Carbon footprint impact of the choice of inhalers for asthma and COPD

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Abstract

In the 1990s, metered dose inhalers (MDIs) containing chlorofluorocarbons (CFCs) as propellant were the most common way to administer inhaled therapy for asthma and chronic obstructive pulmonary disease (COPD). In 1987, the Montreal Protocol on Substances that Deplete the Ozone Layer included the phasing out of CFCs, warranting the development of new ways to deliver inhaled therapy for asthma and COPD. This included dry-powder inhalers (DPIs), CFC-free MDIs that used hydrofluorocarbons (HFCs) as a propellant and, aqueous/soft mist inhalers.

Studies of prescription patterns in Europe have found large differences among countries in choice of inhalation device. A study published in 2011 concluded that approximately 90% of inhaled corticosteroid (ICS) devices used in Sweden were DPIs, whereas in the UK, approximately 80% were MDIs.

Unlike CFCs, HFCs are not ozone-depleting substances but they are still greenhouse gases that have a high global warming potential (GWP). In 2017, the British Thoracic Society issued a statement to encourage prescribers and patients to consider switching pressurised MDIs to non-propellant devices because of this difference in environmental impact. This statement was recently updated.

This study aimed to compare the environmental impact of DPI and MDI combinations using calculated carbon footprint data for two DPIs, Elipta and Accuhaler, and one MDI, Evohaler. A secondary aim was to compare the inhaler-related carbon footprint impact between England and Sweden and the potential for reduction of annual carbon footprint (CO₂e) in England if the pattern of inhalation devices chosen in England were to resemble that in Sweden.

Introduction

Until the early 1990s, metered dose inhalers (MDIs) containing CFCs were the most common way to administer inhaled therapy for asthma and chronic obstructive pulmonary disease (COPD). In 1987, the Montreal Protocol on Substances that Deplete the Ozone Layer included the phasing out of CFCs, warranting the development of new ways to deliver inhaled therapy for asthma and COPD. This included dry-powder inhalers (DPIs), CFC-free MDIs that used hydrofluorocarbons (HFCs) as a propellant and, aqueous/soft mist inhalers.

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Results

The EVohaler MDIs had 20–30 times larger carbon footprints than the Accuhaler and Elipta DPIs (table 1). This difference was mainly related to the use phase (treatment) and the end of life phase (disposal) when the propellant is released.

The combination of Relvar Ellipta (9.5 kg CO₂e) and Ventolin Accuhaler (7.3 kg CO₂e) had an annual carbon footprint of 17 kg CO₂e, while the corresponding value for using the combination Seretide Evohaler (234 kg CO₂e) and Ventolin Evohaler (205 kg CO₂e) was 439 kg CO₂e (figure 1).

In England in 2017, 70% of all inhalers sold were MDI, whereas the corresponding figure for Sweden was 13%. The difference was largest for SABA: 94 versus 10% MDIs in England and Sweden respectively, while the corresponding difference for devices that contained ICS was 62 versus 14%.
Table 1  Contribution of phases in the life cycle of different inhaler devices to their individual carbon footprint (net kg CO₂e/per pack) and annual carbon footprints of each device

<table>
<thead>
<tr>
<th>Device</th>
<th>RELVAR ELLIPTA 92/22 µg</th>
<th>SERETIDE ACCUHALER 50/500 µg</th>
<th>VENTOLIN ACCUHALER 200 µg</th>
<th>SERETIDE EVOHALER 25/250 µg</th>
<th>VENTOLIN EVOHALER 100 µg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active pharmaceutical ingredients</td>
<td>0.02</td>
<td>0.25</td>
<td>0.02</td>
<td>0.08</td>
<td>0.10</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.73</td>
<td>0.46</td>
<td>0.42</td>
<td>2.12</td>
<td>1.11</td>
</tr>
<tr>
<td>Distribution</td>
<td>0.03</td>
<td>0.06</td>
<td>0.02</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>User phase</td>
<td>0.00</td>
<td>0.12</td>
<td>0.12</td>
<td>10.68</td>
<td>19.39</td>
</tr>
<tr>
<td>End of life</td>
<td>0.03</td>
<td>0.01</td>
<td>0.01</td>
<td>6.08</td>
<td>7.38</td>
</tr>
<tr>
<td>Net kg CO₂e/pack</td>
<td>0.80</td>
<td>0.90</td>
<td>0.60</td>
<td>19.00</td>
<td>28.00</td>
</tr>
<tr>
<td>Net kg CO₂e/year</td>
<td>9.5</td>
<td>11.0</td>
<td>7.3*</td>
<td>234.0</td>
<td>205.0*</td>
</tr>
</tbody>
</table>

*If using on average two doses per day.

If England had the same rates of MDI use as Sweden, 550 kt CO₂e would be saved annually (table 2).

**DISCUSSION**

Using Ellipta and Accuhaler DPIs instead of Evohaler MDIs resulted in an annual carbon footprint reduction equivalent to 422 kg CO₂e per patient. Applying the Swedish DPI and MDI distribution to England would result in an estimated annual reduction of 550 kt CO₂e annually.

The impact of HFCs from inhalers on overall greenhouse gas emissions can be viewed from many perspectives. Internationally, HFC release from MDIs in 2014 was equivalent to 0.013 gt CO₂e, which was about 3% of global GWP-weighted CO₂e emissions of HFCs. HFCs are also used as refrigerants in refrigeration, air-conditioning and heat pump equipment (80%); as blowing agents for foams (11%); as solvents and in fire extinguishers (5%). From an individual patient’s perspective, a comparison of Ventolin and Seretide Evohalers with Relvar Ellipta and Ventolin Accuhaler could save 422 kg CO₂e per year per patient. This is similar to the per capita carbon reductions obtained if changing from a meat-based to a plant-based diet. This calculation was based on a usage of two doses SABA per day. In patients that are very well controlled and therefore not using any SABA at all the difference was 234 kg CO₂e per year.

We found a large difference between England and Sweden in the distribution of inhalation devices. This is in accordance with previous data. The reason for this difference is not entirely clear but could be related to marketing strategies and prescribers’ and patients’ biases. In England, the carbon footprint of the National Health Service (NHS) is ≈23 mt CO₂e. Pharmaceuticals procurement is 16% of the footprint, one quarter of which comes from MDIs. Other carbon footprint sources include building and energy and travel (4.6 and 2.8 mt CO₂e, respectively). The predicted reduction of 550 kt CO₂e annually that we calculated by applying the Swedish distribution of inhalation devices to the population in England thus corresponds...
to approximately 2.6% of the total carbon footprint for NHS England." The main weakness of this analysis was that the analysis was limited to GlaxoSmithKline devices as accurate carbon footprint data were not available from other manufacturers.

Key considerations for inhaler selection include healthcare professional knowledge of all the devices; inhalation manoeuvre achieved; airway disease severity, patient’s ability to use their device correctly and their personal preferences. Thus the final choice of inhaler includes many factors, such as the fundamental efficacy of the molecules, patient-use factors, and the environmental burden. It should be noted that any change from an MDI to DPI device in clinical practice should be based on a clinical assessment and needs to be actively supported by appropriate programmes of education and assessment to ensure correct inhaler technique.

We conclude that Ellipta and Accuhaler DPIs have considerably lower carbon footprints than Evohaler MDIs, at both an individual and a national level. The lower carbon footprint of DPIs should be considered alongside other factors for patients who are able to use these devices effectively.

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Contributors The authors declare the following contributions to this study: AKW, CJ, ML and RH developed the study concept; AKW, CJ and RH were involved in the data analysis; all authors contributed to drafting and finalising the manuscript and approved the final version for submission; CJ is the guarantor, taking responsibility for work and/or conduct of study, full access to data, and control of decision to publish.

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Competing interests All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coiDisclosure.pdf and declare the following: CJ reports personal fees from AstraZeneca, Boehringer Ingelheim, Chiesi, GlaxoSmithKline, Novartis and TEVA outside the submitted work; MH reports honoraria from GlaxoSmithKline for presenting scientific data on climate change; AKW has nothing to disclose; RH and RS are GlaxoSmithKline employees and hold GlaxoSmithKline stocks/shares; ML is an employee of GlaxoSmithKline.

Table 2  Proportion of MDI use in different classes and potential reduction in kilo tons (kt) of CO$_2$e if changing the proportion of MDI use in the England to the level of Sweden

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>SABA</td>
<td>21 931 511</td>
<td>94</td>
<td>1 477 692</td>
<td>10</td>
<td>414.00</td>
</tr>
<tr>
<td>LABA</td>
<td>700 195</td>
<td>65</td>
<td>377 415</td>
<td>2</td>
<td>9.30</td>
</tr>
<tr>
<td>SAMA</td>
<td>421 191</td>
<td>100</td>
<td>No data</td>
<td>100</td>
<td>8.40</td>
</tr>
<tr>
<td>ICS</td>
<td>6 733 445</td>
<td>94</td>
<td>765 796</td>
<td>15</td>
<td>127.00</td>
</tr>
<tr>
<td>ICS+LABA</td>
<td>14 075 067</td>
<td>47</td>
<td>1 719 428</td>
<td>13</td>
<td>140.00</td>
</tr>
<tr>
<td>LAMA and LAMA+LABA</td>
<td>6 549 448</td>
<td>0</td>
<td>428 732</td>
<td>0</td>
<td>6.55</td>
</tr>
<tr>
<td>LAMA+LABA + ICS</td>
<td>5211</td>
<td>99</td>
<td>2 626</td>
<td>100</td>
<td>–0.10</td>
</tr>
<tr>
<td>Total</td>
<td>49 994 877</td>
<td>70</td>
<td>4 771 689</td>
<td>13</td>
<td>705.0</td>
</tr>
</tbody>
</table>

Analysis uses 2017 community prescribing data from the NHS in England (https://digital.nhs.uk/) and assumes carbon footprint of MDI is 20 kg CO$_2$e and DPI is 1 kg CO$_2$e. SAMA not included in analysis, as no DPI SAMA alternative is available. Potential annual reduction shows the hypothetical carbon savings if England were to prescribe the same proportions of MDI as Sweden.

DPI, dry powder inhaler; ICS, inhaled corticosteroid; LABA, long-acting β$_2$-agonist; LAMA, long-acting muscarinic antagonist; MDI, metered dose inhaler; SABA, short-acting β$_2$-agonist; SAMA, short-acting muscarinic antagonist.

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REFERENCES
7 Wynes S, Nicholas KA. The climate mitigation gap: education and government recommendations miss the most effective individual actions. Environ Res Lett 2017;12.