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**Greenhouse Gas Emissions From Respiratory Treatments: Results From the SABA CARBON International Study**

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## Supplementary material

### SUPPLEMENTARY METHODS

#### Study Design and Population

##### *SABINA III analyses*

Patient eligibility criteria for SABINA III have been described previously [1]. Patients aged  $\geq 12$  years with a documented diagnosis of asthma,  $\geq 3$  consultations with a healthcare practitioner and medical records containing data for  $\geq 12$  months preceding the study visit were included. Patient data were recorded on electronic case report forms during the study visit to a primary care physician or a respiratory medicine specialist. Patients with a diagnosis of other chronic respiratory diseases, such as chronic obstructive pulmonary disease, or with an acute respiratory condition that in the opinion of the investigator would prevent them from attending the study visit were excluded. Informed consent was obtained from all patients or their legal guardians.

#### Study Variables

Greenhouse gas (GHG) emissions were quantified over a 12-month period using the following formula:

$$\sum \text{CO}_2\text{e emission value}_{\text{SABA or ICS-containing medication item}} \times n_{\text{item used/prescribed}}$$

*CO<sub>2</sub>e* carbon dioxide equivalent, *ICS* inhaled corticosteroids, *SABA* short-acting  $\beta_2$ -agonist

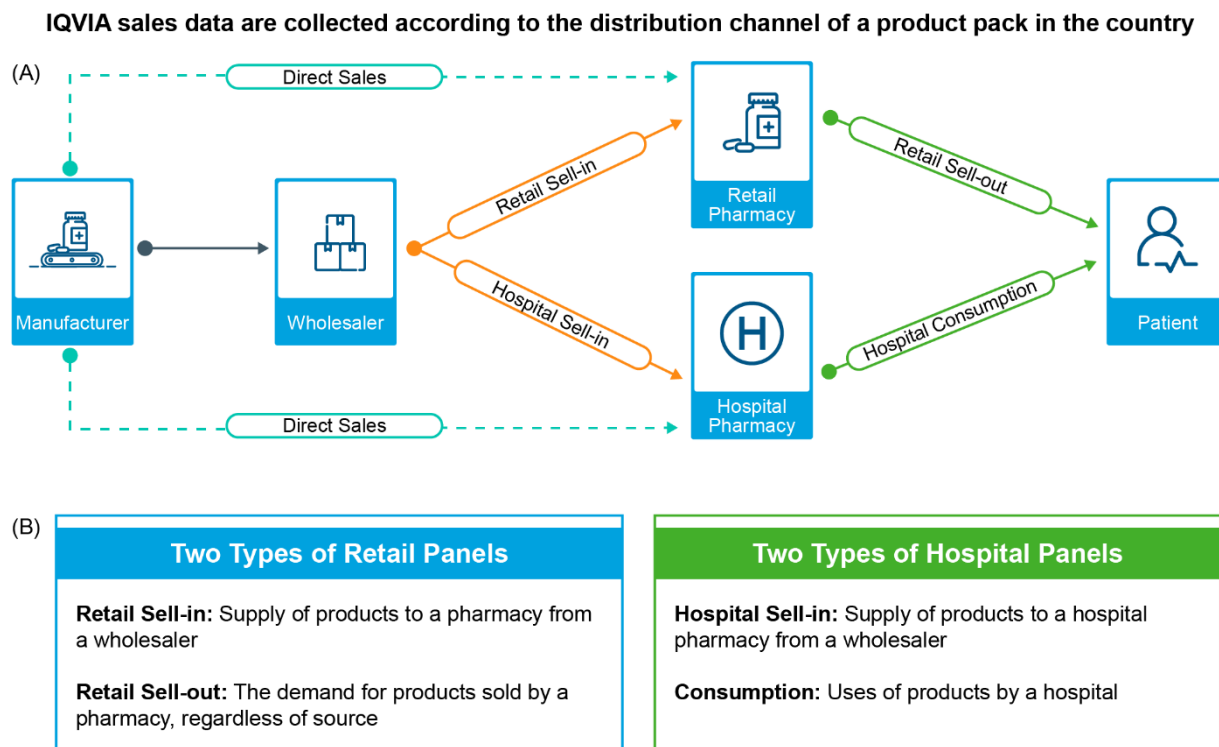
The principles of Greenhouse Gas Protocol Pharmaceutical and Medical Device Sector Guidance for Product Life Cycle Accounting 2012 and the World Business Council for Sustainable Development, World Resources Institute 2011 Product Life Cycle Accounting and Reporting Standard were followed in estimating the GHG emissions of AstraZeneca asthma medications.

### **Sensitivity Analysis**

Product life cycle assessments (LCAs) generated using the global warming potential (GWP) values of hydrofluoroalkanes (HFAs) for a 100-year time period from the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4) compared with those generated using the IPCC Fifth Assessment Report (AR5) resulted in a negligible (1.4%) increase in total pressurised metered-dose inhaler (pMDI)–related GHG estimates [2]. Product LCAs generated using GWP of HFAs for a 100-year time period from the IPCC Sixth Assessment Report (AR6) compared with IPCC AR5 resulted in an 8.1% increase in total pMDI–related GHG estimates [3]. Similarly, the variation in calculations of GHG estimates based on recently published studies [4-7] and modelled estimates revealed a 0.2% increase in total dry powder inhaler–related GHG estimates.

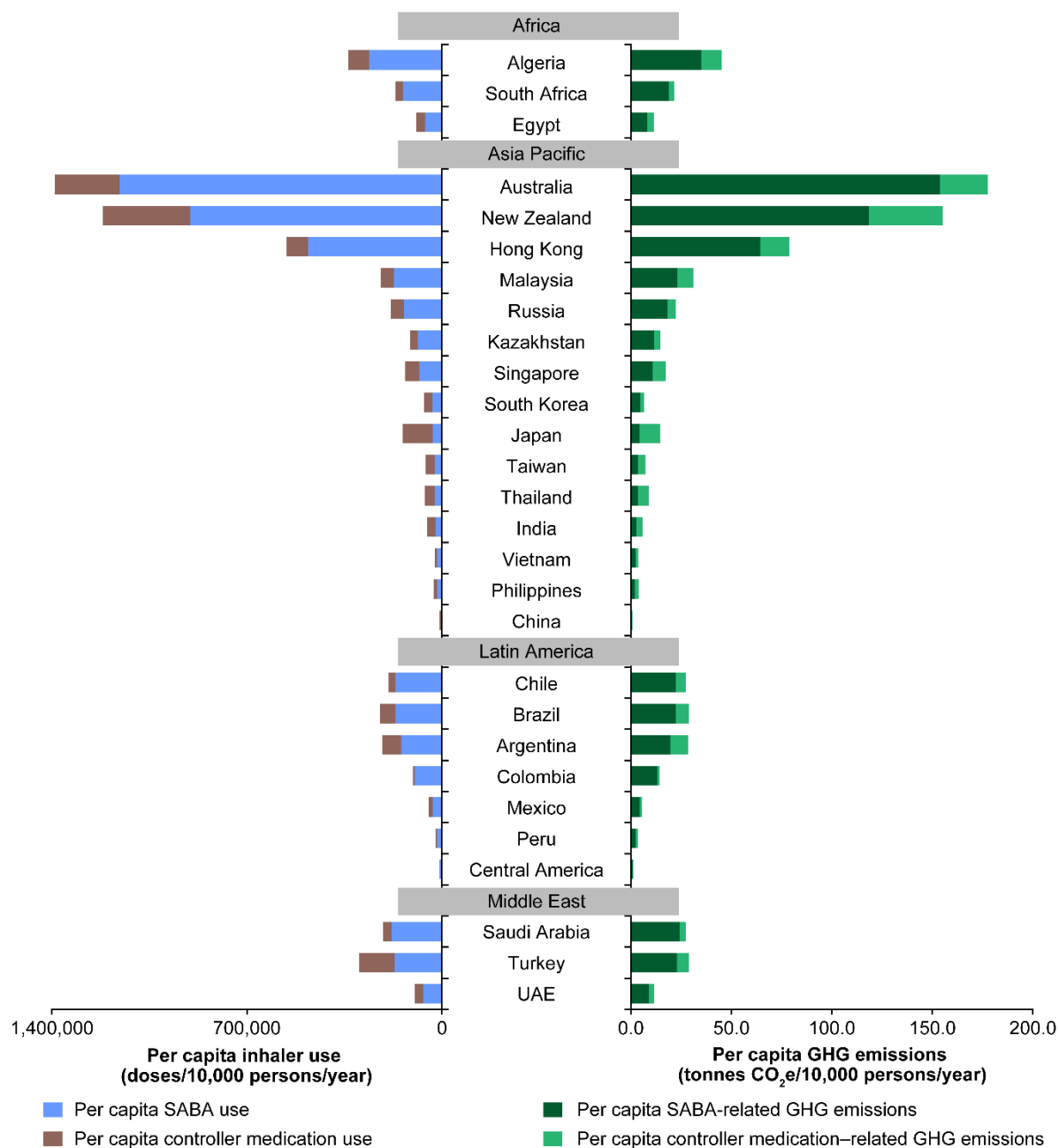
## SUPPLEMENTARY FIGURES

**Supplementary Fig. S1** (A) Overview of IQVIA MIDAS data collection\* and (B) types of data sources.



\*Depending on the country, data is collected at different points in this distribution channel. Data is collected at sell-in for all retail and hospital panels, with a few exceptions.

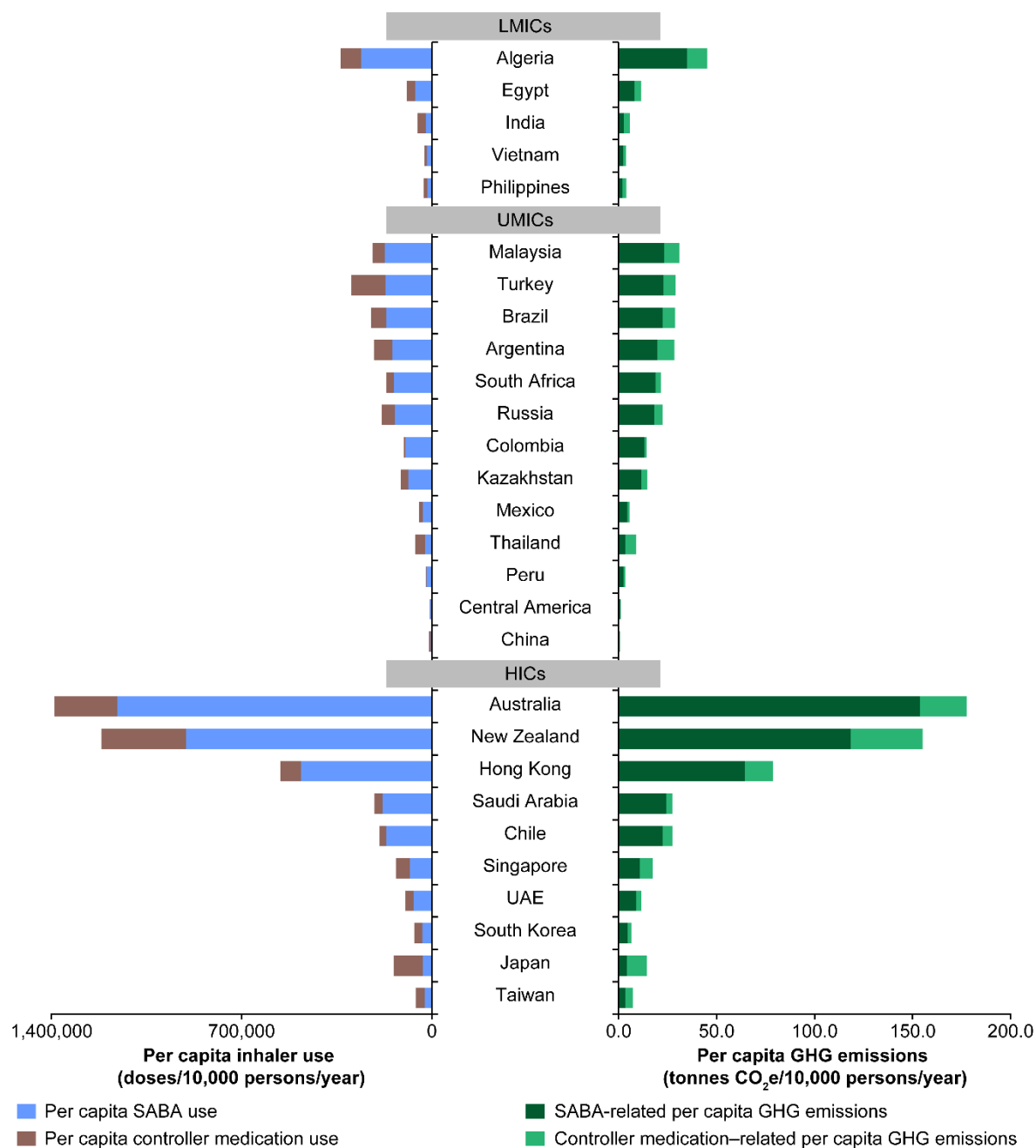
**Supplementary Fig. S2** Per capita SABA and controller medication use and associated GHG emissions based on the IQVIA MIDAS sales data\* stratified by geographical region.



\*Based on internal analysis by the authors using IQVIA MIDAS<sup>®</sup> data, reflecting estimates of real-world activity. Copyright IQVIA. All rights reserved.

CO<sub>2</sub>e carbon dioxide equivalent, GHG greenhouse gas, *per capita* per 10,000 persons/year, SABA short-acting  $\beta_2$ -agonist, UAE United Arab Emirates

**Supplementary Fig. S3** Per capita SABA and controller medication use and associated GHG emissions based on the IQVIA MIDAS sales data\* stratified by gross national income<sup>†</sup>.



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<sup>†</sup>Gross national income per capita based on the 2020 World Bank classifications [8]: LMIC, 1046 USD–4095 USD; UMIC, 4096 USD–12,695 USD; HIC, >12,695 USD.

*CO<sub>2e</sub>* carbon dioxide equivalent, *GHG* greenhouse gas, *per capita* per 10,000 persons/year, *HIC* high-income country, *LMIC* lower-middle-income country, *SABA* short-acting  $\beta_2$ -agonist, *UAE* United Arab Emirates, *UMIC* upper-middle-income country, *USD* United States Dollar



## SUPPLEMENTARY TABLES

**Supplementary Table S1** Estimates of GHG emissions associated with medication use

<b>Drug</b>	<b>Drug class</b>	<b>Device</b>	<b>Minimum carbon footprint of device (kg CO<sub>2</sub> eq/device)</b>	<b>Maximum carbon footprint of device (kg CO<sub>2</sub> eq/device)</b>	<b>References</b>
Beclomethasone dipropionate	ICS	pMDI	12.4	19.6	[9-12]
Beclomethasone dipropionate	ICS	DPI	0.4	0.8	[9,11,12]
Ciclesonide	ICS	pMDI	8.4	12.6	[10]
Fluticasone propionate	ICS	pMDI	17.9	19.3	[9,10]
Fluticasone propionate	ICS	DPI	0.5	0.9	[9,12,13]
Mometasone furoate	ICS	pMDI	47.9	47.9	[10]
Mometasone furoate	ICS	DPI	0.4	0.8	[14]
Beclomethasone dipropionate/formoterol fumarate dihydrate	ICS/LABA	pMDI	11.3	16.0	[10,11]
Beclomethasone dipropionate/formoterol fumarate dihydrate	ICS/LABA	DPI	0.5	0.9	[11,12]
Budesonide/formoterol fumarate dihydrate	ICS/LABA	pMDI	22.1	37.6	[10,15]
Budesonide/formoterol fumarate dihydrate	ICS/LABA	DPI	0.3	1.0	[15]
Fluticasone propionate/salmeterol xinafoate	ICS/LABA	pMDI	17.9	19.5	[9,10]
Fluticasone propionate/salmeterol xinafoate	ICS/LABA	DPI	0.9	0.9	[9]
Fluticasone furoate/vilanterol trifenate/umeclidinium bromide	ICS/LABA/LAMA	DPI	0.8	0.8	[9]
Formoterol fumarate dihydrate/mometasone furoate	ICS/LABA	pMDI	32.4	47.9	[10]
Formoterol fumarate dihydrate	LABA	pMDI	12.0	12.0	[10]
Formoterol fumarate dihydrate	LABA	DPI	0.3	0.8	[12,13,15]
Salmeterol xinafoate	LABA	pMDI	12.6	26.9	[9,10]
Salmeterol xinafoate	LABA	DPI	0.6	0.9	[9]
Acclidinium bromide	LAMA	DPI	0.7	1.5	[15]
Glycopyrronium bromide	LAMA	DPI	0.7	0.8	[13,15]
Umeclidinium bromide	LAMA	DPI	0.7	0.9	[9]
Acclidinium bromide/formoterol fumarate dihydrate	LABA/LAMA	DPI	0.7	1.5	[15]
Indacaterol maleate/glycopyrronium bromide	LABA/LAMA	DPI	0.4	0.8	[13]
Olodaterol hydrochloride/tiotropium bromide	LABA/LAMA	pMDI	16.3	16.3	[10,14]
Vilanterol trifenate/umeclidinium bromide	LABA/LAMA	DPI	0.8	0.9	[9]
Formoterol fumarate dihydrate/glycopyrronium bromide	LABA/LAMA	pMDI	8.4	15.3	[15]
Salbutamol sulphate	SABA	pMDI	8.9	28.0	[9,10,16]

<b>Drug</b>	<b>Drug class</b>	<b>Device</b>	<b>Minimum carbon footprint of device (kg CO<sub>2</sub> eq/device)</b>	<b>Maximum carbon footprint of device (kg CO<sub>2</sub> eq/device)</b>	<b>References</b>
Salbutamol sulphate	SABA	DPI	0.6	0.8	[9,12]
Terbutaline sulphate	SABA	DPI	0.5	0.7	[15]
Ipratropium bromide	SAMA	pMDI	15.6	18.4	[10]

*CO<sub>2</sub>e* carbon dioxide equivalent, *DPI* dry powder inhaler, *GHG* greenhouse gas, *ICS* inhaled corticosteroids, *LABA* long-acting  $\beta_2$ -agonist, *LAMA*

long-acting muscarinic antagonist, *pMDI* pressurised metered-dose inhaler, *SABA* short-acting  $\beta_2$ -agonist, *SAMA* short-acting muscarinic antagonist

**Supplementary Table S2** Estimates of GHG emissions associated with pMDIs based on IPCC AR5 [2] by countries included in the analyses performed using IQVIA\* data and asthma medication class

	<b>ICS (tonnes CO<sub>2</sub>e)</b>	<b>ICS/LABA (tonnes CO<sub>2</sub>e)</b>	<b>ICS/LAMA/LABA (tonnes CO<sub>2</sub>e)</b>	<b>LABA (tonnes CO<sub>2</sub>e)</b>	<b>LAMA (tonnes CO<sub>2</sub>e)</b>	<b>LABA/LAMA (tonnes CO<sub>2</sub>e)</b>	<b>SABA (tonnes CO<sub>2</sub>e)</b>
Algeria retail	39,980	3007	0	0	0	0	155,444
Argentina retail	11,650	34,135	0	0	0	0	86,215
Australia combined	12,978	58,907	0	0	0	0	354,648
Brazil combined	100,865	30,553	0	0	0	0	461,158
Central America retail	1875	2338	0	0	0	0	16,633
Chile retail	3901	6790	0	53	0	0	42,495
China hospital	18,944	1752	0	0	0	0	73,250
Colombia retail	4407	1110	0	0	0	0	68,172
Egypt retail	5865	26,473	0	453	0	0	83,921
Hong Kong combined	5949	9079	0	34	0	0	48,747
India combined	32,540	305,274	0	36	22,030	8099	321,434
Japan combined	14,461	100,111	119	0	0	7	54,449
Kazakhstan combined	1928	3155	0	0	0	0	22,026
Malaysia combined	21,832	3609	0	0	0	0	75,690
Mexico combined	3485	14,500	242	9	0	0	54,560
New Zealand retail	7914	10,098	0	350	0	0	57,802
Peru retail	1064	2027	0	0	0	0	8389
Philippines combined	431	23,077	0	0	0	0	22,213
Russia combined	26,887	23,197	0	851	0	0	259,474
Saudi Arabia retail	2386	6985	0	0	0	0	68,443

	<b>ICS (tonnes CO<sub>2e</sub>)</b>	<b>ICS/LABA (tonnes CO<sub>2e</sub>)</b>	<b>ICS/LAMA/LABA (tonnes CO<sub>2e</sub>)</b>	<b>LABA (tonnes CO<sub>2e</sub>)</b>	<b>LAMA (tonnes CO<sub>2e</sub>)</b>	<b>LABA/LAMA (tonnes CO<sub>2e</sub>)</b>	<b>SABA (tonnes CO<sub>2e</sub>)</b>
Singapore combined	1008	3211	0	0	0	0	6425
South Africa total market	6202	8186	0	306	0	0	102,166
South Korea combined	824	11,557	0	0	0	0	23,915
Taiwan hospital	1064	9852	0	0	0	0	8316
Thailand hospital	18,015	20,335	0	19	0	0	23,718
Turkey retail	10,039	25,958	25	4	0	0	195,558
UAE retail	611	2529	0	0	0	0	9068
Vietnam combined	810	10,339	0	0	0	0	23,987

*CO<sub>2e</sub>* carbon dioxide equivalent, *GHG* greenhouse gas, *ICS* inhaled corticosteroids, *IPCC AR5* Intergovernmental Panel on Climate Change Fifth Assessment Report, *LABA* long-acting  $\beta_2$ -agonist, *LAMA* long-acting muscarinic antagonist, *pMDI* pressurised metered-dose inhaler, *SABA* short-acting  $\beta_2$ -agonist, *UAE* United Arab Emirates

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**Supplementary Table S3** Estimates of GHG emissions associated with DPIs based on published LCA estimates [10,11,17] by countries included in the analyses performed using IQVIA\* data and asthma medication class

	<b>ICS (tonnes CO<sub>2</sub>e)</b>	<b>ICS/LABA (tonnes CO<sub>2</sub>e)</b>	<b>ICS/LABA/LAMA (tonnes CO<sub>2</sub>e)</b>	<b>LABA (tonnes CO<sub>2</sub>e)</b>	<b>LAMA (tonnes CO<sub>2</sub>e)</b>	<b>LABA/LAMA (tonnes CO<sub>2</sub>e)</b>	<b>SABA (tonnes CO<sub>2</sub>e)</b>
Algeria retail	136	1870	0	246	252	0	20
Argentina retail	54	2015	2	45	140	62	0
Australia combined	437	3797	129	97	607	214	466
Brazil combined	469	9296	0	506	115	145	0
Central America retail	18	119	0	36	7	9	0
Chile retail	3	130	0	0	3	14	0
China hospital	58	9807	0	86	1631	3	12
Colombia retail	0	74	0	4	11	15	0
Egypt retail	1051	1140	0	976	49	30	114
Hong Kong combined	16	155	0	3	23	29	22
India combined	858	33,754	0	95	908	710	8234
Japan combined	2623	13,753	71	422	431	663	215
Kazakhstan combined	7	477	0	18	0	0	0
Malaysia combined	12	748	0	2	16	16	7
Mexico combined	408	897	15	13	524	131	0
New Zealand retail	121	1090	0	12	106	30	184
Philippines combined	26	1456	0	12	49	142	882
Russia combined	276	6795	0	263	241	45	0
Saudi Arabia retail	11	833	0	0	18	7	0
Singapore combined	25	199	0	0	8	15	1
South Africa total market	96	1231	0	15	53	12	16
South Korea combined	63	1525	0	14	152	214	1
Taiwan hospital	15	576	0	8	21	109	0

	<b>ICS (tonnes CO<sub>2</sub>e)</b>	<b>ICS/LABA (tonnes CO<sub>2</sub>e)</b>	<b>ICS/LABA/LAMA (tonnes CO<sub>2</sub>e)</b>	<b>LABA (tonnes CO<sub>2</sub>e)</b>	<b>LAMA (tonnes CO<sub>2</sub>e)</b>	<b>LABA/LAMA (tonnes CO<sub>2</sub>e)</b>	<b>SABA (tonnes CO<sub>2</sub>e)</b>
Thailand hospital	29	1446	0	4	104	3	26
Turkey retail	465	11,750	3	203	2148	249	0
UAE retail	14	294	0	1	4	1	5
Vietnam combined	0	540	0	3	0	15	NA

*CO<sub>2</sub>e* carbon dioxide equivalent, *DPI* dry powder inhaler, *GHG* greenhouse gas, *ICS* inhaled corticosteroids, *LABA* long-acting  $\beta_2$ -agonist, *LAMA* long-acting muscarinic antagonist, *LCA* life cycle assessment, *SABA* short-acting  $\beta_2$ -agonist, *UAE* United Arab Emirates

\*Based on internal analysis by the authors using IQVIA MIDAS<sup>®</sup> data, reflecting estimates of real-world activity. Copyright IQVIA. All rights reserved

**Supplementary Table S4** Number of SABA prescriptions given to patients overusing SABA and associated GHG emissions based on prescription claims data in patients with asthma from the SABINA III cohort<sup>†</sup> [1] stratified by GINA treatment step, region and gross national income

	Number of SABA prescriptions in patients overusing SABA, n		Total GHG emissions from SABA overuse*, tonnes CO <sub>2</sub> e	
	SABA with OTC	SABA without OTC	SABA with OTC	SABA without OTC
Total (N=8351)	35,867	31,018	723	611
<b>GINA treatment step</b>				
GINA steps 1–2 (n=1958)	10,557	9172	217	184
GINA steps 3–5 (n=6388)	25,308	21,846	507	428
<b>Geographical region</b>				
Africa (n=1778)	10,109	8054	214	166
Latin America (n=1096)	5672	5098	122	108
Middle East (n=1389)	7023	6285	150	132
Asia Pacific (n=4088)	13,064	11,581	240	208
<b>Gross national income<sup>‡</sup></b>				
HICs (n=2336)	10,492	9481	224	202
UMICs (n=3764)	17,512	15,476	353	303
LMICs (n=2251)	7864	6061	144	105

CO<sub>2</sub>e carbon dioxide equivalent, GHG greenhouse gas, GINA Global Initiative for Asthma, HIC high-income country, LMIC lower-middle-income country, OTC over-the-counter, SABA short-acting  $\beta_2$ -agonist, SABINA SABA use IN Asthma, UMIC upper-middle-income country, USD United States Dollar

\*SABA overuse is defined as use of  $\geq 3$  SABA canisters/year. Inhaler prescription data were used as surrogates for actual use

<sup>†</sup>Based on internal analysis by the authors using data from the SABINA III cohort

<sup>‡</sup>Gross national income per capita based on the 2020 World Bank classifications [8]: LMIC, 1046 USD–4095 USD; UMIC, 4096 USD–12,695 USD; HIC, >12,695 USD





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