Environmental sustainability and the carbon emissions of pharmaceuticals

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Received 25 August 2020
Revised 9 February 2021
Accepted 20 March 2021
Published Online First 14 April 2021

ABSTRACT
The US healthcare industry emits an estimated 479 million tonnes of carbon dioxide each year; nearly 8% of the country's total emissions. When assessed by sector, hospital care, clinical services, medical structures, and pharmaceuticals are the top emitters. For 15 years, research has been dedicated to the medical structures and equipment that contribute to carbon emissions. More recently, hospital care and clinical services have been examined. However, the carbon of pharmaceuticals is understudied. This article will focus on the carbon emissions of pharmaceuticals since they are consistently calculated to be among the top contributors to healthcare carbon and assess the factors that contribute to pharmaceutical carbon emissions. Specifically, overprescription, pharmaceutical waste, antibiotic resistance, routine prescriptions, non-adherence, drug dependency, lifestyle prescriptions, and drugs given due to a lack of preventive healthcare will be identified. Prescribing practices have environmental ramifications. Carbon reduction, when focused on pharmaceuticals, can lead to cleaner, more sustainable healthcare.

CARBON IMPACT OF HEALTHCARE

The industrialised world produces an enormous amount of carbon dioxide (CO2). CO2 is a greenhouse gas emission that accelerates climate change. Climate change contributes to climate-change related health hazards[1] and perpetuates environmental racism.[2] In the former, severe weather, altered vector patterns, and diminished air quality compromise the health of all humans.[3] In the latter, the poor suffer a disproportionate burden of disease and may lack available healthcare resources for adequate treatment. Climate change is a globally recognised ethical issue which requires effective steps to minimise carbon emissions in all areas of human life, from transportation, to food, to healthcare.

The US healthcare industry emits an estimated 479 million tonnes (MT) of CO_2 each year; nearly 8% of the country's total emissions. By way of comparison, Germany's healthcare carbon is 55.1 MT and Japan's healthcare carbon is 114 MT.[4] Healthcare carbon has been parsed by sector as well as country. For instance, hospital care and physician/clinical service sectors contribute the most CO_2 within the US medical industry, with structures/equipment and pharmaceuticals at third and fourth, respectively.[5] Ethical attention to healthcare carbon has traditionally focused on medical structures and equipment that contribute to carbon emissions[6] Recently, the internal and less visible aspects of healthcare carbon, such as hospital care[7] and physician/clinical services[8–10] have been examined.

Healthcare is an essential, good, and necessary part of human life. But, like any other carbon-emitting sector, healthcare has an ethical obligation to reduce carbon emissions and mitigate climate change. Additionally, healthcare—as an industry with a mission of well-being and healing at its core—has an unique imperative to reduce CO_2 and minimise impacts on human health, since current healthcare delivery practices are paradoxically creating climate change health hazards.

Having established the ethical rationale for reduction of carbon emissions in healthcare, this article will focus on the emissions of pharmaceuticals, since the carbon of pharmaceuticals are relatively understudied despite the fact that globally, the pharmaceutical industry's carbon emissions are more than 50% higher than the automotive sector.[11]

Pharmaceuticals are resource intensive during both upstream and downstream processes. 'With its high energy costs of manufacturing and researching drugs, combined with high transportation costs for drug distribution'[12] upstream pharmaceutical carbon emissions are significant. Downstream carbon emissions come from prescribing practices. This article will focus on downstream carbon emissions of pharmaceuticals, as it is closer to the interests and scope of biomedical ethics, rather than the upstream carbon emissions of pharmaceuticals, which overlap with research and engineering ethics, as well as biomedical ethics.

The basic causal argument of this paper is: (1) pharmaceuticals have a carbon footprint, therefore (2). reducing the use of pharmaceuticals will reduce the carbon footprint of pharmaceuticals. Instead of presenting examples of specific drugs that have the highest carbon footprint and suggesting that those drugs be reduced, I will highlight factors that contribute to pharmaceutical carbon emissions. Factors that contribute to pharmaceutical carbon emissions include overprescription, pharmaceutical waste, antibiotic resistance, routine prescriptions, non-adherence, drug dependency, lifestyle prescriptions, and drugs given due to a lack of preventive healthcare. The conclusion recognises that many pharmaceuticals contribute to human health and ought to be used whenever clinically indicated, while also identifying barriers and opportunities for reducing their carbon impact.

The article does not claim to present the most numerically impactful path to reduction of pharmaceuticals, in terms of carbon emissions, for several reasons. First, although carbon calculation are increasingly available on national healthcare footprints and by healthcare sector, there is not data on the carbon of each and every individual pharmaceutical. Even if there were data on the total carbon

To cite: Richie C. *J Med Ethics* 2022;**48**:334–337.

footprint of each drug, it would need to be multiplied by number of prescriptions, days of use, dosage amount, and contextualised to each country's carbon infrastructure. This would be an enormous undertaking and would be a moving target, as carbon emissions are impacted by different actors in a supply chain, for instance, chemical compounding, production machines, industrial buildings, shipping facilities, storage units, distribution centres and by-product waste management. Nonetheless, using numerical carbon data, as it becomes more available, will be among many tools for effective carbon reduction.

Second, identifying specific pharmaceuticals with the highest carbon impact may lead to the conclusion that those particular drugs should be minimised or eliminated from use, but in some cases the medical benefit—particularly when there are no satisfying alternatives—would justify the carbon expenditure. It would be a violation of human rights, many would argue, to refuse to produce a lifesaving drug based on the carbon content. That being said, healthcare should be sustainable enough so the carbon from drugs for individuals does not conflict with public health threats from climate change. While a zero-carbon medical industry might be ideal, this article assumes some pharmaceutical emissions will persist in the immediate future and seeks areas for reduction of pharmaceutical carbon emissions instead of elimination of all pharmaceuticals.

Moreover, by focusing on factors that contribute to pharmaceutical carbon emissions, I am able to align my efforts with other work in, for instance, clinical ethics and public health ethics. Overprescription,[13] routine prescriptions,[14] non-adherence,[15] drug dependency,[16] and lifestyle prescriptions[17] have been discussed within the clinical context of harm to patient (non-maleficence). Pharmaceutical waste,[18] antibiotic resistance,[19] and drugs given due to a lack of preventive healthcare[20] are topics in public health. While environmental impact alone may not be a compelling reason for the healthcare industry to examine pharmaceutical use, this article reinforces widely accepted reasons for doing so, thus strengthening normative claims to pharmaceutical reduction.

By identifying broad factors that contribute to pharmaceutical emissions, rather than specific drugs, the potential for both systemic and local change is possible. It may be easier to alter approaches to prescribing practices in healthcare facilities among doctors than to reengineer the carbon life-cycle of a drug. To be sure, effective carbon reduction will depend on 'greening' every step in the excavation, processing, manufacturing, and distribution process. In the meantime, action taken within the therapeutic relationship may have immediate impact.

FACTORS ASSOCIATED WITH THE CARBON IMPACT OF PHARMACEUTICALS

Over the last two decades, the environmental impact of prescription drugs has been flagged as a significant public health and ecological concern. In 2001, Jameton and Pierce recognised that the carbon emissions from 'pharmaceutical products with complex manufacturing processes, (have) environmentally significant precursors…as well as complex and hazardous solid, air and water emissions, including toxic, infectious and radioactive wastes.'[21] The term 'biohazard' initially defined environmental harm done by healthcare. These considerations are still relevant ethical factors in the life-cycle of pharmaceutical development, manufacturing, prescription, and disposal. But as environmental bioethics has evolved with both environmental science and environmental ethics, the language of 'carbon emissions' has become an additional way of quantifying harm to human health and the ecosystem which sustains us.

In 2007, the UK's National Health Services (NHS) reported that pharmaceuticals accounted for nearly a quarter of the 18 MT of CO2 emitted each year by the NHS, or 4 MT of carbon per year.[22] Ten years later, in 2017, the amount of carbon from pharmaceuticals dropped to 3.29 MT, but pharmaceuticals were still the second most carbon contributing component of the NHS, Public Health, and Social Care sectors.[23]

A disproportionally carbon-intensive pharmaceutical sector is reflected in other healthcare systems as well. In 2009, *JAMA* indicated that the US healthcare sector 'including upstream supply-chain activities, contributed an estimated total of 546 MT of CO2 equivalent (MMTCO2Eq), of which 254 MMTCO2Eq (46%) was attributable to direct activities. The largest contributors were the hospital and prescription drug sectors (39% and 14%, respectively).'[24]

Calls from individuals to reduce the carbon of pharmaceuticals began to appear in the early 2010s.[25] Later, the organisational NHS Report from 2018, 'Reducing the Use of Natural Resources in Health and Social Care,' indicated that the carbon impact of pharmaceuticals will need to be addressed as carbon reduction in healthcare moves forward.[26] Here, I assess overprescription, pharmaceutical waste, antibiotic resistance, routine prescriptions, non-adherence, drug dependency, lifestyle prescriptions, and drugs given due to a lack of preventive healthcare.

Overprescription

The National Center for Health Statistics of the Centers for Disease Control and Prevention report that from 2013 to 2016, 45.8% of Americans took a prescription drug in the preceding 30 days.[27] The US, and other countries, exist in a 'drug culture' where both prescription drug use and polypharmacy are increasing annually.[28–30] Drugs are sometimes seen as an easy way to treat a condition. The 2016 National Ambulatory Medical Care Survey found that almost three out of four visits to the doctor's office resulted in a prescription.[31] When drugs are overprescribed, carbon emissions are expended unnecessarily. When drugs are prescribed as needed, carbon emissions are contained.

Pharmaceutical waste

Pharmaceutical waste, in terms of manufacturing byproducts, has already been recognised as an environmental problem. This is an upstream carbon activity. In addition to this, unused pharmaceutical contribute to the carbon of downstream use. In 2019, one of the few studies offering quantitative data on the carbon emissions of a specific set of pharmaceuticals was published. The authors estimated a 'potential additional 23 000 to 105 000 MT of CO2' per year from unused quantities of eyedrops, ocular injection, and systemic medication pharmaceuticals after cataract surgery.[32] All drugs have a carbon footprint regardless of it they are used or not. Careful management and distribution of pharmaceuticals can minimise unnecessary carbon impact.

Antibiotic resistance

Improperly stopping antibiotic treatment and improper disposal of antibiotics contribute to antibiotic-resistant diseases. For many years, antibiotic resistance has been a medical concern, leading to guidelines for drug stewardship and programmes such as Choose Wisely, which support antimicrobial/ antibiotic drug reduction.[33] Drug resistance imperils current attempts to use drugs effectively, which may lead to the production of stronger drugs or new drug compounds to counteract resistant strains of a virus. Pharmaceuticals which are no longer effective are total carbon wastes; if carbon must be expended in the production of drugs, it has to have a dependable clinical effect to be justified.

Routine prescriptions

Routine prescriptions may be given without detailed attention to patient needs or alternative treatments. This may be done for efficiency and is often based on generalisable needs of a particular group of people, for instance the elderly. One representative article from 2002 found that 'individual nursing home residents receive an average of 6.7 routine prescription medications per day' and 'routine medication orders in nursing homes increased by 14% from 1997 to 2000.'[34] While there may be little perceived harm in routinisation of, for instance, laxatives or dietary supplements, the carbon cost of drugs may be unnecessary because the drugs are only minimally beneficial, or in some instances, even harmful due to side effects.[35] Cutting back on routine prescriptions in favour of an individualised approach to medicine is a standard of care that benefits patient and planet. The initial time investment in taking a patient's medical history—including patient preferences, goals of care, and attitudes toward use of routine drugs—does not need to be performed by a physician, who might have extensive demands on her time. Indeed, a reduction in use of pharmaceuticals is contingent on the entire chain of care and all affiliated healthcare workers are needed to support more sustainable healthcare.

Non-adherence

Adherence rates to prescription drugs vary by type of drug, illness it is prescribed for, and age group. WHO estimates nonadherence of any medication from 15% to 93%, with an average estimated rate of 50% for long-term therapies for chronic illnesses.[36] Non-adherence, which is closely related to noncompliance, 'is a complex conundrum characterised by (1) never starting the medication, (2) stopping the medication regimen early without direction or (3) regularly not taking the medication as directed.'[37] In the first two instances, pills are manufactured and distributed, but not all are used, therefore carbon has been expended without a clinical benefit. In the third situation, irregular pharmaceutical use can lead to missed or disposed pills, or reduced efficacy of pills due to expiration, which then require additional prescriptions. Non-adherence is a major source of economic loss, missed opportunities for patient health, and carbon emissions. Adherence rates can be bolstered by a more robust consent process,[38] leading to successful consumption of necessary medicine with purposeful carbon emissions.

Drug dependence

Prescription drug abuse or misuse—in addition to drug addiction or drug dependency—is a serious health concern. Opioid pain relievers are highly addictive in nature, yet they have been the standard of care for acute and chronic pain. Due to the frequency and legality of opioid prescriptions, the United States is now plagued with an opioid epidemic characterised by social, economic, and personal ramifications.[39] Clinicians are faced with the dilemma to treat in the most conventional and medically effective way possible, risking possible drug addiction and abuse, or prescribe a non-traditional substance that is non-addictive, but has lower rates of adherence and efficacy.[40] Whereas many addictive drugs are criminalised by law, in the case of prescription opioids, there are no such legal structures. Since law often circumscribes personal actions while informing morality, in the absence of legal supports, patients who are offered opioids and become drug-dependent may be without support for their addiction, while also failing to find satisfying alternatives to treat their pain. Without minimising the bioethical necessity of reducing opioid use, the carbon impact may also be considered.

The opioid epidemic has highlighted the necessity of finding alternative approaches to pain management, and indeed, drug dependence that are non-addictive and environmentally sustainable. Some effective strategies addressing both the opioid crisis and opioid prescribing practices include non-pharmacological treatments (NPT) like complementary medicine.[41] Detailed carbon analysis of NPTs have yet to be undertake, yet is seems self-evident that meditation, yoga, and Tai Chi would be less environmentally impactful than industrialised medical interventions, since NPTs do not rely on resource-intensive infrastructures. Additional ethical and responsible responses to drug dependency can minimise pharmaceutical carbon, but care must be taken not to replace high-carbon treatments with those that that are similar resources intensive.

Lifestyle prescriptions

Nortin Hadler defines 'type II medical malpractice' as 'doing something to patients very well that was not needed in the first place.'[42] Prescriptions for conditions which may be treated without pharmaceutical use, such exercise instead of psychostimulants for attention deficit hyperactivity disorder (ADHD)[43] may be considered a lifestyle prescription, as well as pills for lactose intolerance, penile erections, and many other personal conditions that are managed through pharmaceutical means. Safe amounts of carbon in the atmosphere have been exceeded, in part, because of medical lifestyles in the industrialised world. Providing drugs as a last resort for lifestyle complaints may lead to carbon reduction.

Lack of preventive healthcare

Many chronic health conditions that depend on medical management can be prevented or postponed. A 2014 report in the *Lancet* indicates that 'the chronic disease burden in the USA largely results from a short list of risk factors—including tobacco use, poor diet and physical inactivity…excessive alcohol consumption, uncontrolled high blood pressure, and hyperlipidaemia.'[44] Pharmaceuticals may be clinically indicated to manage certain medical conditions, however, preventing chronic conditions—even when assisted through diagnostic means like cancer screenings—is not only better for individual flourishing, it will also result in net carbon savings from avoiding the production of pharmaceuticals for preventable diseases.

CONCLUSION

There are significant barriers to reducing the carbon of the pharmaceutical industry. The medical industry—which includes patients, physicians, administrators, healthcare insurance companies, governments that oversee healthcare resources, and developers, suppliers, and distributors of healthcare supplies and treatments—have generally been resistance to integrate systematic carbon reduction into healthcare delivery,[45] including prescribing practices. The pharmaceutical industry is tied to global economic activity[46] and may not be willing to change lucrative production models unless they can be persuaded that sustainability itself is profitable.[47] Moreover, drug companies have a stronghold on the medical industry because they are viewed—oftentimes accurately—as supporting standards of care.[48] Public health policy-makers face resistance to regulations that may prevent health conditions like obesity, thereby limiting attempts to minimise pharmacological intervention. Healthcare insurance policies, or the governments that provide healthcare, face pressure to fund high carbon drugs when effective lower carbon alternatives exist.[49] These obstacles cannot stymie measures to reduce the carbon impact of pharmaceuticals.

In addition to reducing the number of prescriptions for drugs by addressing the factors in this paper, life-cycle assessments of pharmaceuticals may indicate areas that can be made more sustainable. Carbon calculation on anaesthetic drugs,[50] medical devices,[51] and surgical procedures[52] point towards areas where supply chains can be more environmentally efficient. 'Greening' the life-cycle of pharmaceuticals requires the support of chemists, medical engineers, medical manufacturers, product designers, and other supportive stakeholders. Carbon reduction of pharmaceuticals can lead to cleaner, more sustainable healthcare. Those working in the medical industry ought to take the lead, as a matter of urgent concern for patient and global health.

Contributors CR is the sole author.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article.

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