

PERSPECTIVE

CLIMATE CHANGE AND HEALTH

Reducing Inhaler-Related Greenhouse Gas Emissions

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Climate change has been recognized as one of the greatest threats to global health in the 21st century.¹ The World Health Organization projects that climate change-related deaths could reach 250 000 annually between 2030 and 2050.² In the US, the health care sector is responsible for 554 million metric tons of carbon dioxide equivalent (CO₂e) emissions annually—approximately 8% of national emissions and a quarter of health care's global greenhouse gas footprint.^{3,4} A significant portion of these emissions comes from pharmaceuticals and medical devices, with metered-dose inhalers playing a consequential role.

In 2022, inhalers prescribed for Centers for Medicare & Medicaid Services Part D beneficiaries generated an estimated 1.15 million metric tons of CO₂e emissions⁵—equivalent to the annual electricity use of approximately 300 000 homes.⁶ Since their introduction in 1956, metered-dose inhalers remain the most commonly prescribed inhalers in the US, accounting for more than 70% of all inhaler prescriptions.⁵ Within the metered-dose inhaler category, short-acting β-agonists are the most frequently prescribed, accounting for 35.3 million Medicare Part D and Medicaid inhaler claims in 2022.⁵ Metered-dose inhalers use hydrofluorocarbon (HFC) propellants, primarily HFC-134a and HFC-227ea, which are greenhouse gases that have high 100-year global warming potentials of 1530 and 3600, respectively.⁷ The global warming potential is a measure of the amount of heat that the propellant traps in the atmosphere over 100 years relative to the reference greenhouse gas, carbon dioxide, which has a global warming potential of 1.

Because they contain no propellants, dry-powder and soft-mist inhalers have very low greenhouse gas footprints, approximately 1 kg CO₂e emissions per inhaler. In contrast, metered-dose inhalers have high greenhouse gas footprints of up to 48.1 kg CO₂e emissions per inhaler secondary to their high global warming potential propellants.⁵ Transitioning from metered-dose inhalers to dry-powder and soft-mist inhalers mitigates inhaler-related greenhouse gas emissions.⁸ Despite their clear environmental benefits,⁹ dry-powder and soft-mist inhalers are far less used compared with metered-dose inhalers in the US—making up only 30% of inhalers prescribed for Medicare Part D and Medicaid beneficiaries in 2022.⁵ As the effects of climate change become more pronounced on respiratory health, health systems can take steps to mitigate inhaler-related greenhouse gas emissions expeditiously.

Optimizing Inhaler Prescribing Practices

Adherence to guideline-based prescribing practices can substantially reduce unnecessary inhaler use and its associated greenhouse gas emissions. Chronic obstructive pulmonary disease (COPD), one of the primary conditions for which inhalers are prescribed, requires spirometry to confirm diagnosis. Current guidelines for both

asthma and COPD recommend pulmonary function testing to determine whether airflow obstruction is present.^{10,11} The safety and accessibility of short-acting β-agonists may encourage clinicians to prescribe them for acute upper respiratory tract infections. While some data suggest an increased incidence of asthma after SARS-CoV-2 infection,¹² an upper respiratory tract infection alone is not an indication for long-term bronchodilator therapy.

To reduce environmental and health care costs, clinicians should perform regular reassessments of inhaler usage during follow-up visits to determine whether inhaler prescriptions have appropriate indications. Transitioning from metered-dose inhalers to dry-powder and soft-mist inhalers is the most obvious way to reduce inhaler-related emissions. However, maintaining asthma control is also an effective way to reduce emissions by decreasing transportation-related emissions associated with unscheduled clinic or hospital visits and preventing short-acting β agonist overuse.

Among short-acting β-agonists with equivalent number of inhalations per canister, Ventolin HFA (GSK; albuterol sulfate) and its generic have the highest emissions at 28.7 kg CO₂e emissions per inhaler, and Proventil HFA (Merck; albuterol sulfate) and its generic have the lowest at 9.9 kg CO₂e emissions per inhaler.⁵ When generic albuterol is ordered, many electronic health records default to metered-dose inhalers with higher emissions such as generic Ventolin HFA. To ensure that a lower-emissions albuterol sulfate metered-dose inhaler is prescribed, clinicians should specify the weight of the inhaler. For a 200-inhalation canister, the lower-emissions inhaler Proventil HFA and its generic both weigh 6.7 g, while the higher-emissions inhaler Ventolin HFA and its generic weigh 18 g. However, even if the clinician specifies the weight of the inhaler, insurance drug formularies and local availability may dictate which inhaler is ultimately dispensed to the patient. Other lower-emissions metered-dose inhaler options, such as beclomethasone dipropionate, which has 16.6 kg CO₂e emissions per inhaler, or ciclesonide, which has 10.8 kg CO₂e emissions per inhaler,⁵ are currently available for asthma maintenance therapy and can be used when dry-powder or soft-mist inhalers are not an option.

Barriers to Environmentally Sustainable Inhaler Use

Multiple barriers hinder the widespread adoption of dry-powder and soft-mist inhalers, including cost, insurance coverage, clinician awareness, and availability of formulations. In 2022, dry-powder and soft-mist inhalers accounted for 30% of Medicare Part D and Medicaid inhaler claims yet made up nearly two-thirds of total inhaler spending, exceeding \$12 billion.⁵ Currently, ProAir Respiclick (Teva; albuterol sulfate) is the only dry-powder inhaler option for short-acting β-agonists available in the US. Limited options and lack of formulary coverage for short-acting β agonist dry-powder

inhalers contribute to continued use of short-acting β agonist metered-dose inhalers, which can emit up to 144 g of CO₂e emissions per inhalation—the equivalent of driving 0.6 km in an average gasoline-powered passenger vehicle.^{5,6} Even in countries where dry-powder inhalers are widely adopted, short-acting β -agonist metered-dose inhalers are overused, potentially reflecting broader issues with maintaining asthma control.¹³

Additionally, the Global Initiative for Asthma (GINA) recommends a combination of formoterol (a long-acting β -agonist) and inhaled corticosteroid as first-line therapy for asthma.¹⁰ However, these combinations are unavailable in dry-powder inhaler form in the US. As a result, in the US, adherence to GINA recommendations necessitates continued use of formoterol-inhaled corticosteroid metered-dose inhalers, such as budesonide-formoterol and mometasone-formoterol, which have high greenhouse gas footprints of 38.2 kg CO₂e emissions per inhaler and 48.1 kg CO₂e emissions per inhaler, respectively.⁵

The development of low global warming-potential propellants, such as HFC-152a and hydrofluoroolefin-1234ze (HFO-1234ze), may decrease metered-dose inhaler greenhouse gas emissions to a level comparable with that of dry-powder inhalers,¹⁴ resulting in a beneficial environmental effect. Despite their potential as replacements for current HFC propellant-containing inhalers, access to inhalers with low global warming potential propellants may be limited secondary to higher anticipated costs and extended device patents that may restrict generic competition.

The Role of Clinicians and Other Stakeholders in Environmentally Sustainable Inhaler Prescribing Practices

Although similar clinical outcomes have been demonstrated across different inhaler devices,¹⁵ clinicians must weigh multiple factors when selecting inhaler therapy, including insurance coverage, out-of-pocket costs, comorbidities, allergies, and age. Dry-powder inhalers should be avoided in patients with severe cow's milk allergy and are unsuitable for young children who often are unable to generate sufficient inspiratory flow rates and maintain a breath hold.⁸ Although metered-dose inhalers with spacers were also previously thought to be preferred for patients with advanced COPD and severe airflow limitations, recent studies suggested that dry-powder inhalers can be just as efficacious in this population.^{16,17}

Given these considerations, transitioning patients from metered-dose inhalers to lower-emissions alternatives presents both an opportunity and a challenge. While such transitions require shared decision-making and close monitoring to maintain disease control, they also offer a key avenue for medical and environmental optimization, particularly for patients with uncontrolled asthma or COPD who rely on short-acting β -agonist metered-dose inhalers.

The SENTINEL project in the United Kingdom exemplifies this approach, successfully transitioning short-acting β -agonist-dependent patients to GINA-preferred maintenance and reliever therapy, formoterol-inhaled corticosteroid metered-dose inhalers such as budesonide-formoterol and mometasone-formoterol, resulting in fewer exacerbations, fewer short-acting β agonist prescriptions, and lower greenhouse gas emissions.^{18,19} Similarly, the US Department of Veterans Affairs implemented a formulary transition from budesonide-formoterol metered-dose inhalers to fluticasone-salmeterol dry-powder inhalers, demonstrating that

large-scale institutional changes have the potential for achieving environmentally sustainable results.²⁰

Currently, the environmental impact of inhalers is likely underappreciated by many clinicians in the US. By integrating carbon accounting and climate-conscious prescribing practices into medical education curricula, medical conferences, and clinical decision support tools, clinicians can better understand the environmental effects of inhaler device choices, many of which offer comparable clinical efficacy. This approach can foster a culture of environmental sustainability within health care and allow clinicians to knowledgeably discuss lower-emissions inhaler options with patients, turning awareness into tangible action.

Health care institutions seeking to lower inhaler-related emissions can take steps to implement inhaler decarbonization programs. Electronic health records can incorporate clinical decision support tools, such as noninterruptive alerts or labels regarding greenhouse gas emissions associated with inhaler device choices, to support both environmentally friendly and cost-effective inhaler prescribing practices. Assessment of inpatient and outpatient inhaler prescriptions is another way to facilitate carbon accounting and understand physician prescribing habits. Health care institutions can calculate inpatient and outpatient inhaler emissions based on prescribing data and published individual inhaler emissions. Educational campaigns about greenhouse gas emissions associated with inhaler device choices can be implemented by health care institutions to encourage clinicians to follow GINA recommendations, provide evidence-based short-acting β -agonist prescribing, and consider lower-emissions inhalers for patients who are unable to take GINA-preferred maintenance and reliever therapy (formoterol-inhaled corticosteroid). Quality improvement initiatives can help to monitor inhaler accessibility, insurance coverage, out-of-pocket costs, clinical outcomes, and adherence to new inhaler prescriptions. Inhaler-related emissions can be monitored yearly and included as part of health care institutional carbon accounting.

Stakeholders such as insurers, drug manufacturers, and the US Food and Drug Administration (FDA) can take a more active role in reducing greenhouse gas emissions. Specifically, insurers can take steps to make existing lower-emissions inhalers widely available on their drug formularies. Drug manufacturers can take action by applying for FDA approval of budesonide-formoterol dry-powder inhalers, which are currently available in brand and generic formulations in Europe. Given the pressing need to reduce greenhouse gas emissions, the FDA can consider a fast-track approach to approving budesonide-formoterol dry-powder inhalers and inhalers containing low global warming potential propellants.

Future research should focus on assessing how environmental considerations influence inhaler prescribing patterns and conducting large-scale, direct comparisons of different inhaler devices. Such studies would provide more robust evidence to reassure clinicians and patients—particularly those accustomed to metered-dose inhalers—about the safety and efficacy of dry-powder and soft-mist inhaler options. Encouragingly, emerging evidence suggests that environmentally sustainable inhalers may not only be equivalent to but, in some cases, superior to metered-dose inhalers. For example, a recent study showed that maintenance triple combination therapy (inhaled corticosteroid, long-acting β -agonist, and long-acting muscarinic antagonist) for patients with COPD delivered via a once-daily dry-powder inhaler was associated with

a lower incidence of COPD exacerbations compared with triple combination inhaler administered twice daily with a metered-dose inhaler.¹⁵ While metered-dose inhalers with low global warming potential propellants are anticipated to be available in the US in several years, these inhalers may not immediately be widely accessible or covered under insurance plans. Until current propellants are phased out and replaced by low global warming potential propellants, clinicians will likely need to take additional steps to provide access to metered-dose inhalers with low global warming potential propellants, such as completing prior authorization forms or making patients aware of co-pay-reducing coupons provided by pharmaceutical companies to lower out-of-pocket costs.

As the health care sector grapples with the challenges of climate change, inhaler-related emissions present an opportunity for meaningful intervention. By prioritizing evidence-based prescribing, increasing access to lower-emissions inhalers, and fostering clinician and patient awareness, the medical community can take concrete steps toward reducing inhaler-related greenhouse gas emissions. Additionally, policymakers and industry stakeholders should work collaboratively to overcome cost and access barriers so that environmentally sustainable inhaler options are both available and practical for patients. In the end, addressing the environmental impact of inhalers is also a step forward in delivering high-quality care.²¹

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