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Early View

Research letter

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The carbon footprint of respiratory treatments in Europe and Canada: An observational study from the CARBON programme

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Take home message: Relievers account for the majority of inhaler use and associated GHG emissions. Implementing treatment guidelines can reduce the unmet need in respiratory care by improving disease control and reducing reliever overuse and the overall carbon footprint.

Key words: asthma, clinical asthma management, inhaled therapy, inhalers, environmental monitoring

To the Editor:

INTRODUCTION

Climate change represents a global challenge and nations are increasingly looking to decarbonise their economies by developing roadmaps for reducing greenhouse gas (GHG) emissions in accordance with international treaties, such as the Paris Agreement [1]. As the healthcare sector remains a key contributor to GHG emissions [2], an examination of the global carbon footprint of its operations and treatment pathways is essential to identify targets for decarbonisation.

In respiratory treatment, the environmental impact of controller inhalers has received considerable attention due to the hydrofluorocarbon propellants used in metered-dose inhalers (MDIs), which have global warming potential [3]. In the United Kingdom (UK), where MDIs represented ~3% of health and social care system carbon emissions [4] and 13.1% of emissions related to the delivery of care in 2019 [2], targets are in place to reduce total emissions by 80% by 2036–2039, including those from MDIs [5]. However, the focus on controller inhalers omits other contributors, such as the impact of short-acting β_2-agonists (SABAs), presenting an incomplete picture of the carbon footprint of respiratory treatments for both asthma and chronic obstructive pulmonary disease (COPD).

Patients with mild asthma, who represent approximately half of the European asthma population [6], are commonly prescribed SABA-only treatment [7], placing them at increased risk of poor outcomes [8]. Additionally, findings from the real-world SABA use IN Asthma (SABINA) programme revealed that approximately one-third of patients with asthma across Europe overuse SABA (prescription/dispensing of ≥3 canisters/year) [9], which is associated with an increased risk of exacerbations and healthcare resource use (HCRU) [10, 11]. Moreover, increased HCRU in respiratory treatment, whether associated with poor disease control of asthma [12] or progression of COPD [13], carries an additional carbon burden [14].

Rationale and objectives

We considered that sub-optimal care of patients with asthma or COPD may drive a higher, yet potentially modifiable contribution to global GHG emissions, and developed the healthCARe-Based carbON cost of treatment (CARBON)—an evolving healthcare sustainability programme to better understand the carbon footprint of respiratory disease control and progression [15]. As part of the CARBON programme, the SABA CARBON-Europe and Canada observational cohort study quantified the carbon footprint associated with (i) the use of both reliever and controller inhalers in 20 European countries and in Canada and (ii) SABA overuse (prescription/dispensing of ≥3 canisters/year) in five European countries and two Canadian provinces (Alberta and Nova Scotia) from the SABINA programme.

METHODS

Assessment of inhaler use across all respiratory use

Inhaler sales data, as a surrogate of inhaler use, for SABA and controller medications (MDIs and dry powder inhalers [DPI]), across all respiratory uses, were obtained from the IQVIA™ Quarterly MIDAS database Q3 2019 (09/2018–09/2019), accessed and analysed via STAR Inhouse system by AstraZeneca. This analysis included patients treated for any respiratory condition. Controller treatments included inhaled corticosteroid-containing drugs, long-acting β_2-agonists (LABA), long-acting muscarinic antagonists (LAMA) and LAMA/LABA combinations.

Assessment of SABA overuse (≥3 canisters/year) in asthma

SABA overuse in patients with asthma (aged ≥12 years) of any severity was assessed using prescription/dispensing data from the SABINA programme (2006–2019) [10, 16-19].

Data analysis

Data were compared by dose, preventing confounding from inhaler actuation count differences. A 1:1 equivalence of actuation and dose was assumed for SABAs and controller medication delivered via a DPI, whereas a 2:1 ratio for actuation to dose was assumed for controller medication delivered via a MDI. Both analyses were descriptive in nature and annual GHG emissions were expressed as carbon dioxide equivalent (CO_2e) and quantified using published data [3, 20] and internal AstraZeneca estimates. Per capita inhaler usage and associated carbon footprint were calculated using the national population for IQVIA™ sales data and using the study populations for the SABINA data.

RESULTS

Respiratory-related inhaler use and associated GHG emissions across 21 countries

SABA use was common across 20 countries in Europe and in Canada (**Table 1A**). Although SABAs were mostly administered via MDIs, this varied across countries, ranging from 28.2%

in Sweden to 100% in Italy. Per capita SABA use ranged from 98,770 (Poland) to 1,033,535 (UK) doses/10,000 persons/year. Compared with SABA use, per capita controller medication use was lower, ranging from 58,506 (Romania) to 437,945 (UK) doses/10,000 persons/year. As a proportion of total inhaler use, SABA inhalers ranged from 33% (Belgium) to 71% (Canada and Ireland), with SABA GHG emissions ranging from 47% (Netherlands and Sweden) to 80% (Romania). Compared with per capita GHG emissions from SABA, which ranged from 12 (Sweden) to 134 (UK) tonnes CO_2e/10,000 persons/year, per capita GHG emissions from controller medication use were lower and ranged from 4 (Romania) to 65 (UK) tonnes CO_2e/10,000 persons/year. Total GHG emissions from the use of SABA and controller medications were approximately 2 and 1 million tonnes CO_2e, respectively, with SABA use accounting for 66% of the total GHG emissions from inhalers.

SABA overuse in asthma and associated GHG emissions across the 7 SABINA datasets

Across the seven SABINA datasets comprising 1,131,416 patients with asthma (**Table 1B**), most SABA prescriptions were received by patients who were overusing SABA (≥3 canisters/year), ranging from 69% (Italy and Sweden) to 94% (Canada [Nova Scotia]). SABA overuse contributed to excess per capita GHG emissions, ranging from 78 (Sweden) to 864 (Canada [Nova Scotia]) tonnes CO_2e/10,000 persons/year. Per capita GHG emissions from SABA overuse in Canada (Nova Scotia) were 1.6- to 11.1-fold higher vs the UK and Sweden, respectively. As an example, SABA overuse when scaled to the national asthma population of ~5.4 million in the UK translated to an excess carbon footprint of 293,227 tonnes CO_2e. Across the two Canadian provinces, both SABA overuse and the associated per capita emissions were higher in Nova Scotia compared with Alberta.

Limitations

Although inhaler sales and prescriptions/dispensing data may not reflect actual medication use and final disposal (together accounting for ~90% of the GHG emissions) (3), this study provides an understanding of how high SABA use, a marker of poor disease control and sub-optimal disease management [8], drives the associated carbon footprint of respiratory treatment.

DISCUSSION

Overall, our findings reveal that sub-optimal respiratory treatment, in the form of high SABA use across Europe and Canada, remains widespread, representing approximately two-thirds of total GHG emissions. These findings highlight the importance of assessing the contribution of SABAs to the carbon footprint of respiratory treatment, which in many countries were commonly used and administered by MDIs, thereby explaining higher GHG emissions associated with SABA vs controller inhaler use. Furthermore, an analysis of SABINA datasets demonstrated that SABA overuse, as defined by the threshold of ≥3 canisters/year [8], drives the majority of SABA prescriptions/dispensing in asthma, suggesting sub-optimal disease management in a high proportion of patients who are at increased risk of asthma exacerbations and exacerbation-related HCRU, thereby further contributing to the total carbon footprint.

In most countries, SABAs represented the majority of respiratory-related inhaler use, indicating suboptimal disease control in these populations. The highest per capita use of both SABA and controller inhalers was observed in the UK. SABA overuse in asthma was prevalent despite the different healthcare and reimbursement policies of each country, a finding consistent with previous studies [9-11, 17, 18, 21, 22]. Across all SABINA datasets, SABA prescribing/dispensing was primarily driven by patients who were potentially overusing SABA relievers. However, these findings should be interpreted in light of diverse asthma management practices and differences in healthcare delivery systems and socio-economic status across the individual datasets, particularly in relation to access to medications [19]. For example, in Germany and Sweden, SABA is a prescription-only medicine [9], while in Italy, SABA is available without a prescription [17]. Thus, actual SABA use in Italy may have been higher than observed. SABA prescribing/dispensing patterns in

Poland may be attributable to underfunding of the healthcare system, leading to relatively high out-of-pocket spending [23]. Variations in SABA overuse between the two Canadian provinces may be due, in part, to differences in socio-economic status [24] that may have influenced access to recommended asthma medications. However, further research is needed to verify these findings.

Although global asthma guidelines no longer recommend as-needed SABA use alone due to safety concerns [8] and an inconsistent evidence base, asthma management practices have not yet caught up with current evidence-based recommendations, and SABA overuse therefore continues to drive the majority of GHG emissions across countries. Consequently, implementation of clinical guidelines, adherence to asthma action plans, and delivery of personalised care along with a focus on the management of modifiable risk factors for poor disease control, such as SABA overuse, poor medication adherence, and incorrect inhaler technique should be prioritised to improve patient outcomes [8]. This approach will subsequently reduce SABA reliever use and additional HCRU, thereby benefiting patients and realising carbon savings that go beyond the reduction in SABA use alone. As sub-optimal disease management continues to be an unacceptable unmet need in respiratory treatment, this is a call to action for healthcare professionals and policymakers to ensure that treatment-related decisions are guided by current evidence-based recommendations and tailored to patient needs, thereby reducing SABA use and associated carbon emissions in respiratory treatment, without risking improvements in patient outcomes or causing harm.

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Conflict of interest

Christer Janson reports personal fees from AstraZeneca, Boehringer Ingelheim, Chiesi, GlaxoSmithKline PLC, Novartis and Teva outside the submitted work.

Alexander Wilkinson is a member of the Montreal protocol Medical and Chemical Technical Options Committee and has made unpaid contributions to publications on the carbon footprint of inhalers and respiratory treatment which were sponsored by GlaxoSmithKline and AstraZeneca.

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Claus F. Vogelmeier has delivered presentations at symposia and/or served on scientific advisory boards sponsored by Aerogen, AstraZeneca, Boehringer Ingelheim, CSL Behring, Chiesi, GlaxoSmithKline, Grifols, Menarini, Novartis, Nuvaira and MedUpdate.

Maciej Kupczyk reports grants from AstraZeneca and personal fees from AstraZeneca, Chiesi, GlaxoSmithKline, Novartis, Lekam, Alvogen, Emma, Nexter and Berlin Chemie. Ekaterina Maslova, Nigel Budgen and John Bell are employees of AstraZeneca. Andrew Menzies-Gow has attended advisory boards for GlaxoSmithKline, Novartis, AstraZeneca, Sanofi and Teva. He has received speaker fees from Novartis, AstraZeneca, Vectura, Teva and Roche. He has also participated in research with AstraZeneca and attended international conferences with Teva. He has consultancy agreements with AstraZeneca, Vectura and Sanofi.

Author contributions

JB and EM conceptualised the study design. EM, NB, and JB performed the data analysis. All authors contributed to data collection, data interpretation and writing.

Disclaimer

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TABLE 1 (A) GHG emissions related to SABAs vs controller medication in 21 countries. (B) SABA overuse among patients with asthma from the seven SABINA datasets and associated GHG emissions

(A) Country	Per capita SABA use, doses/10,000 persons/year	Per capita controller medication use, doses/10,000 persons/year	SABA vs total inhaler use, %	GHG emissions from SABA, tonnes CO_2e	GHG emissions from controller medication, tonnes CO_2e	SABA vs total inhaler GHG emissions, %	Per capita GHG emissions from SABA, tonnes CO_2e/10,000 persons/year	Per capita GHG emissions from controller medication, tonnes CO_2e/10,000 persons/year
Belgium	131,047	267,567	33	19,672	17,422	53	17	15
Bulgaria	125,630	141,248	47	11,959	6,949	63	17	10
Canada	543,796	224,999	71	193,356	73,898	72	55	21
Croatia	126,186	111,056	53	7,253	4,175	64	17	10
Czech Republic	125,088	210,556	37	17,563	18,485	49	17	17
Denmark	281,377	284,622	50	10,889	8,017	58	19	14
Finland	278,298	337,388	45	10,963	11,563	49	20	21
France	383,001	229,696	63	334,716	126,131	73	50	19
Germany	275,899	234,476	54	293,638	144,077	67	36	18
Greece	237,510	288,218	45	34,223	20,988	62	32	19
Hungary	182,449	144,174	56	22,597	12,560	64	23	13
Ireland	743,424	300,928	71	48,986	16,782	75	98	34
Italy	125,516	144,659	46	104,503	86,040	55	17	14
Netherlands	256,961	288,783	47	46,559	52,922	47	27	31
Norway	285,983	279,637	51	14,776	10,188	59	28	19
Poland	98,770	166,863	37	49,893	43,738	53	13	11
Romania	126,896	58,506	68	36,749	9,371	80	17	4
Spain	318,751	222,311	59	195,771	86,977	69	40	18
Sweden	238,512	349,211	41	11,632	12,895	47	12	13
Switzerland	154,456	150,331	51	16,067	6,174	72	20	8
UK	1,033,535	437,945	70	862,685	415,345	68	134	65

(B) Country	Total patients in	Volume of SABA	SABA prescriptions	Total GHG	Per capita GHG

	SABINA database (GINA equivalent steps 1–2; 3–5)	prescriptions (GINA equivalent steps 1–2; 3–5)	received by patients potentially overusing SABA reliever (GINA equivalent steps 1–2; 3–5), %	emissions from SABA overuse, tonnes CO_2e within this cohort	emission from SABA overuse, tonnes CO_2e/10,000 persons
Canada (Alberta)	107,444 (41,868; 65,576)	274,175 (101,854; 172,321)	81 (77; 83)	4,303	401
Canada (Nova Scotia)	8,034 (4,183; 3,851)	34,677 (18,169; 16,508)	94 (93; 94)	694	864
Germany	13,030 (6,267; 6,763)	39,643 (16,883; 22,760)	74 (68; 78)	540	415
Italy	22,102 (8,082; 14,020)	17,866 (6,749; 11,117)	69 (69; 69)	240	108
Poland*	98,876 (13,412; 28,386)	135,424 (49,694; 85,730)	74 (78; 71)	1,928	195
Sweden#	365,324 (173,546; 183,717)	794,589 (418,878; 369,709)	69 (64; 76)	2,844	78
UK	516,606 (309,218; 207,388)	1,753,804 (760,098; 993,706)	85 (76; 91)	28,052	543

Data from Alberta and Nova Scotia from the SABINA datasets were analysed separately to compare SABA overuse and associated emissions across the 2 provinces. *Patients with zero SABA use could not be categorised across GINA steps. #Total of 8,061 patients from Sweden could not be categorised according to GINA steps. GHG emissions associated with medication use were quantified using SimaPro LCA software modelling resource and energy consumption data, in addition to Ecoinvent® datasets and certified published studies. Per capita GHG emissions were calculated to allow comparisons across countries/datasets.

CO_2e, carbon dioxide equivalent; DPI, dry powder inhaler; GHG, greenhouse gas; GINA, Global Initiative for Asthma; LCA, life cycle assessment; MDI, metered-dose inhaler; SABA, short-acting β_2-agonist; SABINA, SABA use IN Asthma; UK, United Kingdom.