

# Reducing the carbon footprint of inhalers: Pharmacist-led screening of inhaler regimens at an outpatient respirology clinic

As climate change becomes an increasingly pressing concern and more patients become conscious of their carbon footprint, options for reducing the health care–related carbon footprint are a priority for both patients and health care professionals.

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## ABSTRACT

**Background:** Inhaler medications are a cornerstone of treatment for respiratory diseases but are associated with substantial greenhouse gas emissions.

**Methods:** In this quality improvement project, we implemented pharmacist-led screening of inhaler regimens at our outpatient respirology clinic to assess for more environmentally friendly modifications. Patients were first screened by a pharmacist, who flagged them for respirologist review if potential modifications to their regimens were identified. The respirologist then intervened as appropriate.

**Results:** In total, 106 patients were pre-screened by a pharmacist, 88 were flagged

for respirologist review, and 68 had changes made to their inhaler regimen. The average reduction in greenhouse gas emissions per patient screened was 200 gCO<sub>2</sub>e per day. The total reduction in greenhouse gas emissions for all screened patients was 19 208 gCO<sub>2</sub>e per day, the equivalent of driving 79 km per day in a standard gasoline-powered passenger car.

**Conclusions:** This project highlights the substantial reductions in greenhouse gas emissions that can be achieved through pharmacist-led screening of inhaler regimens.

## Background

Climate change is an issue of significant international concern, and the health care sector is a major contributor. In 2021, health care–related air pollution contributed to an estimated 4.6 million disability-adjusted life years.<sup>1</sup> In Canada, health care accounts for 4.6% of the country's total greenhouse gas emissions.<sup>2</sup> Inhaler medications, a mainstay of treatment for common respiratory conditions such as asthma and chronic obstructive pulmonary disease, account for a considerable proportion of these emissions. Metered-dose inhalers commonly use a propellant to deliver a set amount of medication. These propellants contain hydrofluorocarbons, greenhouse gases that are released with each use. For instance, a typical dose (two puffs) of a salbutamol

metered-dose inhaler releases 282 g of carbon dioxide equivalents (CO<sub>2</sub>e),<sup>3</sup> the equivalent of driving 1.16 km in a standard gasoline-powered passenger car.<sup>4</sup> In the UK, metered-dose inhalers are estimated to account for 3.1% of the health care–associated carbon footprint.<sup>5</sup> A review of community inhaler prescriptions in the Fraser Health region from 2016 to 2021 indicated that the annual carbon footprint of inhalers was 8478 tonnes of CO<sub>2</sub>e,<sup>6</sup> the equivalent greenhouse gas emissions of driving 2000 gasoline-powered passenger cars for 1 year or powering 1100 homes for 1 year;<sup>4</sup> metered-dose inhalers accounted for more than 98% of those emissions.<sup>6</sup> During that period, almost twice as many metered-dose inhalers as nonmetered-dose inhalers (dry powder inhalers and soft mist inhalers combined) were dispensed in the Fraser Health region.<sup>6</sup> In contrast, metered-dose inhalers account for less than 20% of inhaler sales in some European countries,<sup>7</sup> which demonstrates that it is possible to reduce the use of metered-dose inhalers.

In this quality improvement project, we conducted pharmacist-led screening of inhaler regimens of outpatients at our respirology clinic to identify more environmentally friendly potential modifications. We subsequently examined the impact of this change on inhaler-associated greenhouse gas emissions.

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Methods

We conducted plan-do-study-act (PDSA) cycles of pharmacist-led screening of inhaler regimens of outpatients at the lung health clinic at the Jim Pattison Outpatient Care and Surgery Centre in Surrey, BC. The mandate of this multidisciplinary clinic is to educate, diagnose, and treat respiratory diseases. The clinic has administrative staff, respiratory therapists, and respirologists. Our study sought to integrate pharmacist expertise into the existing multidisciplinary team. The pharmacist was involved in the clinic 2 days per week (Thursdays and Fridays) over a 4-month period (January to April 2024). Prior to each clinic day, the pharmacist screened every other patient scheduled for a follow-up appointment. Screening consisted of reviewing patients' electronic medical records to identify previous diagnoses and investigations, such as pulmonary function tests, X-rays, and CT scans. Medication dispensing history was also reviewed via PharmaNet. Initially, the pharmacist focused on patients with unconfirmed diagnoses for follow-up assessments, but with ongoing PDSA cycles, they prioritized those with confirmed diagnoses, because it was a more efficient use of limited pharmacist resources. A list of key questions was developed to clarify the patients' respiratory symptoms, obtain vaccination history, assess inhaler affordability, and determine the exact number of weekly doses of as-needed inhalers and daily doses of scheduled inhalers. This information was shared with respiratory therapists to ensure consistent patient assessment. On clinic days, patients were seen first by the respiratory therapist (as availability permitted), then by the pharmacist, who asked them the designated questions, reviewed their pulmonary function tests to confirm their diagnosis, and documented their medication usage. Patients whose inhaler regimens could potentially be switched to more environmentally friendly inhalers were flagged for further review by the respirologist. The pharmacist provided recommendations, such as switching to more environmentally friendly inhalers, reducing usage of

as-needed inhalers, reviewing inhaler technique, optimizing the use of long-acting and inhaled corticosteroids, and providing education on appropriate metered-dose inhaler disposal. These recommendations were then reviewed by the respirologist, who made interventions as appropriate.

Data analysis

We calculated greenhouse gas emissions per inhalation using data from CASCADES Canada<sup>8</sup> to determine the difference between each patient's greenhouse gas emissions prior to and after their appointment. The pharmacist then calculated the total greenhouse gas emissions of each patient's daily inhalations prior to the clinic visit and compared them with those postclinic visit. The Box shows an example of how greenhouse gas emissions were calculated based on reported inhaler use.

Results

In total, 106 patients were prescreened by a pharmacist, of which 96 (91%) attended the clinic. Of the patients who attended the clinic, 88 (92%) were flagged for physician review, and 65 (68%) had changes made to their inhaler regimen by a physician [Figure 1]. Three (3%) patients who were not flagged also had changes made to their inhaler regimen by a physician.

The total reduction in greenhouse gas emissions during the project for all patients who were screened by a pharmacist and attended the clinic was 19 208 gCO<sub>2</sub>e per day [Table]. The average reduction per

BOX. Example calculation of greenhouse gas emissions based on reported inhaler use.

If a patient was using 12 inhalations per week of salbutamol, the calculation would be as follows:

$$12 \text{ inhalations per week divided by 7 days} = 1.71 \text{ inhalations per day}$$

$$1.71 \text{ inhalations per day multiplied by } 141 \text{ gCO}_2\text{e per actuation} = 241.71 \text{ gCO}_2\text{e per day}$$

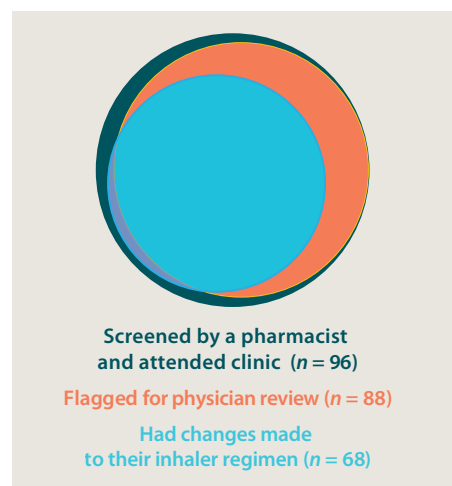
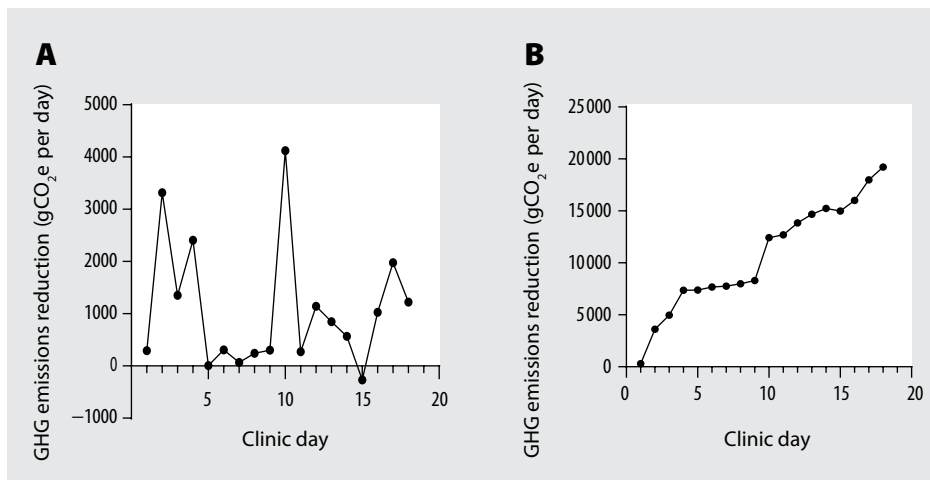


FIGURE 1. Number of patients who were screened by a pharmacist and attended the clinic (n = 96), who were flagged for physician review (n = 88), and who had changes made to their inhaler regimen (n = 68).

patient was 200 gCO<sub>2</sub>e per day for patients who were screened by a pharmacist and attended the clinic and 280 gCO<sub>2</sub>e per day for patients who had changes made to their inhaler regimen [Table]. The

TABLE. Inhaler-related greenhouse gas (GHG) emissions during the project (January to April 2024).

	Preclinic GHG emissions (gCO <sub>2</sub> e per day)	Postclinic GHG emissions (gCO <sub>2</sub> e per day)	GHG emissions reduction (gCO <sub>2</sub> e per day)
<b>Patients who were screened by a pharmacist and attended the clinic (n = 96)</b>			
Total GHG emissions	37 796	18 588	19 208
Average GHG emissions per patient (SD)	394 (540)	194 (320)	200 (432)
<b>Patients who had changes made to their inhaler regimen (n = 68)</b>			
Total GHG emissions	30 646	11 579	19 067
Average GHG emissions per patient (SD)	450 (583)	170 (283)	280 (492)



**FIGURE 2. (A)** Reduction in greenhouse gas (GHG) emissions for all patients who were screened by a pharmacist and attended the clinic, per clinic day; **(B)** cumulative reduction in GHG emissions during the project (January to April 2024).

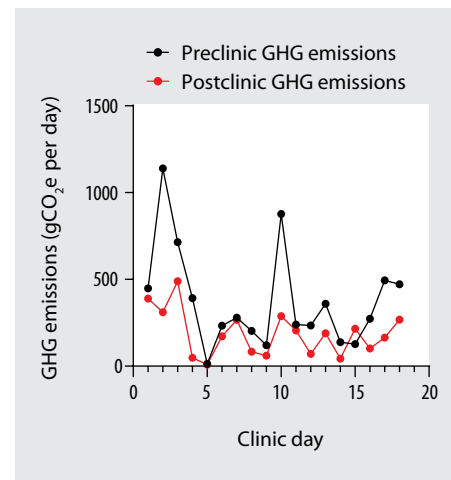
postclinic change in greenhouse gas emissions per patient ranged from an increase of 359 gCO<sub>2</sub>e per day to a decrease of 2758 gCO<sub>2</sub>e per day. Greenhouse gas emissions of two patients (1.9%) increased by more than 200 gCO<sub>2</sub>e per day after their clinic visit; these appeared to be astronomical data points. Both patients underwent escalated management for suboptimal control of their airway conditions. Excluding these two patients, the postclinic change in greenhouse gas emissions per patient ranged from an increase of 53 gCO<sub>2</sub>e per day to a decrease of 2758 gCO<sub>2</sub>e per day. Overall, the greenhouse gas emissions of 91% of patients decreased after their clinic visit. **Figure 2A** shows the total reduction in greenhouse gas emissions of all patients who were screened by a pharmacist and attended the clinic, per clinic day; **Figure 2B** shows the cumulative reduction during the project. **Figure 3** shows the average preclinic and postclinic greenhouse gas emissions of all patients who were screened by a pharmacist and attended the clinic, per clinic day.

## Discussion

Pharmacist-led review of inhaler regimens at our centre reduced inhaler-associated greenhouse gas emissions by an average of 19 208 gCO<sub>2</sub>e per day, the equivalent of driving a standard gasoline-powered passenger vehicle 79 km per day, or 29 000

km per year.<sup>4</sup> These results demonstrate the potential of integrating pharmacists into a specialty respiratory clinic workflow to reduce inhaler-associated greenhouse gas emissions. This intervention could be considered in any practice in which inhalers are prescribed or pharmacists are part of a multidisciplinary team. More broadly, this project highlights the reduction in greenhouse gas emissions that could be achieved if the carbon footprint of inhalers is considered. Previous studies conducted in five European countries showed that the inhaler-associated carbon footprint could be reduced by as much as 89% by changing inhaler prescribing practices.<sup>9</sup> Similarly, other models have estimated that switching from metered-dose inhalers to other more environmentally friendly inhalers could result in carbon savings of up to 85% to 93%.<sup>10,11</sup> Models based on Fraser Health data have shown that different prescribing scenarios for inhalers could result in up to a 78% reduction in annual greenhouse gas emissions.<sup>6</sup>

Adjusting prescribing practices to favor inhalers with lower greenhouse gas emissions could also result in cost savings for health care systems. A model based on data from England indicated that drug costs could be reduced by Can\$14.9 million annually for every 10% of metered-dose inhalers that are replaced with dry powder



**FIGURE 3.** Per-patient average preclinic and postclinic greenhouse gas (GHG) emissions of all patients who were screened by a pharmacist and attended the clinic, per clinic day.

inhalers,<sup>12</sup> although extrapolation of this study to BC is limited by differences in drug cost models. However, there may be other ways in which different prescribing scenarios could lead to cost savings locally, such as improved disease control as a result of inhaler regimen optimization. This in turn could lead to a decrease in the use of reliever medications and in overall health care use. A culture shift in which prescribers favor more environmentally friendly options could also lead to stronger provincial purchasing power in negotiating lower costs of more environmentally friendly inhalers. **Figure 4** lists common inhalers available in British Columbia and their local cost. Assessment of the local cost effect of different prescribing scenarios should be considered in future studies.

One of the theoretical concerns with modifying inhaler regimens is the potential loss of disease control. While we did not collect specific data on disease control, previous studies have shown no differences in the clinical efficacy of metered-dose inhalers and dry powder inhalers.<sup>13-15</sup> In a UK-based randomized control study, adult outpatients with symptomatic asthma either were switched to a combination of an inhaled corticosteroid and a long-acting beta agonist dry powder inhaler or continued their usual care.<sup>16</sup> A *post hoc* analysis on a subset of 2236 of those patients found

# Common inhalers available in BC and their costs










## Short-acting bronchodilators

<b>Ventolin pMDI</b> salbutamol  100 mcg: \$21 <b>pMDI</b>	<b>Atrovent pMDI</b> ipratropium  20 mcg: \$36 <b>pMDI</b>	<b>Teva-Salbutamol pMDI</b> salbutamol  100 mcg: \$18 <b>Low-volume pMDI</b>	<b>Ventolin Diskus</b> salbutamol  200 mcg: \$26 <b>DPI</b>	<b>Bricanyl Turbuhaler</b> terbutaline  0.5 mg: \$24 <b>DPI</b>	<b>Combivent Respimat</b> ipratropium/salbutamol  20/100 mcg: \$49 <b>SMI</b>
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## ICS maintenance therapy

<b>Qvar pMDI</b> beclomethasone dipropionate  50 mcg: \$64 100 mcg: \$113 <b>pMDI</b>	<b>Flovent pMDI</b> fluticasone propionate  50 mcg: \$51 125 mcg: \$78 250 mcg: \$145 <b>pMDI</b>	<b>Alvesco pMDI</b> ciclesonide  100 mcg: \$76 200 mcg: \$118 <b>pMDI</b>	<b>Pulmicort Turbuhaler</b> budesonide  100 mcg: \$58 200 mcg: \$102 400 mcg: \$144 <b>DPI</b>	<b>Aermony RespiClick</b> fluticasone propionate  55 mcg: \$32 113 mcg: \$49 232 mcg: \$68 <b>DPI</b>	<b>Asmanex Twisthaler</b> mometasone furoate  200 mcg: \$59 400 mcg: \$103 <b>DPI</b>	<b>Flovent Diskus</b> fluticasone propionate  100 mcg: \$51 250 mcg: \$78 500 mcg: \$115 <b>DPI</b>	<b>Arnuity Ellipta</b> fluticasone propionate  100 mcg: \$69 200 mcg: \$128 <b>DPI</b>
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## ICS/LABA maintenance therapy

<b>Zenhale pMDI</b> mometasone/formoterol  100/5 mcg: \$132 200/5 mcg: \$160 <b>pMDI</b>	<b>Advair pMDI</b> fluticasone propionate/salmeterol  125/25 mcg: \$149 250/25 mcg: \$207 <b>pMDI</b>	<b>Wixela Inhub</b> fluticasone propionate/salmeterol  100/50 mcg: \$64 250/50 mcg: \$71 500/50 mcg: \$97 <b>DPI</b>	<b>Advair Diskus</b> fluticasone propionate/salmeterol  100/50 mcg: \$126 250/50 mcg: \$150 500/50 mcg: \$208 <b>DPI</b>	<b>Symbicort Turbuhaler</b> budesonide/formoterol  100/6 mcg: \$102 200/6 mcg: \$129 <b>DPI</b>	<b>Breo Ellipta</b> fluticasone furoate/vilanterol  100/25 mcg: \$138 200/25 mcg: \$208 <b>DPI</b>	<b>Atectura Breezhaler</b> mometasone furoate/indacaterol  80/150 mcg: \$51 160/150 mcg: \$61 320/150 mcg: \$77 <b>DPI</b>
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Covered by BC PharmaCare



Special Authority required



Not covered by BC PharmaCare

pMDI = pressurized metered-dose inhaler

DPI = dry powder inhaler

SMI = soft mist inhaler

ICS = inhaled corticosteroid

LABA = long-acting beta agonist

Please refer to [www.bcinhalers.ca](http://www.bcinhalers.ca) for up-to-date information.

Drug prices are approximate and sourced from [www.drugsearch.ca](http://www.drugsearch.ca)—a free online tool showing BC drug prices with dispensing fees. This resource does not include all available inhalers or all information on each inhaler. Please refer to the product monographs before prescribing.

Resource adapted with permission from CASCADES Canada—an initiative led by the Centre for Sustainable Health Systems.

**FIGURE 4.** Common inhalers available in British Columbia and their costs. Up-to-date information is available at [www.bcinhalers.ca](http://www.bcinhalers.ca).

Source: This is an updated version of Figure 3 from “Climate impact of inhaler therapy in the Fraser Health region, 2016–2021” by Liang and colleagues [*BCM J* 2023;65:122-127].

that there was no loss of asthma control, and there was a more than 50% reduction in carbon emissions when patients were switched from a metered-dose inhaler to a dry powder inhaler maintenance therapy.<sup>16</sup> The Salford Lung Study, from which that *post hoc* analysis was derived, was an industry-sponsored randomized control trial that was meant to closely simulate real-world conditions; thus, it was designed to be generalizable and relevant to routine clinical practice. However, modifying inhaler regimens for nonclinical reasons, such as environmental impact, is a complex issue that can lead to a variety of outcomes. A systematic review of 21 real-world studies that examined the ramifications of inhaler switches for nonclinical reasons on patients with chronic obstructive pulmonary disease or asthma identified improved disease control in five data sets ( $n = 7530$ ) but worsened disease control in one data set ( $n = 1648$ ).<sup>17</sup> The same review found heterogeneity in data sets regarding the effect of switching inhaler regimens on exacerbation rates.<sup>17</sup> Notably, only 8 of the 21 studies provided patients with training on inhaler technique prior to switching, although it was unclear whether training was provided in 11 of these studies.<sup>17</sup> Providing adequate training and close clinical follow-up are crucial elements in successful inhaler switches. Woodcock and colleagues,<sup>16</sup> who found no loss of asthma control with inhaler switching, provided patients with education on inhaler technique in addition to regular monitoring for adverse events. An abundance of evidence has demonstrated a link between worsened disease control and inhaler technique errors,<sup>18-22</sup> this underscores the importance of both patient education and appropriate patient characteristics for the proposed inhaler type. For instance, dry powder inhalers require generation of sufficient peak inspiratory flow to facilitate optimal medication delivery,<sup>23</sup> a feat that can be challenging in patients with severe pulmonary disease. Thus, future studies of environmentally driven inhaler regimen modifications, especially in BC, should not only examine patient-relevant outcomes,

such as exacerbation rates, hospitalization rates and emergency department visits, and symptom control, but also incorporate education and assessment of inhaler technique at regular intervals to facilitate successful transitions. Collection of longitudinal data could also facilitate assessment of patient adherence to their new regimen. Indeed, a major limitation of this project was that data were obtained from only a single point in time for each patient.

**Educating patients about the environmental impact of their medications and involving them in shared decision making are indispensable.**

As-needed inhalers are commonly metered-dose inhalers, the type associated with the largest carbon footprint. As a result, variations in metered-dose inhaler usage can greatly affect greenhouse gas emissions. Usage can vary with physical activity, inhaled exposures, and other factors that may not remain consistent, which makes it more challenging for patients to estimate their as-needed inhaler usage. The effects of seasonal variations on respiratory diseases such as asthma can also affect usage. We collected data from mid-winter to early spring, which somewhat limits the extrapolation of results to other seasons. Having patients fill out inhaler usage diaries could help mitigate some of the uncertainty associated with reporting their usage. Similarly, a major limitation of our methodology was the reliance on patient self-report for quantifying inhaler usage, particularly since patients were asked to estimate their as-needed inhaler usage. To mitigate this, we cross-referenced patient-reported usage with PharmaNet records. However, even with cross-referencing, there was still recall bias.

We identified 18 patients for whom changes to their inhaler regimen led to increases in greenhouse gas emissions. However, this occurred in only a minority of cases (19% of patients who attended the clinic), and for most of those patients (16), the increase in greenhouse gas emissions was small, ranging from an increase of 0.16 to 53.00 gCO<sub>2</sub>e per day. Therefore, we believe that under most circumstances, inhaler regimen optimization will lead to reduced greenhouse gas emissions.

We did not examine the reasons that inhaler regimens were modified; for example, inhaler regimen changes could have been made solely to reduce greenhouse gas emissions or to improve disease control. If future projects examine the rationale behind inhaler regimen modifications, this would help elucidate how many changes would not have been made without pharmacist screening and would subsequently lead to a more accurate assessment of the impact of this intervention.

We had funding to conduct PDSA cycles with pharmacist services only 2 days per week and screened half the patients who attended the clinic on those 2 days. Future PDSA cycles with expansion of pharmacist services beyond 2 days per week could yield further learning. Some centres may not have the resources available to integrate a pharmacist into their routine workflow. While we believe education of physicians on the environmental impact of inhalers should be widely promoted, pharmacist screening of inhaler regimens, in line with the current trend of enlisting physician extenders, helps reduce the cognitive workload of physicians, particularly since environmental impact is not commonly considered in treatment decisions.

Finally, educating patients about the environmental impact of their medications and involving them in shared decision making are indispensable. Incorporating a pharmacist into the clinic workflow helped facilitate patient education in our fast-paced clinic environment.

## Conclusions

One important learning point we gleaned from consultation with patient advisors is that more and more patients have become conscious of their carbon footprint. As climate change becomes an increasingly pressing concern, exploring options to reduce the health care-related carbon footprint is more of a priority for both patients and health care professionals than ever before. Our study demonstrates the potential of integrating routine pharmacist-led screening in respiratory clinics to reduce inhaler-related greenhouse gas emissions, thus highlighting a practical intervention that can help address this critical global issue. ■

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## Competing interests

None declared.

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