

Portuguese Nephrology: We can be greener

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INTRODUCTION

Healthcare facilities are among the greatest contributors to resource consumption and waste generation. The average carbon footprint of the European Union's (EU) healthcare systems is 249 MtCO₂e. In the EU, 75% of healthcare-related ecological footprint relates to the healthcare's supply chain. The Portuguese healthcare-related carbon footprint is 4.8% of total national emissions, which is above the world average – 4.4%¹. Yet several studies have demonstrated that a bidirectional causal relationship exists between kidney disease incidence and climate change²⁻⁵.

Internationally, there is an increasing awareness of the ecological impact of nephrology and a claim for sustainable practices^{6,7}. In the UK, a Sustainable Healthcare Group was founded within the National Health Service (NHS). The Green Nephrology Initiative – one of its branches – promotes investigation, financing and implementation of ecological solutions. It has brought both financial savings and ecological benefits^{8,9}.

There are no precise data on the contribution of kidney care to the environmental impact of healthcare systems, but it is likely to be high. It is estimated that up to 11% of the Portuguese population have chronic kidney disease (CKD)¹⁰. In 2019, there were 20,640 patients with CKD stage 5D/T in Portugal – 12,523 under hemodialysis, 852 under peritoneal dialysis (PD) and 7,265 transplant patients with a functioning graft¹¹.

We present a review on the environmental impact of different nephrology areas, with ecological measures and our center's experience.

GENERAL APPROACH / NEPHROLOGY

Medical visits and drug therapy

The ecological impact of nephrology clinic relates mostly to drugs' production and distribution cycle and patient transportation. Producing and distributing medical drugs has a significant, albeit not quantified, ecological impact. Measures against drug hoarding and waste should be taken by every patient and clinician, in close collaboration with the community and hospital pharmacies¹².

A collaborative program with primary care facilities allows most patients to be followed in the community units by a general practitioner until later stages of CKD. Bringing kidney care out of the hospitals reduces travels, and telehealth is a tool yet to be optimized.

Patient education and autonomy play a critical role in preventing the need for medical care¹³.

Ward

Admission to a medical ward implies a non-negligible ecological impact, namely energy and waste related to the functioning of the hospital. Every department should be aware of its expenses related to lighting, heating, feeding, cleaning and laundry. Setting all computers to shut down or hibernate when not in use, setting two-sided printing in all printers. Computerization and paperless clinical files should be a priority. Simple domestic environment-friendly measures can minimize waste and resource consumption in hospitals, such as turning off air-conditioning and lighting when not in use. Thermal insulation is a structural energy and money-saving investment. Architectural optimization of natural light source and usage of energy efficient lighting and automatic switch controls (movement sensors) are tools for lighting-related energy savings. Choosing reusable, recyclable and recycled materials minimizes waste¹⁴.

Waste

Waste generated in a renal unit is either clinical or nonclinical. Nonclinical waste consists of packaging material, office paper, leftover food, etc., which can be treated as it would be at home. Appropriate segregation of recyclable materials is a key step in wisely managing waste from renal units¹⁴.

Clinical waste from healthcare facilities includes pharmaceutical waste, sharps and infectious waste, among others¹⁵. The financial cost of hazardous waste disposal is high, reaching for instance €16 per hemodialysis session¹⁶. Even though incineration remains the cornerstone for treating contaminated clinical waste and sharps, there are more eco-friendly alternatives, such as autoclaving¹⁷.

Biopsy performance and catheter placements are among the most waste-generating procedures, generating mostly contaminated plastic.

Recycling of packaging material and substituting hazardous materials help minimize environmental impact of kidney care-related waste¹⁷.

Dealing with transmissible diseases, namely during the COVID-19 pandemic, entails a high burden in managing contaminated waste consisting of personal protective equipment (PPE). Simple organization and communication measures can be taken to minimize PPE usage – for example, synchronizing blood draws with drug administration avoids unnecessary entries in contaminated areas.

RENAL REPLACEMENT THERAPIES

Hemodialysis

Hemodialysis machines, water treatment and distribution systems require large amounts of energy and water. Thrice weekly in-center chronic hemodialysis implies non-calculated emissions related to patient transportation. This poses a severe environmental burden. Eco-dialysis practices are easy, simple and commonly cost-neutral or long-term cost saving¹⁸.

Water

A 4-hour hemodialysis treatment session requires 350L of water (unpublished data). Prolonged droughts may increase water prices – and hence the cost of hemodialysis –, in severe cases making it impossible to perform.

A variable amount of water presented to a reverse osmosis (RO) machine is sent to drain as RO reject water (RW). RW is considered unfit for human intake¹⁹. Despite not fitting the criteria for potable water due to a complete lack of chlorine, RW poses no infectious risk²⁰. Reuse of RW from RO machines is gaining interest²¹, as it may be stored in tanks and used in gardening, laundry, cleaning, toilet flushes and sterilization of medical material, both at home or in hemodialysis centers²². Some experiences have shown full return of initial investment (tank and plumbing) in few years²³ and savings of €11,059 (£10,000) per year (in a center with 45 hemodialysis machines)²⁴, making ecological concerns economically rational.

Loop water distribution systems have become mainstream in Portugal and allow recirculation of treated water, therefore saving water and energy. Installation of automatic flow regulators that adapt the water flow to the distribution loop to the hemodialysis machine's needs has proven to reduce water waste²⁰.

Decreasing dialysate flow rate (Qd) from 500-800ml/min to 400-500ml/min is not associated with significant reduction of dialysis efficacy^{25,26}. The evidence so far shows that reducing it closer to 400 mL/min may be feasible, especially in patients with a body weight of less than 70kg¹⁹. This could represent saving up to 100L of water per hemodialysis session.

Sorbent dialysis is regaining interest as a means of saving water for hemodialysis²⁷. The REDY system requires only about 6L of untreated water per treatment. The effluent recirculates through a sorbent column allowing effluent regeneration. The wearable artificial kidney – based on this dialysate regenerating sorbent technology – is

currently under technical redesign²⁸. Wearable and implantable artificial kidney technology has undergone only small-scale clinical trials in humans. There are currently no such devices that provide a feasible alternative to standard PD or hemodialysis. When in place, these will generate far less nonbiodegradable plastics and spent dialysate (29, 30), while being a suitable clinical alternative.

Reuse of dialysate effluent of hemodialysis for agriculture was studied in Morocco, a region that frequently experiences periods of water scarcity³¹. Dialysate effluent, a high conductivity water, was treated with RO – a treatment that proved to be more efficient and cheaper than seawater desalination. Nevertheless, dialysate effluent reuse has some problems, such as potential transmission of infections and high concentrations of substances such as ammonium, phosphates, sulphates and other nitrous compounds³².

Waste

The Portuguese Directorate-General of Health recommends that all waste generated in a hemodialysis facility should be incinerated (or equivalent)³³. Solid waste includes plastics from the dialyser, blood tubing sets, syringes and concentrate containers, metals from needles, and glass from pharmaceutical drugs. Less than one third of non-hazardous waste is potentially recyclable – use of different types of plastic, glues, inks and labels prevents the remaining materials from being recycled¹⁶.

Central delivery systems that provide concentrated dialysate acid reduce dialysate and plastic waste derived from dialysate bags¹², as well as the need for its transportation. On the other hand, locally preparing and centrally delivering liquid bicarbonate makes it susceptible to microbiological contamination processes and is therefore not advised³⁴.

Although dialyzer reuse seemed an ecologically attractive solution, it is no longer a common practice in Europe mainly because of potential transmission of infections and decreased dialyzer performance. Issues related to dialyzer sterilization have a non-negligible environmental impact^{12,26}.

At our unit (which has no central delivery of acid system), each patient generates 546 kg of waste yearly, 37% of which is plastic (unpublished data) (Table 1).

Energy and carbon emissions

Carbon footprint – defined as the sum of greenhouse gas emissions released by an organization, product or service – expressed as carbon dioxide equivalents (CO₂e), has been calculated to be 3.8-10.2 ton

Table 1

Ecological impact of dialysis	Peritoneal dialysis		Hemodialysis
	APD	CAPD	
Water	Unknown		350L/treatment
Waste	671-739 Kg/year/patient (60-72% plastic)	533-613 Kg/year/patient (35-60% plastic)	546 Kg/year/patient (37% plastic)
Energy	Unknown		9-10kWh/treatment

CO₂/year/patient in hemodialysis³⁵. A standard hemodialysis treatment session consumes 9-10 kWh (unpublished data).

Usage of renewable energy sources has demonstrated to be economically attractive and ecologically wise. Portugal benefits from high solar radiation availability with a low annual variability, especially in the south, which makes solar energy a rational investment. An Australian pilot study has shown how installing solar panels may produce a neutral net power consumption and how the system may even become profitable^{36,37}.

Dialysate heating consumes energy. As an alternative, heat exchangers – a device that can be attached to some hemodialysis machines – transfer energy from dialysis effluent to the incoming dialysate before it enters the heater. Annual savings from heat exchanger installation were €53 (£48.05) per machine, with full return of investment achieved after four years. Thereafter, annual savings of €2,763 (£2,498.60) were anticipated for the 52-machine hemodialysis unit³⁸.

Home dialysis is anecdotal in Portugal. It has shown modest ecological benefits (7.2 ton CO₂ per patient per year)^{35,39}. As the frequency of treatments is the main factor influencing the carbon footprint of hemodialysis, rising the prevalence of home hemodialysis – dialyzing more frequently and for longer – would increase the emissions associated with hemodialysis programs despite reductions in travels¹³.

■ Peritoneal Dialysis

In Portugal, around 6% of patients on dialysis are under peritoneal dialysis¹¹, making the ecological impact of this type of treatment less significant than hemodialysis. The real carbon footprint of PD is, however, unknown. Peritoneal dialysis requires 6-12L of PD solution daily, yet, there is no information available about the amount of water required to produce PD solutions nor about the carbon footprint of transporting PD solution from the point of manufacture to the point of care³⁵. In addition, producing one kilogram of plastic requires 180L of water²².

Telehealth and telemonitoring are becoming increasingly important in PD patients' care. Some technologies such as Claria© transfer information on peritoneal dialysis exchanges over the internet onto a proper clinical software, allowing physicians and nurses to solve several problems remotely.

Plastic consumption is greater in PD than hemodialysis. However, Biofine© is a PVC-free polymer used in the majority of Fresenius Medical Care® products for peritoneal dialysis, which provides an ecological alternative to conventional plastic that requires less energy for production and does not release hydrochloric acid upon incineration. Some plastic reduction alternatives such as the U-drain© systems have been put in place. This requires installation of drainage tubing from a cyclor to allow direct drainage of peritoneal effluent into the sewerage system (some patients in our PD Unit use homemade alternatives to this system).

At our unit the weight of total waste generated by each patient on continuous ambulatory peritoneal dialysis (CAPD) varies between 533-613

Kg yearly (of which 35-60% is plastic). On automated peritoneal dialysis (APD), this grows to 671-739 Kg yearly (60-72% plastic) (unpublished data) – this variation depends on the number of exchanges and on the brand of PD solution used. Other centers found similar values¹⁷. (Table 1)

■ Kidney transplantation

Kidney transplantation is by far the most ecological treatment for CKD stage 5D/T. Its environmental impact relates mostly to initial hospital admission and kidney transplantation surgery, as well as the use of immunosuppressive drugs. In Portugal, however, follow-up of kidney transplant recipients is the responsibility of the kidney transplant center as long as the graft is functioning. This has a heavy ecological burden in terms of patient transportation.

Remote consultation has shown to be an acceptable carbon-saving alternative for follow-up of renal transplant recipients⁴⁰. At our unit, and since the COVID-19 pandemic started, an integrated telehealth programme has been extended. Remote consultations take place with either the patient or the local nephrology assistant alone, or both. Agreements with local laboratories allow patients to perform blood and urine analysis in their local communities and results are automatically sent to our center. Immunossupressants are sent by mail to the patient's address.

We also believe follow-up of post-transplant patients by their local nephrology department is a suitable alternative, unless there is other clinical indication for follow-up in a transplant center.

■ STRATEGIES TO REDUCE DIALYSIS BURDEN

No therapeutic decision should be made based on ecological concerns. The priorities of treatment must be clinical outcomes and patient quality of life. However, reducing the environmental burden of dialysis, whenever clinically suitable, may be an ecological solution, as dialysis is a resource-consuming technique. In such cases, the argument for protecting the environment adds to clinical benefits.

Well-established conservative therapy programs for end-stage kidney disease – lacking in Portugal – may offer a structured option for some patients. Optimized kidney selection in deceased- and living-donor transplant may bring more patients out of dialysis. CKD prevention reduces its ecological and economical burden. Reducing social and economical risk factors for CKD should be a priority¹².

■ THE FUTURE

Reducing the ecological impact of kidney care can be performed both locally or nationally, as well as in dialogue with industry. Health policy and regulations contribute strongly to this balance (Table 2).

Locally, each nephrology department should define a Green Person, responsible for drawing up and implementing green projects, taking into account the specificities of each department. Collecting data on electricity consumption, water usage and waste production should

Table 2

Reducing Kidney Care ecological impact	
General/National measures	Local measures
<ul style="list-style-type: none"> • CKD prevention programs; • National guidelines with ecological recommendations and targets for Dialysis Units; • Implement conservative therapy programs; • Optimized deceased- and living donor kidney transplantation programs; • Telehealth, telemonitoring and remote specialist consulting; • Patient autonomy and health education; • Follow-up of post-transplant patients at their local nephrology department. 	<ul style="list-style-type: none"> • Define a Green Person; • Computerization and paperless clinical files; • Optimize heating/lighting energy use; • Choosing reusable, recyclable and recycled materials when signing contracts with the industry; • Choose autoclaving (or other ecologic alternatives to incineration) for treating contaminated waste; • Reuse RW from RO machines; • Use automatic dialysate flow regulators; • Use centrally delivered acid concentrated systems.

be the cornerstone of this action, setting improvement targets. Regular evaluation of the impact of implemented measures will guide further interventions. All members of staff should be involved in the green projects. Measures such as recycling waste materials should be implemented after adequate staff education (errors with recycling in potentially contaminated environments may pose a risk to public health).

National guidelines such as the Portuguese guidelines for chronic dialysis (*Manual de Boas Práticas de Diálise Crónica da Ordem dos Médicos*) should include ecological recommendations and targets in its next update.

Ecological criteria should be considered when institutions sign contracts with industry. New dialysis units and nephrology departments should be designed according to eco-friendly principles.

CONCLUSION

Kidney care is ecologically and economically onerous. Green nephrology projects have high innovative potential. Research in this field may combine clinical benefits with lowering environmental impact. Although some work has been done already, Portuguese nephrology can become greener.

Acknowledgments

Luis Libório; Elisabete Avelar Dias; José Pires; Sara Lobo; Elisabete Santos; Rita Reis; Cristina Lobo Oliveira; Célia Gil; Margarida Gonçalves; Sara Querido; André Weigert; Carlos Palma; José Augusto; Paulo Dinis; Pedro Ponce.

Disclosure of potential conflicts of interest: none declared.

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