Finding the Sweet Spot in Green Nephrology: The Intersection of Environmental Sustainability and Excellence in Patient Care

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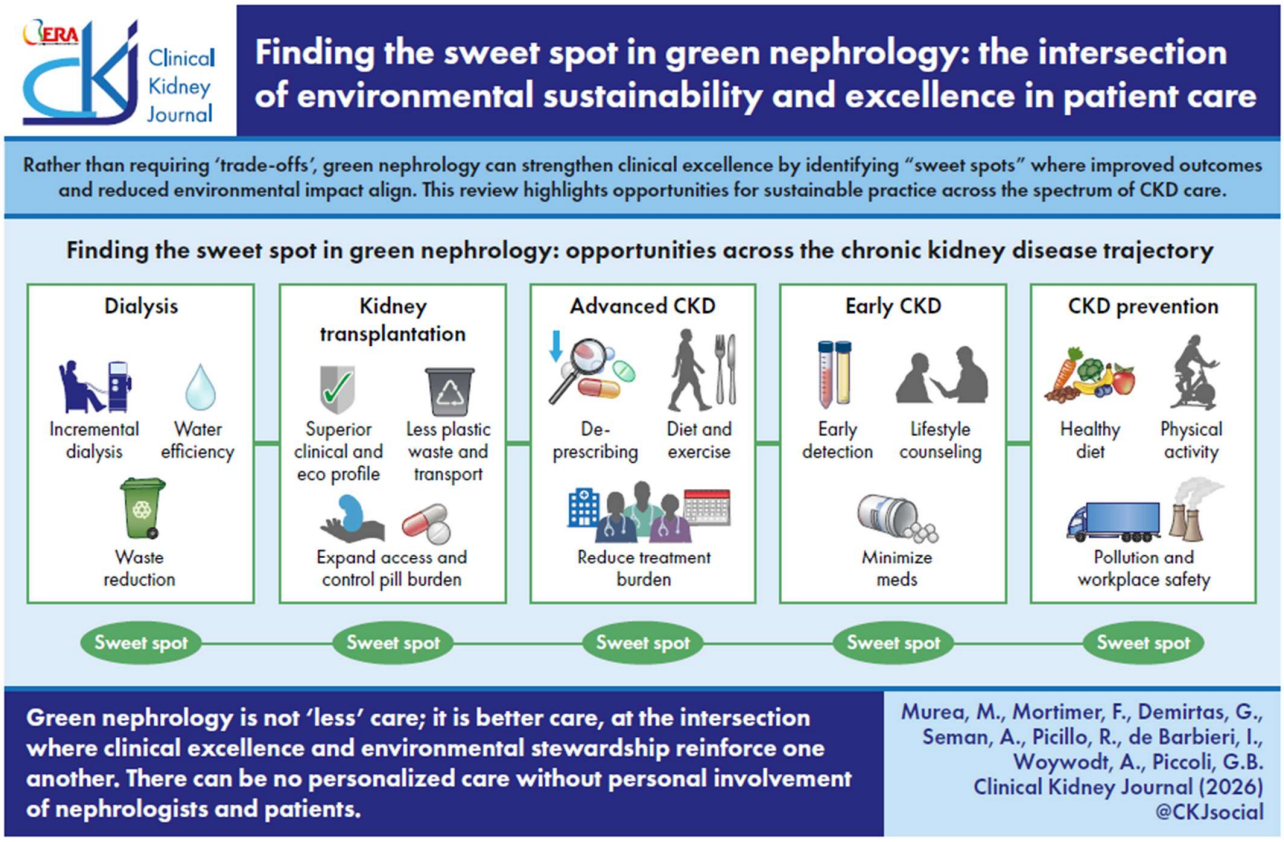
Graphical Abstract



Abstract

Sustainability in kidney care is often perceived as requiring trade-offs in clinical quality, yet green nephrology can strengthen clinical excellence by identifying "sweet spots" where improved outcomes and reduced environmental impact align. Organized along the chronic kidney disease (CKD) trajectory, this review highlights opportunities for responsible practice at each stage. Dialysis, the most resource-intensive component of kidney care, finds a sweet spot in reducing redundancy, personalizing treatment, optimizing vascular access, and empowering patients. Approaches such as incremental dialysis, water-efficient systems, and well-planned vascular access improve both clinical and environmental performance. Upstream, CKD prevention remains the most powerful strategy for increasing survival and reducing human and planetary burden. The sweet spot on early diagnosis and optimized CKD care may be identified in shifting away from medication escalation toward lifestyle-focused interventions, deprescribing when appropriate, and reducing treatment burden. Research also plays a critical role, with substantial potential to reduce waste by minimizing redundancy, promoting data sharing, adopting efficient trial designs, and leveraging digital tools. Options that are resource sparing are however usually more time-consuming, thus highlighting the central role of the nephrologists in individualized kidney care. In essence, green nephrology is not "less" care; it is better care, sitting at the intersection where clinical excellence and environmental stewardship reinforce one another.

Keywords: chronic kidney disease, green nephrology, haemodialysis, sustainability

Introduction

The concept of green medicine—an evocative term that combines sustainability, equity, and nature—has evolved in the last two decades, in parallel with the acceptance of the importance of changing our attitudes before irreversibly endangering the planet. Nephrology, thanks also to the pioneering work of John Agar and colleagues, was among the first clinical disciplines involved in a paradigm shift from consuming to sparing in care (1).

Dialysis became the initial focal point for this transformation. Although not the most polluting medical therapy, its unique characteristics made its ecological footprint particularly visible (2-3). Dialysis is a lifelong treatment for many patients, with substantial requirements for water, energy, consumables, transportation, and waste management. From this starting point, all phases of kidney care, from prevention to kidney transplantation, were embraced, shifting from *green dialysis* to *green nephrology* (4-5).

The measurement of the ecologic impact of care is challenging, and knowledge gaps impair precise quantifications and comparisons. Logically, the life cycle analysis (LCA) is indispensable to start the quantification of the ecologic impact of an object and (even more complex) of a procedure (Figure 1) (6-7). However, in a globalized world, extraction of raw materials and the different phases of "making" usually occur in different settings, with wide variability of intermediate phases, such as transportation, or waste disposal. Hence, to cite the iconic book *How Bad Are Bananas?*, while it is possible to assess the carbon footprint of "almost everything", this comprehensive measure is based on theoretical averages, that present a very imperfect fit to real-life situations, and have a unsurprisingly large margin of uncertainty (8, 9).

The general concepts of reducing needs, limiting the use of goods and supplies, choosing wisely, recycling whenever possible, and disposing carefully, apply to all healthcare fields. However, we have to be aware of the risks of over-simplification and on the need for contextualization. One example regards peritoneal dialysis. Notwithstanding clinical equivalence, this option is economically sound in Australia or Hong Kong, but carries a huge economic burden in Egypt, where the few existing programs strive to survive, due to the high costs (and carbon footprint) of importing supplies (6, 10).

Hence, limits, knowledge gaps and uncertainty of measures should be considered when critically exploring the potential axes of action for finding the "sweet spot" as the intersection where clinical excellence, medical progress and respect for the planet reinforce rather than undermine each other.

There is no reason why excellent patient care should compete with planet stewardship, and vice versa.

This principle underpins the Centre for Sustainable Healthcare's concept of "sustainable value" defined as patient and population outcomes relative to the environmental, social, and financial costs of providing care (11).

Why, then, is green nephrology so often framed as a compromise, where improving sustainability is assumed to require a reduction in the quality of care, to fulfill the incontrovertible need to reduce the environmental footprint of kidney care?

A similar framework is used beyond nephrology, when it is argued that progress with sustainability will lead to less freedom, wealth, or comfort, needing a trade-off between those aims and the green agenda (12, 13). Here, we argue that quality and green nephrology can be aligned, provided a change in the current mindset. In this review we follow the chronic kidney disease (CKD) trajectory "downstream to upstream," beginning with dialysis, the most demanding component of kidney care, progressing through advanced CKD, early CKD care, and finally CKD prevention. To operationalize the concept of "sweet spots" across this trajectory, we summarize the areas in which clinical excellence and environmental responsibility converge (Table 1) and illustrate the three pillars underpinning this convergence (Figure 2). This structure reflects our central argument that "sweet spots" between sustainability and clinical excellence exist at every stage of care.

Green nephrology is not low-cost, low-intensity nephrology

The case of dialysis

The famous three "r" of environmentalism—reduce, reuse, recycle—with the added fourth of "repair" apply naturally to nephrology (14). In dialysis, the foremost 'r'—reduce—applies directly to minimizing redundancy, such as delivering un-needed dialysis sessions, for the sake of an easier management of the dialysis ward, concerns on profit (unused "empty chairs"), or using of high dialysate flows following a consolidated praxis in the absence of proven clinical advantages (15, 16).

It has been calculated that 4-10 tonnes of CO_2-equivalent are generated per patient-year, on a standard schedule (hemodialysis, four hours, thrice weekly). Calculating the carbon footprint of dialysis means summing the effects of water/energy use, materials, waste management and transportation. As expected, the result range is very broad, according to the setting, type of calculation and items considered (4). Recent studies from Spain and Germany highlight that simple measures, including the use of a hemodialysis carbon footprint calculator, could substantially reduce greenhouse gas emissions (about 9% in the multicenter German study). The most effective, ready-to-implement actions included lowering dialysate flow, expanding the use of solar energy, and replacing snacks provided during dialysis with healthier diet options (17, 18). Dialysis hardware warrant re-evaluation. Recent studies of end-of-life of hemodialysis machines illustrate that current devices have very limited recycling potential (19). These findings underline the need to redesign dialysis machines according to

cradle-to-cradle principles, to enable meaningful material recovery, aligning device life-cycles with sustainablity goals.

Personalized dialysis, started upon clinical indications, and adapted to residual kidney function and metabolic needs, may allow for reducing the treatment burden. The choice is patient-friendly, and its "planet friendly" nature is likewise evident. Safe personalization, in particular when the dialysis dose is lower than the standard "kidney replacement therapy", however, requires investments in time and controls (20, 21). While the balance is favorable for the health-care system and the environment, the concept that personalized dialysis is not merely "less dialysis" should be stressed if its undeniable advantages have to be maintained. Less dialysis, or no dialysis in patients with whom a conservative pathway has been chosen, should remain framed by a policy of avoiding futility, limiting useless interventions, while improving the overall quality of care (22, 23).

A recent meta-analysis of 22 observational studies confirms that an incremental dialysis start does not increase mortality but may lower hospitalizations, preserve residual kidney function, and lead to better patient-centered outcomes (20). Further studies analysed the environmental and economic perspective. For instance, Choo et al. described sustainable kidney care practices at Bradford Teaching Hospitals NHS Trust. Incremental/decremental dialysis demonstrated the largest benefit, exceeding all other approaches (like online priming, centralized acid delivery, dialysate autoflow, upgrading water treatment systems, etcetera). Twice-weekly hemodialysis resulted in the highest cost savings and the largest reduction in GHG emissions (≈30,000 kg CO_2e per year if applied in 25 patients) (21). Torreggiani et al. showed that, in a large French center, incremental dialysis start (one or two sessions per week) was feasible in about two thirds of patients, with about half them remaining on less frequent schedules for one year or more (24).

Incremental peritoneal dialysis represents another strategy, adapted to residual kidney function along with peritoneal clearance characteristics (25). It has been calculated that one patient on full-schedule peritoneal dialysis generates approximately 600 kg of waste annually, with a carbon footprint of 1.2 to 4.5 tonnes of CO_2-equivalent each year (22). Besides clinical benefits, like reduced glucose exposure, fewer infections, and better quality of life, incremental peritoneal dialysis obviously reduces water usage, plastic waste, and carbon emissions. However, the advantages of incremental strategies are differently quantified; inconsistent definitions highlight the need for uniform reporting.

Hemodiafiltration is relevant in the sphere of green nephrology. Without entering into technical details, offering this dialysis option, that has demonstrated better survival results in randomized studies and meta-analyses, is not necessarily associated with a higher water and carbon footprint. However, once more, its "iso-resource adaptation" needs an investment in time and controls (26, 27).

In its broader meaning, green dialysis also encompasses the principle of equity. Global estimates suggest that about four million of people who need dialysis or transplantation are unable to obtain it. Hence, ensuring access to dialysis is an ethical imperative (28, 29). However, lower-impact dialysis practices in high-income

countries will not, by themselves, translate into increased access to care in low-resource settings. The drivers of limited access—insufficient infrastructure, workforce shortages, political instability, supply-chain vulnerability, and financial constraints—are largely structural and disconnected from efficiencies achieved in wealthier systems.

Nevertheless, sustainability efforts in high-income settings remain relevant globally. They help identify best practices, promote technological innovation, reduce the overall carbon footprint of the sector, and may influence the design of future systems. Importantly, strategies developed in well-resourced health systems—such as water-efficient technologies, renewable-energy integration, and reduction of clinical redundancy—can inform the creation of lower-impact programs when and where new facilities are built. Green nephrology, therefore, cannot claim that responsible practice in one region directly enables access elsewhere, but rather that sustainability principles should accompany expansion of dialysis without replicating low-sustainability models (1,4,30).

Reducing intervention redundancy means also empowering patients. Therapeutic adherence, arguably one of the best indicators of responsible resource use, depends on shared decision-making and patients' empowerment. Life on dialysis is demanding, and when several modalities are available (e.g., peritoneal dialysis, home hemodialysis, satellite-unit dialysis, or in-center care), the ethical principles of equity, justice, and autonomy inevitably intersect (5,30-32). Once a modality is chosen, informed patients can meaningfully contribute to improving sustainability of their care pathway. Importantly, a green dialysis perspective should not mean imposing a modality because it is presumed to be "better for the planet". Rather, sustainability should be integrated into holistic care planning, supporting patients in adopting clinically appropriate and environmentally responsible practices, such as optimizing diet and lifestyle, minimizing unnecessary travel, preventing medication waste, and safely managing treatment-related waste.

The case of dialysis vascular access

Vascular access represents a pivotal domain where clinical quality and environmental stewardship may converge. Well-planned access is associated with reduced complications, hospitalizations and treatment burden, consequently avoiding further procedures. Each prevented infection, thrombosis or access failure can is a "green metric", although rarely visible on standard dashboards (33). A "first-time-right" strategy requires timely referral, modality-aligned shared decision-making, and coordinated input from nephrologists, surgeons, interventionalists and access nurses. This approach yields fewer bloodstream infections, related to the use of temporary catheters, fewer unplanned vascular access interventions and hospitalizations (34) curtailing consumption of procedure kits, medications, imaging and inpatient resources. The environmental implications of procedural burden, including the carbon footprint of interventional radiology suites, which can generate up to 23,500 kg CO_2-equivalents over just five weekdays, warrant careful consideration (35). Along the same line, crash dialysis starts and emergency catheter insertions represent environmental "hotspots" along the CKD trajectory, triggering resource-intensive cascades, such as emergency evaluation, urgent central venous

catheter placement, unplanned admission and high-dose hemodialysis (36). Conversely, proactive vascular access preparation represents a high-yield strategy not only improving patient outcomes, but also reducing the environmental footprint of dialysis.

The case of kidney transplantation

Detailed in a dedicated paper in this Special Issue, kidney transplantation (KT) can be considered by itself the sweet spot in kidney replacement therapy, since it associates a superior clinical profile with a better ecologic performance. Cadaveric kidney donation has even been taken as an example of circularity of life, and, even though this has been seen as culturally sensitive in some settings, for instance in the Mediterranean countries the concept of life arising from life has been extensively employed in educational campaigns in favour of kidney donation (57).

Comparing dialysis and kidney transplantation is not easy. While the advantages in the case of a well-functioning KT, are clear, and spam from lower blood tests, lower need for transportation, and, of course, lower production of plastic waste, less is known on the ecologic burden of a less-than optimal kidney graft, and comparisons are impaired by the lack of data on the lifecycle and carbon footprint of most of the employed drugs (36).

Since KT is well-acknowledged as the best type of kidney replacement therapy, every effort should be addressed to expand its availability, addressing the main barriers of lack of donors in high income countries and lack of infrastructure in low-medium income countries. In the context of the excellent combination or quality of care and sustainability, to optimize long-term results in people living with KT, a main clinical focus should be on drug management, avoiding noncompliance, still one of the main causes of KT failure. Controlling the pill burden, with the same caveats described for CKD care, has the double advantage of reducing the carbon footprint of care, and of limiting non-compliance (37). Attention to dietary management and life-style may further enhance the therapeutic advantages.

The case of optimizing advanced CKD care

Identifying the “sweet spot” in advanced CKD care is challenging. Access to both new and established kidney-protective agents remains largely confined to high-income settings and to wealthier individuals in low- and middle-income countries. Treating *all* eligible CKD patients could generate significant clinical benefits in the medium-long term but would also substantially increase both economic and environmental costs in the short term (42). The goal—treating everyone who stands to benefit—remains essential, but achieving a sustainable equilibrium requires a shift in mindset. Rather than relying solely on medication escalation, truly optimized CKD care should more efficiently integrate lifestyle modification, dietary counseling, deprescribing where appropriate, and collaborative patient engagement to reduce treatment burden while preserving clinical effectiveness (Figure 3). Pharmacological and non-pharmacological approach are allied and complementary.

Indeed, the strategy of progressively adding kidney-protective drugs (whose carbon-footprint is not fully established) to counteract kidney function impairment is appealing, but may have the side effect of diverting attention from non-pharmacologic actions. Among them, nutritional management, associated with physical activity, does not only have a well-established potential to reduce the progression of CKD, but is also planet friendly, as elsewhere discussed in this issue (38-39). Treatment burden is inversely associated with quality of life in chronic diseases, including kidney failure, and is also inversely proportional to therapeutic adherence, leading to indirect increases in the ecologic burden of care (wasted drugs) (40, 41).

A large body of evidence—including the landmark MDRD trial—demonstrates that *prescribing* a diet is insufficient to achieve meaningful lifestyle change (43). Ultra-processed food is less expensive and often more user friendly, but is less healthy. The recent KDIGO guidelines on CKD clearly resume how physical activity goals are met by a small percentage of individuals. Hence, while logically what is attainable without a pharmacologic treatment should come first, the need for more dedicated time to change daily habits favours a drug-based approach potentially leading to the "Prescribing Paradox". To meet clinical targets, clinicians often prescribe more pills, with frequent side effects and even a worse quality of life, potentially leading to generalized non-compliance (44-46). Avoiding this paradox is a clear instance where clinical excellence and ecological stewardship converge.

Despite their relevance, deprescribing strategies remain absent from current nephrology guidelines, even though they are well established in geriatric medicine and associated with improved outcomes, better quality of life, and fewer hospital readmissions (46-48). Deprescribing implies a shift from the "prescription cascade" of more medications leading to more side effects, prompting still more medications. Deprescribing is clinically, ethically, and environmentally sound, but requires time: time to prioritize which therapies are essential, time to discuss changes with patients, and time to build the therapeutic alliance needed to maintain adherence (48, 49).

Empowering patients, one of the Centre for Sustainable Healthcare's core principles (49) is a crucial component of optimizing advanced CKD care. Effective patient empowerment improves clinical outcomes and reduces healthcare demand by enabling meaningful lifestyle change, supporting adherence, and facilitating early recognition and management of complications. Patient empowerment necessitates good communication, goal setting, patient-accessible health records, structured education, peer support networks and shared-decision making (50). While the diffusion of electronic health records facilitates this task, strategies for elderly and culturally fragile individuals (more prone to develop side effects, but with low electronic literacy) should also be undertaken.

While demonstrating the advantages of early kidney care is difficult (51), measuring the negative impact of late referral is feasible and a large body of evidence supports that late nephrology care is associated with poor outcomes (52-54). Avoiding what has defined "suboptimal pre-dialysis care" (55) with "crash start" of

dialysis, is clinically and economically sound, and is expected to be also ecologically advantageous. However, no study so-far explored these issues from the point of view of ecologic (carbon footprint) impact.

Expanding high-quality pre-dialysis care cannot rely solely on individual clinicians; it requires rethinking the configuration and capacity of the nephrology workforce in both high- and low-middle-income settings. Strengthening upstream nephrology engagement, with prevention and early diagnosis, and referral in any case before patients reach crisis, is a sweet spot where clinical excellence, health-system efficiency, and environmental stewardship converge.

The case of early diagnosis and early CKD care

Current guidelines generally recommend referral for patients with significant proteinuria or advanced CKD (stages 4–5), thereby restricting nephrologists' intervention perimeter, limiting interventions when treatments are likely to be most effective. In contrast to this narrow approach, the recent WHO guidance elevates kidney disease as a global health priority and explicitly emphasizes the importance of early diagnosis, particularly in vulnerable populations (56). The WHO document notes, among others, that kidney disease is both a risk factor for and a consequence of hypertensive disorders of pregnancy, which are linked to maternal mortality, preterm delivery, and low-birth-weight infants who themselves face increased lifetime risk of kidney. This highlights the need for earlier assessment and more proactive kidney care across the life course.

Prevention, early diagnosis, and timely intervention are inherently time-intensive, and workforce limitations remain a major barrier. To date, no studies have examined the carbon footprint associated with clinician time spent in nephrology visits, nor have they compared long-term outcomes when education and counselling are delivered, and, in this latter case, have explored outcome differences when education rests mainly on nephrologists versus generalists or other health professionals (57, 58). These gaps underscore the need to better understand not only when nephrology care should start, but who is best positioned to deliver it, and how these choices influence both patient outcomes and the environmental impact of kidney care.

Diagnosis kidney disease in its earliest stages remains challenging. A decline in estimated glomerular filtration rate (eGFR) becomes apparent only after substantial nephron loss—typically more than 50%—has already occurred. Albuminuria is a sensitive marker of cardiovascular risk, yet it is not consistently present in the early phases of all kidney diseases; for example, children with congenital anomalies of the kidney and urinary tract (CAKUT) may have normal albumin excretion. Imaging studies, while fundamental, are time-consuming, operator-dependent, and often insufficient for early detection of common diseases such as nephroangiosclerosis.

A substantial body of evidence indicates that early initiation of established and newer kidney-protective therapies—including ACE inhibitors, ARBs, SGLT2 inhibitors, and GLP-1 receptor agonists—can stabilize kidney function and delay progression for prolonged periods (57, 59, 60).

To maximize the benefits of these therapies, CKD must be identified earlier than it currently is. In Europe, for example, nearly 30% of individuals who start dialysis have had no prior or only irregular nephrology follow-up, underscoring missed opportunities for timely interventions. Although standardizing referral criteria may improve consistency, rigid thresholds risk overlooking the "sweet spots" where specialist involvement could meaningfully alter disease trajectory (61).

No single model of early CKD care will suit all settings. However, a paradigm that primarily relies on adding medications at predetermined thresholds is not consistent with the principles of sustainable or "green" nephrology. Personalized care requires time: time for counseling, lifestyle guidance, diet optimization, and shared decision-making (**Figure 4**) (57). Shifting from a fast-medicine, drug-intensification model to one centered on education and behavior change is labor-intensive and demands appropriate expertise. How much of this responsibility should rest with nephrologists, and how much can be shared with primary care or other health professionals, remains uncertain, and is probably context sensitive. The optimal configuration depends on local workforce capacity and health-system structure and participation of multiple experts should be balanced against the risk of fragmenting care.

The case of CKD prevention

Prevention appropriately sits at the forefront of discussions on green nephrology, as the most effective way to reduce its clinical, social, and environmental burden. In high-income countries, most CKD and kidney failure cases arise from preventable conditions, such as type 2 diabetes, obesity, hypertension and cardiovascular diseases (29, 62-64). Obesity and type 2 diabetes are strictly related to lifestyle and nutrition patterns, and are favoured by genetic and environmental factors, including low birth-weight (partly preventable in itself) (65). In low-resource settings, several kidney diseases, such as Mesoamerican Nephropathy, are linked to environmental exposures and hazardous working conditions and are largely preventable. Achieving this, however, requires substantial societal engagement, regulatory action, and a fundamental shift in occupational and environmental protections (2, 30).

The global rise in the so-called lifestyle-related diseases is not inevitable; rather, it is sustained through wealth inequalities, unhealthy food systems and low physical activity levels (66, 67). Addressing lifestyle determinants of health is however complex and important initiatives, such as investing in transport infrastructure to reduce car dependence, or promoting healthy plant-based diets, require sustained efforts and time to yield population-level changes. Nevertheless, some policy actions can achieve rapid public health gains, for example through regulation of the food industry.

Prevention should begin early in life, a principle not specific to nephrology. The role of the nephrologists is usually mainly supportive, through communicating the evidence on prevention of kidney diseases to colleagues, policy makers and the public. Prevention is not always possible: cardiovascular ageing is one of the limiting factors of the lifespan, and prevalence cardiovascular diseases increases with the ageing of the

population. Nephroangiosclerosis is the one of the most common kidney diseases, and is related to vascular impairment. The longer the life spam, the higher its incidence. In this context, prevention becomes synonymous of retarding the clinical onset of severe CKD (and need for kidney replacement therapy) and not of avoiding it absolute terms. Type 2 diabetes provides an example of how competitive mortality reduction leads to an increase in other end-organ damage, including kidney failure, dispelling the claims of the St Vincent Chart that, in 1989, set the ambitious goal of reducing kidney failure incidence by 33% in five years by improving diabetes care (68, 69). The sharp decrease in mortality allowed more individuals with type 2 diabetes to survive, and patients with diabetes now account for 25-over 50% of incident dialysis patients. Hence, even if foreseeing the net effects of prevention is not easy, retarding the clinical onset of CKD has the potential to lead to an absolute reduction in the incidence and duration of kidney failure which has a real impact on resource use needed for dialysis.

The case of research in nephrology

Research is a foundational component of medicine. Although it is resource intensive, it has the potential to drive the development of greener technologies, treatments, and models of care (70). A first step is identifying redundancy: research activities that consume resources without adding value—such as unnecessary investigations, repetitive studies, or failure to use existing datasets. Improving dissemination practices could prevent costly and unnecessary duplication of experiments, facilitate reproducibility and promote inclusivity. Research laboratories often use hazardous or non-recyclable materials (71) and sustainable practices are probably underrepresented and underreported. Sharing of equipment, data and resources (72) should be promoted to deliver environmental benefit while improving the quality of the evidence (73).

The carbon footprint of clinical trials can be reduced by optimizing trial sites and sample collection, preventing low-value studies, and using approaches like basket and umbrella trials, which evaluate various treatments and conditions concurrently, following also the 2019 National Institute for Health and Care Research recommendations (74, 75). Furthermore, digital platforms like Epic and Telehealth may support efficient and sustainable science, even if they may increase need for transfers of biological samples and drugs. Among the few available examples, the Nightlife study, one of the few RCT evaluating its carbon emissions, reported having lowered the carbon footprint by 136 tons of CO_2-equivalent with respect to a conventional in-presence approach, via online conferencing, remote work, and virtual interviews (76).

Patients' view on green nephrology

The role of the patient is fundamental not only in the early stages, but throughout the entire course of care, which, for those of us with chronic kidney disease, means lifelong care.

The priorities of a patient who has just been diagnosed with a severe chronic illness, such as kidney failure (KF), revolve around their suffering and the limitations that result from it. The immediate goal is to find a way to feel better, despite the new condition.

Clear information makes it possible to choose the treatment pathway that is most appropriate and compatible with one's lifestyle — whether it involves work, retirement, physical activity, family commitments, and so on. When a patient understands what is happening, adheres better to therapies and becomes responsible and engaged. Compliance arises from knowledge, but also from mutual respect and the relationship of trust that the physician is able to build. An informed patient develops the ability to look beyond the own clinical experience and becomes more aware of the choices. Green dialysis is not only technology: it is also culture, education, and a conscious alliance between those who provide care and those who receive it.

We, Alina (nicknamed Ali, meaning Wings in Italian), and Rossella, in short Ross or Red, selected two examples: for Ross, the transition from three dialysis sessions per week to two. The physician took a strong responsibility at that time, when incremental dialysis was not a common option, of course considering compatible laboratory results. Individual well-being and sustainability were and are the same sweet spot; however, mutual trust is needed for personalization. In 2005, Ali underwent her first dialysis on the same day as diagnosis: hemoglobin was 5 g/dL and creatinine 13 mg/dL. It was an abrupt, sudden entry into an unfamiliar world. Her first kidney transplant, in 2007 lasted almost ten years. When, in 2016, dialysis was needed again, the situation was different. Ali was prepared: informed, autonomous, aware of her clinical history, her body, her limits and resources. She recalls: "I expected an "incremental" approach, which would allow me to preserve autonomy and quality of life, adapting to the new changes. My new doctor, however, told me: "I am the doctor, I decide what is best for you." At that moment, I felt that I was losing my active role in the care process. I replied that the therapeutic choice belonged to me, because no one knows better than the patient the physical and emotional experience of illness. After a heated discussion, I managed to restart with only one dialysis session per week. Then, by carefully monitoring my values and maintaining dialogue with the team, I moved to two, and to three sessions, ultimately at night, to allow continue working. It was a shared path, built step by step. In the end, the entire team embraced my personalized pathway."

What we claim is nothing more than the right to a free and informed choice. Our experiences may support something every physician should know, but which is sometimes difficult to practice in the current system of care. When patients are informed, listened to, and involved, they become powerful allies. And care, inevitably, works better.

To support dialysis choice, we hold that patients should also be informed about the level of sustainability of their treatments. However, we believe that this vital choice should not be constrained by economic or environmental costs. Overall, patients want personalized care, and prefer "light care", avoiding overtreatment, minimizing complications. This is also more sustainable. The objectives we have sought to summarize are reported in Box 1.

Box 1

OBJECTIVES BY 2030:

• Effective yet sustainable treatments, with attention to avoiding unnecessary waste of resources, ensuring coherence between caring for one's health and respecting the environment

• Greater information to increase environmental awareness, with a focus on waste during dialysis sessions (water, plastic, single-use materials), because knowing that "green" practices exist increases trust and reassurance

• Patients' mental well-being — fostering pride and participation in contributing to a more sustainable healthcare system

• Promoting awareness of the convenience of home dialysis, also experienced as an ecological choice in addition to a personal one (for example, reducing travel to dialysis centers, resulting in less stress and lower environmental impact through reduced CO_2 emissions)

• Transparent environmental communication: patients appreciate when their dialysis center communicates the sustainable actions it has adopted

Conclusions

Green nephrology should not be seen as a constraint but as an opportunity to redefine high-quality kidney care. Across the CKD trajectory, multiple "sweet spots" demonstrate that improved clinical outcomes and reduced environmental impact can be achieved simultaneously, including promotion of kidney transplantation, incremental-personalized dialysis, first-time-right vascular access, deprescribing with lifestyle-centered advanced CKD care, early CKD management, and upstream prevention. Together, these examples show that environmentally responsible nephrology often mirrors patient-centered, evidence-based practice.

Nevertheless, important gaps remain. The carbon footprint of nephrology, particularly the life-cycle impact of pharmaceuticals and the ecological implications of upstream care, remains insufficiently characterized. Environmental metrics are rarely embedded in clinical practice or research, and deprescribing frameworks are still absent from nephrology guidelines. Addressing these limitations will require methodological innovation, standardized reporting, and integration of sustainability into routine quality-improvement efforts.

Looking ahead, sustainability should become a defining dimension of excellence in kidney care. Achieving this will depend on engaging all stakeholders, redesigning workflows, allocating time for individual patient care and education, and strengthening interdisciplinary collaboration. Green nephrology does not imply a choice between people and planet; rather, it offers a framework in which better clinical outcomes and lower environmental impact reinforce each other. In this sense, sustainable nephrology is not about providing less care, but providing better care, including for the world we inhabit.

Figures

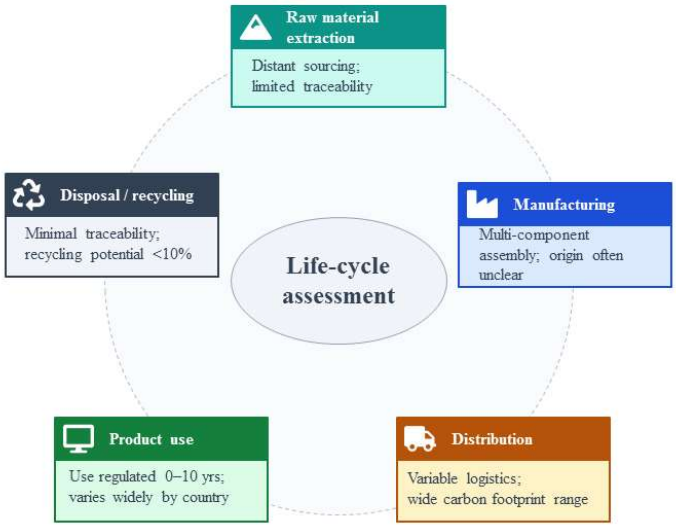


Figure 1. Life-cycle assessment of a dialysis machine: sources of uncertainty at each stage.

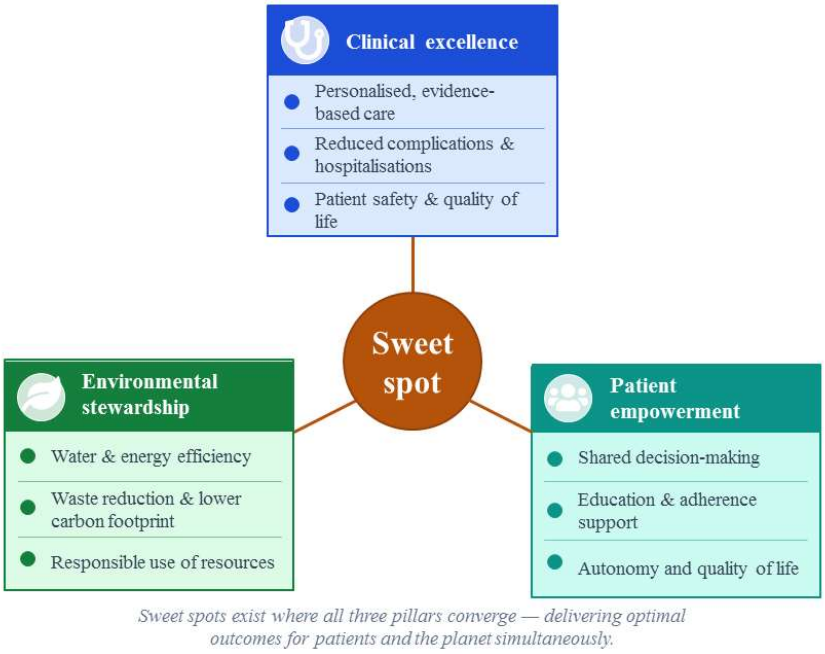


Figure 2. The sweet spot in green nephrology: convergence of three pillars of sustainable care.

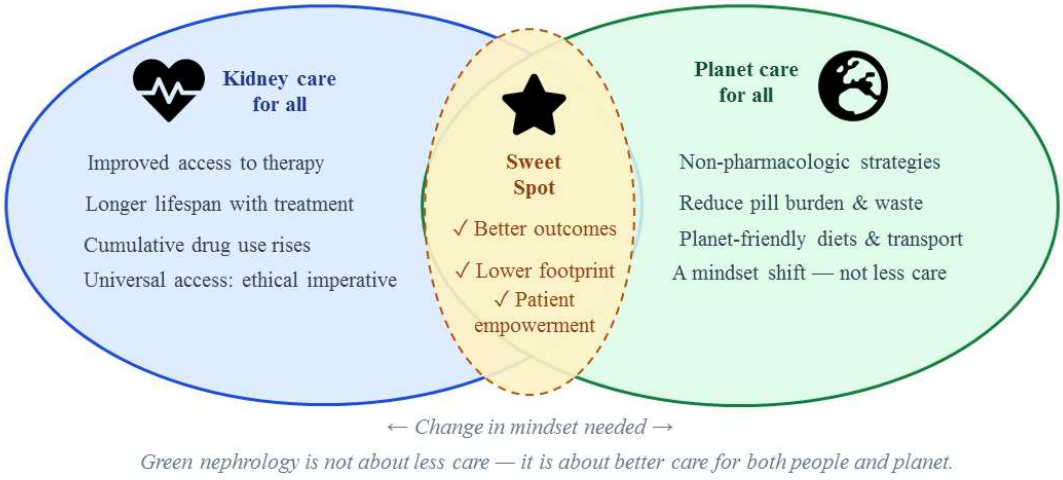


Figure 3. How kidney care for all can be balanced with planet care for all: reaching the sweet spot.

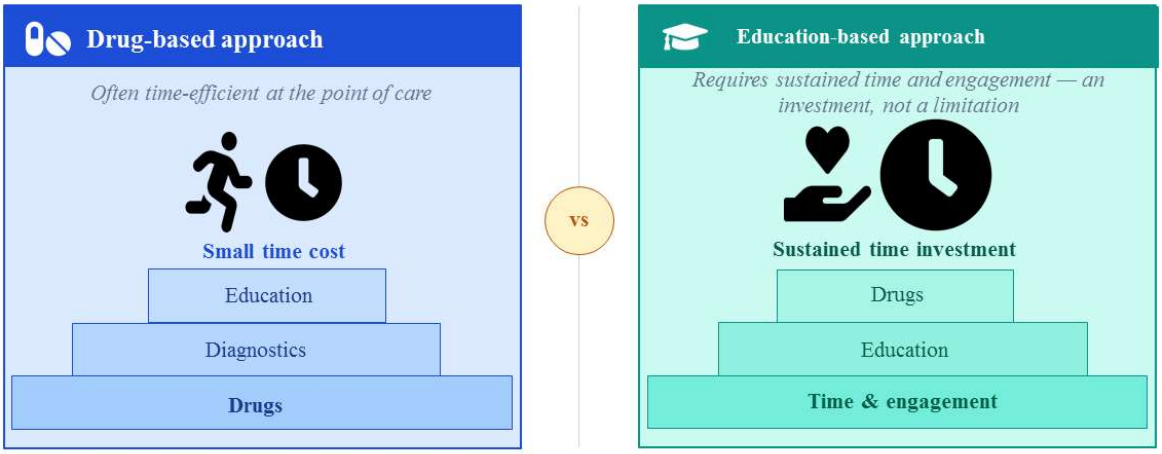


Figure 4. Personalised, planet-friendly care requires time: drug-based vs education-based approaches.

Table 1. Integrated "sweet-spot" opportunities and tradeoffs across the CKD trajectory				
CKD stage / Domain	**Intervention**	**Clinical advantages**	**Environmental advantages**	**Tradeoffs / Evidence gaps**
Dialysis	Incremental HD/PD	Preserves RKF; fewer hospitalizations	Reduced water/energy use; fewer consumables	Requires monitoring; not suitable for all
Dialysis	High-volume HDF (iso-resource)	Improved survival in select patients	Comparable footprint when optimized	Protocol-dependent; equipment variability
Vascular Access	First-time-right AV access	Fewer complications and procedures	Avoids procedural waste; lower interventional suite emissions	Needs early referral and coordination
Advanced CKD	Deprescribing + lifestyle interventions	Better QoL; fewer side effects	Reduced pharmaceutical production and waste	Time-intensive; absent from guidelines
Early CKD	Lifestyle-focused early care	Slower CKD progression; metabolic benefit	Plant-forward diets reduce emissions; fewer meds	Requires patient engagement; workforce limits
Prevention	Public health & policy strategies	Reduced CKD and CVD incidence	Largest long-term footprint reduction	Delayed impact; requires societal change
Research	Low-redundancy, efficient trial models	Faster evidence generation; better efficiency	Lower footprint—less travel/materials	Complex design; expertise required

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