

Addressing the Environmental Impact of Pharmaceuticals: A Call to Action

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Abstract

The contribution of health care to environmental and climate crises is significant, under-addressed, and with consequences for human health. This editorial is a call to action. Focusing on pharmaceuticals as a major environmental threat, we examine pharmaceutical impacts across their lifecycle, summarising greenhouse gas emissions, pollution, and biodiversity loss, and outlining challenges and opportunities to reduce this impact. We urge health care decision-makers and providers to urgently consider environmental factors in their decision-making relating to both policy, and practice, promoting actions such as rational prescribing, non-pharmaceutical interventions, and research and advocacy for sustainable production, procurement, and use.

Key words: climate change; environmental pollutants; biodiversity; sustainable health care; pharmaceuticals; health personnel

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Introduction

Climate change and environmental degradation are irrevocably intertwined with our lives and our health. While we are witness to extreme weather and significant impacts on health, to date climate change has received insufficient attention within health care education and practice. The contribution of health care to climate change and environmental degradation has received even less attention. Health care is estimated to contribute 4–5% of global greenhouse gas emissions, generate extensive waste, leak pharmaceuticals into the environment, and contribute to biodiversity loss (Pichler et al, 2019). Humanity has already crossed six of the nine planetary boundaries—key Earth system thresholds that are essential to sustaining life, including climate stability, biodiversity, and freshwater availability (Caesar et al, 2024). Exceeding these boundaries endangers the resilience of these systems and, consequently, human and ecological wellbeing. We are on the brink of a global health crisis. It is imperative that we all work to reverse, mitigate, and adapt to these crises.

This editorial focuses on the contribution of pharmaceuticals to health care's environmental impact. Pharmaceuticals are integral to managing and treating illness. However, the pharmaceutical pipeline has already had considerable environmental impact—across research, development, production, distribution, storage, use, and disposal of pharmaceuticals. Such harms occur across multiple global supply chains and are removed from everyday health care, leaving providers often unaware of their extent and potential mitigation strategies. Our editorial summarises

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the environmental impact of pharmaceuticals and sets out the challenges and opportunities for reducing environmental impacts. It serves as a call for health care decision-makers and providers to take urgent action.

The Environmental Impact of Pharmaceuticals

We focus on three critical areas: (a) contribution of pharmaceuticals to greenhouse gas emissions, (b) pharmaceutical residues in the environment, and (c) biodiversity loss as a result of pharmaceutical development and production.

Contribution of Pharmaceuticals to Greenhouse Gas Emissions

Pharmaceuticals are estimated to contribute between 13–55% of greenhouse gas emissions of the carbon footprint of health systems (Booth, 2022). Pharmaceutical products release greenhouse gas emissions across their lifecycle; however, there is sparse data on the carbon footprint of individual drugs. Carbon footprint estimates of anaesthetic gases indicate that desflurane is the most polluting anaesthetic gas, while metred-dose inhalers contain propellants that, in some estimates, are 3800 times more polluting than carbon dioxide (Bosenberg, 2011; Emeryk et al, 2021). Awareness of these carbon footprints have led to efforts to reduce emissions from anaesthetic gases and inhalers—desflurane has been banned in some health systems (e.g., Scotland), while prescribers are encouraged to switch to lower-carbon dry powder inhalers. Carbon footprint data of other pharmaceutical products is limited. Despite the lack of data, available evidence indicates considerable greenhouse gas emissions, and associated climate impacts, across the pharmaceutical pipeline. Significant work is needed to understand and mitigate the climate impact of pharmaceutical products.

Pharmaceutical Residues in the Environment

Pharmaceutical residues (e.g., active pharmaceutical ingredients—the biologically active component of drugs, metabolites, by-products, and other compounds) have severe environmental impacts, affecting both ecosystems and human health. These enter the environment (e.g., water, soil) via several routes, including through excretion of residues after consumption by humans and animals; improper disposal of unused pharmaceuticals (e.g., in landfill or by flushing into sewage plants, typically ill-equipped to deal with pharmaceuticals); effluent from pharmaceutical manufacturing and domestic wastewater containing residues; and runoff from pharmaceutical use in agriculture and aquaculture. A database of published literature on pharmaceutical residues in the environment indicates the presence of over 900 pharmaceutical products in the environment (UBA, 2024). This is likely an underestimate.

Pharmaceuticals that persist in the environment and cross ecological thresholds (thresholds within an ecosystem where minor environmental changes trigger major shifts in ecosystem structure or function) can harm ecosystems and humans. Antimicrobial products in the environment contribute to antimicrobial resistance through selective pressure on natural pathogens. Endocrine disruptors, such as oestrogen, affect the development, growth, and reproductive behaviour of species

causing, for example, the feminisation of fish ([Ortúzar et al, 2022](#)). In one notable case, the anti-inflammatory drug diclofenac wiped out 95% of Southeast Asia vultures that ingested the drug via cattle carcasses, leading to acute kidney injury ([Frank and Sudarshan, 2024](#)). Work is ongoing to quantify the presence and fate of pharmaceutical residues in the environment, their impact on ecosystems and human health, and how to mitigate this—numerous gaps remain.

Biodiversity Impact as a Result of Pharmaceutical Development and Production

Biodiversity—the variety and variability of life on Earth—is a complex and vital aspect of planetary health. Biodiversity loss occurs when species decrease or disappear. We are on the verge of the sixth mass extinction, driven by human activities that disrupt planetary boundaries; our actions—deforestation, pollution, greenhouse gas emissions—are pushing Earth’s systems beyond their natural limits, threatening species with extinction and destabilising ecosystems that support life on the planet.

The development and production of pharmaceuticals is reliant on biodiversity, but simultaneously contributes to biodiversity loss. Nature holds immense potential for expanding our drug repertoire. An estimated 70% of medicines are derived from plants (e.g., morphine, artemisinin); other medicines are derived from animals (e.g., captopril, an anti-hypertensive, is an analogue of snake venom); and there is increasing interest in leveraging technology to investigate new natural drug candidates (e.g., in deep oceans) ([Theodoridis et al, 2023](#)). Research on the direct impact of pharmaceuticals on biodiversity loss is sparse. However, it is clear we are exploiting nature to its—and our—detriment. Take the example of the horseshoe crab, a 450-million-year-old species whose blood is harvested to test for toxic substances in intravenous drugs—this practice has contributed to a decline in populations, disrupting ecosystems and affecting species like shorebirds that depend on their eggs for food ([Maloney et al, 2018](#)). Little has been done to mitigate threats to biodiversity and there are concerns that we are losing at least one important medicine to biodiversity loss each year ([Neergheen-Bhujun et al, 2017](#)).

Indirect biodiversity loss is also happening through resource extraction (e.g., paper, plastic) to produce ancillary pharmaceutical products, like packaging. While we lack data on the contribution of pharmaceutical packaging to biodiversity loss, it likely plays a significant role. Primary forests, home to two-thirds of biodiversity, have declined by 9% since 2022, partly due to commercial forestry for packaging ([Weisse et al, 2024](#)). Pharmaceuticals, therefore, are reliant on intact ecosystems and biodiversity, while simultaneously contributing to its loss. There is a huge gap in data here, that warrants critical exploration and action.

What are the Challenges in Reducing the Environmental Impact of Pharmaceuticals?

Climate change, environmental pollution, and biodiversity loss represent significant environmental harms from pharmaceuticals. Key challenges must be addressed to reduce this environmental impact.

First, there is limited awareness within health care about the environmental impacts of pharmaceuticals. This gap is partly due to health systems' focus on immediate priorities like resource constraints and workforce shortages leaving little capacity to consider environmental issues. Education for health care providers on health care's environmental impact remains limited, and providers often have little time and headspace to address and mitigate against environmental impacts. Furthermore, embedding sustainability into health care practices requires behaviour change among clinical guideline developers, like prescribing, health care providers, and patients. Prescribers already consider many factors (e.g., clinical indications, cost, side-effects) when making decisions about patient care, and it can be challenging to adjust or add to this in ways that incorporate environmental considerations.

Incorporating environmental considerations is further complicated by data gaps. Pharmaceutical companies rarely disclose the environmental impacts of their products. Additionally, estimating the environmental impact of pharmaceutical products is complex and context-dependent; for instance, carbon footprints vary depending on the location of production and allied distribution, and are often based on proxy data in the absence of manufacturer disclosures. Efforts to fill the data gap are ongoing. These efforts include collaborations between pharmaceutical companies and the public sector (e.g., Sustainable Markets Initiative Health Systems Task Force) to develop standards for measuring and reporting environmental impacts of pharmaceutical products; policy and regulatory initiatives like National Health Service (NHS) England's NHS Supplier Road Map, which mandates companies to disclose product carbon footprints by 2028; and growing pressure from academics and health care providers urging companies to release environmental data. Alongside this data being published, questions remain about how best to use it to drive environmental action.

While critical for ensuring patient safety, existing policies and regulations often hinder efforts to make products more environmentally sustainable. For example, strict regulations around pharmaceutical packaging can obstruct eco-friendly changes, while regulatory barriers to reuse medicines—even when safe—exist in many countries (Smale et al, 2024). Finally, infrastructure barriers exist, particularly in the safe disposal of pharmaceuticals. Pharmacy take-back programmes, where patients can drop off unused pharmaceuticals at pharmacies for safe disposal, are often lacking, and current wastewater treatment technologies are insufficient to filter pharmaceutical residues.

What can We do to Reduce the Environmental Impact of Pharmaceuticals?

Reducing pharmaceuticals' environmental impact requires collective effort from industry, policymakers, academics, health care providers, and patients. Actions like environmentally sustainable manufacturing, regulatory adjustments, and new technologies are critical. In this section we focus on the part that health care decision-makers and providers can play in reducing the environmental impact of pharmaceuticals.

Health care decision-makers, including policymakers, administrators, procurers, and clinical leads, play a vital role in shaping policies, regulations, priorities, and practices within health systems. Their decisions affect how health care is designed and delivered and, crucially, whether health care is delivered in an environmentally sustainable manner. While some decision-makers are factoring the environment into their decisions, for instance, in policy reducing the use of desflurane and the incentivisation of prescribing dry powder inhalers, this is not yet mainstream. Decision-makers must consider the environment across their work streams—in procurement policy, hospital waste management protocols, clinical care guidelines, medical training, public health initiatives, health research. Decision makers hold immense power in influencing health care practices, as well as the practices of the pharmaceutical industry; and are critical in maintaining awareness and action relating to the environment.

For health care providers, a key step in reducing environmental harm from pharmaceuticals is to avoid unnecessary prescriptions, aligning with broader efforts in health promotion and disease prevention. Initiatives like public health measures, socioeconomic support, and non-pharmaceutical interventions—such as social prescribing (connecting patients to community resources and green spaces)—can improve health outcomes while reducing medication use. When medication is needed, it is crucial that patients receive the correct drug, at the right dose, and for an appropriate duration, reducing overprescription, prolonged use, and polypharmacy—known as ‘rational prescribing’. There is potential for deprescribing, with prescribers planning and supervising cessation of prescribed drugs that are no longer considered necessary, and bringing benefits both to patients, through limiting risk of side-effects and interactions, as well as the environment. Additionally, providers play an essential role in supporting patients with proper medication use and disposal. Increasingly, pharmacies, often in collaboration with pharmaceutical companies (e.g., Novo Nordisk and insulin pens) offer take-back programmes for patients to return unused medication for correct disposal. Prescribers can play a role in signposting these options.

Efforts are underway to incorporate environmental considerations into prescribing practices, allowing prescribers to select drugs with the lowest environmental impact when multiple effective options exist (Piët et al, 2024). However, this shift requires pharmaceutical companies to publish environmental data and for decision-makers to integrate it into formularies while equipping prescribers to use this data effectively. And it is crucial for medicines formularies to flag existing data on carbon footprints (e.g., of metred-dose inhalers) where they are available, to prime prescribers on the environmental impact of drugs.

Advancements in personalised prescribing and digital tools further support these efforts by tailoring treatments to individual needs, reducing unnecessary resource use, and pharmaceutical waste. Digital innovations, such as automated medication reminders and optimised delivery systems, help minimise excess medication, improve adherence, and reduce waste. Lastly, health care providers (and decision-makers) are encouraged to engage in research and advocacy, supporting sustainable pharmaceutical production, procurement, and use.

Conclusion

Pharmaceuticals are crucial for health care delivery, yet detrimental to the environment. Greenhouse gas emissions are released along pharmaceuticals lifecycle, residues pollute our environment and harm ecosystems, and the production of drugs and their ancillary components (e.g., packaging) poses a biodiversity threat. There remain immense challenges in reducing this impact—limited awareness of the impact, lack of data, regulatory and infrastructure barriers, and a lack of coordinated efforts by stakeholders. Health care decision-makers and providers stand at a critical juncture: the environmental impact of pharmaceuticals and of health care demands immediate and decisive action to prevent irreversible harm. This is not an ideal—it is a necessity. Each policy, each prescription, and each decision must now reflect a commitment to sustainable health care. The stakes are high, and the time to act is now.

Key Points

- Pharmaceuticals contribute to health care's environmental harm through release of greenhouse gas emissions, environmental pollution from entry of drug residues to ecosystems, and biodiversity loss through their production.
- Key obstacles to reducing the environmental impact of pharmaceuticals include limited awareness and knowledge, a lack of comprehensive data on pharmaceuticals' environmental footprint, challenges in bringing about behaviour change in prescribing and use practices, restrictive regulations, and infrastructure gaps.
- Health care decision-makers and providers are positioned to reduce the environmental impact of pharmaceuticals by considering the environment in health care decisions, and through actions such as rational prescribing, and promoting non-pharmaceutical interventions.
- Reducing pharmaceuticals' environmental impact requires collaboration across governments, industry, and health care systems, with a focus on sustainable industry practices, reforming regulation, data transparency, and integrating environmental considerations into health care decision-making.

Availability of Data and Materials

Not applicable.

Author Contributions

AB conceived and wrote the manuscript. SES participated in the conception and provided revisions, edits, and additional comments. Both authors contributed to important editorial changes in the manuscript. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

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Conflict of Interest

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