Open Forum Infectious Diseases

REVIEW ARTICLE

Environmental Sustainability in the Outpatient Clinic Setting

Matthew M. Sattler,[1,a] Monica Abdelnour,[1,a] Virginia R. McKay,[2] and Jason P. Burnham[3]

[1]Department of Pediatrics, Division of Pediatric Infectious Diseases, Washington University in St Louis School of Medicine, St Louis, Missouri, USA, [2]Center for Public Health Systems Science, Brown School at Washington University in St Louis, St Louis, Missouri, USA, and [3]Department of Medicine, Division of Infectious Diseases, Washington University in St Louis School of Medicine, St Louis, Missouri, USA

This article will highlight recent efforts published in the medical literature to promote environmental sustainability in the outpatient clinic setting, which are likely to be feasible for health professionals to implement in their own practices. These potential efforts are divided into 3 broad categories: (1) reducing travel to the clinic when feasible, (2) reducing waste production in the clinic, and (3) optimizing the use of high-value diagnostics and therapeutics. As research specifically related to interventions to promote environmental sustainability in outpatient clinics is relatively limited, health professionals are encouraged to continue sharing success stories from their own practice.

Keywords. environmental; outpatient; sustainability; telemedicine; waste.

A child born in 2019 is likely to experience a world that is more than 4°C warmer than the average preindustrial temperature [1]. In addition to the myriad of environmental and sociopolitical ramifications, increases in global temperatures have a direct impact on human health, and a marked impact on the field of infectious diseases (ID), with more than half of known pathogenic diseases estimated to be aggravated by climate change [2]. The healthcare industry itself is responsible for 2 billion tons of greenhouse gas emissions (GHGe) annually, accounting for between 4.4%–4.6% of total global emissions [3]. Outpatient visits per capita have increased by more than 25% over the past 20 years, and ambulatory care is now the second-fastest growing component of the healthcare industry, surpassed only by home health services [4]. Consequently, it is now estimated that outpatient offices are now responsible for nearly as many emissions as inpatient facilities [5]. Despite the growth of outpatient healthcare in recent years, efforts at promoting environmental sustainability have primarily focused on inpatient facilities.

Nearly 80% of more than 1000 US health professionals surveyed by the Commonwealth Fund in late 2023 reported that it is important to them that their employers play a role in addressing climate change [6]. Similarly, in a multinational survey of nearly 4000 health professionals, 75% of respondents indicated that the issue of climate change is very or extremely important to them [7]. At the same time, most respondents in this survey identified significant barriers to acting on their concerns about climate change, most notably lack of time, lack of knowledge, and the perception that their actions would not make a difference. The primary aim of this article is to address the mismatch between what health professionals believe is important, and what they feel empowered to accomplish.

This article will review the recent literature on efforts to decrease the climate impacts in outpatient healthcare settings. With the assistance of a medical librarian, we identified articles published within the past 5 years via keyword search of Embase, and supplemented our narrative reviewing with the references in those articles. We focused on areas for which there is a critical mass of literature supporting beneficial climate impact, and in many cases, also improve the quality of patient care. This study did not include factors necessitating patient consent.

We divided possible interventions into 3 broad categories: reducing transportation burden, reducing clinic waste, and optimizing the use of high-value diagnostics and therapeutics. Many of these interventions are practical (Box 1) and can be implemented by readers in a variety of clinic settings. When appropriate, we have highlighted efforts that apply specifically to adult and pediatric ID clinics. However, we believe it is important not to silo sustainability interventions, and we encourage the ID community to learn from efforts made by our colleagues in other specialties, and vice versa. The goal of this article is to motivate and empower individuals practicing in outpatient

Received 26 March 2024; editorial decision 30 September 2024; accepted 01 October 2024; published online 16 October 2024

[a]M. M. S. and M. A. contributed equally to this work.

Correspondence: Matthew M. Sattler, MD, Department of Pediatrics, Division of Pediatric Infectious Diseases, Washington University in St Louis School of Medicine, 660 S Euclid Ave, St Louis, MO 63110 (sattler@wustl.edu).

Open Forum Infectious Diseases®

https://doi.org/10.1093/ofid/ofae586

healthcare settings to engage in sustainability work in their own clinics and to share the results of their efforts.

Box 1. Strategies to Reduce Greenhouse Gas Emissions in Outpatient Healthcare

Reducing travel to clinic when feasible
- Implement telemedicine visits, especially for patients who would travel longer distances for their appointment
- Perform same-day procedures
- Space out recurring visits as appropriate
- Group visits with multiple subspecialty providers on the same day

Reducing waste in the clinic
- Transition from single-use to reusable products when possible
- Reduce reliance on paper products
- Conduct a waste audit in the clinic to identify opportunities to reduce and properly segregate waste
- Identify opportunities to reduce energy consumption

Optimizing the use of high-value diagnostics and therapeutics
- Prescribe oral antibiotics over outpatient parenteral antibiotics when feasible
- Order outpatient laboratory tests and imaging only when they are likely to change patient management
- Prescribe no more than the amount necessary of a medication (especially antibiotics) to achieve the intended clinical response.
- Prescribe dry-powder inhalers instead of metered-dose inhalers when able and clinically appropriate

REDUCING TRANSPORTATION BURDEN

Transportation energy consumption is the second-largest user of energy in the United States. Initially, there was a 15.6% decline in transportation energy use during the early part of the coronavirus disease 2019 (COVID-19) pandemic, providing proof of principle of what is achievable. Unfortunately, transportation energy use has since rebounded to near-prepandemic levels [8]. The use of telemedicine has been one of the main methods by which the healthcare sector has reduced patient travel-related energy costs, especially since the start of the COVID-19 pandemic. Although telemedicine was largely implemented to facilitate social distancing measures, its widespread use nonetheless presented an opportunity to study its environmental impact compared with traditional in-person clinic visits [9].

Patients traveling from rural areas have longer commutes, which has been exacerbated by hospital closures. Between January 2013 and February 2020, 101 rural hospitals closed, resulting in patients driving approximately 20 miles farther for common services (eg, inpatient care) or approximately 40 additional miles for less common services (eg, alcohol or drug abuse treatment) [10]. Telemedicine offers a solution for patients facing these long drives, especially for visits that require minimal patient-provider interaction, which both reduces patient burden in seeking care and has a beneficial climate impact. However, it is worth noting that 22.3% of rural households lack access to broadband internet, compared with 1.5% of those living in urban areas [11]. Access to adequate internet services or other additional patient preferences and limitations should be considered when offering a telemedicine option.

Despite potential challenges, telemedicine has tremendous potential in terms of climate impact. Over a period of 2 years at 5 university hospital centers, investigators found that more than 200 years of person-time, 53 million miles worth of travel, $33 million, and 21 000 metric tons of GHGe were saved by telemedicine use [12]. A survey of patients attending an adult ID clinic found that the potential per-person savings enabled by offering telemedicine included a reduction in round-trip travel distance of 227 miles, a reduction in travel time of 3.6–4.5 hours, a decrease in travel costs of $131, and a 91-kg decrease in GHGe [13]. This illustrates the importance of incorporating patient distance from a clinic when calculating potential telemedicine-related savings. Importantly, another study estimated that telemedicine is only likely to reduce GHGe compared with in-person visits if a patient would have to travel a distance of at least 3.6–7.2 km (2.2–4.7 miles) via car to reach the appointment [14], although this is less than the average distance patients travel for visits [9]. Studies conducted outside of the United States have found similar environmental benefits [15, 16].

Telemedicine may also provide value when used between healthcare professionals. For example, the use of smartphones for pediatric ID consultation in children with a rash demonstrated >96% compatibility with the final diagnosis, potentially reducing the need for separate emergency department or subspecialty clinic visits [17]. Importantly, telemedicine can also prevent disease transmission, such as in cases of measles and varicella. Unfortunately, despite its effectiveness in a variety of settings, issues related to reimbursement currently limit widespread implementation of telemedicine for this purpose [18, 19].

The Infectious Diseases Society of America (IDSA) supports the use of telemedicine, highlighting its utility in managing infections such as human immunodeficiency virus (HIV) and tuberculosis and in implementing antimicrobial stewardship programs in community settings. The use of telemedicine and mobile device interventions for HIV has shown improved antiretroviral therapy adherence and virologic suppression [20, 21]. A randomized control trial, funded by the Centers for Disease Control and Prevention, found that electronic directly observed therapy for active tuberculosis disease was equivalent to an in-person model when evaluating the percentage of completed doses and issues affecting medication observation, with 84% of participants preferring to continue treatment with electronic directly observed therapy [22]. Similarly, the use of telemedicine antimicrobial stewardship consultation in a community hospital demonstrated a reduction in antimicrobial consumption, cost, and isolation of multidrug-resistant organisms [23].

Across a variety of outpatient settings, telemedicine appears to be an effective means for reducing GHGe. Two systematic reviews have affirmed this finding, with one quantifying the

savings of 0.70–372 kg carbon dioxide (CO_2) per consultation when compared with traditional outpatient care models, with the most dramatic reductions seen when patients would otherwise need to travel to the clinic via personal vehicle or air travel [24, 25]. These savings are not only important for the environment, but they may also be preferred by patients if they save either time or money. The Pediatric Infectious Diseases Society (PIDS) has a toolkit that may be of use to healthcare professionals seeking to increase their use of telemedicine [26].

Nontelemedicine methods for reducing travel to clinics have also been studied, such as performing same-day procedures rather than scheduling patients to return for them on a later date. Same-day surgery for patients with skin cancer was associated with an average savings of approximately 15 kg CO_2 equivalents (CO_2e) per patient encounter, for an overall savings of 6020 kg CO_2e for 389 patients who underwent same-day surgeries during a 1-year period [27]. Clinics that perform outpatient procedures should evaluate whether there are patients who can realistically have procedures performed on the same day as their initial evaluation. These findings may be extrapolated to ID clinics, where patients are often followed up by other subspecialty services. If feasible, visits in the ID clinic can be coordinated with other services to reduce the need for separate visits. Many patients and families are likely to appreciate this change from a time management perspective as well.

Similarly, travel-related emissions can be reduced by decreasing in-person visit frequency when considered safe. For example, among patients receiving injectable long-acting antipsychotics, investigators found most patients were receiving injections more frequently and at higher doses than available evidence suggests is necessary for optimal therapeutic effect [28]. It was estimated that reducing the frequency of visits and the total dose administered at each visit, in alignment with evidence-based recommendations, would result in a net carbon savings of up to 170 000 kg CO_2e annually if applied across England and could potentially result in improved patient safety on lower doses of medication. Put in perspective, the impact of this intervention alone is equivalent to removing 37.8 gasoline-powered passenger vehicles from the road [29].

REDUCING CLINIC WASTE

Waste audits have been used as a starting point to identify key waste generators in the healthcare system, categorizing waste into either solid, regulated medical, recyclable, or pharmaceutical waste. As solid waste (defined as discarded materials such as paper, plastics, glass, and food waste) contributes to a substantial percentage of the waste identified in audits, it is a tangible starting point for waste reduction in the outpatient setting [30]. This section will also identify means to reduce excess energy consumption.

One study in a physical medicine and rehabilitation clinic identified that health professionals who performed in-clinic procedures using prepackaged procedure kits produced almost twice as much waste as those who selected individual sterile components for their procedures [4]. Over the course of a year, this reflected an excess of 819.5 kg of waste and an estimated 1550 kg GHGe each year [30]. This study highlights how waste audits both identify sources of waste and sustainable practices already in place that should be expanded. My Green Doctor (a free, nonprofit, online model designed to improve environmental sustainability in outpatient practice) provides an excellent starting point for conducting a waste audit and also provides a variety of other practical tips [31].

Many medical devices are now single-use, disposable products, driven largely by infection control policies. However, devices such as blood pressure (BP) cuffs, stethoscopes, and toys are categorized as noncritical portable medical devices, meaning that only low- or intermediate-level disinfection is necessary if devices are shared between patients [32, 33]. In one study, the use of reusable BP cuffs cleaned after each encounter and disposed of by incineration when no longer usable was associated with 40-fold reduction in GHGe as compared with single-use BP cuffs [34]. Similarly, reusable cystoscopes were associated with approximately one-fifth of the GHGe of single-use cystoscopes even when accounting for the energy consumed reprocessing reusable scopes [35]. The use of reusable cloth patient gowns, as opposed to disposable paper gowns, should be considered as another method for reducing solid waste. Online waste calculators such as the M+WasteCare Calculator can help quantify the waste produced by medical devices in a particular outpatient setting [36]. Calculating waste data and the associated cost may provide the necessary financial incentive for change. Appropriate segregation of medical waste can also yield cost savings, as regulated medical waste costs 5–10 times more to dispose of than solid waste [37]. Organizations such as Practice Greenhealth provide toolkits and protocols to assist clinics in appropriate waste segregation, as a significant portion of what is currently processed as regulated medical waste can be safely disposed of as solid waste.

Paper products also contribute to the waste produced in the ambulatory setting, especially in pediatric clinics, where vaccine information sheets are typically provided to families at each well-child visit. One practice replaced individual vaccine information sheets with a single sheet including quick response (QR) codes linking to the information provided by the Centers for Disease Control and Prevention. Ultimately, the authors replaced their handout with a single laminated sheet in every examination room, with paper copies provided only on parental request [38]. The authors estimate that this change resulted in the use of nearly 80 000 fewer sheets of paper. This initiative led to increased awareness for sustainability practices and inspired employees to advocate for additional measures in the clinic

such as use of recycling bins and reusable water bottles. Paper reduction in particular may be attractive to ID clinics that provide travel medicine services, typically requiring a variety of vaccines, but it can also be applied to routine printing of potentially lengthy after-visit summaries. In addition, patient documentation and charts can be safely and digitally faxed using smartphones and tablets, reducing paper waste and also eliminating the electric waste produced by powering fax machines, fax servers, and the server rooms supporting them.

Reducing energy consumption is another way to reduce waste in the clinic. A critical step is purchasing products with lower environmental impact. The Electronic Product Environmental Assessment Tool (EPEAT) helps identify environmentally preferable electronic products needed for clinics such as desktops, televisions and printers [39]. This list can be cross-referenced when purchasing new equipment, and resources such as Earth911 can be used to identify local facilities for recycling old equipment [40].

However, in many cases it is preferable to optimize the use of existing functioning technology rather than purchase new equipment. The American Medical Association has identified several ways to reduce electricity consumption, including turning off electronics at the end of each day, using energy-efficient thermostat set points and upgrading lightbulbs [41]. These "demand-side" management interventions are easy solutions that can be implemented in any clinic and that typically result in cost savings [42].

Finally, some clinics may seek to reduce their reliance on fossil fuels and either purchase their energy from renewable sources (eg, wind, hydroelectric, etc), or generate their own energy onsite (eg, solar energy). These changes may be federally subsidized and supported by legislation, such as the 2022 Inflation Reduction Act [43].

OPTIMIZING THE USE OF HIGH-VALUE DIAGNOSTICS AND THERAPEUTICS

Studies indicate that children routinely receive low-value interventions, including medications, such as antibiotics and steroids, as well as procedures such as radiographs and blood sampling [44], suggesting that clinicians should consider reducing low-value interventions. Similar to telemedicine, reducing low-value interventions has the potential for reducing environmental impact and improving the quality of patient care.

Acute hematogenous osteomyelitis (AHO), a condition commonly seen in pediatric ID clinics, provides an excellent case study for how GHGe can be reduced by limiting the use of low-value interventions. PIDS and IDSA published guidelines on the management of AHO in 2021, which recommend an early transition from parenteral to oral antibiotics in most children with uncomplicated AHO [45]. This differs from the historical management of patients with osteomyelitis, in which patients tended to receive outpatient parenteral antibiotic therapy (OPAT); this is especially true in adults, although studies in recent years have called this practice into question [46]. The use of OPAT typically requires more frequent laboratory assessments than oral antibiotic therapy and often requires more frequent clinic visits, both of which are important drivers of healthcare-associated GHGe. In addition, the placement of indwelling lines is associated with a complication rate of nearly 20% in outpatients, most of which complications require patients to present for unplanned healthcare visits, generating additional GHGe [47]. Telemedicine has been identified as a safe option for patients in whom the use of OPAT is deemed appropriate [48]. Additional research will be helpful at identifying situations where OPAT is commonly used that can be managed safely with oral antibiotics.

Most pediatric ID providers managing AHO will typically obtain laboratory studies such as a complete cell blood count and a C-reactive protein level to monitor response to therapy and to monitor for toxic effects related to therapy in the outpatient setting. However, as the PIDS/IDSA AHO guidelines identify, the evidence supporting this practice is of relatively low quality; additional research is necessary to define the optimal use of these studies [45]. Diagnostic stewardship is an area of growing interest within the field of ID, which, in addition to its many other benefits, offers the opportunity to reduce laboratory waste and decrease GHGe. The Society for Healthcare Epidemiology of America has developed a free online course on the benefits of diagnostic stewardship which may be of interest to some [49]. Other articles in this supplement will discuss opportunities to reduce laboratory waste further.

The impact of excessive radiologic studies on the environment is becoming increasingly recognized [50]. Magnetic resonance imaging is identified as an especially large contributor to GHGe resulting from the radiology department, due both to its electricity consumption and to challenges related to the disposal of gadolinium used for contrast material [51]. Imaging procedures such as plain radiography and especially magnetic resonance imaging are key to the diagnosis of AHO in children. However, the value of repeated imaging at the end of therapy is less evident. The PIDS/IDSA AHO guidelines recommend performing end-of-therapy imaging only when disease involves the physis, although the evidence supporting this practice is limited, and in practice, radiographs are often obtained routinely at many orthopedic follow-up visits regardless of the extent of disease [45]. Given the potentially large environmental impact, we encourage outpatient ID health professionals to reflect on the added clinical value of follow-up imaging.

Conversations around the duration of therapy related to AHO provide an opportunity to focus on the potential environmental benefits of shorter antibiotic courses, in addition to the many other benefits of the "shorter is better" approach [52].

The PIDS/IDSA AHO guidelines recommend a duration of therapy of 3–4 weeks for most cases of uncomplicated AHO, a departure from the previous typical practice of 4–6 weeks of therapy [45]. While climate change is known to be accelerating antimicrobial resistance (AMR) worldwide, the One Health approach has illustrated that AMR may in and of itself have a deleterious environmental impact [53–55]. As the appropriate use of shorter courses of antibiotics is less likely to drive AMR, such courses may also have a smaller environmental impact. This is especially important when considering that the prescription of longer courses of any therapy often leads to unused medication remaining in patients' homes. In one study from Hong Kong, <1% of leftover medications were returned to pharmacies to be disposed of properly, with the majority being placed in general waste bins, which can lead to contamination of wastewater and unintended consequences on various ecosystems [56, 57]. Additional studies are needed evaluating opportunities to safely reduce the duration of therapy prescribed in other conditions.

Finally, when possible, health professionals should take the opportunity to prescribe medications which are known to have a smaller environmental impact. A prime example of this in outpatient medicine is the use of inhaled medications. Metered dose inhalers (MDIs) contain hydrofluorocarbon propellants and are a significant source of GHGe in the outpatient setting, having a climate impact 10–40 times that of dry-powder inhalers (DPIs). One study estimated that if 75% of all German patients with asthma or chronic obstructive pulmonary disease had their prescriptions for MDIs exchanged for prescriptions for DPIs. This change would result in a reduction of 46 million kg of CO_2e annually [58]. In one survey, 59% of patients with asthma or chronic obstructive pulmonary disease identified that using an inhaler with a lower climate impact is either important or very important to them, indicating that this change would be well received [59]. That being said, there are important limitations to the widespread adoption of DPIs: many American health insurance plans do not currently include DPIs on their preferred drug lists, few generic DPIs are available in the United States and DPIs may not be appropriate for all patients. Importantly, patients with well-controlled asthma have been found to have one-third of the climate impact of patients with poorly controlled asthma because of less frequent use of short-acting albuterol MDIs, highlighting that improved patient and environmental outcomes often go hand in hand [60].

CONCLUSIONS

Climate change is an urgent health threat affecting both our patients and our planet. It directly affects human health, for example through increasing severe weather events, but it is also increasing strain and burden on healthcare systems as more individuals suffer from its effects [61]. Addressing the contribution of healthcare systems to climate change is a critical avenue to avoid this dynamic problem. Although most recognize that it is our responsibility as healthcare professionals to lead the way in reducing GHGe in our day-to-day clinical practice, limited knowledge about best practices for promoting sustainability in the outpatient setting can make this task feel daunting, and at times insurmountable. This review of evidence-based strategies demonstrates that there are a variety of actions that individual providers and clinics can take to meaningfully reduce their GHGe, whether they practice in an ID clinic or in another environment. Resources such as My Green Doctor, Practice Greenhealth, and the BMJ interactive sustainable practice tool can provide additional support [31, 37, 62]. We encourage readers who have championed GHGe-reducing initiatives in their own offices to share their successes, contribute to the small but growing literature on outpatient sustainability, and empower others to take the next step toward a more sustainable future.

Acknowledgments

Author contributions. M. M. S. and M. A. developed the article framework. All authors conducted a literature review, participated in the writing and editing of the final manuscript, and approved the final manuscript.

Potential conflicts of interest. All authors: No reported conflicts.

References

1. Watts N, Amann M, Arnell N, et al. The 2019 report of The *Lancet* Countdown on health and climate change: ensuring that the health of a child born today is not defined by a changing climate. Lancet **2019**; 394:1836–78.
2. Mora C, McKenzie T, Gaw IM, et al. Over half of known human pathogenic diseases can be aggravated by climate change. Nat Clim Chang **2022**; 12:869–75.
3. Pichler PP, Jaccard IS, Weisz U, Weisz H. International comparison of health care carbon footprints. Environ Res Lett **2019**; 14:064004.
4. Taylor AL, Levin J, Chan J, et al. Improving environmental sustainability in outpatient clinics: lessons from a waste audit. J Clim Chang Health **2021**; 4:100070.
5. Eckelman MJ, Sherman J. Environmental impacts of the U.S. health care system and effects on public health. PLoS One **2016**; 11:e0157014.
6. Shah A, Gustafsson L. U.S. health care workers want their employers to address climate change. Commonwealth Fund. Published 24 January 2024. Available at: https://www.commonwealthfund.org/publications/issue-briefs/2024/jan/us-health-care-workers-want-employers-address-climate-change. Accessed 17 October 2024.
7. Kotcher J, Maibach E, Miller J, et al. Views of health professionals on climate change and health: a multinational survey study. Lancet Planet Health **2021**; 5: e316–23.
8. Transportation statistics annual report 2022. Washington, DC, 2022. Available at: https://rosap.ntl.bts.gov/view/dot/65841. Accessed 17 October 2024.
9. Dacones I, Cave C, Furie GL, Ogden CA, Slutzman JE. Patient transport greenhouse gas emissions from outpatient care at an integrated health care system in the Northwestern United States, 2015–2020. J Clim Chang Health **2021**; 3:100024.
10. US Government Accountability Office. Rural hospital closures: affected residents had reduced access to health care services. Published 21 January 2021. Available at: https://www.gao.gov/products/gao-21-93. Accessed 26 February 2024.
11. Federal Communications Commission. 2020 broadband deployment report. Published 8 June 2020. Available at: https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2020-broadband-deployment-report. Accessed 26 February 2024.
12. Sharma S, Yellowlees PM, Gotthardt CJ, Luce MS, Avdalovic MV, Marcin JP. Environmental impact of ambulatory telehealth use by a statewide university health system during COVID-19. Telemed J E Health **2023**; 29:1134–42.
13. Evers EC, Fritz SA, Colditz GA, Burnham JP. Perceptions of telemedicine and costs incurred by a visit to a general infectious diseases clinic: a survey. Open Forum Infect Dis **2022**; 9:ofab661.
14. Holmner A, Ebi KL, Lazuardi L, Nilsson M. Carbon footprint of telemedicine solutions–unexplored opportunity for reducing carbon emissions in the health sector. PLoS One **2014**; 9:e105040.

15. Blenkinsop S, Foley A, Schneider N, Willis J, Fowler HJ, Sisodiya SM. Carbon emission savings and short-term health care impacts from telemedicine: an evaluation in epilepsy. Epilepsia **2021**; 62:2732–40.
16. Morcillo Serra C, Aroca Tanarro A, Cummings CM, Jimenez Fuertes A, Tomás Martínez JF. Impact on the reduction of CO2 emissions due to the use of telemedicine. Sci Rep **2022**; 12:12507.
17. Devrim İ, Düzgöl M, Kara A, et al. Reliability and accuracy of smartphones for paediatric infectious disease consultations for children with rash in the paediatric emergency department. BMC Pediatr **2019**; 19:40.
18. Gonzalez BE, Sabella C, Esper FP, et al. Physician-to-physician electronic consultation: a tool for the pediatric infectious diseases specialist to document encounters and quantify effort. J Pediatric Infect Dis Soc **2021**; 10:334–6.
19. Madhavan VL, El Saleeby CM. So you want to start an infectious diseases telemedicine service? J Pediatric Infect Dis Soc **2020**; 9:357–61.
20. Young JD, Patel M, Badowski M, et al. Improved virologic suppression with HIV subspecialty care in a large prison system using telemedicine: an observational study with historical controls. Clin Infect Dis **2014**; 59:123–6.
21. Gárate FJ, Chausa P, Whetham J, et al. EmERGE mHealth platform: implementation and technical evaluation of a digital supported pathway of care for medically stable HIV. Int J Environ Res Public Health **2021**; 18:3156.
22. Burzynski J, Mangan JM, Lam CK, et al. In-person vs electronic directly observed therapy for tuberculosis treatment adherence: a randomized noninferiority trial. JAMA Netw Open **2022**; 5:e2144210.
23. Ceradini J, Tozzi AE, D'Argenio P, et al. Telemedicine as an effective intervention to improve antibiotic appropriateness prescription and to reduce costs in pediatrics. Ital J Pediatr **2017**; 43:105.
24. Purohit A, Smith J, Hibble A. Does telemedicine reduce the carbon footprint of healthcare? A systematic review. Future Healthc J **2021**; 8:e85–91.
25. Pickard Strange M, Booth A, Akiki M, Wieringa S, Shaw SE. The role of virtual consulting in developing environmentally sustainable health care: systematic literature review. J Med Internet Res **2023**; 25:e44823.
26. Pediatric Infectious Diseases Society. Telemedicine toolkit. Available at: https://pids.org/telemedicine-toolkit/. Accessed 12 March 2024.
27. Doyle C, McFeely O, Beatty P, et al. Same-day surgery promotes sustainability in dermatology. Clin Exp Dermatol **2023**; 48:692–3.
28. Maughan DL, Lillywhite R, Cooke M. Cost and carbon burden of long-acting injections: a sustainable evaluation. BJPsych Bull **2016**; 40:132–6.
29. US Environmental Protection Agency. Greenhouse gas equivalencies calculator. Updated January 2024. Available at: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator. Accessed 22 February 2024.
30. US Environmental Protection Agency. Criteria for the definition of solid waste and solid and hazardous waste exclusions. Updated 16 July 2024. Available at: https://www.epa.gov/hw/criteria-definition-solid-waste-and-solid-and-hazardous-waste-exclusions. Accessed 27 August 2024.
31. My Green Doctor Foundation. My Green Doctor. Available at: https://mygreendoctor.org. Accessed 17 October 2024.
32. Centers for Disease Control and Prevention. Healthcare Infection Control Practices Advisory Committee (HICPAC). Updated 22 January 2024. Available at: https://www.cdc.gov/hicpac/index.html. Accessed 26 February 2024.
33. Rutala WA, Weber DJ. Best practices for disinfection of noncritical environmental surfaces and equipment in health care facilities: a bundle approach. Am J Infect Control **2019**; 47s:A96–A105.
34. Sanchez SA, Eckelman MJ, Sherman JD. Environmental and economic comparison of reusable and disposable blood pressure cuffs in multiple clinical settings. Resour Conserv Recycl **2020**; 155:104643.
35. Kemble JP, Winoker JS, Patel SH, et al. Environmental impact of single-use and reusable flexible cystoscopes. BJU Int **2023**; 131:617–22.
36. Mazzetti. M+WasteCare Calculator. Available at: https://www.mazzetti.com/resources/mtools/wastecare-calculator/. Accessed 26 February 2024.
37. Practice Greenhealth. Sustainability solutions for health care. Available at: https://www.practicegreenhealth.org. Accessed 17 October 2024.
38. Yun YM, Kirby C, Bob N, et al. Promoting sustainability practices in the outpatient pediatric setting. Yale J Biol Med **2023**; 96:261–5.
39. US Environmental Protection Agency. Electronic Product Environmental Assessment Tool (EPEAT). Updated 3 November 2023. Available at: https://www.epa.gov/greenerproducts/electronic-product-environmental-assessment-tool-epeat. Accessed 12 March 2024.
40. Earth911. Earth911 recycling search. Available at: https://search.earth911.com. Accessed 12 March 2024.
41. Staff News Writer. Fight climate change and save money—go green at your practice. American Medical Association. 19 April 2022. Available at: https://www.ama-assn.org/delivering-care/public-health/fight-climate-change-and-save-money-go-green-your-practice. Accessed 22 February 2024.
42. Fathy R, Nelson CA, Barbieri JS. Combating climate change in the clinic: cost-effective strategies to decrease the carbon footprint of outpatient dermatologic practice. Int J Womens Dermatol **2020**; 7:107–11.
43. US Department of the Treasury. Fact sheet: how the Inflation Reduction Act's tax incentives are ensuring all Americans benefit from the growth of the clean energy economy. Published 20 October 2023. Available at: https://home.treasury.gov/news/press-releases/jy1830#:~:text=The%20Inflation%20Reduction%20Act%20modifies%20and%20extends%20the%20Renewable%20Energy,meet%20prevailing%20wage%20standards%20and. Accessed 12 March 2024.
44. Trapani S, Montemaggi A, Indolfi G. Choosing wisely in pediatric healthcare: a narrative review. Front Pediatr **2023**; 10:1071088.
45. Woods CR, Bradley JS, Chatterjee A, et al. Clinical practice guideline by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America: 2021 guideline on diagnosis and management of acute hematogenous osteomyelitis in pediatrics. J Pediatric Infect Dis Soc **2021**; 10:801–44.
46. Wald-Dickler N, Holtom PD, Phillips MC, et al. Oral is the new IV. Challenging decades of blood and bone infection dogma: a systematic review. Am J Med **2022**; 135:369–379.e1.
47. Grau D, Clarivet B, Lotthé A, Bommart S, Parer S. Complications with peripherally inserted central catheters (PICCs) used in hospitalized patients and outpatients: a prospective cohort study. Antimicrob Resist Infect Control **2017**; 6:18.
48. Tan SJ, Ingram PR, Rothnie AJ, et al. Successful outpatient parenteral antibiotic therapy delivery via telemedicine. J Antimicrob Chemother **2017**; 72:2898–901.
49. Society for Healthcare Epidemiology of America. Diagnostic and antibiotic stewardship. Available at: https://learningce.shea-online.org/content/diagnostic-antibiotic-stewardship-0. Accessed 12 March 2024.
50. Lee A, Schoen J, Scheel JR, Frederick-Dyer K. A CT scan of our earth: the radiology department's how-to guide for addressing planetary health. J Am Coll Radiol **2024**; 21:280–4.
51. Chaban YV, Vosshenrich J, McKee H, et al. Environmental sustainability and MRI: challenges, opportunities, and a call for action. J Magn Reson Imaging **2024**; 59:1149–67.
52. Spellberg B, Rice LB. The shorter is better movement: past, present, future. Clin Microbiol Infect **2023**; 29:141–2.
53. Burnham JP. Climate change and antibiotic resistance: a deadly combination. Ther Adv Infect Dis **2021**; 8:2049936121991374.
54. Magnano San Lio R, Favara G, Maugeri A, Barchitta M, Agodi A. How antimicrobial resistance is linked to climate change: an overview of two intertwined global challenges. Int J Environ Res Public Health **2023**; 20:1681.
55. Leach R. Exploring the environmental impact of antibiotic overuse. *Infection Control Today*. Published 26 May 2023. Available at: https://www.infectioncontroltoday.com/view/exploring-environmental-impact-antibiotic-overuse. Accessed 12 March 2024.
56. Chung S, Brooks BW. Identifying household pharmaceutical waste characteristics and population behaviors in one of the most densely populated cities. Resour Conser Recycl **2019**; 140:267–77.
57. Daughton CG. Eco-directed sustainable prescribing: feasibility for reducing water contamination by drugs. Sci Total Environ **2014**; 493:392–404.
58. Bickhardt J, Czupalla C, Bader U. Reduction of greenhouse gas emissions by inhaler choice in the therapy of asthma and COPD patients [in German]. Pneumologie **2022**; 76:321–9.
59. Florman K, Wickham H, Hodge A, et al. S65 global warming impact of inhalers: the patient perspective. Thorax **2022**; 77:A41.
60. Alzaabi A, Bell JP, Montero-Arias F, et al. Greenhouse gas emissions from respiratory treatments: results from the SABA CARBON international study. Adv Ther **2023**; 40:4836–56.
61. Seervai S, Gustafsson L, Abrams MK. The impact of climate change on our health and health systems. Commonwealth Fund. Published 4 May 2022. Available at: https://www.commonwealthfund.org/publications/explainer/2022/may/impact-climate-change-our-health-and-health-systems. Accessed 29 August 2024.
62. Wedmore F, Nolan T, Watts N. Sustainable practice: what can I do? BMJ **2023**; 383:2461.