SPECIAL COMMUNICATION

Thinking "Green" When Treating "Pink Puffers" and "Blue Bloaters"—Reducing Carbon Footprint When Prescribing Inhalers

Harland T. Holman, MD, Michael J. Bouthillier, PharmD, and Frank Müller, MD, PhD

The impact of man-made climate change is already affecting millions of people worldwide. The health care sector in the US is a relevant contributor, accounting for about 8 to 10% of national greenhouse gas emissions. This special communication describes the harmful impact of propellant gases in metered dose inhalers (MDI) on the climate and summarizes and discusses current knowledge and recommendations from European countries. Dry powder inhalers (DPI) are a good alternative to MDIs and are available for all inhaler drug classes recommended in current asthma and COPD guidelines. Changing an MDI to PDI can significantly reduce carbon footprints. The majority of the US population is willing to do more to protect the climate. Primary care providers can engage in this by addressing the impacts of drug therapy on climate change in medical decision making. (J Am Board Fam Med 2023;00:000–000.)

Keywords: **Asthma, Carbon Dioxide, Carbon Footprint, Climate Change, COPD, Drug Prescriptions, Dry Powder Inhalers, Environmental Medicine, Family Medicine, Global Warming, Greenhouse Gases, Metered Dose Inhalers, Norflurane**

Climate change is a serious threat to the foundations of human life, and mitigation of climate change can be considered the main challenge to mankind in the 21st century. Human-induced climate change is already having a major adverse impact on the health of millions of people worldwide[1]. Effective steps to minimize carbon emissions in all areas of human life, especially in the industrialized world, are required to reduce global warming. Ironically, the health care sector is responsible for a significant proportion of greenhouse gas emissions. In the US, an estimated 8 to 10% of national greenhouse gases are emitted by the health care sector[2,3] with production chains for pharmaceuticals being a significant portion. Worldwide, the pharmaceutical industry emits significantly more climate-damaging gases than the automotive industry[4]. *Upstream carbon emissions* comprise emissions due to drug research, production processes, and transport. *Downstream carbon emissions* occur at the provider and their patient level and can be reduced by changes in prescription habits such as avoiding unnecessary prescriptions and drug product selection. Preventing illnesses that require drug treatment as well as reducing nonadherence can also reduce downstream carbon emissions[5]. A further step can be taken by providers and patients replacing particularly harmful prescriptions with less harmful ones. Pharmaceutical companies have been reluctant to apply measures to reduce their carbon footprints in the past,[6] and governments and health insurance companies do not regulate or incentivize the carbon emission reduction of pharmaceutical companies. Health care providers can lead the way with changing prescription patterns that might add economic pressure to foster change. A good case in point here can be asthma and COPD medications.

Propellant gases in metered dose inhalers (MDI) in particular have been a major source of

This article was externally peer reviewed.
Submitted 29 August 2022; revised 3 November 2022; accepted 8 November 2022.
This is the Ahead of Print version of the article.
From the Department of Family Medicine, Michigan State University, Grand Rapids, MI, USA (HTH, MJB, FM); Spectrum Health Family Medicine Residency Center, Grand Rapids, MI, USA (HTH, MJB, FM); College of Pharmacy, Ferris State University, Big Rapids, MI, USA (MJB); Department of General Practice, University Medical Center Göttingen, Göttingen, Germany (FM).
Funding: FM is Peter C. and Pat Cook Endowed Clinical Research Fellow 2022/2023.
Conflict of interest: None.
Corresponding author: Harland T. Holman, MD, Department of Family Medicine, Michigan State University, 15 Michigan St NE, Grand Rapids, MI 49503 (E-mail: holmanha@msu.edu).

climate-damaging gases in outpatient care. The USA and Puerto Rico have the highest proportion of inhaler doses delivered by MDIs in the western world at 88.5% and 90.4%, respectively[7]. When first introduced, chlorofluorocarbons were used as propellant gases, but their use was banned under the Montreal Protocol 1989 due to their harmful effect on the ozone layer[8]. However, the now frequently used hydrofluorocarbon-based propellants norflurane and aplaflurane have a devastating impact on the climate[7,9]. These propellant gases disintegrate very slowly, and thus allow solar radiation in the upper atmosphere to penetrate to the earth's surface but trapping reflected emissions and reradiating heat energy back toward the earth.[10]

A German guideline on climate-friendly prescription of asthma medication recently released by the German College of General Practitioners and Family Physicians estimated that replacing MDI with dry powder inhalers reduces the CO_2 footprint of a typical patient by 455 kg CO_2 for each patient/year. This reduction is more than changing to a vegetarian diet (-440 kg CO_2) or taking a 1250 mile airline flight (-210 kg CO_2).[11]

Beta$_2$-agonists and inhaled corticosteroids, the key components of asthma drug treatment

Table 1. Dry Powder, Soft Mist, and Nebulization Solutions Available in the US

Generic Drug Name	Brand Names*
Short-Acting Beta$_2$-Agonists (SABA)	
Levalbuterol	Xopenex and generic (Neb)
Albuterol (Salbutamol)	ProAir Digihaler, ProAir RespiClick, and generic (Neb)
Long-Acting Beta$_2$-Agonists (LABA)	
Formoterol	Perforomist and generic (Neb)
Arformoterol	Brovana and generic (Neb)
Salmeterol	Serevent Diskus
Olodaterol	Striverdi Respimat
Corticosteroids	
Budesonide	Pulmicort Flexhaler, generic (Neb)
Fluticasone furoate	Arnuity Ellipta
Fluticasone propionate	Flovent Diskus, ArmonAir Digihaler, RespiClick
Mometasone	Asmanex Twisthaler
Combination of Long-Acting Beta$_2$-Agonists + Corticosteroid (LABA/ICS)	
Salmeterol/fluticasone propionate	Advair Diskus, Airduo Digihaler, Wixela Inhub
VilanterolI/fluticasone furoate	Breo Ellipta and generic
Short-acting Anticholinergics (SAMA)	
lpratropium bromide	Atrovent and generic (Neb)
Long-acting Anticholinergics (LAMA)	
Aclidinium bromide	Tudorza Pressair
Glycopyrronium bromide	Lonhala Magnai (Neb)
Revefenacin	Yupelri (Neb)
Tiotropium	Spiriva HandiHaler, Spiriva Respimat (SMI)
Umeclidinium	Incruse Ellipta
Combination Short-Acting Beta$_2$-Agonists + Short-acting Anticholinergics (SABA/SAMA)	
Albuterol/ipratropium	Combivent Respimat (SMI), Duoneb and generic (Neb)
Combination Long-Acting Beta$_2$-Agonists + Long-acting Anticholinergics (LABA/LAMA)	
Formoterol/aclidinium	Duaklir Pressair
Vilanterol/umeclidinium	Anoro Ellipta
Olodaterol/tiotropium	Stiolto Respimat (SMI)
Triple Combination (LABA/LAMA/ICS)	
Fluticasone/umeclidinium/ vilanterol	Trelegy Ellipta

*Products are Dry Powder Inhalation formulations unless otherwise specified.
Abbreviations: SMI, soft mist inhaler, Neb, Nebulization solution.

guidelines[12] are available as dry powder inhalers (DPI). For treatment of chronic obstructive pulmonary disease (COPD),[13] long-acting anticholinergics and combination products are available as DPIs or soft mist inhalers (SMI). In addition, some drugs may also be administered using nebulizers (Table 1).

Despite the different application techniques, the efficacy between MDI and DPI medications is considered equivalent in current asthma and COPD guidelines. Some research suggest that drug adherence is higher among asthma patients using DPI than those using MDI.[14] Although the nebulization of the inhalation powder requires a flow of breath against a resistance, we could not find any evidence in the existing literature that this is associated with a feeling of unease in patients. Regardless of which inhaler type is preferred, providers should be aware that errors in inhaler technique are very common[15] and associated with reduced symptom control and increased risk of exacerbations[16]. This should encourage providers to regularly check in with patients to demonstrate the correct use of the prescribed inhaler. As inadequate skill in the use of asthma inhalation devices is also frequent among health care professionals[17], external education resources, for example, YouTube videos showing the correct use, can be considered. DPI should not be used in children under 4 years of age with asthma, as their respiratory volume is not sufficient to inhale the powder. In such cases, MDIs with spacers are still recommended[18]. For patients with impaired peak inspiration flow rates <60L/min that can be found in elderly patients or patients with severe or exacerbated COPD, MDIs, mist inhaler or nebulized therapy should be considered.[19]

Although there is a strong case for prescribing DPIs rather than MDIs for climate change reasons, implementation of the recommendation should not be automatic but should take into account patient preference and willingness and ability to use DPIs safely. Organizations such as the Arthritis Foundation provide guidance for medical devices for patients with physical limitations that can be used in optimizing product selection. From a practical point of view, changing an ongoing and efficient inhaler therapy should be well considered, weighing the pros and cons, and always discussed with the patient in the context of shared decision-making. There is scarce research on patient and health care provider openness to medication changes in favor of climate protection. Although generic DPIs are becoming available, potential barriers might exist for patients involving copayments and insurance prior authorization requirements. Importantly, in a recent representative study 65%[20] of Americans agreed with the statement that citizens should do more to address global warming. This opens a window of opportunity for including climate change in medical decision-making and drug therapy changes that patients may welcome.

Teaching Point of Significant Clinical Relevance

Two-thirds of the US population agree that citizens should do more to address global warming. Currently, used propellant gases in MDIs are a major source of climate-damaging gases in outpatient care[7,9]. Changing a patient from an MDI to a DPI can save greenhouse gas emissions per year that are equivalent to burning 50 to 60 gallons of gas each year. For all asthma and COPD guidelines recommended inhaler drug classes, alternatives to MDIs are available. Hospitals, health plans, insurance programs all have formulary decision-making procedures. Individuals can make formal requests to add agents or to make DPIs costs equal to MDI or preferred over MDIs. MDI as a delivery method has, in adult patients with sufficient peak inspiration flow, no proven advantages over DPI. Where appropriate, combination products in favor of individual drug products (eg, in mild intermittent asthma Budesonide/Albuterol combination) rather than rescue and maintenance inhalers can be considered. Optimize control and maintenance therapy and patient education can reduce exacerbations and positively impact the environment.

To see this article online, please go to: http://jabfm.org/content/00/00/000.full.

References

1. Rossati A. Global Warming and Its Health Impact. Int J Occup Environ Med 2017;8:7–20.
2. Eckelman MJ, Sherman J. Environmental Impacts of the U.S. Health Care System and Effects on Public Health. Ahmad S, ed. PLOS ONE 2016;11: e0157014.
3. Pichler PP, Jaccard IS, Weisz U, Weisz H. International comparison of health care carbon footprints. Environ Res Lett 2019;14:064004064004.

4. Belkhir L, Elmeligi A. Carbon footprint of the global pharmaceutical industry and relative impact of its major players. J Clean Prod 2019;214:185–94.
5. Richie C. Environmental sustainability and the carbon emissions of pharmaceuticals. J Med Ethics 2021;medethics-2020-106842. April 14.
6. Richie C. Can United States Healthcare Become Environmentally Sustainable? Towards Green Healthcare Reform. J Law Med Ethics 2020;48:643–52.
7. Pritchard JN. The climate is changing for metered-dose inhalers and action is needed. Drug Des Devel Ther 2020;14:3043–55.
8. About Montreal Protocol. Accessed August 9, 2022. Available from: https://www.unep.org/ozonaction/who-we-are/about-montreal-protocol.
9. Janson C, Henderson R, Löfdahl M, Hedberg M, Sharma R, Wilkinson AJ. Carbon footprint impact of the choice of inhalers for asthma and COPD. Thorax 2020;75:82–4.
10. Stocker T. *Climate Change 2013: The Physical Science Basis: Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University press; 2014.
11. Klimabewusste Verordnung von inhalativen Arzneimitteln: DEGAM S1-Handlungsempfehlung: AWMF-Register-Nr. 053-059Schmiemann G, Dörks M. Deutsche Gesellschaft für Allgemeinmedizin und Familienmedizin e.V., ed. Published online March 2022. Available from: https://www.degam.de/files/Inhalte/Leitlinien-Inhalte/Dokumente/DEGAM-S1-Handlungsempfehlung/053-059_%20Klimabewusste%20Verordnung%20von%20Inhalativa/053-059l_S1%20Klimabewusstes%20VO%20Inhalativa_16-05-2022.pdf.
12. US Department of Health and Human Services, ed. 2020 Focused Updates to the Asthma Management Guidelines: A report from the National Asthma Education and Prevention Program Coordinating Committee Expert Panel Working Group. Published online 2020. Accessed November 8, 2022. Available from: https://www.nhlbi.nih.gov/sites/default/files/publications/AsthmaManagementGuidelinesReport-2-4-21.pdf.
13. Global Initiative for Chronic Obstructive Lung Disease, ed. Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease - 2022 Report. Published online 2022. Accessed November 8, 2022. Available from: https://goldcopd.org/wp-content/uploads/2021/12/GOLD-REPORT-2022-v1.1-22Nov2021_WMV.pdf.
14. Darbà J, Ramírez G, Sicras A, García-Bujalance L, Torvinen S, Sánchez-de la Rosa R. Identification of factors involved in medication compliance: incorrect inhaler technique of asthma treatment leads to poor compliance. Patient Prefer Adherence 2016;10:135–45.
15. Sanchis J, Gich I, Pedersen S, Aerosol Drug Management Improvement Team (ADMIT). Systematic Review of Errors in Inhaler Use. Chest 2016;150:394–406.
16. Kocks JWH, Chrystyn H, van der Palen J, et al. Systematic Review of Association between Critical Errors in Inhalation and Health Outcomes in Asthma and COPD. Npj Prim Care Respir Med 2018;28:43.
17. Self TH, Arnold LB, Czosnowski LM, Swanson JM, Swanson H. Inadequate Skill of Healthcare Professionals in Using Asthma Inhalation Devices. J Asthma 2007;44:593–8.
18. Gillette C, Rockich-Winston N, Kuhn JA, Flesher S, Shepherd M. Inhaler Technique in Children With Asthma: A Systematic Review. Acad Pediatr 2016;16:605–15.
19. Mahler DA. Peak Inspiratory Flow Rate as a Criterion for Dry Powder Inhaler Use in Chronic Obstructive Pulmonary Disease. Ann Am Thorac Soc. Published online May 8, 2017:AnnalsATS.201702-156PS.
20. Marlon JR, Neyens L, Jefferson M, Howe P, Mildenberger M, Leiserowitz A. Yale Climate Opinion Maps 2021. Yale Climate Opinion Maps 2021. Published June 2015. Accessed August 29, 2022. Available from: http://www.nature.com/articles/nclimate2583.