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Green CKD care: 10 tips to make nephrology outpatient clinics more environmentally sustainable

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ABSTRACT

Green nephrology has often focussed on dialysis, with its intensive use of water and energy. In comparison, non-dialysis outpatient care of chronic kidney disease (CKD) has received less attention. This is surprising, given how much time most of us spend in outpatient clinics. For most of us, this is where we not only see the majority of our patients but also have regular encounters with their relatives and loved ones. Non-dialysis outpatient clinics are therefore an important opportunity to start a dialogue on green nephrology with our patients and with the general public. It is also where we can act as role models for the next generation of nephrologists and where it is easier to talk about green nephrology than in a busy inpatient setting or ward environment. Excellent and modern CKD care is in itself highly effective in reducing the environmental footprint of nephrology, where it delays progression, facilitates early and pre-emptive transplantation and avoids dialysis. CKD medication also has an environmental footprint, which can be addressed through medication reviews and fixed combinations. Innovative provision of care, e.g. through video consultations, needs to consider how patients will access medication in this scenario. Recycling and avoiding waste are also very important, although in practice they face many challenges. Reducing paper use is another option to improve sustainability, but transition to paper-free outpatient care takes time and effort. Simple steps can be taken to reduce paper use where clinic letters are still paper based. Video consultations are increasingly used where safe and appropriate and reduce the environmental footprint of care. Artificial intelligence will, in the near future, help us to triage new and existing patients and prioritize scarce resources and face-to-face care on those at highest risk. Outpatient clinics, although busy, offer an opportunity to interact with colleagues, patients and relatives to educate about green nephrology.

Keywords: clinical nephrology, green nephrology, outpatient care, service development, sustainability

INTRODUCTION

Concerns around climate change are not new [1], nor is the concept of reducing the environmental footprint of our specialty [2]. However, the focus of 'green' efforts in nephrology has often been on in-centre haemodialysis (ICHD) due to its enormous environmental footprint [3]. In comparison, non-dialysis

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chronic kidney disease (CKD) care of outpatients has received much less attention. Overall, outpatient care is now the second fastest growing aspect of healthcare in most Western countries, surpassed only by home care [4]. Outpatient care now accounts for 85% of all hospital-based activities [5]. In terms of environmental footprint, outpatient visits now account for nearly as many emissions as inpatient facilities [6]. Some specialties have begun to scrutinise the environmental footprint of their outpatient activities [7–9] but nephrologists have yet to focus on this aspect of green nephrology. This is surprising given that many nephrologists spend most of their working time there. We also teach trainees and medical students and have most of their patient-facing interactions in this environment. Across all medical specialties, the main environmental aspects of outpatient care include energy use, waste and transportation [4, 8], which are often beyond the remit of individual nephrologists to change since they require significant funding, lengthy planning and negotiations with multiple stakeholders. But what can a clinical nephrologist do in their own outpatient department? In this 10 tips paper we aim to provide a number of practical ideas to assess, visualise and improve the environmental footprint of our non-dialysis CKD outpatient activities. Where available, we provide examples of evidence-based practice in nephrology but also highlight evidence from other specialties as well as provide a glimpse of forward-looking concepts. We also provide our opinion on key barriers and ways to overcome them.

Tip 1: Focus efforts on avoiding CKD progression and screening and promote the concept of improving planetary health through prevention of end-stage kidney failure

There is evidence that as patients advance through the stages of CKD, not only do clinical outcomes become worse, but the environmental footprint of care increases substantially. While the initiation of kidney replacement therapy represents the most carbon-intensive phase of CKD, the environmental impact of pre-dialysis care is significant. A recent study from Japan demonstrated the relationship between CKD severity, rate of kidney function decline and greenhouse gas (GHG) emissions. The authors estimated that the annual carbon footprint per patient initiating dialysis was ≈4 tCO_2e, compared with 0.31 tCO_2e in patients not requiring dialysis. However, within pre-dialysis CKD care, carbon emissions increased as estimated glomerular filtration rate (eGFR) declined and disease progression accelerated. The carbon footprint of patients with stable kidney function in CKD stage G2 or better was estimated at 300 $kgCO_2e$ per year; in contrast, patients with CKD stages G3a–G3b or worse and a rapid eGFR decline (≥30% per year) had 4-fold higher emissions, reaching up to 1270–1440 $kgCO_2e$ per year [10]. Thus interventions that slow CKD progression are not only clinically relevant but also represent an opportunity to reduce the environmental impact of care. In line with this concept, effective screening, early detection of CKD and, therefore, the timely initiation of evidence-based therapies and interventions (as recommended by Kidney Disease: Improving Global Outcomes guidelines [11]) can simultaneously improve patient outcomes and mitigate the environmental impact of kidney care. As suggested by Talbot *et al.* [12], the life-cycle analysis of the CREEDENCE trial showed that the production of sodium–glucose co-transporter 2 inhibitor (SGLT2i) generated ≈63 tCO_2e. These emissions were outweighed by the benefits of treatment, including reductions in healthcare utilisation, with fewer inpatient days and fewer dialysis treatments, resulting in a net reduction in mean GHG emissions from 196 $kgCO_2e$ to 157 $kgCO_2e$ per participant-year.

Tip 2: Consider the environmental footprint of medication, avoid waste and consider polypills, fixed combinations and long-acting medications

Medication is an often overlooked aspect of efforts to improve the environmental aspect of care. Medication in the environment causes harm to wildlife [13]. A 2024 report in the UK estimated that medication generates GHG emissions of 0.1558 $kgCO_2e$ per 1£ spent [14]. The replacement of metered dose inhalers with dry powder inhalers in respiratory medicine led to a reduction in annual CO_2 output through inhalers by half and is an enlightening example of how there is room for improvement [15]. Reviewing medication regularly with the aim of avoiding overprescribing is important, as is avoidance of waste when medication has reached its sell by date [16]. Identifying unused medication is equally important, with contemporary studies suggesting unused medication rates of up to 15% [17]. Avoiding £150 million of unused medicines equates to total avoidable emissions of 23.4 thousand tonnes CO_2e [18]. The half-life of medications should be considered, as longer-acting formulations may reduce dosing frequency and pill burden, particularly for subcutaneous therapies where shorter-acting agents are associated with the use of a greater number of single-use delivery devices and waste. For example, the use of once-weekly insulin has been shown to reduce the carbon footprint of treatment by up to 75% [19]. Finally, we should perhaps reconsider the use of fixed dose combinations and polypills: in respiratory medicine, using fixed dose combinations of inhalers has had significant environmental benefits [20]. Significant evidence already exists on the use of fixed dose combinations in hypertension [21] and increased affordability of such combinations is often quoted as an additional advantage [22]. In nephrology, diabetic kidney disease, with its recent advances in combination therapy [23], may be the most likely area where such an approach may be exploited.

Tip 3: Consider the carbon footprint of patients accessing medication, offer delivery as part of virtual care and consider innovative forms of dispensing medication

The way in which medication is dispensed is changing worldwide, with significant growth in demand and loss of pharmacies in rural areas due to commercial issues [24]. This change is compounded by the fact that the delivery of care in all medical specialties is changing, with a significant trend towards virtual and remote care, a trend that has also started in nephrology in some areas [25]. This is important, and ideally all telemedicine services covering large geographic areas should consider some form of delivery [26]. Alternatively, nephrologists providing telemedicine across large distances should explore ways for patients seen remotely to access local pharmacies, where this is not so far possible, in order to avoid commuting. It is also worth noting that the technology to dispense medication via community-based robots, akin to vending machines, is already in clinical trials and used in clinical pilots [27] (Fig. 1). The same applies to delivery of medication via drone [28]. Although the carbon footprint of these innovative delivery systems has yet to be defined, they seem a promising option. It remains to be assessed whether such approaches work at scale and regu-

Figure 1: Medication-dispensing vending machine outside the hospital in Dolgellau, Wales, UK. With permission from the British Broadcasting Corporation.

latory obstacles, cost and infrastructure will be key barriers to overcome.

Tip 4: Minimise the use of single-use items, reduce waste generation and promote recycling

The use of personal protective equipment became routine in outpatient care during the COVID-19 pandemic. Gloves are frequently used despite clear guidance that their use should be limited to certain situations [29]. Educational interventions targeting clinicians have been shown to reduce unnecessary glove use by ≈25% while improving hand hygiene compliance [30].

It is also worth considering the environmental footprint of therapeutic regimes: in oncology, there is evidence that treatment regimens with comparable clinical efficacy may differ substantially in their carbon footprint [31]. Although similar data are currently lacking in nephrology, when clinically equivalent options exist, prescribing regimens that minimise the number of administrations should be considered. For example, in anti-neutrophil cytoplasmic antibody–mediated vasculitis , rituximab protocols requiring fewer infusions (e.g. 1 g administered twice) [32] may reduce the use of single-use consumables compared with more fragmented dosing schedules.

Another way to reduce waste is through the redispensing of unused medication, although this strategy is seldom used due to quality concerns related to unknown storage conditions and legal restrictions. There is evidence that this can be feasible with oral anticancer drugs with the use of special packaging and time–temperature indicators, leading to a lower carbon footprint and cost savings per patient compared with the standard practice of disposal [33]. Finally, outpatient nephrology clinics should ensure robust waste management practices, including appropriate segregation of general waste, recyclable materials and regulated medical waste. The availability of clearly labelled recycling bins in consultation rooms, nursing areas and pharmacies, combined with staff education, has been demonstrated to increase the quality of waste segregation and the amount of medical recycled waste [34].

Tip 5: Reduce paper use, consider the carbon footprint of e-mails and send letters electronically wherever possible

Outpatient services are print-intensive environments. A single standard A4 sheet of office paper has an estimated carbon footprint of ≈4–6 gCO_2e per sheet while higher estimates (≈10 gCO_2e) have been reported when broader factors such as ink/toner, printer energy use and transport are included [35]. Printer cartridges also have a significant environmental footprint [36] and printers generate particle pollution in office environments [37]. It is noteworthy that e-mails also have a carbon footprint—the average footprint of an e-mail without attachments has been estimated at ≈4 gCO_2e [38]. Thus e-mails are not carbon neutral—particularly given the enormous global volume of messages—but they remain a relatively small contributor to the overall GHG emissions [39]. A simple calculation illustrates the trade-off: a two-page printed letter may generate higher GHG emissions than an e-mail with a 1 MB attachment [40]. For these reasons, shifting toward a paper-reduced or paper-free workflow is a sensible goal.

Many health systems have implemented electronic health record systems that can support the sharing of medical information [41] and laboratory results, and some systems also support digital prescribing. However, a transition from paper-based letters to a digital environment will take time. Several measures can be used to reduce the amount of paper used (Table 1). Consent is also typically still taken on paper, which can be replaced by digital consent forms [42] with corresponding patient infor-

Table 1: How to reduce paper used where letters are still paper-based.

Ensure that letters are concise and well structured, preserving essential information and avoiding duplication
Keep header and footer short
Reduce margins of clinic letter templates to increase writing space
Keep line spacing to the minimum necessary
Reduce paper use by using double sided printing
Consider the use of text reminders instead of appointment letters
Stop printing letters in intradepartmental patient-related communication and e-mail letters instead
Stop printing previous clinic letters as part of preparing for clinics and consider digital alternatives, such as preparing a digital folder with previous letters for each clinic
Consider the use of more environmentally friendly paper
Take advantage of electronic health record systems, where available, supporting the sharing of medical information, included laboratory tests

mation available online [43]. Patient leaflets can also be replaced with QR codes displayed on clinic computers or in the footer of letter templates. Paper versions should still be available for patients who are not information technology literate.

Tip 6: Avoid futility: reduce redundant or poor-value tests not required for decision-making

Laboratory testing represents a substantial proportion of healthcare costs for outpatients with CKD [44], although the environmental footprint of our laboratory tests is less well defined [45]. Clinical laboratories use 3–6 times more energy than typical office buildings and produce a considerable amount of waste [46]. In addition to renal function tests, repeated measurements of full blood count and other CKD-specific parameters, such as parathyroid hormone (PTH), calcium, phosphorus and C-reactive protein, contribute further. A single full blood count has been estimated to generate an average of 116 gCO_2e, while urea testing with electrolytes accounts for ≈99 gCO_2e per test [47]. Transport to a central laboratory will also incur an environmental footprint and, in some scenarios, point-of-care testing may have a reduced footprint overall.

The concept of medical futility, introduced in the 1980s to describe treatments unlikely to provide meaningful benefit to patients [48], can be extended to diagnostic testing. Laboratory tests that are redundant, unnecessary or unlikely to influence clinical decision-making may be considered futile. Estimates suggest that up to 20% of laboratory tests are overutilized [49]. For example, a Canadian educational intervention conducted in an internal medicine ward reduced unnecessary laboratory testing by ≈18% over 1 year without adversely affecting length of hospital stay, readmission rates or 30-day mortality [50]. Targeted educational strategies may be particularly effective for junior residents, who may rely more heavily on laboratory investigations due to limited clinical experience [51].

Stable patients may require less frequent testing and patients with early-stage CKD may not require intensive monitoring of PTH or phosphorus. Nevertheless, an appropriate balance between reducing unnecessary testing and ensuring adequate patient monitoring is essential, as higher testing frequency has been associated with reduced mortality in certain populations, notably patients receiving haemodialysis [52]. We therefore suggest avoiding redundant laboratory tests and rigid predefined laboratory panels in favour of individualized, patient-centred testing strategies; smaller samples, akin to those used in paediatric patients, might also be employed to reduce waste [53].

Tip 7: Offer patients video consultations where safe and appropriate, coordinate face-to-face attendance and consider one-stop clinics

Face-to-face reviews were the cornerstone of outpatient care in our specialty until the COVID-19 pandemic. Today, the extent to which nephrologists provide virtual care varies, as does the way in which such care is provided. Telephone consultations are still common, but video consultations have become more common [54] and deliver impressive reductions in environmental footprint [55]. Advantages and limitations of video consultations are well described [56]. We should also reconsider the way in which outpatient appointments are coordinated in our clinical practice. Often, this occurs in a haphazard and uncoordinated way, e.g. when a patient who requires a kidney biopsy attends several times face to face to undergo a kidney ultrasound, have blood tests for clotting studies and to give written consent on paper. Similarly, a patient with advanced CKD may see a physician face to face on one day and a dialysis nurse specialist, a dietician or vascular surgeon on other days. The resulting carbon footprint solely through repeat commuting can be quite considerable, as shown for live donor assessments [57]. A one-stop approach may be used where face-to-face attendance is still required or desirable.

Tip 8: Consider how use of artificial intelligence (AI) can reduce the environmental footprint of care

AI will undoubtedly change the way we all work within the next decade [58]. One key role will be to identify patients at risk of deterioration. AI tools are likely to be integrated into outpatient workflows. Both pre-visit review and post-visit monitoring may soon help to decide which patients can be safely monitored with virtual consultations [25] and identify those at highest risk who will be better off with a face-to-face encounter. Remote monitoring of low-risk patients will be possible too [59]. Overall, eliminating low-value care and waste will be key roles of AI. Reducing unnecessary face-to-face visits, with the associated commute, will reduce the environmental footprint of care significantly [60]. It is also likely that more sophisticated AI symptoms comparable to the iBOX in transplant aftercare [61] will help with prognosis and with prioritization of resources. It should be noted that AI in CKD care currently emphasizes efficacy and workflow optimiza-

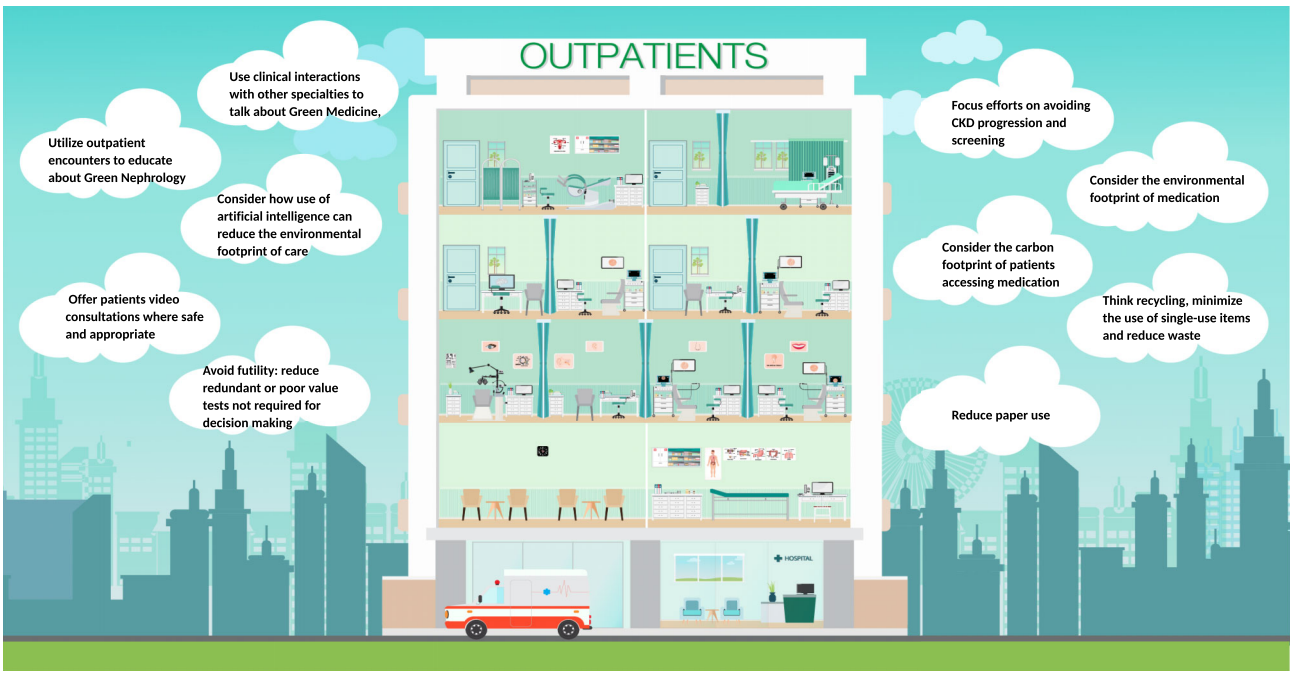

Figure 2: Summary graphic of our 10 tips to make nephrology outpatient clinics more environmentally sustainable (some tips shortened). Template purchased from Vectorstock with commercial licence. Adaptation by Catherine Sulzman, Mediart, Cambridge, UK.

tion, but others have emphasized that it could be developed to also take into account the environmental footprint of care [62].

Tip 9: Utilize outpatient encounters to educate patients and their families about green nephrology

Any progress in this arena will likely require cooperative action not just from healthcare professionals but also our patients and their families. They, too, influence decisions in healthcare, be it is as voters or through more subtle ways, e.g. when providing feedback and suggestions or through patient representatives and self-help groups. Outpatient encounters are a remarkable opportunity in this regard and we should make more of an effort to involve our patients and their loved ones in green nephrology. Not much is known about the views of our renal patients on this topic, but other specialties have provided interesting evidence. In one study, up to 79% of outpatients in a Dutch gynaecology department stated that they were concerned about climate change [63]. Others have emphasised that patients lack access to suitable information on this topic [64]. It should not be difficult for institutions and green nephrology task forces to come up with high-quality information on green nephrology that can be made available in our outpatient areas. We should not underestimate that, for many of our patients, we are respected and trusted voices in society [65] and that we will be listened to if, for example, at the end of a consultation, we mention our efforts to make care more sustainable. In that sense we can also act as role models; for instance, by making more sustainable choices for our commute to work and our holidays and other activities.

Tip 10: Use clinical interactions with other specialties to talk about green medicine, share ideas and learn from others

Environmentally sustainable healthcare requires cross-sectoral and interdisciplinary collaboration to reduce healthcare's environmental footprint while improving patient outcomes [66]. Clinical interactions with colleagues from other specialties offer a powerful, yet often underused, opportunity to advance green medicine. Modern healthcare is inherently multidisciplinary: physicians, surgeons, anaesthesiologists, nurses, pharmacists and allied health professionals routinely collaborate around patient care. These encounters—ward rounds, multidisciplinary team meetings, tumour boards, perioperative briefings or outpatient referrals—create natural spaces to share best practice and learn from others [67]. For example, discussions between anaesthesiologists and surgeons have led to reductions in the use of anaesthetic gases with high global warming potential [68]. Ultimately, using routine clinical interactions to talk about green medicine normalizes sustainability as part of professional practice, not as an optional add-on. Such dialogue fosters a shared culture of environmental stewardship, encourages mutual learning and aligns clinical excellence with planetary health—an approach increasingly recognized as essential for the future of healthcare [69].

CONCLUSIONS

The statement that 'the future is already here—it is just unevenly distributed' is attributed to American fiction author William Gibson [70]. To some extent, this statement also applies to a more environmentally friendly version of our non-dialysis outpatient care. In some areas, environmental footprint is a constant topic of discussion and service improvement, whereas elsewhere cost and workload pressures have relegated green nephrology to a secondary role. Here we present a number of practical ideas for clinicians. Figure 2 serves as a summary graphic of our tips. Much of the care that we deliver in an outpatient setting is determined by tradition and habit and the way we were taught to do things. In this sense, the green nephrology agenda is also a notable opportunity to re-evaluate and scruti-

Table 2: Key barriers and enablers for our 10 tips to improve the environmental footprint of non-dialysis outpatient CKD care.

Tip	Key barriers	Key enablers
1. Focus efforts on avoiding CKD progression	Cost of new medication, lack of access in the community, workload issues/competing priorities	Funding incentives in primary care, educational programs outside nephrology, decision aids in electronic health records both in nephrology and in primary care
2. Medication	Lack of visibility of the environmental footprint of medication, polypharmacy normalised even in elderly patients approaching the end of life, lack of structured approach to deprescribing	Involve renal pharmacists and senior leaders, visualise the environmental footprint of medication, foster a culture of regular medication reviews and deprescribing at the end of life
3. Patients' commute to access medication	Lack of regional cooperation, missing links between nephrology and primary care, patients and relatives' perception of unavoidable commute	Involve regional senior leaders, obtain funding for improved electronic links and involve patient representatives and self-help groups
4. Reducing waste	Inertia and habit, staff feeling that waste is unavoidable, lack of visibility of the amount of waste	Nominate waste avoidance champions, visualise the amount of waste and develop an organisational culture of waste avoidance
5. Reduce paper use	Long-standing practice of sending letters on paper, lack of information technology infrastructure to e-mail letters to primary care, workload implications for recipient	Start with e-mailing letters within the department or hospital, involve local and regional senior leaders
6. Avoid futile tests	Inertia, lack of experience among younger members of the staff, lack of visual environmental footprint	Education of the workforce, dedicated tip 1 training for trainees and medical students, finding ways to visualize the environmental footprint of tests
7. Virtual care	Lack of suitable software and funding, infrastructural barriers, patients with low information technology literacy	Regional procurement of video consultation software, coordinated action with other specialties, supporting patients and help them do video consultations
8. Use of AI	Lack of funding, competing interests and workload, inertia and lack of familiarity	Explain the utility of AI, use examples where AI helps with care, train the workforce
9. Educating patients and families	Workload and lack of time, communication barriers, low reach	Produce information material, provide versions in different languages, use social media and patient representatives and self-help groups
10. Talking to colleagues	Workload and other competing priorities, inertia, lack of opportunities to meet face to face	Being proactive and using chance encounters, offering to present to other departments, developing cross-specialty regional and national forums

nise our clinical practice. Does every patient need a face-to-face appointment for every interaction? Is it still appropriate for all of our clinic letters to be printed, put in a paper envelope and sent out to primary care? Is it necessary to measure calcium and phosphate levels at every visit in all patients with stable, early-to-moderate CKD? These kinds of reflections may help improve the environmental impact of many nephrologists mostly working in outpatient care.

Our tips also have limitations. Some of our tips, such as the use of fixed dose combinations, rely on extrapolation of published data from other specialties. The use of delivery robots or drones is still in its infancy with very little published evidence, but the utility of these approaches to improve the environmental footprint of care is highly plausible. It remains to be seen whether such interventions also work well in our specialty. There is some overlap among our tips, but this actually highlights an important point: the repetition centres on two key themes—waste (tips 2, 4, 5 and 6) and transport (tips 3 and 6). We believe that most nephrologists will be able to identify waste and unnecessary transport in their daily practice and we suggest a conscious effort to reduce both. Finally, we are aware that carbon footprint estimates are subject to some variability. As an example, where we suggest an improved carbon footprint through video consultations, we need to acknowledge that the work reporting such benefit assumed that all patients previously attended face-to-face clinics in the regional renal centre via commuting in fossil fuel–operated cars [60]. With more widespread use of electric vehicles these assumptions may become increasingly imprecise.

There are significant barriers to implementing our recommendations (Table 2). It is therefore important to distinguish between measures that are readily achievable in the near term and those that require institutional or system-wide transformation. We can, at present, optimise the use of contemporary pharmacological therapies to slow the progression of CKD (tip 1) and support colleagues in primary care to ensure equitable access to

these treatments. Similarly, we can reduce unnecessary investigations that do not inform clinical decision-making (tip 6). Reducing paper use (tip 5) appears straightforward and individual actions can be taken immediately (Table 1). However, a comprehensive shift to fully electronic correspondence requires coordinated, institution-wide implementation. Modifying prescribing (tip 2) and dispensing practices (tip 3) represents longer-term objectives, necessitating collaboration with pharmacy teams as well as engagement with patients and their families. Engaging patients (tip 9) and colleagues in other specialties (tip 10) in discussions on green nephrology is feasible in the short term and can foster broader cultural change. Virtual care (tip 7), while dependent on organisational support, offers a clear example of transformational practice—maintaining high standards of safe, effective care while reducing environmental impact and incurring minimal additional cost [25, 60]. In contrast, the integration of AI (tip 8) is likely to require more extensive system-level investment, policy development and time before widespread adoption is possible. Overall, non-dialysis outpatient services represent a substantial and familiar opportunity to reduce the environmental footprint of nephrology practice. We hope that these recommendations will stimulate further discussion and innovation and encourage others to develop additional strategies for sustainable care.

AUTHORS' CONTRIBUTIONS

All authors contributed to the writing and revision of the manuscript and approved the final version.

CONFLICT OF INTEREST STATEMENT

A.W. is on the editorial board of *Clinical Kidney Journal*, serves as associate editor and serves as guest editor for the *CKJ* Green Nephrology Mini Series. The remaining authors declare no conflicts of interest.

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REFERENCES

1. Kerr RA. Climate change. Humans and nature duel over the next decade's climate. *Science* 2007;**317**:746–7. https://doi.org/10.1126/science.317.5839.746
2. Agar JWM. Reusing dialysis wastewater: the elephant in the room. *Am J Kidney Dis* 2008;**52**:10–2. https://doi.org/10.1053/j.ajkd.2008.04.005
3. Pruijm M, Rho E, Woywodt A *et al*. Ten tips from the Swiss Working Group on Sustainable Nephrology on how to go green in your dialysis unit. *Clin Kidney J* 2024;**17**:sfae144. https://doi.org/10.1093/ckj/sfae144
4. Taylor AL, Levin J, Chan J *et al*. Improving environmental sustainability in outpatient clinics: lessons from a waste audit. *J Clim Change Health* 2021;**4**:100070. https://doi.org/10.1016/j.joclim.2021.100070
5. Royal College of Physicians. *Outpatients: the future. Adding value through sustainability*. London: Royal College of Physicians, 2021. https://rcp.ac.uk/media/bqvk1nuj/outpatients-the-future-report.pdf [5 December 2025, date last accessed].
6. Eckelman MJ, Sherman J. Environmental impacts of the U.S. health care system and effects on public health. *PLoS One* 2016;**11**:e0157014. https://doi.org/10.1371/journal.pone.0157014
7. Akgun Z, Palamar M. Sustainability and minimization of carbon footprint in ophthalmology: what can we change in the outpatient clinic routine? *Eye* 2025;**39**:2363–8. https://doi.org/10.1038/s41433-025-03885-0
8. Sattler MM, Abdelnour M, McKay VR *et al*. Environmental sustainability in the outpatient clinic setting. *Open Forum Infect Dis* 2025;**12**:ofae586. https://doi.org/10.1093/ofid/ofae586
9. Tsagkaris C, Nikolakea M, Laskaratou ED *et al*. Environmental sustainability in healthcare: time to make outpatient care in orthopaedics and rheumatology greener. *Int J Health Plann Manag* 2023;**38**:547–56. https://doi.org/10.1002/hpm.3617
10. Nagai K, Hata S, Itsubo N *et al*. Carbon footprints by stage of chronic kidney disease: the case of Japan. *J Clim Change Health* 2024;**15**:100294. https://doi.org/10.1016/j.joclim.2023.100294
11. Stevens PE, Ahmed SB, Carrero JJ *et al*. KDIGO 2024 clinical practice guideline for the evaluation and management of chronic kidney disease. *Kidney Int* 2024;**105**(4 Suppl):S117–314. https://doi.org/10.1016/j.kint.2023.10.018
12. Talbot B, Fletcher RA, Neal B *et al*. The potential for reducing greenhouse gas emissions through disease prevention: a secondary analysis of data from the CREDENCE trial. *Lancet Planet Health* 2024;**8**:e1055–64. https://doi.org/10.1016/S2542-5196(24)00281-X
13. aus der Beek T, Weber F-A, Bergmann A *et al*. Pharmaceuticals in the environment—global occurrences and perspectives. *Environ Toxicol Chem* 2016;**35**:823–35. https://doi.org/10.1002/etc.3339
14. Department of Health and Social Care. Good for you, good for us, good for everybody: a plan to reduce overprescribing to make patient care better and safer, support the NHS, and reduce carbon emissions. London: Department of Health and Social Care, 2021. https://assets.publishing.service.gov.uk/media/614a10fed3bf7f05ab786551/good-for-you-good-for-us-good-for-everybody.pdf (5 December 2025, date last accessed).
15. Woodcock A, Janson C, Rees J *et al*. Effects of switching from a metered dose inhaler to a dry powder inhaler on climate emissions and asthma control: post-hoc analysis. *Thorax* 2022;**77**:1187–92. https://doi.org/10.1136/thoraxjnl-2021-218088
16. Korzec K, Blackburn LM, Deyhim N *et al*. REcycle soon-to-expire program (RESTEP): sustainability efforts in hospital pharmacy. *Am J Health Syst Pharm* 2026;**83**:204–10.
17. Buck TC, Lund ML. Unused medication among outpatients receiving cost-free medication from a community pharmacy in the Region of Southern Denmark. *Eur J Hosp Pharm* 2025;ejhpharm–2025-004615. https://ejhp.bmj.com/content/early/2025/09/14/ejhpharm-2025-004615
18. National Institute for Health and Care Excellence. Environmental impact report: medicines optimisation. Implementing the NICE guideline on medicines optimisation (NG5). London: National Institute for health and Care Excellence, 2018. https://www.nice.org.uk/Media/Default/About/what-we-do/Into-practice/resource-impact-assessment/Medicines-optimisation-sustainability-report.pdf (5 December 2025, date last accessed).

19. Bellier L, Antier C, Soggiu M *et al*. EE212 Environmental impact of switching from daily to weekly basal insulin administration in France. *Value Health* 2024;**27**(12 Suppl):S96. https://doi.org/10.1016/j.jval.2024.10.496
20. Vartiainen V, Woodcock AA, Wilkinson A *et al*. Thoughtful prescription of inhaled medication has the potential to reduce inhaler-related greenhouse gas emissions by 85. *BMJ Open Respir Res* 2024;**11**:e001782. https://doi.org/10.1136/bmjresp-2023-001782
21. O'Hagan ET, McIntyre D, Nguyen T *et al*. Hypertension therapy using fixed-dose polypills that contain at least three medications. *Heart* 2023;**109**:1273–80.
22. O'Connell SS, Whelton PK, Mills KT. Global trends in hypertension prevalence, awareness, treatment, and control. *Curr Opin Nephrol Hypertens* 2026;**35**:174–80.
23. van Raalte DH, Bjornstad P, Cherney DZI *et al*. Combination therapy for kidney disease in people with diabetes mellitus. *Nat Rev Nephrol* 2024;**20**:433–46. https://doi.org/10.1038/s41581-024-00827-z
24. Kavanagh ON, Courtenay A, Khan F *et al*. Providing pharmaceutical care remotely through medicines delivery services in community pharmacy. *Explor Res Clin Soc Pharm* 2022;**8**:100187. https://doi.org/10.1016/j.rcsop.2022.100187.
25. Woywodt A, Payne RE, Huuskes BM *et al*. Ten tips to carry out video consultations in nephrology. *Clin Kidney J* 2024;**17**:sfae287. https://doi.org/10.1093/ckj/sfae287
26. Garilus FE, Cassion K, Cajusma Y *et al*. Pathways to optimize a pediatric telemedicine and medication delivery service: a multi-level qualitative study in Haiti. *medRxiv* [Preprint]. 2025 May 3:2025.03.26.25324692. https://doi.org/10.1101/2025.03.26.25324692.
27. ISRCTN. A study exploring whether urgently required medication can be remotely issued from the REMEDY medicine machine in rural communities. 2025. https://www.isrctn.com/ISRCTN83312675 (5 December 2025, date last accessed).
28. Chen Y-H, El-Adle AM, O'Brien KJ *et al*. Drone-based medication delivery for rural, flood-prone coastal communities. *PLoS One* 2025;**20**:e0333696. https://doi.org/10.1371/journal.pone.0333696
29. Peters A, Močenić M, Spitilli A *et al*. Quick and dirty: improper glove use increases infection risk and has global consequences. *Antimicrob Resist Infect Control* 2025;**14**:52. https://doi.org/10.1186/s13756-025-01563-0
30. Lalakea ML, Noel JE, Meiklejohn DA. Reducing glove overuse in outpatient specialty clinics: cost reduction and environmental benefit. *OTO Open* 2025;**9**:e70103. https://doi.org/10.1002/oto2.70103
31. Piffoux M, Cabannes-Hamy A, Ben Souda H *et al*. Should the carbon footprint of care be taken into account when choosing a treatment for lymphoma? A case application on mantle cell lymphoma. *Blood* 2023;**142**:7243. https://doi.org/10.1182/blood-2023-188890
32. Floege J, Jayne DRW, Sanders J-SF *et al*. KDIGO 2024 clinical practice guideline for the management of antineutrophil cytoplasmic antibody (ANCA)-associated vasculitis. *Kidney Int* 2024;**105**(3 Suppl):S71–116. https://doi.org/10.1016/j.kint.2023.10.008
33. Smale EM, Ottenbros AB, van den Bemt BJF *et al*. Environmental outcomes of reducing medication waste by redispensing unused oral anticancer drugs. *JAMA Netw Open* 2024;**7**:e2438677. https://doi.org/10.1001/jamanetworkopen.2024.38677
34. Sahiledengle B. Self-reported healthcare waste segregation practice and its correlate among healthcare workers in hospitals of southeast Ethiopia. *BMC Health Serv Res* 2019;**19**:591. https://doi.org/10.1186/s12913-019-4439-9
35. Dias AC, Arroja L. Comparison of methodologies for estimating the carbon footprint—case study of office paper. *J Cleaner Prod* 2012;**24**:30–5. https://doi.org/10.1016/j.jclepro.2011.11.005
36. Ding Y, Shen C, Feng D. Pricing and collection for printer cartridge recycling under retailers' ordering and collection. *J Cleaner Prod* 2020;**276**:122814. https://doi.org/10.1016/j.jclepro.2020.122814
37. He C, Morawska L, Taplin L. Particle emission characteristics of office printers. *Environ Sci Technol* 2007;**41**:6039–45. https://doi.org/10.1021/es063049z
38. Walkley S. The carbon cost of an email: update! Carbon Literacy Project, 2022. https://carbonliteracy.com/the-carbon-cost-of-an-email/ (16 December 2025, date last accessed).
39. Viana LR, Cheriet M, Nguyen K-K *et al*. Sending fewer emails will not save the planet! An approach to make environmental impacts of ICT tangible for Canadian end users. *Sustain Prod Consump* 2022;**34**:453–66. https://doi.org/10.1016/j.spc.2022.09.025
40. Assuncao M. E-mail pollution underestimated. Global Climate Initiatives, 2025. https://www.globalclimateinitiatives.com/la-pollution-des-mails-sous-estimee/ (16 December 2025, date last accessed).
41. Organisation for Economic Co-operation and Development. Progress on implementing and using electronic health record systems: developments in OECD countries as of 2021. 2023. https://www.oecd.org/en/publications/progress-on-implementing-and-using-electronic-health-record-systems_4f4ce846-en.html (16 December 2025, date last accessed).
42. Houten R, Hussain MI, Martin AP *et al*. Digital versus paper-based consent from the UK NHS perspective: a micro-costing analysis. *Pharmacoecon Open* 2024;**9**:27–39. https://doi.org/10.1007/s41669-024-00536-0
43. Gesualdo F, Daverio M, Palazzani L *et al*. Digital tools in the informed consent process: a systematic review. *BMC Med Ethics* 2021;**22**:18. https://doi.org/10.1186/s12910-021-00585-8
44. Betts KA, Song J, Elliot J *et al*. Geographical variation in kidney function testing and associations with health care costs among patients with chronic kidney disease and type 2 diabetes. *Am J Manag Care* 2022;**28**:S112–9. https://doi.org/10.37765/ajmc.2022.89211
45. Lopez JB, Jackson D, Gammie A *et al*. Reducing the environmental impact of clinical laboratories. *Clin Biochem Rev* 2017;**38**:3–11.
46. Ozben T, Fragão-Marques M. Chemical strategies for sustainable medical laboratories. *Clin Chem Lab Med* 2023;**61**:642–50. https://doi.org/10.1515/cclm-2022-1157
47. McAlister S, Barratt AL, Bell KJ *et al*. The carbon footprint of pathology testing. *Med J Aust* 2020;**212**:377–82. https://doi.org/10.5694/mja2.50583
48. Schneiderman LJ, Jecker NS, Jonsen AR. Medical futility: its meaning and ethical implications. *Ann Intern Med* 1990;**112**:949–54. https://doi.org/10.7326/0003-4819-112-12-949
49. Zhi M, Ding EL, Theisen-Toupal J *et al*. The landscape of inappropriate laboratory testing: a 15-year meta-analysis. *PLoS One* 2013;**8**:e78962. https://doi.org/10.1371/journal.pone.0078962

50. Toman I, Mathura P, Kassam N. A multifaceted quality improvement initiative to reduce unnecessary laboratory testing on internal medicine inpatient wards. *Can J Gen Intern Med* 2020;**15**:30–7. https://doi.org/10.22374/cjgim.v15i2.357
51. Faisal A, Andres K, Rind JAK *et al*. Reducing the number of unnecessary routine laboratory tests through education of internal medicine residents. *Postgrad Med J* 2018;**94**:716–9. https://doi.org/10.1136/postgradmedj-2018-135784
52. Kim DH, Cho, A, Park HC *et al*. Regular laboratory testing and patient survival among patients undergoing maintenance hemodialysis: a Korean nationwide cohort study. *Sci Rep* 2023;**13**:18360. https://doi.org/10.1038/s41598-023-45502-8
53. Wu Y, Spaulding AC, Borkar S *et al*. Reducing blood loss by changing to small volume tubes for laboratory testing. *Mayo Clin Proc Innov Qual Outcomes* 2020;**5**:72–83.
54. Hezer B, Massey EK, Reinders MEJ *et al*. Telemedicine for kidney transplant recipients: current state, advantages, and barriers. *Transplantation* 2024;**108**:409–20. https://doi.org/10.1097/TP.0000000000004660
55. Moore L, Balmer F, Woywodt A. The environmental impact of changing to virtual transplant aftercare: 2-year experience with a single outpatient clinic. *Future Healthc J* 2024;**11**:100004.
56. Payne R, Clarke A, Swann N *et al*. Patient safety in remote primary care encounters: multimethod qualitative study combining Safety I and Safety II analysis. *BMJ Qual Saf* 2024;**33**:573–86.
57. Centre for Sustainable Healthcare. Mapping the living kidney donor assessment pathway. 2024. https://sustainablehealthcare.org.uk/activity/mapping-the-living-kidney-donor-pathway-project/ (2 December 2025, date last accessed).
58. Cheungpasitporn W, Athavale A, Ghazi L *et al*. Transforming nephrology through artificial intelligence: a state-of-the-art roadmap for clinical integration. *Clin Kidney J* 2026;**19**:sfag004. https://doi.org/10.1093/ckj/sfag004
59. Laranjinha I, Peired A, Knoeller S *et al*. Nephrology meets AI—environmental perspective. *Nephrol Dial Transplant* 2025;**40**:1449–51. https://doi.org/10.1093/ndt/gfaf027
60. Moore L, Balmer F, Woywodt A. The environmental impact of changing to virtual renal transplant aftercare: 2-year experience with a single outpatient clinic. *Future Healthc J* 2024;**11**:100004. https://doi.org/10.1016/j.fhj.2024.100004
61. Loupy A, Aubert O, Orandi BJ *et al*. Prediction system for risk of allograft loss in patients receiving kidney transplants: international derivation and validation study. *BMJ* 2019;**366**:l4923. https://doi.org/10.1136/bmj.l4923
62. Balakrishnan S, Thongprayoon C, Miao J *et al*. Artificial intelligence (AI) and green nephrology: assessing the commitment of ChatGPT models to environmental sustainability: SA-PO008. *J Am Soc Nephrol* 2024;**35**(10S):https://doi.org/10.1681/ASN.2024mvfvyp3q
63. Cohen ES, Kringos DS, Kouwenberg LHJA *et al*. Patient perspectives on climate friendly healthcare: an exploratory study in obstetrics and gynaecology. *Patient Educ Couns* 2025;**130**:108427. https://doi.org/10.1016/j.pec.2024.108427
64. Cohen ES, Grandiek F, Kringos DS *et al*. Attitudes towards addressing environmental sustainability in patient-provider interactions: a qualitative study among Dutch physicians. *BMJ Open* 2025;**15**:e107454. https://bmjopen.bmj.com/content/15/12/e107454
65. Caraballo-Betancort AM, Marcilla-Toribio I, Notario-Pacheco B *et al*. Health professionals' perceptions of climate change: a systematic review of qualitative studies. *Public Health* 2025;**245**:105773. https://doi.org/10.1016/j.puhe.2025.105773
66. Romanello M, Whitmee S, Mulcahy E *et al*. Further delays in tackling greenhouse gas emissions at COP28 will be an act of negligence. *Lancet* 2023;**402**:2055–7. https://doi.org/10.1016/S0140-6736(23)02584-9
67. Mortimer F, Isherwood J, Wilkinson A *et al*. Sustainability in quality improvement: redefining value. *Future Healthc J* 2018;**5**:88–93. https://doi.org/10.7861/futurehosp.5-2-88
68. Andersen MPS, Nielsen OJ, Sherman JD. Assessing the potential climate impact of anaesthetic gases. *Lancet Planet Health* 2023;**7**:e622–9. https://doi.org/10.1016/S2542-5196(23)00084-0
69. World Health Organization. *WHO manifesto for a healthy recovery from COVID-19*. https://www.who.int/publications/m/item/who-manifesto-for-a-healthy-recovery-from-covid-19 (13 December 2025, date last accessed).
70. Kennedy P. William Gibson's future is now. *NY Times* 13 January 2012. https://www.nytimes.com/2012/01/15/books/review/distrust-that-particular-flavor-by-william-gibson-book-review.html (26 January 2026, date last accessed).

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