

Greening Healthcare: Systematic Implementation of Environmental Programmes in a University Teaching Hospital

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1 Highlights

- *Healthcare contributes significantly to environmental degradation*
- *Healthcare sustainability requires inclusive, interacting policies*
- *Coordination of stakeholders' actions is a prerequisite to facilitate change*
- *Action frameworks including education facilitate inclusiveness and coordination*
- *Cooperation amongst stakeholders reduces risks of unintended consequences*

2 Abstract

The provision of healthcare creates significant environmental impacts, and their mitigation is being attempted in a variety of ways which vary from nation to nation in line with differing policy priorities and resource availability. The environmental performance of hospitals has been enhanced through, for example, green building, waste and energy management, and product design. However, unpredictable occupant behaviour, new research outcomes and evolving best practice requires healthcare to react and respond in an ever challenging and changing environment, and clearly there is no one set of actions appropriate in all jurisdictions. Many authors have pointed up negative environmental impacts caused by healthcare, but these studies have focused on particular aspects of mitigation in isolation, and are for this reason not optimal. Here it is argued that tackling impact mitigation through a whole system approach is likely to be more effective. To illustrate what this approach might entail in practice, an evaluation of a systematic implementation of impact mitigation in Ireland's largest teaching hospital, Cork University Hospital is presented. This approach brings together voluntary initiatives in particular those emanating from governmental and non-governmental organisations, peer supports and the adaptation of programmes designed originally for environmental education purposes. Specific measures and initiatives are described, and analysis of results and planned future actions provides a basis for evaluation of successes achieved in achieving mitigation objectives. A crucial attribute of this approach is that it retains its flexibility and connectivity through time, thereby ensuring continual responsiveness to evolving regulation and best practice in green healthcare. It is demonstrated that implementation in Cork resulted both in mitigation of existing impacts, but also a commitment to continual improvement. For such a systems approach to be widely adopted, the healthcare sector needs both leadership from regulators and stakeholders, and strong supports. In Cork it was found that environmental education programmes, especially action and reward based programmes, as utilised by the campus's academic affiliates in particular University College Cork, were especially effective as a framework to address sustainability challenges and should be developed further. This approach has now been adopted for delivery across the health services sector in Ireland¹.

¹**Abbreviations** CUH: Cork University Hospital, EPA-GHCP: Environmental Protection Agency Green Healthcare Programme, GCP: Green-Campus Programme, GGHHN: Global Green and Healthy Hospitals Network, HSE: Health Service Executive, NGO: Non-Governmental Organisation, SHESG: Sustainable Healthcare Environment Steering Group, UCC: University College Cork,

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1 Introduction

Incorporation of sustainable development (SD) in higher education facilities presents significant challenges such as: strengthening SD competencies, facilitating multi-stakeholder dialogue between organisations and individuals, consistency and rigour of methods, ensuring relevance, benchmarks and quality, systemic approaches and promotion of campus sustainability (Leal Filho et al., 2015). Evidence of campus' engagement in sustainability initiatives is growing, some elect for public commitments to act on sustainability through peer agreements and declarations (Lozano et al., 2013), peer support networks have been established e.g. Environmental Association for Universities and Colleges in the UK, whilst more engage in metrics and rankings (Lauder et al., 2015). Prior to the emergence of green rankings, concerns had been expressed regarding the use of cross institutional comparison assessment tools, noting that the more useful tools "reflect the transition in thought from environmental management to management for sustainability" (Shriberg, 2002) and more recently calls have been made for means to recognise campus community participation in assessment tools (Disterheft et al., 2015) and the significance of human factors, empowerment and communication in delivering change (Verhulst and Lambrechts, 2015). Systematic approaches are required to green campuses; they are complex ecosystems comprising many independent components and successful evolution necessitates consideration of all of these components (Koester et al., 2006). Some best practice guidance on greening education is available through international peer reviewed literature and support organisations, yet there is also a need to "better link commitment and implementation through holistic SD approaches". Grass root, student led initiatives on campus sites have proven effective (Mason et al., 2003; Reidy et al., 2015) as recognition grows that key life events such as starting university, changing employment, becoming a parent etc. present opportunities to influence behaviour and induce sustainable consumption patterns in creative ways (DEFRA, 2011; Ongondo and Williams, 2011).

Healthcare is a major contributor to environmental pollution contributing pathological, pharmaceutical, chemical, radioactive, health risk and other wastes (World Health Organization, 2014). Retrofits of facilities with new technologies and new-build greener hospitals have yielded positive results (Thiel et al., 2014). However due to economic constraints, refurbishments, new builds and technologies cannot be solely relied on to deliver required environmental improvements (Huesemann, 2011), and existing facilities must act. There is a growing body of research comparing reusable and single use medical instruments (Campion et al., 2015; Sørensen and Wenzel, 2014), water conservation and wastewater treatment (Faezipour and Ferreira, 2014; 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, including hazardous waste management continues to feature in sustainable healthcare research (Gavilán-García et al., 2015; Saad, 2013; Xin, 2015). This is hardly surprising, since Harhay et al. (2009) reported that approximately 50% of the world's population are 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). Whilst 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 distinct from procurement, distribution, use, and decommission. Best practice guidance on sustainable healthcare tends to come from international bodies such as the World Health Organisation and Healthcare Without Harm; however 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 present that do not deliver direct financial benefits or contribute to legislative compliance, yet make a meaningful contribution to the environment and society, for example, prioritising preventative care where fewer health interventions ultimately reduce associated environmental impacts (Weisz et al., 2011). In a comprehensive review of environmental sustainability in hospitals, McGain and Naylor (2014) identified a need for additional information to guide decision-making, and better inter-disciplinary coordination in research, to deliver more sustainable healthcare.

To help fill this gap, this paper is structured around a case study of Cork University Hospital, Ireland (CUH) and aims to explain and evaluate a systems based action framework designed to create synergies between both regulatory requirements and voluntary initiatives, supported by government agencies and NGOs, so as to best meet environmental impact mitigation objectives. The framework and actions are presented in relation to energy and waste management. Initiatives within an environmental education programme, previously successfully adopted by educational institutions, to illustrate and evaluate examples of technical and support measures adopted in CUH are evaluated. Nascent work on water conservation, sustainable travel, biodiversity enhancement and developing wider visions and actions for sustainable healthcare within CUH are discussed. While other healthcare institutions in Ireland and elsewhere may be expected to have different priorities, the authors believe that the framework is sufficiently flexible to accommodate this and will have wide application, and offer reasons why this should be so.

2 Material and Methods

This research was facilitated through the active participation of CUH, which had selected as a policy priority the enhancement of environmental management. The hospital sought external expertise in implementation of environmental initiatives and was advised to establish a representative environmental committee, which included an author of this paper (YRF). The research team had full access to allow both input into the approach to be adopted by CUH, and also allow evidence based evaluation of the effects of policy and action effectiveness. CUH decided to apply for accreditation under the Green-Campus Programme (GCP) (EnviroCentre, 2014) and the research team acted as advisors in successfully achieving this. Data sources included, pre-programme implementation screening, policy implementation reports required within Green-Campus applications, and published descriptions of policy outcomes from CUH, the National Health Sustainability Office, the Irish Environmental Protection Agency (EPA) and the Sustainable Energy Authority of Ireland (SEAI). This paper is structured so as to reflect the Seven Steps of the GCP, namely establishing an environmental committee, conducting an environmental review, developing an action plan, monitoring and evaluation (using sustainability indicators), informing and involving, linking to learning on campus and developing a green charter (to ensure continuity).

2.1 The Study Site

CUH is the largest teaching hospital and only Level 1 trauma centre in Ireland, containing >40 medical and surgical specialities. Whole time equivalent staff and student numbers totals 3,297 and 408 respectively. During 2013 the hospital catered for 234,752 patient bed days, 166,103 outpatient attendances and 15,983 births. The hospital contains 18 buildings with a total floor area of 96,720m². As with all Irish hospitals, government austerity policy in recent years has resulted in a tightening in budgets and reductions in staff numbers. The hospital's main academic affiliation lies with UCC, a campus making sustained efforts toward SD and engagement in diverse SD initiatives e.g. GCP and 2nd placed in UI Green Metric 2014 (Lauder et al., 2015; UCC Green Campus, 2015). The sites are not co-located and do not share facilities, other management or budgets. UCC have 11 affiliated teaching hospitals (UCC School of Medicine, 2015), in addition students present in CUH come from many other higher education institutions and disciplines (midwifery, nursing, pharmacy etc.).

2.2 Environmental Programmes Employed

CUH requested to join the GCP in 2010 and was accepted to participate as a teaching hospital; its academic affiliate, University College Cork (UCC), was the first Irish university to implement the GCP. The GCP is both an environmental education programme and award system based on the International Eco-Schools Programme. The Eco-Schools programme is based on ISO 14001 (Hens et al., 2010; Nan et al., 2006). In Ireland the programme is known as Green-Schools and coordinated by an environmental NGO. 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 the 7 step environmental management system. Participants are facilitated to determine which environmental targets to pursue; some organisations have extensive buildings and estates management whilst others do not. Green-Campus status stipulates that institutions be registered a minimum of 1.5 academic years and have implemented all 7 steps of the programme. Assessment is site-specific based on a written application submitted to an assessment panel, followed by a site audit and interview. In order to retain GCP status, annual renewal reports must be submitted with full reassessments required every 3 years (An Taisce, 2014).

CUH enlisted in the Irish EPA's Green Healthcare Programme (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 (Environmental Protection Agency, 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 Healthcare Without Harm, a global network of healthcare systems that research and develop guidance on issues pertaining to healthcare and environmental sustainability (Healthcare Without Harm, 2015). The SEAI developed the PSEEP (SEAI, 2015), consisting of resources, training and peer support for energy management, in order to assist the public sector to meet national commitments to improve energy efficiency by 33% by 2020 (Ireland, Department of Communications, Energy and Natural Resources, 2009). Because CUH is publically funded, it is obliged to meet these targets; however, participation in the PSEEP is voluntary.

2.3 Internal Management Interventions: Sustainable Healthcare Environment Steering Group, Green Advocates and Green Teams

Within CUH a Sustainable Healthcare Environment Steering Group (SHESG) was formed and a Sustainable Environment Officer appointed in 2013, previously CUH had one part-time waste officer and no energy manager. The Irish public healthcare system is managed by the Health Service Executive (HSE) with buildings management shared on regional rather than site requirements. The SHESG, appointed by the Senior Management Group for two year terms, includes representatives from hospital management, medical specialties, HSE, and UCC representatives including management and students.

The SHESG identified as most significant the challenges of resource availability and staff engagement. With the exception of energy reduction targets, the implementation of environmental programmes is a voluntarily undertaking for staff within the hospital (additional to other duties). Therefore, the engagement of frontline staff, although crucial, provided a significant challenge because of workload demands, staffing and funding level constraints where the main priority of clinical staff is delivery of high standard patient care. To address these issues the SHESG established a Green Advocates Network, following the advocacy model in healthcare. The advocacy role is

voluntary and the steering committee aimed to have Green Advocates and Teams in every ward and department. Not all departments have Green Teams e.g. the Porter Service, which is not locational or departmental based, have a number of Green Advocates but no Green Team. In this way all employees with an interest in environmental improvement can participate regardless of department, job title or location.

2.4 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 Green Advocate Network and stakeholders were logged into the Register of Opportunities for further discussion and action.

2.4.1 Energy

The Irish Public Sector has committed to improve energy efficiency by 33% by 2020, in order to expedite this resources and training were provided to CUH through the PSEEP. The energy review was conducted by the HSE Regional Energy Champion and CUH Sustainable Environment Officer and results were disseminated to the SHESG. The review methodology and major findings are compiled in Table 1.

Review Method	Key Findings
Energy billing analysis <i>Spend on energy and analysis of consumption outlined by bills and invoices for electricity, natural gas, fuel oil, and water</i>	No evidence of cross departmental communications regarding energy spend and consumption Meters installed on larger power distribution boards but no evidence that metering was checked i.e. there were no further analysis other than bills received Discovered additional gas point references on site for analysis Annual energy spend approximately €3,144,000
Detailed analysis of energy consumption by use, process and time <i>Identification of primary and secondary energy as well as consumption patterns and opportunities for improvement</i>	Electricity costs more than gas despite consumption per kWhr being less, previous targets focused on cost reduction, new targets to focus on demand reduction Identified high energy use departments Identified high energy use equipment as priority for intervention measures Degree day analysis showed heating control opportunities
Appliance and technical audit <i>Overview of services infrastructure on site including high energy use departments and equipment</i>	Single Display Energy Certificate for the entire site due to lack of sub-metering, energy certificate not reflective of true rating of each building Inefficient lighting and fixtures identified Opportunity for reuse of stored diesel on site Air conditioning units require timers and controls Opportunity to increase energy efficiency in radiotherapy units Valves and pumps not lagged in plant room Potential to reduce boiler cycling and reduce internal heat losses Opportunities for improvements in wards and departments
Energy Management Diagnostic Assessment <i>A self-analysis tool used to track improvements in the organisations level of understanding of energy management</i>	Identified where staff knowledge of energy management was low Identified education opportunities for key stakeholders Analysed barriers to development of effective energy management systems

Energy Efficiency Design Review Process <i>New buildings in design phase, potential for future energy conservation opportunities</i>	Potential use for monitoring and evaluation purposes New buildings planned in future An Energy Efficient Design review process required to future projects
Energy People Matrix Profile <i>Examined six elements: commitment, awareness, motivation, promotion, training and momentum of SHESG and Green Advocates</i>	Energy efficiency viewed as a peripheral issue, patient care more important Differing views showed disparity between management and frontline staff Awareness levels relatively low Identified training needs of frontline staff

Table 1: Energy Review Methods and Key Findings

2.4.2 Waste

Initial waste characterisation including detailed analysis of food and healthcare risk waste together with reports containing specific recommendations were provided by the EPA-GHP 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 2.

Method/ Description	Key Findings
General Waste Management: Overview <i>An overview of waste management practice, ensuring compliance with legislation</i>	All waste disposal and collection is in compliance with national legislation Waste services contracts are managed centrally by the HSE through Service Level Agreements. CUH have input into tender specifications Contract caterers and other contractors working in the hospital are obliged to remove their waste Identified over 20 separate waste collection streams on site Waste is benchmarked against EPA indicators although there is a need for internal waste metrics
Food Waste Survey <i>Portion size and composition of food reviewed</i>	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
Hazardous Waste Management: Laboratories <i>Review of microbiology, pathology, histology, haematology, clinical biochemistry</i>	Identified and quantified hazardous wastes Best practice requirements identified for prevention, storage, recording, and management
General and Healthcare Risk Waste <i>Categorised and quantified wastes arising in every part of the hospital</i>	Potential for increased waste prevention, better segregation and waste management costs reductions across all departments Some wards not recycling glass and infant formula disposed to waste water Polystyrene and non-reusable cups in use Some offices not recycling or preventing paper waste Inadequate numbers of recycling bins to meet demand
External Litter Survey	25 external bins No records of quantities collected Litter black spots identified
Review of good practice	Prevention: food waste prevention measures, non-toxic cleaning solutions, refill

<i>Identified waste prevention, minimisation, recycling and reuse practices to ensure continuity and further enhancement</i>	toners and inks, reduced packaging in purchasing contracts Minimisation: printing instructions, rechargeable batteries, durable equipment covered by warranties, daily deliveries in reusable containers Reuse and Recycling: cooking oil, paper used internally, interoffice envelopes, ceramic cups and glasses in addition to paper based versions
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Table 2: Waste Review Methods and Key Qualitative Findings

Supplementary to the findings of reviews presented in Tables 1 and 2, additional opportunities and staff suggestions were captured in the Register of Opportunity.

2.5 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 Green-Charter. The action plan remains a live document to guide implementation of environmental performance targets on site.

In terms of energy and waste savings measures, all issues identified in Tables 1 and 2 were addressed through the action plan. Responding to the overarching energy target set by the national government, 33% reduction in energy consumption by 2020, CUH have targeted 5-10% annual energy consumption reductions. Currently there are no public sector targets pertaining to waste management; however, CUH wished at least to meet benchmarks set by the EPA-GCHP programme.

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

2.5.1 Technical Initiatives

Back of house initiatives refer to engagement with specific systems or key staff and can be described as being technical and process driven in nature as opposed to the wider hospital community involvement described in the front of house initiatives. Technical initiatives in order to increase energy efficiency both implemented and planned are listed in Table 3.

Energy Reduction Measures 2013-2014	Planned Investment
Low voltage area distribution board metering (to improve monitoring)	Thermal insulation and pump upgrades in plant rooms
Lighting upgrades	Further boiler house upgrades
Cleaning and recycling of stored diesel	Controls and external lighting upgrades
Timer controls on air conditioning units	Heat recovery on air handling units
Air Handling Unit controls in Radiotherapy Units	Building fabric upgrades
Lagging jackets for valve and pump sets in plant rooms	Upgrade of building management systems
Boiler optimisation	Subdivision of heating circuits
Engagement with high use departments	Electric car charge points

Checklists for wards and departments

Renewable energy options

Display Energy Certificate applied and displayed

Energy Efficiency Design review process established and used on design of new unit

Table 3: Past and Planned Investment in Technical Energy Efficiency Solutions

Return on investment analysis conducted for all technical solutions showed that payback periods varied between 9 months and 3 years. However, it is estimated that to bring the hospital to the 2020 energy reduction target, investment in the region of €750m is required. Waste management initiatives are listed in Table 4.

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 infant 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

Table 4: Back of House Waste Management Solutions

2.5.2 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 and that stakeholders within the hospital and outside in the wider community needed to participate in order 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 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 lists further informing and involving actions.

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
Energy and Waste Reporting	Detailed energy and waste monitoring Data presented: consumption, carbon dioxide emissions, costs, degree day analyses, and key waste management statistics Specific actions communicated to staff Made data relevant to staff e.g. "energy saved = heating and power to 66 households for 1 year" Developed Best practice checklists for wards, offices, and laboratories
Environmental Events	Green Home Hub established for staff to utilise sustainability principles at home Energy and waste exhibitions, information stands, and experts on hand to meet staff and visitors
Cross Departmental Co-operation	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 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

Engagement with national and international peer institutions	National Spring Clean in locality Facilitation of National HSE Training Day on site Presentation at HSE National Sustainability Office Events SEAI Advance Awareness programme with public sector institutions Linking with GCP and GGHHN participants nationally and internationally
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Table 5: Informing and Involving Initiatives and Actions

2.5.3 Linking to learning

The SHESG, 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 6.

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 advocates 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 both 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
	Interschool 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 2 nd 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
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 6: Linking to Learning Initiatives

3 Results and Discussion

In this section outcomes and results of application of the framework are described and evaluated. Included, as results, are the emplacement of monitoring and evaluation methods adopted and mechanisms to ensure continuity in implementation of all steps of the GCP. The Discussion focuses on identification of crucial supports for the healthcare sector and those within it who work to implement sustainability initiatives in hospital settings.

2.6 Sustainability Indicators

The SHESG developed an indicator set to establish a baseline and monitor progress made since 2012, and relevant data are presented in Table 7.

	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 m ²	-	92,989	96,720	+4
Energy Management	Energy kWhr	40,585,925	41,545,925	41,106,196	+1
Total Energy: Actual Consumption	Energy Conversion to tonnes CO ₂	14,038	14,254	14,308	+2
Total Energy: Adjusted (takes account of energy consumption arising from change of use and additional heating capacity)	kWhr	40,585,925	39,468,628	38,543,520	-5
	kWhr/patient bed-day	67.94	64.85	58.34	-14
	Energy Conversion to tonnes CO ₂	14,038	14,211	13,255	-6
	Kilogram CO ₂ /patient bed-day	23.50	23.35	21.60	-14
Waste Management	Total waste generated tonnes	1,813.45	1,678.62	1,601.20	-11
Total Waste	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	2.68	2.51	2.35	-12

		kg/patient bed-day			
	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	296.26	340.01	372.44	+26
	% waste recovered from total waste	16	20	23	+30

Table 7: Energy and Waste Management Indicator Set

Despite increased hospital activity and building size, over the three year monitoring period, energy and waste management are trending to target. Energy consumption adjusted shows a downward 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 in-patient bed-day (Environmental Protection Agency, 2014b). CUH falls below the benchmarks in all except healthcare risk waste, indicating that further opportunities need to be investigated. The higher rate of healthcare risk waste might be explained by the structure of the hospital as a Level 1 Trauma Centre with a higher surgical caseload (Xin, 2015). The environmental review (Table 2) revealed that over 20 separate waste streams are collected in CUH, however, for ease of reporting these are aggregated into 4 sub grouped categories. Additional resource efficiency and waste prevention opportunities exist given that separate collections are in place for many materials and wastes e.g. milk and infant formula milk wastes are collected separately in wards. Healthcare risk waste, comprising 6 categories, is collected in accordance with EU regulations and Irish legislation, but reported collectively for ease of comparison. Within departments, targets and monitoring exist, yet the lack of published verifiable data and clear case studies demonstrates need for further research. The indicator set includes patient bed-days 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, whilst others have full control. This implies that there are many more opportunities for waste prevention strategies at national, hospital and department levels. Technical initiatives, particularly in energy conservation (Table 3), are relatively easy to assess, for example a lagged boiler versus un-lagged 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 as identified in Table 4. 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), and linking to learning (Table 6) events and initiatives on site as required by the GCP. To date, CUH has over 110 Green Advocates and several departmental Green Teams.

2.7 Ensuring Continuity and Expansion of Current Initiatives

CUH began work on greening the organisation through two voluntary initiatives, EPA-GHCP and GCP. CUH are currently 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 7 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 7 steps, CUH developed a continuity plan containing short and longer 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 three years in order to retain Green-Campus status. By these means CUH's engagement in a voluntary environmental accreditation has secured the development of targeted realistic continuity plans, ensured that initiatives are documented, and progress toward targets is continually assessed. The "CUH Green-Charter" was developed and displayed publically on websites, notice boards, and hospital documentation. The Green-Charter serves as a guide to environmental and sustainability management on site (An Taisce, 2014), this provides information, policy and procedures, and contributes towards providing accountability to stakeholders. The long term viability of the programmes on site is reliant on the continued support of management, staff engagement and the support of external bodies and programmes. The commitment made by CUH in participating in voluntary initiatives and pledging to ensure continuity on site offers security for new targets and initiatives to be developed through the existing framework.

2.7.1 Water, Travel and Biodiversity

Although energy and waste management initiatives at CUH have been the focus of data presented significant progress was made in reviewing water management, biodiversity, and sustainable travel initiatives. Measures to conserve water and prevent pollution include leak detection, identification of high water use equipment, and upgrade of fuel storage bunds. Biodiversity plans include species and habitat mapping in conjunction with students in UCC and restoration of natural areas to provide accessible green space for patients and the public. This serves a dual function, both environmental and well-being, since increasing green spaces and biodiversity in hospitals has been linked to improved recovery and rehabilitation (Bengtsson and Grahn, 2014). Waste generation and resource consumption increase the longer a patient spends in hospital. Preliminary work on sustainable travel includes surveys and sustainable travel initiatives to increase active travel, reduce travel in single occupancy cars, and increase public transport accessibility. A register of opportunity for travel has been established to gain input and linkages have been formed with transport companies, regional and national authorities. The SHESG plans to use active travel as both a health promotion strategy and an environmental initiative on site and in the wider community. Engagement of hospital sites on meeting future environmental targets is reliant on appropriate and accessible expertise. Currently no specific programmes or governmental initiatives exist for biodiversity protection and enhancement, or water quality protection. A national sustainable travel initiative offers site specific consultations and tailored supports. Access to information and expertise through a university partner may prove effective as demonstrated by the actions of CUH and its affiliate university, UCC.

2.7.2 Green Healthcare Model

Participation in Global Green and Healthy Hospitals and researching existing work on sustainability in healthcare led the SHESG to review overall approaches to sustainable healthcare on site. The description of a sustainable healthcare system provided by the NHS Sustainable Development Unit (NHS England, 2015) was adopted for the review, presented in Table 8.

	Element 1: Sustainable Health Sector	Element 2: Sustainable Health Care
Description	Greening health sector: energy, waste, travel, procurement, water, infrastructure adaptation and buildings	Adapting services delivery, health promotion and disease prevention, corporate social responsibility, and developing sustainable models of care.
CUH Review	Work underway on almost all activities which effect the environment. Developing	Staff and patient vaccination programmes

protective and restorative measures such as biodiversity enhancement plans.	Fall prevention
	Medication safety
	Patient self-management (diabetes and dialysis)
	Early intervention
	Day of surgery admissions
	Rehabilitation programmes
	Hospice Friendly Hospitals Programme
	Arts programmes enable patients to recover more quickly
	Maternity services and out of hospital clinics

Table 8: NHS UK Sustainable Health and Care System and Initial Review of CUH activities

The review recognised measures that are contributing positively to environmental protection as well as emergent best practice in healthcare. Notable examples include establishment of local outpatient maternity clinics to reduce travel requirements for routine appointments, and the introduction of Kanban systems eliminating waste due to obsolescence. Recognition is growing both nationally and internationally that healthcare needs to shift to preventative and more demand led measures to circumvent needless hospital procedures thereby achieving more than incremental improvements in order to move toward sustainability (McGain and Naylor, 2014; NHS England, 2014; Watts et al., 2015). The HSE formed and launched the National Health Sustainability Office in 2014 to coordinate a National Sustainability Plan for the health service (HSE, 2015). The programmes and supports utilised in CUH have become best practice for other hospitals in the health system to emulate.

2.8 Supports, Support Bodies and Voluntary Initiatives

Concerns regarding use of voluntary initiatives and standards in industry and organisations have stemmed from 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 participatory initiatives benefitted public healthcare where regulations and benchmarks are available for some targets, (energy and waste) but not for others (water, biodiversity, travel, a broader environmental agenda and preventative care to protect the environment). Notwithstanding this, the importance of governmental policy and targets coupled with legislation should not be understated. The Irish Government public sector energy reduction targets, supported with grants, technical assistance, and training from the SEAI, have driven energy initiatives on site. Because of the need to reach these targets the HSE and CUH appointed dedicated staff to champion and lead actions. 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. Calls have been made for the greater inclusion of participatory approaches into higher education sustainability assessment practices (Disterheft et al., 2015; Karatzoglou, 2013). Suitably qualified NGOs and other peer groups have proved to be trusted vectors to deliver environmental programmes in a non-judgemental framework (Cook and Inman, 2012; Nelson, 2007). Both the EPA-GHCP and the GCP do not chastise the participants but rather assist in developing better practice. The GCP is not based on a defined target, instead focussing on a process; the GCP programme supports the site throughout this. The focus on the process allows creativity and engagement with others, but crucially 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 ranging but do not necessarily return revenue, for example, the removal of litter at source prevents contamination of water courses which protects marine biodiversity (see Tables 5 and 6 for examples). The programme is led by a national

environmental NGO, allowing CUH to become involved in further national sustainability initiatives (examples included in Table 5). Healthcare 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 (Boone, 2012; Karliner and Guenther, 2011).

2.9 Environmental Education

Teaching hospitals offer unique opportunities to foster environmental education as described in Table 6. Graduates move to other healthcare facilities, 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 the majority of healthcare practitioners, patient safety takes priority and so a wider understanding of how unpolluted environments support patient safety is required. Green Advocates are offered environmental training counting toward continuing professional development on résumés. Opportunities that hospitals and other public buildings can exploit as visible presences in cities can promote environmental sustainability (Redmond et al., 2015). Footfall of visitors and staff is high so public engagement was included in CUH action plans. Some patients are receptive to environmental education, as described in Table 6, 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 as detailed in Table 5. Healthcare facilities need to recognise the niche in which they operate and nurture relationships with academic partners, community groups and local authorities, since these have access to research, expertise and infrastructure. Within healthcare facilities exists an invaluable resource: people who have interests and knowledge of environmental issues, perhaps they are members of NGOs, care about the environment or have particular interests such as biodiversity or active travel. These are potential champions, willing to act on their knowledge when they are provided with management support and a forum for their ideas and vision to be realised.

2.10 Systematic Approach

Adoption of the framework resulted in outcomes which could not be achieved by stakeholders working independently of one another. Figure 1 illustrates the structure of the system and Table 9 provides examples of outcomes which were achieved as a result of stakeholders contributing to the working of the framework. The establishment of the SHESG and Green Advocates Network led to the facilitation of both lateral and vertical communication. Significantly, it was found that maintenance and finance departments did not communicate regarding energy spend, resulting in missed opportunities (Table 4). Management and front line staff held differing attitudes to energy efficiency measures (Table 1). In some cases hospital management might not have a medical background or training. Energy or waste management measures suggested, regarded as normal in other organisations, may have a detrimental effect on patient safety in healthcare. Engaging frontline health workers empowers them as they have much to contribute to improving environmental sustainability (Chenven and Copeland, 2013). McGain et al. (2012) described a life cycle assessment of reusable and single use catheter insertion kit, concluding that method of energy generation significantly altered the environmental impact of these items. When researchers make such discoveries, opportunities arising need to be communicated to management to respond accordingly. As presented in Table 6, the SHESG has diversified relationships with CUH's academic affiliates to access expertise and research. Likewise if buildings management identify opportunities for savings, these need to be communicated to medical management lest implementation jeopardises patient care. In CUH the establishment of the SHESG ensures all initiatives and suggestions are processed through a diverse organising committee, so that potential issues are

flagged early. Senior management of hospitals might lack understanding of the benefit of protecting community health as it may not appear on the balance sheet of the hospital accounts (Zimmer and McKinley, 2008). As described in Table 8, CUH have initiated a review of opportunities for such measures. Organisations like the Irish Doctors Environmental Association demonstrate that many medical professionals welcome opportunities to engage with environmental protection. A hospital with thousands of staff may host a willing cohort of volunteers and experts. Staff members in CUH and elsewhere participate in projects and citizen science that contribute significantly to biodiversity protection (Cosentino et al., 2014). As recorded in Tables 1 and 2, CUH complied with environmental legislation, yet management sought to engage further with voluntary environmental protection measures. The energy spend equates to around 1% of total budget and waste management costs are generally lower than energy. Many of the measures that CUH have committed to are likely to generate cost to the hospital in the short term but deliver lasting benefit. In this way, CUH have moved from reactionary environmental management to more progressive and anticipative environmental management. Figure 1 is a schematic of the systematic approach in implementing environmental initiatives at CUH. The system is both dynamic and flexible and allows for the integration of future supports and environmental concerns.

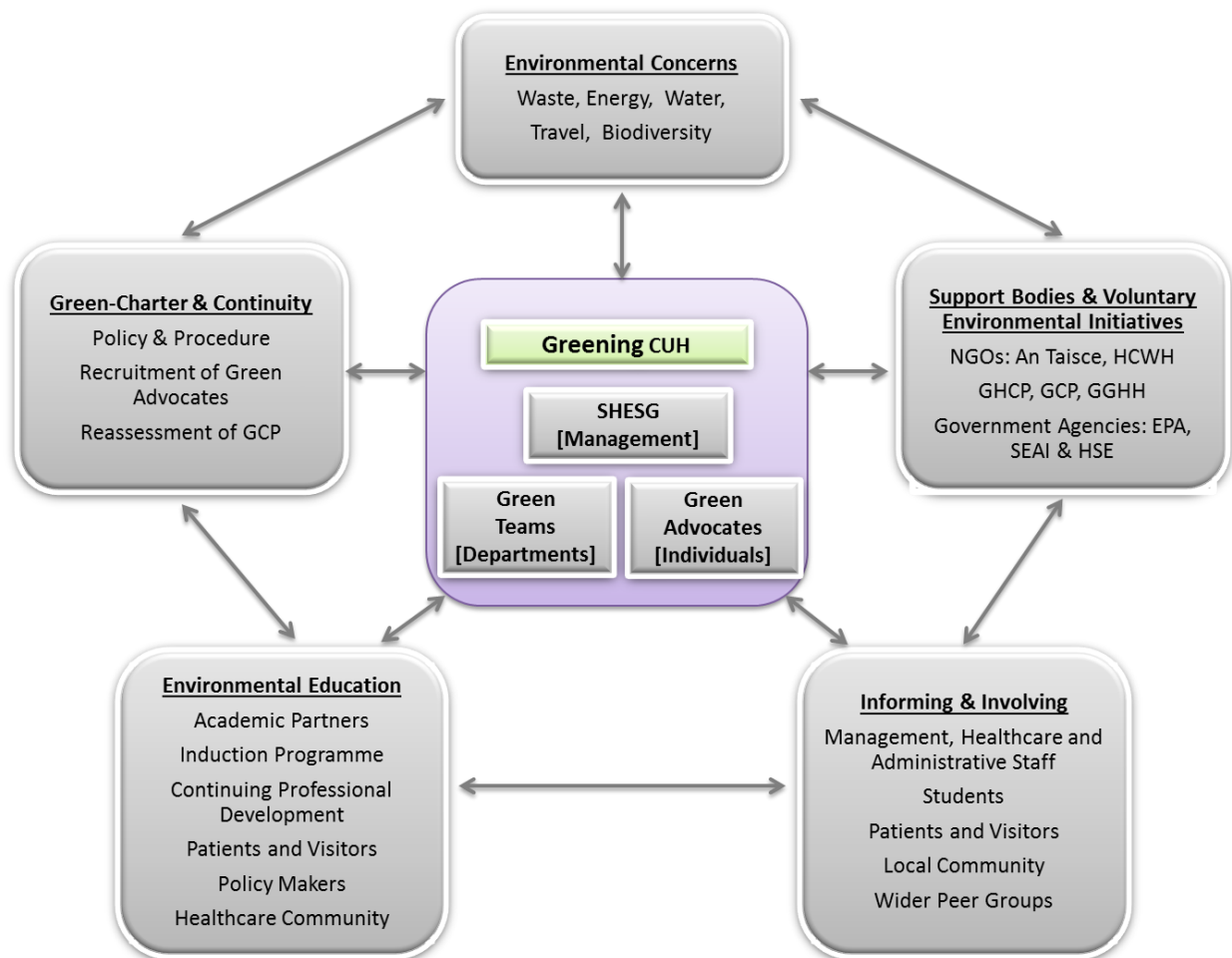


Figure 1: Systematic Implementation of Environmental Initiatives at CUH

System attribute	Quality	Examples
Holism	A change in part of a system affects the whole system	A change in waste management practice in one department is rolled out across the entire hospital
Non-summativity	The whole is more than the sum	Continual improvement is achieved as stakeholders have collectively committed to adherence to long-term sustainability

	of the parts	enhancement
Equifinality	Open systems can attain the same state or result via different starting-points and stages	The framework adopted by CUH has been taken up by others (UCC, suppliers, visitors, etc.) and has influenced approaches taken by HSE management at nation level. Similar results have been obtained in university campuses in Ireland which have adopted this framework.
Circular and manifold causality and non-linearity	Causal connections are not linear as many parts of the system may be affected in differing ways and at different times	Energy efficiency is complicated by the need to have consistency in supply. Waste prevention initiatives are heavily influenced by patient safety concerns. Changes made in one area impacts resource demand in procurement, portering and waste management.

Table 9: System Attributes, Properties and Examples from CUH (Boulding, 1985, Litterer, 1973 and Van Bertalanffy 1968 cited in Jokela et al., 2008).

4 Conclusions

Utilisation of an environmental programme designed for use in the education sector, the GCP, as a framework resulted in a systematic approach to environmental action and education. Adoption of the framework has proved to be successful. CUH gained GCP creditation, other institutions and campuses have adopted it and the HSE National Health Sustainability Office has included the framework used within national guidelines. A crucial strength of the framework is that it brings together disparate stakeholders who otherwise would work in isolation, thus enhancing efficiency, innovation, knowledge and awareness. Additional stakeholders became involved for the first time, thus adding to the effectiveness of the system. Similar to higher education, healthcare is intrinsically very complex yet the key focus of healthcare remains patient care to the highest possible standard. To drive sustainability in this particular sector, expert knowledge of the needs of patients is equally crucial as expertise in for example carbon emission reduction and solid waste management: without this synergy both are liable to be compromised. Awareness raising of both clinical and environmental stakeholders is enabled by the framework. In the complex healthcare sector, the law of unintended outcomes is very important as lives are at risk. Facilitating engagement of disparate practitioners anticipates and mitigates risk. Teaching hospitals should be facilitated to engage with their academic affiliates to work together on SD.

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4 References

- An Taisce, 2014. Green-Campus Guidebook 2013-2014. Environmental Education Unit, Dublin, Ireland
- Bengtsson, A., Grahn, P., 2014. Outdoor environments in healthcare settings: A quality evaluation tool for use in designing healthcare gardens. *Urban For. Urban Gree.* 13, 878–891. doi:10.1016/j.ufug.2014.09.007
- Boone, T., 2012. *Creating a Culture of Sustainability: Leadership, Coordination and Performance Measurement Decisions in Healthcare.* Healthcare Without Harm, Chicago
- Boulding, K.E., 1985. *The world as a total system.* Sage Publications, Beverly Hills, California

- Campion, N., Thiel, C.L., Woods, N.C., Swanzy, L., Landis, A.E., Bilec, M.M., 2015. Sustainable healthcare and environmental life-cycle impacts of disposable supplies: a focus on disposable custom packs. *J. Clean. Prod.* 94, 46–55. doi:10.1016/j.jclepro.2015.01.076
- Chenven, L., Copeland, D., 2013. Front-line Worker Engagement: Greening Health Care, Improving Worker and Patient Health, and Building Better Jobs. *New Solut.* 23, 327–345. doi:10.2190/NS.23.2.h
- Cook, H., Inman, A., 2012. The voluntary sector and conservation for England: Achievements, expanding roles and uncertain future. *Journal of Environmental Management* 112, 170–177. doi:10.1016/j.jenvman.2012.07.013
- Cosentino, B.J., Marsh, D.M., Jones, K.S., Apodaca, J.J., Bates, C., Beach, J., Beard, K.H., Becklin, K., Bell, J.M., Crockett, C., Fawson, G., Fjelsted, J., Forys, E.A., Genet, K.S., Grover, M., Holmes, J., Indeck, K., Karraker, N.E., Kilpatrick, E.S., Langen, T.A., Mugel, S.G., Molina, A., Vonesh, J.R., Weaver, R.J., Willey, A., 2014. Citizen science reveals widespread negative effects of roads on amphibian distributions. *Biol. Conserv.* 180, 31–38. doi:10.1016/j.biocon.2014.09.027
- DEFRA, 2011. Moments of Change as Opportunities for Influencing Behaviour. Department for Environment, Food and Rural Affairs, London.
- Disterheft, A., Caeiro, S., Azeiteiro, U.M., Filho, W.L., 2015. Sustainable universities – a study of critical success factors for participatory approaches. *J. Clean. Prod.* 106, 11–21. doi:10.1016/j.jclepro.2014.01.030
- EnviroCentre, 2014. Cork University Hospital is first teaching hospital in the world to get Green-Campus award [online] available: <http://envirocentre.ie/News.aspx?ID=79D21E24-862B-4685-A66A-2D7059FB72E2&PID=a257bece-c1e7-464a-9cd0-fde10d3a18c3&NID=2661fd8f-f90b-4968-a9af-96660aa2b2d5&M=2> (accessed 12/08/15)
- Environmental Protection Agency, 2014a. Environmental Protection Agency: Green Healthcare Programme [online], available: <http://www.greenhealthcare.ie/about/> (accessed 12/08/15)
- Environmental Protection Agency, 2014b. Green Healthcare: Overview of Programme and Main Findings [online], available: <http://www.greenhealthcare.ie/wp-content/uploads/2013/08/Overview-of-programme-and-main-findings.pdf> (accessed 12/08/15).
- Faezipour, M., Ferreira, S., 2014. Assessing Water Sustainability Related to Hospitals Using System Dynamics Modeling. *Procedia Comput. Sci.* 36, 27–32. doi:10.1016/j.procs.2014.09.025
- Gavilán-García, I.C., Fernández-Villagomez, G., Gavilán-García, A., Alcántara-Concepcion, V., 2015. Alternatives of management and disposal for mercury thermometers at the end of their life from Mexican health care institutions. *J. Clean. Prod.* 86, 118–124. doi:10.1016/j.jclepro.2014.08.013
- Harhay, M.O., Halpern, S.D., Harhay, J.S., Oliaro, P.L., 2009. Health Care Waste Management: a Neglected and Growing Public Health Problem Worldwide: Managing Health Care Waste Worldwide. *Trop. Med. Int. Health* 14, 1414–1417. doi:10.1111/j.1365-3156.2009.02386.x
- Health Service Executive, 2015. National Health Sustainability Office [online], available <http://www.hse.ie/eng/services/news/newsfeatures/healthsustainabilityoffice/Aboutus/> (accessed 12/08/15)
- Healthcare Without Harm, 2015. Who We Are [online], available: <https://noharm-europe.org/content/europe/who-we-are> (accessed 12/08/15)
- Hens, L., Wiedemann, T., Raath, S., Stone, R., Renders, P., Craenhals, E., Richter, B., 2010. Monitoring environmental management at primary schools in South Africa. *J. Clean. Prod.* 18, 666–677. doi:10.1016/j.jclepro.2009.11.001
- Huesemann, M., 2011. *Techno-Fix: Why Technology Won't Save Us or The Environment*. New Society Publishers, Gabriola Island, Canada

Ireland, Department of Communications, Energy and Natural Resources, 2009. Maximising Ireland's Energy Efficiency: The National Energy Efficiency Action Plan 2009-2020. Department of Communications, Energy and Natural Resources, Dublin

Jokela, P., Karlsudd, P., Östlund, M., 2008. Theory, Method and Tools for Evaluation Using a Systems-based Approach. *EJISE* 11, 197–212

Karatzoglou, B., 2013. An in-depth literature review of the evolving roles and contributions of universities to Education for Sustainable Development. *J. Clean. Prod.* 49, 44–53. doi:10.1016/j.jclepro.2012.07.043

Karliner, J., Guenther, R., 2011. Global Green and Healthy Hospitals-Agenda: A Comprehensive Environmental Health Agenda for Hospitals and Health Systems Around the World. Healthcare Without Harm, Buenos Aires

Koester, R.J., Eflin, J., Vann, J., 2006. Greening of the campus: a whole-systems approach. *J. Clean. Prod.* 14, 769–779. doi:10.1016/j.jclepro.2005.11.055

Labatt, S., Maclaren, V.W., 1998. Voluntary Corporate Environmental Initiatives: A Typology and Preliminary Investigation. *Environ. Plann. C Gov. Policy* 16, 191–209. doi:10.1068/c160191

Lauder, A., Sari, R.F., Suwartha, N., Tjahjono, G., 2015. Critical review of a global campus sustainability ranking: GreenMetric. *J. Clean. Prod.* 108, 852–863. doi:10.1016/j.jclepro.2015.02.080

Lauder, A., Sari, R.F., Suwartha, N., Tjahjono, G., 2015. Critical Review of a Global Campus Sustainability Ranking: Green Metric. *J. Clean. Prod.* In Press. doi:10.1016/j.jclepro.2015.02.080

Leal Filho, W., Manolas, E., Pace, P., 2015. The future we want: Key issues on sustainable development in higher education after Rio and the UN decade of education for sustainable development. *International Journal of Sustainability in Higher Education* 16, 112–129. doi:10.1108/IJSHE-03-2014-0036

Litterer, J.A., 1973. The analysis of organizations, 2d ed., The Wiley series in management and administration. Wiley, New York

Lozano, R., Lukman, R., Lozano, F.J., Huisingh, D., Lambrechts, W., 2013. Declarations for sustainability in higher education: becoming better leaders, through addressing the university system. *J. Clean. Prod.* 48, 10–19. doi:10.1016/j.jclepro.2011.10.006

Mason, I.G., Brooking, A.K., Oberender, A., Harford, J.M., Horsley, P.G., 2003. Implementation of a zero waste program at a university campus. *Resour. Conserv. Recy.* 38, 257–269. doi:10.1016/S0921-3449(02)00147-7

McDiarmid, M.A., 2006. Chemical Hazards in Health Care: High Hazard, High Risk, but Low Protection. *Ann. N. Y. Acad. Sci.* 1076, 601–606. doi:10.1196/annals.1371.032

McGain, F., McAlister, S., McGavin, A., Story, D., 2012. A Life Cycle Assessment of Reusable and Single-Use Central Venous Catheter Insertion Kits. *Anesth. Analg.* 114, 1073–1080. doi:10.1213/ANE.0b013e31824e9b69

McGain, F., Naylor, C., 2014. Environmental Sustainability in Hospitals - A Systematic Review and Research Agenda. *J. Health Serv. Res. Policy* 19, 245–252. doi:10.1177/1355819614534836

Nan, C., Xiaoqiang, W., Jin, W., 2006. Development of National Assessment Criteria for Green Schools in China. *South. African J. Environ. Education* 23, 64–77

Nelson, J., 2007. The Operation of Non-Governmental Organizations (NGOs) in a World of Corporate and Other Codes of Conduct (No. Working Paper No. 34), Corporate Social Responsibility Initiative. John F. Kennedy School of Government, Harvard University, Cambridge MA.

NHS England, 2014. Five Year Forward View [online], available: <https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf> (accessed 12/08/15)

NHS England, 2015. What is Sustainable Health? [online], available: <http://www.sduhealth.org.uk/policy-strategy/what-is-sustainable-health.aspx> (accessed 12/08/15)

Ongondo, F.O., Williams, I.D., 2011. Greening academia: Use and disposal of mobile phones among university students. *Waste Manage.* 31, 1617–1634. doi:10.1016/j.wasman.2011.01.031

Ozder, A., Teker, B., Eker, H.H., Altindis, S., Kocaakman, M., Karabay, O., 2013. Medical waste Management Training for Healthcare Managers – A Necessity. *J. Environ. Health Sci. Eng.* 11, 20. doi:10.1186/2052-336X-11-20

Porter-O’Grady, T., Malloch, K., 2010. Innovation: Driving the Green Culture in Healthcare. *Nurs. Adm. Q.* 34, E1–E5. doi:10.1097/NAQ.0b013e3181fb48d3

Redmond, A., Fies, B., Zarli, A., 2015. Developing an integrated cloud platform for enabling “holistic energy management” in urban areas, in: Martens, B., Mahdavi, A., Scherer, R. (Eds.), *eWork and eBusiness in Architecture, Engineering and Construction: Proceedings of the 10th European Conference on Product and Process Modelling (ECPPM 2014)*, Vienna, Austria, 17-19 September 2014. CRC Press, Leiden, The Netherlands, 409-416

Reidy, D., Kirrane, M., Curley, B., Brosnan, D., Koch, S., Bolger, P., Dunphy, N., McCarthy, M., Poland, M., Ryan-Fogarty, Y., O’Halloran, J., 2015. A Journey in Sustainable Development in an Urban Campus, in: Leal Filho, W., Brandli, L., Kuznetsova, O., Paço, A.M.F. (Eds.), *Integrative Approaches to Sustainable Development at University Level*, World Sustainability Series. Springer International Publishing, pp. 599–613.

Saad, S.A.G., 2013. Management of Hospitals Solid Waste in Khartoum State. *Env. Monit. Assess.* 185, 8567–8582. doi:10.1007/s10661-013-3196-1

Shriberg, M., 2002. Institutional assessment tools for sustainability in higher education: Strengths, weaknesses, and implications for practice and theory. *International Journal of Sustainability in Higher Education* 3, 254–270. doi:10.1108/14676370210434714

Sonnino, R., McWilliam, S., 2011. Food Waste, Catering Practices and Public Procurement: A Case Study of Hospital Food Systems in Wales. *Food Policy* 36, 823–829 doi:10.1016/j.foodpol.2011.09.003

Sørensen, B.L., Wenzel, H., 2014. Life Cycle Assessment of Alternative Bedpans – A Case of Comparing Disposable and Reusable Devices. *J. Clean. Prod.* 83, 70–79 doi:10.1016/j.jclepro.2014.07.022

Sustainable Energy Authority of Ireland (2015) Public Sector Programme [online], available http://www.seai.ie/Your_Business/Public_Sector/Public_Sector_Programme/ (accessed 12/08/15)

Teke, A., Timur, O., 2014. Assessing the Energy Efficiency Improvement Potentials of HVAC Systems Considering Economic and Environmental Aspects at the Hospitals. *Renew. Sustainable Energy Rev.* 33, 224–235. doi:10.1016/j.rser.2014.02.002

Thiel, C.L., Needy, K.L., Ries, R., Hupp, D., Bilec, M.M., 2014. Building Design and Performance: A Comparative Longitudinal Assessment of a Children’s hospital. *Build. Environ.* 78, 130–136. doi:10.1016/j.buildenv.2014.04.001

UCC Green Campus, 2015. Green Campus Environmental Policy [online], available: <https://www.ucc.ie/en/greencampus/> (accessed 1.30.16).

UCC School of Medicine, 2015. Teaching Hospitals | School of Medicine UCC [online], available: <http://www.ucc.ie/en/medical/prostud/dem/teachlearn/hospitals/> (accessed 1.26.16).

Van Bertalanffy, L., 1968. *General system theory: foundations, development, applications*. Braziller, New York

Vatovec, C., Senier, L., Bell, M., 2013. An Ecological Perspective on Medical Care: Environmental, Occupational, and Public Health Impacts of Medical Supply and Pharmaceutical Chains. *Ecohealth* 10, 257–267. doi:10.1007/s10393-013-0855-1

Verhulst, E., Lambrechts, W., 2015. Fostering the incorporation of sustainable development in higher education. Lessons learned from a change management perspective. *J. Clean. Prod.* 106, 189–204. doi:10.1016/j.jclepro.2014.09.049

Verlicchi, P., Galletti, A., Petrovic, M., Barceló, D., 2010. Hospital Effluents as a Source of Emerging Pollutants: An Overview of Micropollutants and Sustainable Treatment Options. *J. Hydrol.* 389, 416–428. doi:10.1016/j.jhydrol.2010.06.005

Vidal, R., Moliner, E., Pikula, A., Mena-Nieto, A., Ortega, A., 2015. Comparison of the Carbon Footprint of Different Patient Diets in a Spanish hospital. *J. Health Serv. Res. Policy* 20, 39–44. doi:10.1177/1355819614553017

Watts, N., Adger, W.N., Agnolucci, P., Blackstock, J., Byass, P., Cai, W., Chaytor, S., Colbourn, T., Collins, M., Cooper, A., Cox, P.M., Depledge, J., Drummond, P., Ekins, P., Galaz, V., Grace, D., Graham, H., Grubb, M., Haines, A., Hamilton, I., Hunter, A., Jiang, X., Li, M., Kelman, I., Liang, L., Lott, M., Lowe, R., Luo, Y., Mace, G., Maslin, M., Nilsson, M., Oreszczyn, T., Pye, S., Quinn, T., Svensdotter, M., Venevsky, S., Warner, K., Xu, B., Yang, J., Yin, Y., Yu, C., Zhang, Q., Gong, P., Montgomery, H., Costello, A., 2015. Health and climate change: policy responses to protect public health. *The Lancet*. doi:10.1016/S0140-6736(15)60854-6

Weisz, U., Haas, W., Pelikan, J.M., Schmied, H., 2011. Sustainable Hospitals: a Socio-Ecological Approach. *Gaia* 20, 191–198

World Health Organization, 2014. *Safe Management of Wastes from Health-Care Activities*. Geneva, Switzerland

Xin, Y., 2015. Comparison of Hospital Medical Waste Generation Rate Based on Diagnosis-Related Groups. *J. Clean. Prod.* 100, 202–207. doi:10.1016/j.jclepro.2015.03.056

Zimmer, C., McKinley, D., 2008. New Approaches to Pollution Prevention in the Healthcare Industry. *J. Clean. Prod.* 16, 734–742. doi:10.1016/j.jclepro.2007.02.014