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Review

Call for sustainable food systems including (medical) nutrition for hospitalised children and their families

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ABSTRACT

The climate emergency presents a profound threat to global health, adversely affecting the health and well-being of children who are projected to bear a substantial disease burden, as well as impacting children's right to food, water, healthcare and education. The healthcare sector strives to prioritise preventative healthcare policies improving the health of individuals across the life course. However, current healthcare practices significantly contribute to greenhouse gas (GHG) emissions and waste generation, in which (medical) nutrition plays an important role.

Plant-based proteins offer sustainability benefits, and potential health advantages, and have a lower climate footprint, although there may also be unintended consequences of land-use change and deforestation for certain crops. However, to develop suitable plant-based alternatives to medical nutrition, it will be necessary to address regulatory obstacles as well as ensure nutritional profiles are suitable, particularly protein (amino acid) and micronutrient composition. Additionally, the development of heat-tolerant and water-efficient plant genotypes could bolster adaptation to changing climatic conditions. Effective waste management, including wasted food and medical nutrition, emerges as a key strategy in mitigating the climate impact of medical nutrition. While research on food waste in healthcare settings is limited, minimising waste spillage in medical nutrition is a crucial area to explore. Healthcare professionals must acknowledge their roles in curbing the climate footprint of medical nutrition as well as recommendations for food-based approaches. This review aims to investigate the sustainability of medical nutrition for paediatric care, focusing on factors contributing to GHG emissions, plant-based alternatives, waste management and plastic packaging. Such an exploration is vital for healthcare professionals to fulfil their responsibilities in addressing the climate crisis while advocating for change.

KEY MESSAGE

⇒ The climate emergency is a pressing global issue that poses significant threats to human health and the environment.
⇒ A call to collective action from industry, legislators, and non-governmental organisations to develop standardised processes to reduce the amount of plastic in medical nutrition and associated waste.
⇒ To develop scalable circular economy for medical nutrition there needs to be standardisation of process and methodology, as a current lack of transparency and large-scale action hinders progress towards effecting change.
⇒ Research is required around behaviour change models to support the transition from animal-based to plant-based diets, including medical nutrition, for hospital patients, visitors, and staff.
⇒ Collective action is required for all of us, although small acts can save our planet – we need large scale action.
⇒ How can you get involved in advocating for your hospital to reduce the amount of medical nutrition waste?

INTRODUCTION

The climate emergency is a pressing global issue that poses significant threats to human health and the environment. The goal of the Paris Agreement, an international treaty, is to limit global warming to well below 2°C compared with pre-industrial levels.[1] However, temperatures have already exceeded the 1.5°C threshold in 2023, despite the prediction of this only occurring between 2030 and 2050.[2] The rise in global temperatures is likely to lead to severe consequences such as animal and plant extinctions, water, crop failures, rising food prices, poverty, famine and extreme weather events.[2] Children are particularly vulnerable, as climate change is projected to cause a significant burden of disease, including malnutrition, malaria, diarrhoea and heat stress, with an estimated 88% of the disease burden affecting children under the age of 5 from low-income and middle-income countries.[3 4]

Global greenhouse gas (GHG) emissions by economic sectors are estimated to be, (1) electricity and heat production (25%), (2) industry (21%), (3) agriculture, forestry and other land use (24%), (4) transportation (14%), buildings (6%) and other (10%).[5] The healthcare sector, despite its commitment to improving health, contributes significantly to the climate emergency, accounting for 4.4% of global net emissions and being the fifth largest emitter of annual GHGs.[5] The healthcare industry's overall impact on the climate emergency is significant and multifaceted, with GHG stemming from energy consumption, transportation, waste generation and pharmaceutical and medical device production.[6–9] The sector's reliance on fossil fuels and improper disposal of medications and medical waste further exacerbate environmental damage. Additionally, global food-system emissions, ingredients for medical nutrition and medical supplies contribute to a third of all human-generated GHG, leading to deforestation and biodiversity loss, while chemical pollution poses risks to water and soil.[10] Healthcare professionals should better understand their roles and responsibilities with regard to the climate emergency, as climate change, food security and nutrition are inextricably linked.[11] (Medical) nutrition within hospitals has direct and indirect environmental implications, particularly through the consumption of cow's milk protein-based products. Reducing meat and dairy consumption and opting for sustainably sourced plant-based alternatives may help mitigate environmental burdens, although additional research is required to understand the impact of the destructive land-use practices within global agriculture systems such as palm oil and soy.[12] Also, while (plastic) packaging serves important functions such as preserving food freshness, extending shelf life and preventing food waste, it has environmental implications that are interconnected with the climate emergency.

In this review, we will focus on four key areas: (1) factors contributing to GHG, (2) plant-based nutrition versus cow milk-based nutrition, (3) food waste/spillage and (4) plastic/packaging. We will explore the environmental implications of these factors and identify barriers and solutions to reduce GHG emissions.

Factors contributing to GHG emissions

Supply chain

The supply chain encompasses the entire lifecycle of a product or service, from raw material extraction and production to distribution, use and disposal. This holistic perspective is crucial for accurately measuring the climate impact, as it allows for the identification of emissions, and resource consumption at each stage providing material flow and life cycle analysis.[13] Healthcare supply chain emissions are the largest source category of GHG emissions and, for medical nutrition and hospital food, the most difficult to influence. Two important strategies have been identified to reduce the carbon footprint through green procurement within healthcare; (1) reduce the overall demand for goods and services including the reduction of nutrition-related wastage from food and medical nutrition and (2) shift to low-carbon good services including locally source food and plant-based diets.[14–16]

Healthcare professionals must acknowledge that the environmental repercussions of hospital nutrition go beyond the facility itself, encompassing the entire supply chain. The assessment of supply chain sustainability involves gauging the carbon footprint associated with various stages, such as food sourcing, transportation, packaging, preparation, storage and addressing issues like food spillage. Crucial steps in evaluating climate impact include analysing the distance travelled by food, prioritising local sourcing and assessing suppliers' environmental practices. Additionally, the energy consumption in hospitals with on-site kitchens and food service areas, especially in food preparation and storage, can contribute to GHG emissions. In hospitals employing centralised catering, where chilled-cooked meals are transported to organisations by road for reheating on-site, the impact on carbon emissions is significant. The dietary composition of hospital meals also plays a substantial role in influencing their climate impact.[17]

The transport of medical nutrition products is likely to significantly contribute to carbon emissions with multicentre raw material source and manufacture, followed by international distribution. Reduction of emissions is already occurring as a result of efficiency designs within manufacturing processes. Healthcare systems can incentivise suppliers of goods (including medical nutrition and food) in future through partnerships with suppliers pledging aggressive emissions reduction targets.[14] In the UK National Health Service (NHS) food and catering services are estimated to produce 1543 ktCO2e each year, which is estimated to contribute to approximately 6% of total NHS emissions. The NHS and other healthcare systems have

an ambition to promote healthier and locally sourced food with a goal to cut emissions related to agriculture, transport, storage and waste across the supply chain.[18] However, there are significant challenges in achieving this goal as it will require systemic changes to healthcare facilities including the reintroduction of onsite catering facilities, procurement strategies and organisation cultures.

Although is it not possible to determine what percentages of global cow's milk production are used to make medical nutrition products, in Europe, 160 million tonnes of cow's milk is produced per annum of which 59.9 million tonnes is made into whey protein.[19] Organisation for Economic Cooperation and Development–Food Agriculture Organisation estimates that approximately 8% of the world's milk production is traded internationally. Per capita consumption of processed and fresh dairy products in milk solids (including butter cheese, skim milk powder and whole milk powder) is expected to be around 15 kg/capita/year by 2029. Only a small share of dairy products, especially skim milk powder and whey powder, are used in animal feed.[20] The European Union has a major deficit in growing plant protein, with the majority being imported.[21] Approximately 400 million metric tonnes of soybeans are grown annually with Brazil being the biggest global producer. However, only 7% of soybeans are used for human consumption with 77% being used for animal feed.[22]

Environmental impact analysis methods for supply chains

While GHG emissions are most commonly used when describing the impact on the climate and the environment, other environmental factors such as water use, land use, eutrophication (excessive nutrient runoff leading to water pollution), deforestation and loss of biodiversity should also be considered. To measure the impact of medical nutrition and food, and the supply chain on the environment, a comprehensive approach is required. This involves considering the measurement and analysis of factors such as GHG emissions associated with the supply chain including food production, processing, transportation, storage and waste management which can be described using a variety of measurement techniques such as

Material flow analysis (MFA)

MFA is a method used to quantify and track the flow of materials through a system, such as a production process or an entire economy.[23] It examines the inputs, outputs and transformations of materials within a defined system boundary. MFA provides a comprehensive view of material flows, including extraction, production, use and disposal. It helps identify resource consumption, waste generation and potential inefficiencies within the system. MFA is particularly useful for analysing material efficiency and waste management. MFA helps identify inefficiencies and waste generation within specific stages of the supply chain, allowing for targeted interventions and improvements. It focuses on material inputs and outputs, providing insights.[24]

Life cycle assessment (LCA)

LCA is a broader assessment methodology that evaluates the environmental impacts of a product or service throughout its entire life cycle, from raw material extraction to end-of-life disposal.[25 26] It considers the resource use, energy consumption, emissions and other environmental indicators associated with each stage of the product's life cycle. LCA can identify hotspots in the supply chain, highlighting stages with significant environmental impacts, and guide decision-making towards more sustainable alternatives or improvements. Both MFA and LCA can be used in the context of supply chain analysis to understand and improve the environmental performance of a product or process.

Alternative approaches used to analyse supply chains and measure the impact on climate include:

Input–output analysis (IOA)

IOA is a method that focuses on the interdependencies between different sectors of an economy.[27] It quantifies the flows of goods, services and resources between industries and tracks the associated environmental impacts. IOA can provide insights into the upstream and downstream effects of a product or service within a supply chain.

Carbon footprinting

Carbon footprinting is a specific type of analysis that quantifies the GHG emissions associated with a product, service or organisation.[24] It measures emissions throughout the entire life cycle, from raw material extraction to end-of-life disposal and is similar to LCA. Carbon footprinting can be used to assess the climate impact of specific products within a supply chain or the overall carbon emissions of an organisation.

Environmental product declarations (EPDs)

EPDs are standardised and independently verified reports that provide transparent and comparable information about the environmental impacts of a product.[27] They include data on energy use, GHG emissions, water consumption and other relevant environmental indicators. EPDs can be used to assess the climate impact of specific products and facilitate comparisons between different options within a supply chain.[28]

Environmental hotspot analysis

Environmental hotspot analysis focuses on identifying specific areas within a supply chain that have a significant impact on social or environmental issues.[29 30] This approach helps prioritise interventions

and improvements in the areas that have the most significant influence on climate change. Hotspot analysis can be complemented by quantitative assessments, such as LCA or carbon footprinting, to provide a more comprehensive understanding of the impact.

However, industry, legislators and non-governmental organisations need to agree on standardised process and methodology concerning these methodologies, as a current lack of independence and transparency hinders progress towards effecting change.

Plant-based (protein) nutrition versus animal-based (protein) nutrition

A comprehensive analysis of the global food system, examining the environmental burdens associated with different types of food production completed by Poore and Nemecek, found that food production is a significant contributor to environmental degradation, accounting for a substantial portion of global GHG emissions and land use.[31] Livestock and mammalian milk production has a significant role in the climate impact of nutrition and environmental sustainability. Embracing sustainable practices, such as reducing meat consumption and exploring plant-based alternatives, is essential to mitigating the environmental impact associated with livestock production and promoting a more climate-friendly food system. From a sustainability and climate footprint perspective, plant-based protein offers clear advantages over animal-based (dairy or meat) protein, as it generates lower levels of GHG emissions and requires less land, water and energy, all resulting in a lower climate footprint.[13]

Participants who consumed healthy plant-based diets had lower cardiovascular disease risk and cancers that is, colorectal, and those diets had lower GHG emissions and use of cropland, irrigation water and nitrogenous fertiliser than diets that were higher in unhealthy plant-based (ie, fruit juices, refined grains (pasta, white rice and processed breads and cereals), potatoes (French fries and potato chips) and sugar-sweetened beverages) and animal-based foods. Participants who ate unhealthy plant-based diets experienced[32] reduced telomere length increasing oxidative stress and inflammation,[33] leading to a higher risk of cardiovascular disease and their diets required more cropland and fertiliser than diets that were higher in healthy plant-based and animal-based foods.[32]

While there is a potential for plant-based nutrition to have a positive environmental impact, there may also be added health benefits.[34] However, shifting to plant-based medical nutrition presents several challenges. Current legislation restricts the use of plant-based protein sources in medical nutrition for hospitalised children, with only cow's milk or soy protein approved[35 36] in Europe. In addition, the protein content and amino acid composition of plant-based protein differ from cow's milk protein, necessitating a careful selection or combination of plant protein sources to provide the optimal quality.[37 38] Also, the digestibility of plant-based protein is lower which can compromise the bio-accessibility of certain amino acids.[39] Additional investigation is required to examine the appropriateness and efficacy of plant-based nutrition across diverse patient groups. This entails assessing the micronutrient composition and availability of sodium, potassium, calcium and phosphate in plant-based nutrition products. Specific micronutrients, like vitamin B12, may necessitate supplementation.[40] Nevertheless, it is crucial to evaluate the environmental impact of micronutrient supplements at every stage of their production, encompassing sourcing, transportation, packaging, preparation, storage and waste. This scrutiny is essential, as the combination of a product and supplementation may yield no net environmental benefit. Despite this, there is encouraging research showing potential benefits of plant-dominated low-protein diets in individuals with certain diseases such as renal problems,[41] but further studies are needed to explore the suitability and effectiveness of plant-based nutrition in paediatric populations requiring medical nutrition or food-based approaches to nutrition support.[42 43] Lastly, in anticipation of the ongoing climate change, plant genotypes that are able to grow and deliver yields required in these climatic conditions need to be developed.[35 36]

Climate change is likely to amplify vulnerability to food security and nutrition impacting (1) agricultural production (availability, monoculture-based systems), (2) access to food (insufficient money, communities with limited ability to compensate for losses in rainfed and pastoral systems) and (3) utilisation (quality of food, nutritional content) and stability (conflict). The greatest impact is likely to occur in the most vulnerable groups of our society, particularly children, women and elderly. Climate change will impact society at all levels, affecting future water availability due to altered precipitation, runoff and snow/ice melt impacting hydrological systems including water quality and temperature. It is likely in many regions of the world there will be reduced water resilience with increased scarcity for many global communities. This impact is likely to be most keenly felt in countries in lower latitudes, where increased ambient temperatures and reduced water will affect crop yields further increasing the risk of food insecurity.[44] As much of the world's global plant protein production occurs in low-latitude regions, such as Brazil and USA (soya), it is important that new crop variations are developed which are more resilient to the effects of climate change, that is, being able to grow in more arid conditions.[45] Agriculture needs to be able to adapt quickly to ensure the supply chain is sustainable. This may include considering, (1) offering different plant varieties, species or cultivars of crops and using short duration cultivars, (2) making more use of rainwater harvesting and capture, (3) use flood, drought and/or saline-resistant varieties and (4)

build on natural regulation and strengthen ecosystem services.[44]

To overcome these challenges and promote plant-based nutrition in hospitals and medical settings, several solutions can be implemented. Advocacy and policy changes are important for engaging policy and lawmakers, healthcare professionals and industry stakeholders in discussions about the environmental impact of medical nutrition. These efforts can lead to policy changes and regulatory adjustments that encourage the adoption of sustainable nutrition practices and expand the range of approved plant-based protein sources. Research and development investment is crucial to optimise plant-based medical nutrition formulations, including protein quality, nutrient profiles and essential micronutrient inclusion. Collaborative efforts between research institutions, healthcare providers and food manufacturers can accelerate innovation in this field. Providing education and training to healthcare professionals on the benefits of plant-based nutrition and strategies for incorporating it into medical practice can drive positive change. Increasing awareness about the environmental impact of food choices and the potential health benefits of plant-based diets can foster acceptance and support among medical professionals and patients.

Plant-based paediatric products have been available for many years, including nutritionally complete nutrition supplements using protein from soya, rice and nut, which have been shown to improve the microbiome of some,[46] as well as support growth and development in children.[47–49] Although additional research is required to ensure the switch to plant-based diets for medical nutrition, further research is required to ensure this does not result in unintended consequences that could damage the environment further. It is important to recognise other novel plant proteins including peanuts, legumes are available. Reliance on just one high biological value plant protein such as soy may have unintended consequences. Soy is an intensively grown crop with high resource needs for energy, water, agrochemicals and soil. Soy farming in South America and Southeast Asia has led to land-use change with deforestation increasing the risk of desertification, water eutrophication and the use of damaging chemicals to promote higher crop yields. For example, Brazilian soy-related emissions stem from land-use change (74.81 Mt), domestic transport (57.89 Mt) and industrial processing (46.03 Mt).[50–52] However, as most soya is grown to feed livestock, a reduced reliance on cow's milk and animal protein for feed and food, and an increased human consumption of plant-based protein/food may reduce the environmental impact of soy and other intensively farmed crops. If we do not reduce the demand for meat and dairy and the crops required to feed animals, it is likely to have a devastating environmental impact as new agricultural land will be required, with further risk of deforestation. A recent study estimated to feed 9 billion people a western diet with western technologies, twice the amount of cropland under cultivation would be required.[53] This can also be applied to prescribing medical nutrition or food-based approaches to nutrition support, including food fortification. However, if additional components need to be added to a plant-based medical nutrition (protein, micronutrients, vitamins), the environmental footprint may change, therefore more research is needed. As more innovative products are developed by academics, commercial companies and clinicians using less well-known plant proteins, research will be required to assess tolerance, acceptability and to maintain optimal macronutrient, micronutrient and body composition levels, and therefore, important growth and development outcomes are achieved. Approaches to food fortification vary considerably and for instance, include the use of ready-to-use therapeutic foods of fortified peanut butter pastes. Peanuts have the smallest carbon footprint of any nut with 0.621 kg CO_{2eq}/kg, requiring less water than tree nuts such as almonds 1.92 kg CO_{2eq}/kg, compared with milk protein 1.19 kg CO_{2eq}/kg[54–56] (table 1).

While there are many health, climate and societal advantages with regard to plant-based diets, there is nuanced complexity with regard to promoting the reduction of animal-source foods,[57 58] particularly where undernutrition is endemic. Some plant sources lack essential amino acids for children and adolescents such as lysine, methionine and cysteine and in infants' phenylalanine and tyrosine, impacting on growth and development. Protein inadequacy may occur when there is an inadequate intake of high-protein plant foods such as legumes, nuts, seeds and soya[57] and consumption of a cereal-based diet associated with poverty.[58] In these circumstances, small amounts of animal-source foods are likely to have an important role in improving health nutrition. Adesogan *et al* argue that 'the nutrition needs of the world's poor, particularly women and children, must be considered in sustainability debates'.[57] Within this context, EAT Lancet 2.0 and the World Wildlife Federation recommend diets that are rich in plant-based foods, with a reduction in the amount of animal sources foods along with sugar is likely to confer health and environmental benefits.[59 60] It is notable that some meat, blue foods and dairy are important components of a balanced diet, but for most, a reduced consumption of especially highly processed and ultra-processed foods would be beneficial, and help to ensure food systems were sustainable and operated within planetary boundaries.[60]

Transitioning from animal-based to plant-based (medical) nutrition in hospitals may significantly reduce the environmental impact on the climate emergency, although further research is required. There may be environmental benefits of plant-based nutrition, such as lower GHG emissions and resource consumption, that align with sustainability goals, but

Table 1 Carbon footprint for medical nutrition and food[87 130 131]

Infant milk	Carbon footprint (kg CO_{2eq}/daily diet)
Breastmilk substitute 1 kg production	
New Zealand	9.2±1.4
USA	7.1±1.0
Brazil	11±2
France	8.4±1.3
Breastmilk substitute 1 kg consumption	
UK/France	11±1
China/New Zealand	14±2
Brazil	14±2
Vietnam	11±1
Breastfeeding	
Food recommended for breastfeeding mothers to replace 1 kg of breastmilk substitute	5.9–7.8
Protein	
Cow's milk	1.15
Soya	1.99
Peanut	0.62
Almond	1.92
Menu	**(kg CO_{2eq}/daily diet)**
Normal or basal diet	5.083
Salt free normal diet	5.081
Liquid diet	1.652
Semi soft diet	3.839
Soft diet	4.696
Liquid anti-diarrhoea diet	0.473
Broad anti-diarrhoea diet	2.385
Residue-free diet	5.143
Residue-rich diet	4.909
Hepatobiliary protective diet	5.389
Low protein diet with 20 g of protein	3.028
Low protein diet with 40 g of protein	4.179
Low protein diet with 60 g of protein	5.304
High protein diet	8.112
Hyperuricaemia diet	4.718
Diet for bowel inflammation	5.684
Gastrectomy diet	4.386

this must not come at the expense of land use change or other unintended consequences. Overcoming legislative barriers, addressing nutritional considerations, conducting further research and promoting education and training will be instrumental in successfully implementing plant-based medical nutrition and driving sustainable practices in healthcare settings.

Food waste generation and spillage

Healthcare generates a significant amount of waste, on average 2.57 kg per bed each day. As poor waste management may increase the environmental footprint due to carbon emissions implementing change at all levels from supply chain to use within a healthcare facility is vital. Food waste occurs at all stages of production,[61] unserved food and food served but not eaten, and makes up the largest proportion of overall waste, have been measured at 37%,[62] 30%[63] and 65%,[64] respectively, of total hospital food waste. Food waste contributes to climate change through interconnected mechanisms.[65–67] First, unnecessary carbon emissions arise from the energy-intensive processes involved in producing, transporting and processing wasted food. The depletion of finite resources, like fossil fuels and minerals, during food production is exacerbated by food waste, as valuable resources are used without realising their full potential. Furthermore, the expansion of agricultural land to meet growing food demand, often driven by wasteful consumption practices, results in deforestation, habitat destruction and increased emissions. Finally, food waste generates significant GHG emissions during decomposition in landfills, releasing methane gas, a potent contributor to global warming.

When food is wasted post-consumption, all resources such as water, energy, labour time and costs are also lost. Avoiding food waste going to landfills is important, as damaging GHGs are produced such as methane and carbon dioxide. It is estimated that one-third of all food wasted costs the global economy US$ 1 trillion annually. This loss of food waste also contributes to food insecurity in all countries around the world, including those in the global south and north. Healthcare organisations producing large amounts of food waste need to consider ways in which to initiate change. Measuring and quantifying food waste in hospital nutrition is necessary to identify areas for improvement and develop strategies to reduce waste and associated emissions. Waste assessment should cover various stages, including food preparation, plate waste and unserved food. The clinical nutrition market is substantial and expected to exceed billions of dollars. Recent studies report approximately 40% of hospital food being wasted each year.[67]

Various factors contribute to food waste in hospitals, including standardised portion sizes mismatching individual patient children's appetites, rejected meals due to preferences or medical conditions, communication gaps about food preferences, undelivered meals, meal timing issues during medical procedures, lack of education on minimising food waste, improper food handling, storage and preparation techniques, overproduction of meals, supply chain delays and complexities in meal planning for diverse paediatric patient populations.[61 68] Addressing these challenges requires a comprehensive approach involving family-patient-centred meal planning, improved communication, staff education, efficient food handling practices, and better coordination between food service and medical procedures (table 1).[69]

To mitigate the impact of hospital food waste and spillage on the climate emergency, several solutions can be enacted.[70 71] Source reduction strategies aim to prevent waste and spillage by enhancing menu planning, portion control and inventory management to minimise overproduction and subsequent waste. Forming partnerships with food banks or local organisations can facilitate the donation of excess edible food, reducing waste and supporting community welfare. Composting and anaerobic digestion provide alternatives to landfill disposal, diverting food waste from landfills. Composting allows organic waste to decompose naturally, transforming it into nutrient-rich compost for use in landscaping or agriculture. Alternatively, anaerobic digestion converts food waste into biogas, which can be used for energy generation.[70 72]

Crucially, educating everyone working or accessing healthcare in a hospital, on the importance of food waste reduction and proper handling practices is essential.[67] Training programmes can increase awareness of the environmental impact of food waste and offer practical strategies for waste prevention and segregation. Adoption of technological solutions, such as inventory management systems and smart kitchen technologies, can optimise food procurement, reduce waste and enhance overall efficiency.[66 67] Real-time data monitoring and analytics provide insights into consumption patterns, identifying areas for improvement.[73]

Regular measurement and monitoring of food waste and spillage through waste audits enable hospitals to track progress, identify trends and target interventions effectively. This data can be used to set waste reduction goals and benchmark performance against industry standards. The centralisation of hospital catering systems significantly contributes to the carbon footprint of hospital meals. For health services, policy changes and reinvestment in local hospital catering facilities are necessary to make better use of locally procured food in order to reduce their environmental footprint.[66 74]

Stakeholder collaboration is vital in addressing the climate impact of hospital food waste and spillage. Engaging stakeholders across the healthcare sector; including healthcare providers, suppliers, policymakers and waste management agencies, helps to foster cohesive strategies and sharing of best practices driving systemic changes promoting waste reduction and recycling.[75] Audit tools may help healthcare organisations identify areas, such as menus, personalised ordering among others where changes could be implemented to affect change.[66 76–79] Healthcare organisations can strive towards making these changes, through the formation of Nutrition and Hydration groups with senior leadership involvement to identify quality improvement programme using plan, do, study and act cycles.

BLENDED DIET

The rising use of blended diets, involving the blending of real food into suitable tube or percutaneous endoscopic gastrostomy feeding consistencies, is gaining popularity in specific paediatric populations. These diets involve creating uniform mixtures from whole foods or minimally processed ingredients for individuals with complex medical conditions.[80] Blended diets may provide psychological and social benefits for parents by using real food over commercial formulas. However, concerns linger about potential blockages, nutrition suitability and adequacy as well as financial considerations for individual families.[81 82] The environmental ramifications of blended diets versus artificial nutrition have not been thoroughly studied, warranting further investigation.[71 83]

HOSPITAL CATERING AND SUSTAINABILITY

Food and catering services, for patients, staff and visitors, in healthcare settings play a significant role in GHG emissions, making a crucial contribution to the climate emergency. The promotion of healthier, locally sourced food alternatives allows healthcare facilities to actively reduce emissions throughout the entire supply chain, including agriculture, transportation, storage and food waste. The decision between in-house food production and outsourcing catering services results in varied environmental effects, with plant-based catering options showing lower environmental footprints compared with their animal-based counterparts.[69]

Prioritising healthier and locally sourced food choices, while simultaneously minimising emissions in the food supply chain, is a vital strategy for achieving sustainability goals within healthcare. It is important to recognise the impact of legislation and company perspectives that shape catering practices, which can differ across regions and organisations.[84 85]

The shift towards sustainable meals, beverages and snacks for patients, staff and visitors within hospitals poses challenges for hospital caterers.[84] Food and catering services within the NHS produce 1543 ktCO2e each year, equating to approximately 6% of total emissions. The Hospital Food Review aims to promote a low-carbon diet based on healthy eating guidelines through sustainable production and transportation practices, locally grown supplies of food, use of vegetables and fruit in season and sustained efforts to reduce food waste. Addressing cost considerations, infrastructural limitations, supplier availability, patient dietary needs and education becomes integral to this transition. Collaborative partnerships among hospitals, caterers, suppliers and other stakeholders are essential catalysts for driving sustainable food initiatives in healthcare settings. These partnerships facilitate the implementation of sustainable practices, drawing on expertise, resources and support from various sectors. Together, these efforts promote knowledge exchange and collective action, leading to a more sustainable and

environmentally conscious food system within healthcare facilities.[84–86]

BEHAVIOURAL FACTORS IN PROMOTING PLANT-BASED DIETS IN HOSPITALS

The shift toward plant-based food options in hospitals encounters various obstacles, many of which stem from the behaviours of children and families, personnel and visitors.[34 34 61 87] These behavioural factors are central, encompassing the preferences and consumption patterns of these stakeholders.[88 89] While micro-environmental studies emphasise the effectiveness of introducing more plant-based choices in hospital dining facilities to drive meaningful changes in dietary preferences, there is a noticeable gap in current evidence regarding large-scale interventions that successfully encourage plant-based diets across the broader paediatric population.[90–93]

To address this gap, a thorough understanding of awareness surrounding sustainability issues, individual dietary preferences and consumption habits becomes crucial. This knowledge can act as a guiding compass for orchestrating more extensive initiatives that promote healthier and climate-friendly food choices. However, research is urgently required to understand drivers of behaviour and barriers to change especially in the context of children with medically complex conditions, where food may be used as a comfort (ie, oncology) or where there is increased reliance of medical nutrition. To increase plant-based food consumption, they need to be more affordable and readily available in a hospital environment. Additionally, involving stakeholders such as food service staff, healthcare professionals and sustainability experts is indispensable. Their engagement provides a wealth of insights, including knowledge, potential facilitators and barriers to change. This collaborative effort aids in identifying strategies that can effectively reduce the climate impact of hospital nutrition, thus advancing the adoption of plant-based food options.[94] However, persuading children to embrace plant-based diets presents distinct challenges. Children may be resistant to substituting 'greens' for meat, even if it is deemed healthier or better for the environment. Additionally, gaining parental acceptance of plant-based alternatives for their children, particularly when traditional choices like cow's milk have been perceived as healthy, raises important questions. Are parents willing to make this change, and do we have a clear understanding of their willingness? Further research is imperative to delve into the dynamics of introducing plant-based diets to paediatric populations, considering both the perspectives of children and the attitudes of parents toward such dietary shifts[88 89 95–97] (figure 1).

Plastic/packaging

Plastic packaging plays a crucial role in safeguarding food products, ensuring their freshness, prolonging shelf life, facilitating safe transportation and preventing contamination. In the realm of medical nutrition, plastic packaging serves an additional function in feeding systems essential for enteral or parenteral nutrition administration.[98] However, its use also presents a substantial climate challenge that cannot be overlooked and behavioural factors also impact sustainable healthcare. For example, healthcare professionals opening wrapped utensils 'just in case', or single wrapping utensils instead of double wrapping and reducing the use of disposable gloves have been shown to significantly reduce the amount

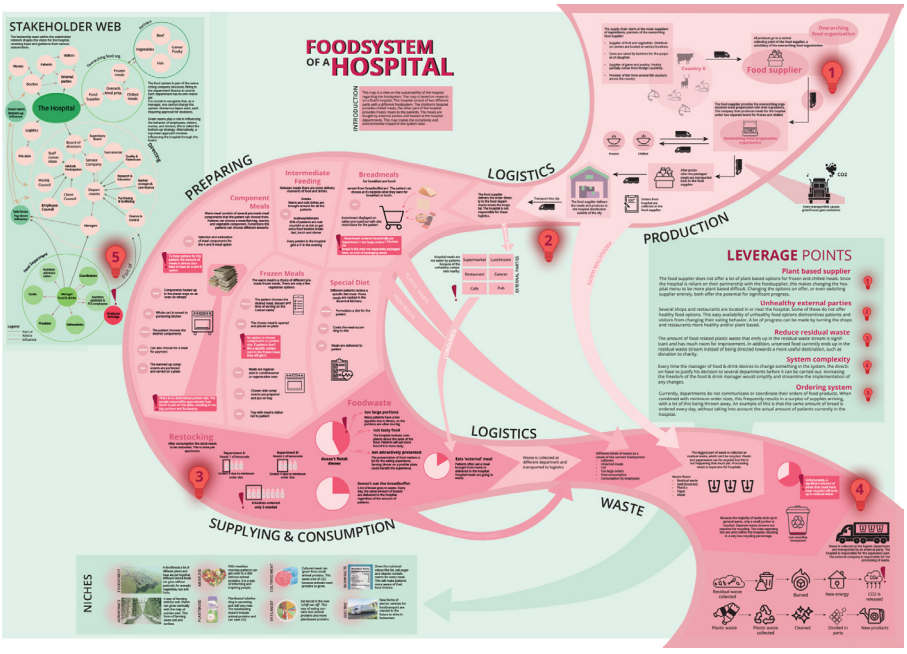

Figure 1 The complexity of food systems within a hospital setting.

of plastic waste in individual organisations. Plastic packaging in the healthcare sector, including medical nutrition, poses a significant threat to global efforts to limit temperature rise below the 1.5°C target.[99 100] The linear supply chain involved in healthcare, from raw materials sourcing to disposal, faces challenges in plastic waste management, hindering efforts to reduce waste and intensifying the environmental impact, particularly in energy recovery processes.[101–103] As such there is an imperative to develop a response to reduce the burden of plastic within healthcare.

Current recycling practices for clinical nutrition products primarily occur in open-loop systems, with a lack of closed-loop systems for recycling high-density polyethylene (HDPE) bottles due to the absence of food grade certification for recycled HDPE. Urgent research and innovation are imperative to develop large-scale closed-loop processes that promote the reuse and recycling of plastic waste in medical nutrition, fostering a circular economy.[104–106]

Medical nutrition products commonly use recyclable polymers like polyethylene terephthalate (PETE) and HDPE, but there is also extensive use of non-recyclable mixed single-use plastics in this sector. The carbon-intensive activities associated with plastic extraction, refining and manufacturing release substantial amounts of carbon dioxide into the atmosphere.[107–109]

To address the plastic packaging issue in medical nutrition and mitigate its impact on climate change, several potential solutions can be implemented. First, exploring and adopting sustainable packaging alternatives, such as bio-based and biodegradable polymers or recycled and recyclable options, can significantly reduce the environmental impact.[110] Second, implementing circular economy principles, using big data,[111] in the healthcare sector can minimise plastic waste by designing products and packaging for reuse, encouraging recycling and developing closed-loop systems.[111] Packaging optimisation, considering how plastic can be reused, is essential in a circular economy approach.[112 113]

The European Union's Waste Framework Directive provides a waste management hierarchy, including waste prevention, preparing for reuse, recycling, recovery and disposal. Hospitals and healthcare facilities can prioritise sustainable procurement practices by partnering with suppliers committed to reducing plastic packaging and offering environmentally friendly alternatives.[114] Improving waste management infrastructure, establishing efficient sorting and recycling systems and providing clear guidelines for waste segregation and disposal can enhance the recovery of recyclable plastics. Educating healthcare professionals, patients and visitors about the environmental consequences of plastic packaging can promote behaviour change and encourage sustainable choices.[115]

Additionally, a fundamental system is needed to make it easier to recycle plastics associated with medical nutrition waste. This requires a coordinated international response involving suppliers, governments and global non-governmental stakeholders to develop a global plastics framework and extended producer responsibility policies and schemes for the collection and processing of original packaging. This approach would help close the packaging recycling loop and hold the industry accountable for packaging choices, supporting the development of a circular economy. Collaborative efforts between researchers, healthcare providers and industry stakeholders can drive advancements in sustainable packaging solutions and support the transition to a more climate-friendly healthcare sector.[114]

The plastic packaging problem in medical nutrition significantly contributes to GHG emissions throughout its life cycle. To mitigate its impact on the climate, it is necessary to explore sustainable packaging alternatives, encourage supplier responsibility, advocate for legislative changes to enable the adoption of circular economy approaches, engage suppliers, improve waste management infrastructure, promote consumer education and behaviour change and invest in research and innovation. Implementing these solutions allows the healthcare sector to play a vital role in reducing plastic waste and achieving more sustainable practices aligned with global climate goals.[116–118]

Legislation

Legislation and company viewpoints related to plastic waste and sustainability are also important considerations. Various voluntary frameworks and organisations aim to tackle plastic pollution and promote circular economy principles; however, urgent adoption of these recommendations is required to support the development of legally binding global rules. Some governments, such as within the European Union, have implemented measures to reduce single-use plastics and promote recycling.[119–121] However, the impact of legislation may be limited, and there is a need for legislative reform to support rapid changes in the way in which medical nutrition waste is categorised to allow for reuse and recycling. There is also the need for secured-financing continuous research, innovation and collaboration to achieve significant sustainability goals in healthcare settings. Climate leadership and the implementation of frameworks and strategies are essential to foster sustainable practices in paediatric healthcare settings[122 123] (figure 2).

PRACTICAL ASPECTS OF SUSTAINABILITY—A CALL TO ACTION

The NHS green paper considers a pathway to achieving net zero healthcare, which includes reducing emissions from hospital estates and facilities (including catering systems). The formation of a Nutrition (& Hydration) group with senior management leadership can help healthcare organisations develop sustainable

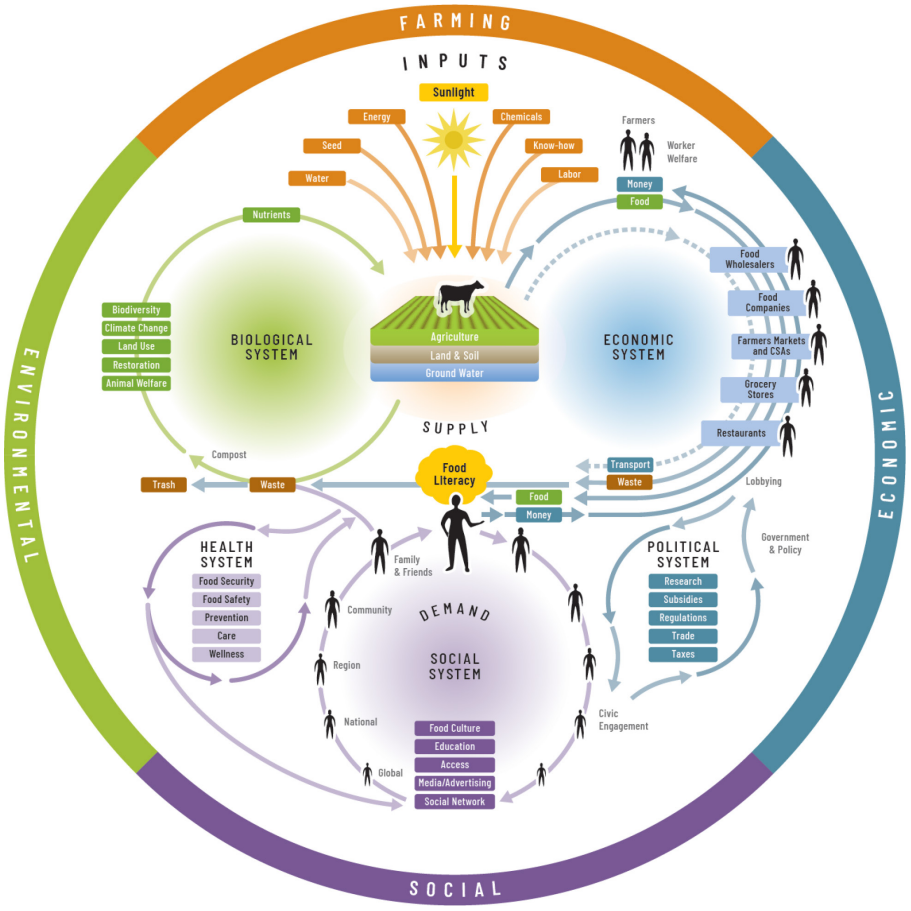

Figure 2 Food systems map (reproduced with permission from https://www.nourishlife.org/; https://icdasustainability.org/learningmodules/sustainability-self-assessment/https://icdasustainability.org/learningmodules/sustainability-self-assessment/).

nutrition and food systems from farm to fork/nasogastric feeds. Local pathways should consider aspects relating to supply chain and food procurement (ie, seasonable fruits and vegetables, local produce), digitising food waste audits from pre-plate to post-plate waste to provide intelligence as dishes children enjoy, individualised meal ordering rather than bulk order for wards.[124] Increasing the number of plant-based meals may need to be done in a staged approach,[55 86] as offering only plant-based meals may significantly increase mean total food waste (+11%) compared with meat-containing meals (293 g/plate vs 259 g/plate; p=0.05). Vegetables were the most wasted category in meat-containing meals, while grains and vegetables were the most wasted category in vegetarian meals consumers.[55] Education of all stakeholders including families, children and staff will be an important strategy to affect this type of behaviour change. To help with this, the British Dietetic Association has developed a sustainable diet implementation toolkit for healthcare professionals. The toolkit addresses challenges that may result for vulnerable groups and individuals (ie, children, pregnant women, communities with health and social inequalities) on providing advice on sustainable diets[125] (table 2).

CLIMATE ACTIVISM—GIVING CHILDREN AND YOUNG PEOPLE A VOICE

Climate change will have significant impacts on the health and future of children and young people, affecting social, economic and the environment, increasing the risk of water and food insecurity. The potential for future adversity is impacting the mental health and well-being of young people. A survey of 10 000 young people aged 16–25 years of age reported that 56% think humanity is doomed, two-thirds feel sad and scared, and across 25 countries these negative emotions are causing insomnia and poorer mental health.[126] Exo-anxiety is increasing,[127] children and young people have become the face of climate activism, but as healthcare leaders we need to provide them with a wider platform and opportunity to amplify their call to action, motivating others to enact change action locally, nationally and internationally,[128] with action extended across the social care and education system, that include changes to curriculum around social, economic and environmental sustainability for all stages of learning from school age to post-graduate and professional study, to ensure system-wide changes are enacted. The global targets identified in United Nations sustainable development goals offer an

Table 2 Practical ways for healthcare professionals to make small changes towards more sustainable healthcare[132 133]

Actions—personal level	Actions—at work
► Read about the impact climate change will have on children, and those most vulnerable in society—and how taking urgent action (however small) will have health benefits	► As part of a consultant consider introducing preventive actions as part of the discussion—being mindful that climate change can evoke anxiety, – Encourage families to consider active travel—such as walking. – Encouraging self-care and mindfulness. – Plant-based diets—for the family or how to introduce aspects as part of medical nutrition/specialist diet. – Reducing medical-associated waste (including over-investigation and over-prescribing). – Consider offering non-pharmacological alternatives (where appropriate) such as social prescribing into community-based projects.
► Move towards a plant-based diet—start with 1–2 meals a week—vegetables should make up ½ plate, grains ¼ and protein rich pulses and legumes such as soya the other 1/4.	► Advise patients (children) and their families, a better diet (increase the number of plants eaten) along with more walking and cycling will improve their health and reduce carbon emissions.
► Walk, cycle, car share or take public transport to work; drive an efficient care; hold remote meetings; attend fewer international congresses.	► Advocate locally, especially in primary care, to maximise home insulation and uptake of relevant grants.
► At home, use less energy with your home heated to around 18°C in winter, and insulate roof and walls to reduce the impact of heat; turn off appliances and lights, and reducing use of goods and service (make do and mend)	► Be a champion: put climate change on the agenda of all meetings—clinical teams, committees, professional networks.
► Influence food menus—by asking for local food, eat seasonable fruit and vegetables, reduce meat consumption, buy meat, fish, poultry that is responsibly reared and source; reduce the amount of processed foods; a low-carbon diet is a healthy diet.	► Find out more about catering and medical nutrition within the organisation—influence change, get involved in research to test new products and approaches; get involved in waste—at all levels; consider being a agent of change.
► Drink tap water.	► Encourage families to drink water instead of carbonated drinks.
► Become a climate activist by joining networks such as: – Climate and Health Foundation https://www.climateandhealthfoundation.org/ – The Centre of Excellence for Sustainable Health (CESH), https://cesh.health/ – Healthcare without harm https://noharm.org/ – Ella MacArthur Foundation https://www.ellenmacarthurfoundation.org/news/the-big-food-redesign-challenge-enters-the-production-phase – NHS Green Champions https://www.nhsfindyourplace.co.uk/greenchampionshub/	► Become a green champion at work—get involved and raise it with the senior leadership team, ► The NHS Green Champions Hub https://www.nhsfindyourplace.co.uk/greenchampionshub/ ► Royal College of Paediatric and Child Health https://www.rcpch.ac.uk/resources/tackling-climate-change-our-action-plan ► Sustainable Healthcare https://www.government.nl/topics/sustainable-healthcare/more-sustainability-in-the-care-sector ► Healthcare without harm https://noharm-europe.org/ ► Sustainability partnership – digital toolkits https://www.sustainabilitypartnerships.uk/digital-toolkits-and-resources ► Link up with others to think about communication channels to promote more sustainable habits. ► Support procurement teams to review contracts for food, equipment and consumables.

engagement framework towards a better future, and to date have been embedded into nursing curriculum in Australia[129] and dietetic curriculum, Winchester University (UK) (personal communication).

Reducing the impact of climate change within healthcare is all of our responsibility. The Sustainable Healthcare group as part of the Metabolism, Endocrinology and Nutrition Section, of the European Society of Paediatric and Neonatal Intensive Care (ESPNIC), have identified a programme of work to advocate for children's rights within healthcare. This includes a current survey of healthcare that provides an understanding of sustainability within paediatric intensive care, from which we plan to develop training and education programmes and research projects considering the development of a circular economy with regard to medical nutrition and associated plastic waste.

CONCLUSION

The climate emergency presents a significant threat to human health, where the healthcare sector's contributions to GHG emissions and plastic, and food waste further exacerbate the crisis. To ensure sustainable paediatric care, it is imperative to comprehend the environmental ramifications of plastic packaging, explore the viability of plant-based nutrition and address waste management in medical nutrition. Mitigating the climate emergency and fostering sustainability demands a comprehensive approach that encompasses healthcare operations, supply chains, medical nutrition, food waste management and catering

services. Implementing the proposed strategies, such as adopting sustainable practices, optimising supply chains, curbing plastic waste through reuse, responsible food waste management, embracing plant-based nutrition and advocating for sustainable food services, can significantly reduce the sector's ecological impact. Collaborative efforts among healthcare professionals, policymakers, suppliers, researchers and patients are paramount in effecting systemic changes and creating a sustainable healthcare system aligned with global climate objectives. Through these measures, healthcare practitioners can contribute to both climate mitigation and the well-being of paediatric patients, ushering in a transformation towards an environmentally conscious and resilient healthcare sector capable of addressing the challenges of the climate emergency and safeguarding the health of future generations.

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