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

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To the Editor:

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 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 three or more canisters per year) [9], which is associated with an increased risk of exacerbations and healthcare resource use [10, 11]. Moreover, increased healthcare resource use in respiratory treatment, whether associated with poor disease control of asthma [12] or progression of COPD [13], carries an additional carbon burden [14].

We considered that suboptimal 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) programme, 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 1) the use of both reliever and controller inhalers in 20 European countries and in Canada and 2) SABA overuse (prescription/dispensing of three or more canisters per year) in five European countries and two Canadian provinces (Alberta and Nova Scotia) from the SABINA programme.

Inhaler sales data, as a surrogate for inhaler use, for SABA and controller medications (MDIs and dry powder inhalers (DPIs)), across all respiratory uses, were obtained from the IQVIA quarterly MIDAS database Q3 2019 (September 2018 to September 2019), accessed and analysed *via* the AstraZeneca in-house STAR system. 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.

Shareable abstract (@ERSpublications)
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. https://bit.ly/3zh3c2B

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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 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.

SABA use was common across 20 countries in Europe and in Canada (table 1). 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 per 10 000 persons per year. Compared with SABA use, per capita controller medication use was lower, ranging from 58 506 (Romania) to 437 945 (UK) doses per 10 000 persons per 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 per 10 000 persons per year, per capita GHG emissions from controller medication use were lower and ranged from 4 (Romania) to 65 (UK) tonnes CO_2e per 10 000 persons per 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.

Across the seven SABINA datasets comprising 1 131 416 patients with asthma (table 1), most SABA prescriptions were received by patients who were overusing SABA (three or more canisters per 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 per 10 000 persons per year. Per capita GHG emissions from SABA overuse in Canada (Nova Scotia) were 1.6- to 11.1-fold higher *versus* 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.

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 suboptimal disease management [8], drives the associated carbon footprint of respiratory treatment.

Overall, our findings reveal that suboptimal 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 *versus* controller inhaler use. Furthermore, an analysis of SABINA datasets demonstrated that SABA overuse, as defined by the threshold of three or more canisters per year [8], drives the majority of SABA prescriptions/dispensing in asthma, suggesting suboptimal disease management in a high proportion of patients who are at increased risk of asthma exacerbations and exacerbation-related healthcare resource use, 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 socioeconomic 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.

TABLE 1 Greenhouse gas (GHG) emissions related to short-acting β_2-agonist (SABAs) *versus* controller medication in 21 countries (IQVIA dataset), and SABA overuse among patients with asthma from the seven SABA use IN Asthma (SABINA) datasets and associated GHG emissions

	IQVIA dataset								SABINA dataset				
	Per capita SABA use, doses per 10 000 persons per year	Per capita controller medication use, doses per 10 000 persons per year	SABA *versus* total inhaler use, %	GHG emissions from SABA, tonnes CO_2e	GHG emissions from controller medication, tonnes CO_2e	SABA *versus* total inhaler GHG emissions, %	Per capita GHG emissions from SABA, tonnes CO_2e per 10 000 persons per year	Per capita GHG emissions from controller medication, tonnes CO_2e per 10 000 persons per year	Total patients in SABINA database (GINA equivalent steps 1–2; 3–5)	Volume of SABA prescriptions (GINA equivalent steps 1–2; 3–5)	SABA prescriptions received by patients potentially overusing SABA reliever (GINA equivalent steps 1–2; 3–5), %	Total GHG emissions from SABA overuse, tonnes CO_2e within this cohort	Per capita GHG emission from SABA overuse, tonnes CO_2e per 10 000 persons
Belgium	131 047	267 567	33	19 672	17 422	53	17	15					
Bulgaria	125 630	141 248	47	11 959	6949	63	17	10					
Canada	543 796	224 999	71	193 356	73 898	72	55	21					
Alberta[#]									107 444 (41 868; 65 576)	274 175 (101 854; 172 321)	81 (77; 83)	4303	401
Nova Scotia[#]									8034 (4183; 3851)	34 677 (18 169; 16 508)	94 (93; 94)	694	864
Croatia	126 186	111 056	53	7253	4175	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	8017	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	13 030 (6267; 6763)	39 643 (16 883; 22 760)	74 (68; 78)	540	415
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	22 102 (8082; 14 020)	17 866 (6749; 11 117)	69 (69; 69)	240	108
The 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	98 876 (13 412; 28 386)	135 424 (49 694; 85 730)	74 (78; 71)	1928	195
Romania	126 896	58 506	68	36 749	9371	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	365 324 (173 546; 183 717)	794 589 (418 878; 369 709)	69 (64; 76)	2844	78
Switzerland	154 456	150 331	51	16 067	6174	72	20	8					
UK	1 033 535	437 945	70	862 685	415 345	68	134	65	516 606 (309 218; 207 388)	1 753 804 (760 098; 993 706)	85 (76; 91)	28 052	543

GHG emissions associated with medication use were quantified using SimaPro life cycle assessment 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; GINA: Global Initiative for Asthma. [#]: data from Alberta and Nova Scotia from the SABINA datasets were analysed separately to compare SABA overuse and associated emissions across the two provinces; [¶]: in the SABINA dataset, patients from Poland with zero SABA use could not be categorised across GINA steps; [+]: in the SABINA dataset, 8061 patients from Sweden could not be categorised according to GINA steps.

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 socioeconomic 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 healthcare resource use, thereby benefiting patients and realising carbon savings that go beyond the reduction in SABA use alone. As suboptimal 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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