG	Sustainable Healthcare Environment Steering Group
UCC	University College Cork
UL	University of Limerick
UMHL	University Maternity Hospital Limerick
UNICEF	United Nations Children's Fund
WEEE	Waste Electrical and Electronic Equipment
WHA	World Health Assembly
WHO	World Health Organization

Appendix 1 Infant Feeding Waste Review Tool for Maternity Hospitals

Infant Feeding Waste Review Tool for Maternity Hospitals

General Information:

This section should be completed with ward managers

Hospital Name:	Circle Appropriate HSE/Voluntary Maternity only/General Hospital
EPA Green Healthcare Participant Yes/No	Baby-friendly Hospital Participation No/Participating/Awarded designation

Number of total live births in last calendar year:_____

Feeding of infants and numbers for last calendar year, i.e. 2014 *(report feeding only on maternity and neonatal wards)*

Number of babies breastfeeding from birth to discharge:_____

Number of babies receiving donor bank human milk:_____

Received combination of breast milk and infant formula during hospital stay:_____

Received infant formula only from birth to discharge:_____

Other/Comment: _____

Designated lactation consultant post(s) WTE: _____

Staff holding current International Board Certification but not in a designated lactation consultant post: _____

Number of bottles of infant formula allocated per infant per day: _____

Is a different number allocated on day of discharge?

Yes

No

If yes what is that number? _____

How do wards obtain infant formula?

Ward maintains its own store

Order from central storage

Other: _____

Frequency of delivery to ward

Daily

Monthly

Weekly

As required

If ward maintains its own store what size is this?_____

Maximum capacity_____

How much is routinely stored? _____

Total quantity of banked human milk bought per annum (litres):_____

Container volume (ml):_____

Delivery frequency:

Weekly

Monthly

As required

Other: _____

Delivery mode:

Direct from milk bank

From central stores

Other: _____

Storage:

In neonatal unit

In pharmacy

Stored other

Cost per annum or per litre: _____

Infant feeding materials purchased by the hospital

This section needs the input of stores/pharmacy to ascertain quantities purchased within the hospital

Equipment	*Provided? (Y/N)*	*Overall quantity provided (in last calendar year)*	*Comment*
Hand pump			
Electric pump (small for personal use)			
Funnel/connection set for hospital electric pump			
Milk storage containers			
Nipple shields			
Nipple creams and ointments:			
Breast pads:			
Feeding pillows:			
Feeding cups:			
Other:			
Other:			
Other:			
Comments:			
Infant formula, bottles and teats			

Brand name and type: ___________________________________ Volume contained in bottle (ml) _________ Bottle type: Glass Plastic Cost per unit:________________________ Number of units purchased per annum:___________ Description of packaging (e.g. 24 bottles per tray, shrink wrap and cardboard) ___________________________________ ___________________________________ ___________________________________	**Brand name and type:** ___________________________________ Volume contained in bottle (ml)_______________ Bottle type: Glass Plastic Cost per unit:________________________ Number of units purchased per annum:___________ Description of packaging (e.g. 24 bottles per tray, shrink wrap and cardboard) ___________________________________ ___________________________________ ___________________________________
Brand name and type: ___________________________________ Volume contained in bottle (ml)________________ Bottle type: Glass Plastic Cost per unit:________________________ Number of units purchased per annum:___________ Description of packaging (e.g. 24 bottles per tray, shrink wrap and cardboard) ___________________________________ ___________________________________ ___________________________________	**Brand name and type:** ___________________________________ Volume contained in bottle (ml)_______________ Bottle type: Glass Plastic Cost per unit:________________________ Number of units purchased per annum:___________ Description of packaging (e.g. 24 bottles per tray, shrink wrap and cardboard) ___________________________________ ___________________________________ ___________________________________
Brand name and type: ___________________________________ Volume contained in bottle (ml)________________ Bottle type: Glass Plastic Cost per unit:________________________ Number of units purchased per annum:___________ Description of packaging (e.g. 24 bottles per tray, shrink wrap and cardboard) ___________________________________ ___________________________________ __________________________________	**Brand name and type:** ___________________________________ Volume contained in bottle (ml)_______________ Bottle type: Glass Plastic Cost per unit:________________________ Number of units purchased per annum:___________ Description of packaging (e.g. 24 bottles per tray, shrink wrap and cardboard) ___________________________________ ___________________________________ ___________________________________
Brand name and type: ___________________________________ Volume contained in bottle (ml)________________ Bottle type: Glass Plastic Cost per unit:________________________ Number of units purchased per annum:___________ Description of packaging (e.g. 24 bottles per tray, shrink wrap and cardboard) ___________________________________ ___________________________________ ___________________________________	**Brand name and type:** ___________________________________ Volume contained in bottle (ml)________________ Bottle type: Glass Plastic Cost per unit:________________________ Number of units purchased per annum:___________ Description of packaging (e.g. 24 bottles per tray, shrink wrap and cardboard) ___________________________________ ___________________________________ ___________________________________

Teat brand name: _____ Material: Latex Silicone Other Cost per unit:_____ Number of units purchased in last calendar year: _____ Packaging description (e.g. 24 bottles per tray, shrink wrap and cardboard) _____ _____ _____	**Teat brand name:** _____ Material: Latex Silicone Other Cost per unit:_____ Number of units purchased in last calendar year: _____ Packaging description (e.g. 24 bottles per tray, shrink wrap and cardboard) _____ _____ _____	**Teat brand name:** _____ Material: Latex Silicone Other Cost per unit:_____ Number of units purchased in last calendar year: _____ Packaging description (e.g. 24 bottles per tray, shrink wrap and cardboard) _____ _____ _____
How is infant formula procured? By hospital stores direct with supplier By central procurement for region/group of hospitals Other: _____ How frequently are stocks replenished? Stores supplies automatically based on previous orders To keep ward stack at a set minimum level Other: _____		
Frequency of formula delivery (number of orders and delivery from suppliers in the last calendar year): _____		
Breast pumps available? For use in hospital No Is a breast pump rental scheme available through the hospital? No Rental scheme run by hospital for all mothers Rental scheme run by hospital for mothers of premature infants Rental scheme by independent company Rental scheme by charity Comments: _____		
For breast pumps provided by hospital		
Brand name:_____ _____ Type: Manual Electric Numbers held in stock:_____ Parts replacement/repair options? Yes, on site Yes, off site No Replacement policy: _____	**Brand name:_____** _____ Type: Manual Electric Numbers held in stock:_____ Parts replacement/repair options? Yes, on site Yes, off site No Replacement policy: _____	**Brand name:_____** _____ Type: Manual Electric Numbers held in stock:_____ Parts replacement/repair options? Yes, on site Yes, off site No Replacement policy: _____

Brand name:_____	**Brand name:**_____	**Brand name:**_____
Type:	Type:	Type:
Manual	Manual	Manual
Electric	Electric	Electric
Numbers held in stock:_____	Numbers held in stock:_____	Numbers held in stock:_____
Parts replacement/repair options?	Parts replacement/repair options?	Parts replacement/repair options?
Yes, on site	Yes, on site	Yes, on site
Yes, off site	Yes, off site	Yes, off site
No	No	No
Replacement policy:	Replacement policy:	Replacement policy:
_____	_____	_____
How are breast pumps procured?		
Centrally		
By ward		
As required		
As per tendering schedule		
Does the hospital/unit have a biomedical engineering department?		
Yes		
No		
If yes, do they maintain and store breast pumps?_____		
Are pumps repaired or serviced?		

Waste Management

This section should be completed with estates management

Who manages waste on site:
Waste manager
Porters
Other:_____
Does the site have a discharge to sewer permit?
Yes
No
Other: _____
Waste management facilities on site?
Compactor
Glass recycling collection point
Plastics collection point
Cardboard and waste paper collection point
Mixed dry recyclables collection
Waste electronic and electrical equipment collection
Other: _____
Comments:_____
_____

How is waste infant formula disposed of?

With bottle and teat in waste bin

With bottle and teat in recycling bin

Waste formula is poured down sink

Waste formula is collected separately, bottle and teat disposed of separately

Other:_____

If waste formula liquid is collected separately:

What type of containment is used to store liquid waste?

At ward level:_____

At hospital level: _____

How much generated per day? _____

Who removes from ward to hospital waste storage? _____

How often is waste removed from ward?_____

Where does waste go to ultimately? (composting, anaerobic digestion etc.)

_____

Waste bottles and teats:

Who disposes?

Parents

Nurses/midwives

Health assistants

Cleaning staff

Other:_____

Are bottles and teats disposed together?

Yes

No

Are plastics and glass separated?

Yes

No

Rinsed using water?

Yes

No

Cost of glass recycling? _____	Cost of formula milk Disposal _____	Cost of plastic recycling _____	WEEE costs/Register _____	Cost of paper and cardboard _____
% attributable to infant feeding _____	% attributable to infant feeding _____	% attributable to infant feeding _____	% attributable to infant feeding _____	% attributable to infant feeding _____

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL
Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: *Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

Eolas: *Soláthraímid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.*

Tacaíocht: *Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaol atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaol inbhuanaithe.*

Ár bhFreagrachtaí

Ceadúnú
Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaol:
- saoráidí dramhaíola *(m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola)*;
- gníomhaíochtaí tionsclaíocha ar scála mór *(m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta)*;
- an diantalmhaíocht *(m.sh. muca, éanlaith)*;
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe *(OGM)*;
- foinsí radaíochta ianúcháin *(m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha)*;
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil
- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Uisce
- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaol
- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil *(m.sh. tuairisciú tréimhsiúil ar staid Chomhshaol na hÉireann agus Tuarascálacha ar Tháscairí)*.

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn
- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil
- Taighde comhshaoil a chistiú chun brúnna a shainaithint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta
- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaol in Éirinn *(m.sh. mórphleananna forbartha)*.

Cosaint Raideolaíoch
- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas
- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol *(m.sh. Timpeall an Tí, léarscáileanna radóin)*.
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta
- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil
Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:
- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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Developing Frameworks for Evaluation and Mitigation of Environmental Impact of Infant Feeding Decisions on Healthcare and Society

Authors: Bernadette O'Regan, Richard Moles, Yvonne Ryan-Fogarty and Rachel Shawe

Identifying Pressures

Healthcare institutions, in an important way, are especially complex settings for taking action to reduce waste. Healthcare employees have many responsibilities; core to this are the health and welfare of patients. This research conducted a study of two Irish maternity units to estimate the range and amount of waste products produced. Parents decided on the initial diet for their new-born infants: breast milk alone, bottled breast milk substitute alone or a combination of both. Bottled milk created waste in maternity units, for example through the disposal of packaging (predominantly plastic) and unused milk (with a high biological oxygen demand). Breast milk created waste streams, for example waste electrical and electronic equipment (WEEE) through the disposal of breast pumps and energy used in the refrigeration of stored milk. A Review Tool, in the form of a set of questions, was developed in order to facilitate the speedy collection of key data in maternity units and identify key personnel who could supply the answers to the Review Tool questions.

Informing Policy

The medical implications of parental decisions regarding the feeding of infants fall outside the scope of this study. The aims of the *National Waste Prevention Programme: Towards a Resource Efficient Ireland. A National Strategy to 2020* are supported in this study through evaluation and mitigation of wasteful consumption. The *National Hazardous Waste Management Plan 2014–2020* is supported through the identification of a previously unreported source of WEEE. Waste management best practice, as set out in *A Resource Opportunity: Waste Management Policy in Ireland*, is supported through identifying feasible resource efficiency measures. Food procurement is one of eight priorities identified within *Green Tenders: An Action Plan on Green Procurement*. This report identifies actions that are designed to mitigate impacts associated with the procurement of ready-to-use breast milk substitutes. The report explores ways of mainstreaming mitigation measures identified in maternity ward case studies, thus supporting a wider agenda for sustainable development, as set out in *Our Sustainable Future: A Framework for Sustainable Development in Ireland*. The study exemplifies the need for, and constraints on, close ties between environmental protection and healthcare provision.

Developing Solutions

Five recommendations within the report identify key issues and, for each, solutions are identified and explained. It was noted that data on waste arising in maternity units were not recorded systematically. Measuring future progress will require better record keeping. The findings suggest that awareness across healthcare personnel and parents about the environmental impacts of infant feeding decisions was often poor. Renewed awareness-raising campaigns are suggested. Procurement policy must reflect the need to maintain the highest standards in healthcare, allied to waste reduction as a priority. Actions to reduce the disposal of unwanted milk to mains drainage are explored. This study found that efficient recycling of plastic bottles that are often used for ready-to-use breast milk substitutes is made difficult as the packaging contains a variety of materials, some of which do not allow identification of the polymer type. The recommendations will have more general relevance for reducing plastic waste. From an environmental perspective, increasing numbers of parents opting for breastfeeding will result in a reduction in the use of plastic bottles, and all reductions in WEEE are to be welcomed. Confining actions to individual maternity units only is unlikely to be fully effective in minimising wastes. This report presents a case study in the adoption of a whole-hospital approach to waste management.

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