Table S1: Full electronic search strategy employed in the literature retrieval

Database		Search Strategy and Keywords Used	Studies Retrieved
Embase via OvidSP (1947 – present)	1	(inhaler and misuse and asthma).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading]	Melani et al. (5) Giraud and Roche (4) Sestini et al. (23) Molimard et al. (19)
	2	(comparison and inhaler and instruction).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading]	Dahl et al. (28) Rootmensen et al. (22)
	3	(inhalation and technique and adult and asthma).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading]	Van Beerendonk et al. (21)
Medline via OvidSP (1946 – present)	1	(inhal* and technique and elderly).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	Armitage and Williams (26) Horsley and Bailie (27)
	2	(inhaler and factors and technique and asthma).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	Sadowski et al. (25) Wieshammer and Dreyhaupt (24) Sestini et al. (23)
PubMed	1	("nebulizers and vaporizers"[MeSH Terms] OR ("nebulizers"[All Fields] AND "vaporizers"[All Fields]) OR "nebulizers and vaporizers"[All Fields] OR "inhaler"[All Fields]) AND ("education"[Subheading] OR "education"[All Fields] OR "training"[All Fields] OR "education"[MeSH Terms] OR "training"[All Fields]) AND ("Differences"[Journal] OR "differences"[All Fields]) AND ("aged"[MeSH Terms] OR "aged"[All Fields] OR "elderly"[All Fields]) AND ("adult"[MeSH Terms] OR "adult"[All Fields] OR "adults"[All Fields])	Epstein et al. (20) Molimard et al. (19)
	2	predictors[All Fields] AND ("inhalation"[MeSH Terms] OR "inhalation"[All Fields]) AND technique[All Fields] AND ("asthma"[MeSH Terms] OR "asthma"[All Fields])	Rootmensen et al. (22)
	3	("inhalation"[MeSH Terms] OR "inhalation"[All Fields]) AND technique[All Fields] AND ("Assessment"[Journal] OR "assessment"[All Fields]) AND ("adult"[MeSH Terms] OR "adult"[All Fields] OR "adults"[All Fields]) AND ("asthma"[MeSH Terms] OR "asthma"[All Fields]) AND ("pulmonary disease, chronic obstructive"[MeSH Terms] OR ("pulmonary"[All Fields] AND "disease"[All Fields] AND "chronic"[All Fields] AND "obstructive"[All Fields]) OR "chronic obstructive pulmonary disease"[All Fields] OR "copd"[All Fields])	van Beerendonk et al. (21)
	4	influence[All Fields] AND ("Age"[Journal] OR "age"[All Fields] OR "Age (Omaha)"[Journal] OR "age"[All Fields] OR "Age (Dordr)"[Journal] OR "age"[All Fields] OR "Adv Genet Eng"[Journal] OR "age"[All Fields]) AND ("nebulizers and vaporizers"[MeSH Terms] OR ("nebulizers"[All Fields] AND "vaporizers"[All Fields]) OR "nebulizers and vaporizers"[All Fields] OR "inhaler"[All Fields])	Goodman et al. (7)

Table S2: Characteristics of studies included in the systematic review

Study	Sample Size		Inhaler Device	Recruitment/Examination Site	Study Duration	Study Design	Interventions	Main Outcome Measures and Findings	
Armitage and Williams (26)	< 65 years:	225	MDI	Patients attending a Chest Clinic	18 months	Comparative cohort study	Assessment of inhaler technique by a respiratory technician at each visit to Chest Clinic	Number of Patients with Correct Technique	Significant elevation in older adults (p<0.01 (95% CI 5-28%))
	≥ 65 years:	101						Number of patients unable to be trained in correct MDI use	Significant elevation in older patients (p<0001, 95% CI 8-26%)
								Differences in the types of errors made with age	Variations in rankings of errors most frequently distributed and level of statistical significance
Horsley and Bailie (27)	86 patients (range: 17-83 years)		MDI	Patients attending the thoracic medicine out-patient clinic; in-patients at Hope Hospital	Unspecified	Cross-sectional community intervention – training as required.	Inhaler technique assessed at baseline according to standardised. Patients with imperfect technique instructed on correct procedure. Technique immediately reassessed according to the same criteria. Statistical significance of risk factors assessed by the Spearman correlation coefficient and effect of instruction assessed by Wilcoxon's matched pairs signed ranks test.	Number of errors	Significant negative correlation between age and performance score (p=0.019)
								Types of errors	Non-significant trends towards older patients who failed to assemble the MDI correctly (p-0.059), and who failed to activate the MDI during inhalation (p= 0.056)

Giraud and Roche (4)	3995	MDI	Adult asthmatics visiting their GP, who had been treated for at least 3 months by regular ICS (500-1500mcg/day) and on-demand SAβ$_2$A administered by MDI without holding chamber. Patients must not have received concomitant treatment within the previous 3 months with LAβ$_2$As, long-term oral corticosteroids,β-blockers, and theophylline.	Unspecified	Observational cross-sectional study.	Inhalation technique was assessed and rated by the GP according to seven omissions and five errors. Patients were classed as 'misusers' if at least one error or omission was made.	Number of Errors vs Age	Significant association identified, with error rates equivalent to 61.0% between 15-30 years, 70.0% between 30-60 years, 77.2% between 60-75 years, and 85.9% in patients > 75 years (p<0.00001).
Molimard et al. (19)	3811	Aerolizer Autohaler Diskus pMDI Turbuhaler	575 GPs randomly selected based on their postal code number agreed to participate in a study assessing the handling by patients of their usual inhaler.	1 February 2002- 14 July 2002.	Observational cross-sectional study.	Consecutive patients were requested to take a puff of their usual inhaler with their usual inhalation technique, which was observed and rated by the GP via reference to a specific standardised checklist.	Number of Errors vs Age	The frequency of critical errors increased with age for all devices.
Epstein et al. (20)	130 subjects 18-83 years of age (mean age 53.9 years): ≤ 55 years (n=61) ≥ 56 years (n=69).	Pressurised aerosol inhalers.	All English-speaking individuals presenting for routine studies to the pulmonary function laboratory of Toronto Western Hospital during the study period.	July 1976 – September 1977.	Single-blinded (patient) observational cross-sectional study.	Participants were given a capped inhaler with the canister in place. Without being given specific instructions or notified of their assessment, their technique was observed by one of two trained pulmonary technologists. A check list was used to record whether 11 standard manoeuvers were correctly demonstrated. The percentage of correct manoeuvers was	Number of errors *(performance score)* vs Age	No significant difference in the mean number of errors with age. Performance score (manouevers performed correctly, out of 11) ≤ 55 years: 7.3 ± 2.8; ≥ 56 years: 7.3 ± 2.4 (p=0.94)

								analysed by the chi-square method. .		
De Blaquiere et al. (29)	163 patients; 24-87 years of age.	Metered dose inhaler	Consecutive outpatients in the General Medical and Pulmonary Clinics of the Seattle Veterans Administration Medical Centre by prospective chart review according to the following criteria: - Currently using MDI bronchodilator(s) - Free of recent exacerbation of asthma or chronic airflow obstruction. - Not blind or deaf - Living in the greater King County area - Not requiring special transportation to the centre - Medically stable at the time of their appointment.	5 month period	Controlled randomized trial – cohort study. All patients were retested 6-10 weeks after the first teaching session, by the same investigator, using the same procedure used at the initial screening.	Patients were asked to demonstrate use of their MDI three times. Results were evaluated by 2 members of the study team, as per a set protocol. Those with incorrect technique were randomised in blocks of 20 to 1 of 2 teaching groups. After training, patients were tested for correct use. Incorrect users were advised of the incorrect steps. All patients were retested 6-10 weeks after the first teaching session by the same investigator, using the same procured used at the initial screening. Differences with respect to continuous variables were tested using Student's t-test and analysis of variance.	Number of errors vs Age	Correct and incorrect users did not differ with respect to age. Mean age of: Correct users: 63.0 ± 8.7 Incorrect users: 60.3 ± 10.9 (p>0.05)

Goodman et al. (7)	59 (age 20-81 years, mean age 38 years).	MDI		Subjects were recruited from a population of patients with established asthma or COPD scheduled by their physicians to have pulmonary function tests with pre- and post-broncho-dilatory assessments. Patients with a history of regular therapeutic MDI use for greater than 1 year were approached about enrolment into the study.	Unspecified	Observational cross-sectional study.	Patients were asked to demonstrate their normal technique by the investigators. During the process, data were collected by a microcomputer system. Manoeuvers were defined as acceptable if inspiratory flow at actuation was between 25-90L/min, actuation occurred during early inspiration, adequate breath-holding time was displayed, and deep inhalation occurred. Tests of statistical significance were performed using two-tailed, two-sample t-tests for independent samples on continuous variables.	Number of errors vs Age	No sig. difference in the number of errors with age between patients < 25 years, 25-39 years, 40-54 years, and ≥ 55 years.
Van Beerendonk (21)	316 patients of mean age 61.83 years (SD=14.56). 20-61: n=147 62-90: n=169	MDI, Turbuhaler, Diskhaler, Rotahaler, Spihaler, Ingelheim Inhaler, Cyclohaler.		Patients with asthma or COPD 18 years and older, who attended Pulmonary Outpatients Department No. 2 of the St Joseph Hospital in Veldhoven, the Netherlands, during the study period.	November 1995-January 1996.	Observational cross-sectional study.	Inhaler technique was assessed for one inhaler. Assessments were made using the standardized inhaler checklist published by the Dutch Asthma Foundation. The various steps of correct usage were checked point by point for the MDIs and DPIs.	Number of Errors vs Age	There was a statistically significant difference in the mean number of errors with age. 20-61 years: mean = 2.73 (SD 1.62) 62-90: mean= 2.16 (SD 1.55) . [t(314) = -3.15, p<0.01]

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						The research or Dr's assistant scored whether the patient demonstrated the step correctly. SPSS was used to calculate the number and percentages of mistakes per inhaler, according to age, using analysis of variance (ANOVA) and t-tests.		
Rootmensen et al. (22)	156 patients at least 18 years of age (mean age 61 years, SD=14)	Diskus/Accuhaler, Dskhaler, Turbuhaler, Cyclohaler/Ingelhei inhaler, DPI, MDI ± spacer	Patients were recruited from a clinical randomised trial investigating the effect of nursing care added to regular care by a pulmonary physician in an outpatient clinic in the Netherlands. All patients were older than 18 years and diagnosed in accordance with GINA and ERS criteria for asthma and COPD respectively.	Unspecified	Observational, cross-sectional study.	A checklist measuring the steps required for adequate drug delivery, was developed by the investigators, defining essential steps for each device. The presentation of one or more errors regarding these essential steps led to a classification of an incorrect technique. Chi-square statistics were used to investigate univariate associations between patient characteristics and inhalation technique. Determinants of an incorrect inhalation technique were entered into a multivariate logistic regression model. Effect sizes were	Number of Errors vs Age	Age < 60: 31% incorrect Age ≥ 60: 47% incorrect.p=0.05 Univariate analysis of the determinants showed statistically significant associations of incorrect inhalation technique for older age.

Study	Number of patients	Devices	Recruitment	Duration	Study type	Methods	Outcome measured	Results
						expressed in odds ratios (OR) with their 95% confidence intervals (CIs).		
Dahl et al. (28)	151 patients at least 50 years of age.	Handihaler (HH), MDI	Patients recruited from outpatient clinics at two hospitals and through advertising in local newspapers in Denmark.	4 weeks	Single-blinded trial (patients blinded)	Patients were instructed, trained and assessed on use of HH and MDI at baseline, according to a 12-step checklist assessment for each device, and re-assessed after a period of 4 weeks by the same investigators. The differences in error rates were tested by means of a two-sided Wilcoxon signed rank test at level of significance of 0.05, using the individual differences in the number of errors when using the two devices. Error rates were analysed by a linear model including factors for device, sequence, patient within sequence, period, centre and population.	Number of errors vs Age	For both devices, the incidence of errors increased with age. 43-65 years: 55% HH; 50% MDI 66-71 years: 50% HH, 55% MDI 72-85 years: 55% HH, 63% MDI.
Sestini et al. (23)	1305 (mean age 57.4, range 15-88 years)	MDIs, DPIs (unspecified)	All adult patients who attended one of 18 chest clinics for a scheduled appointment who were using an inhaler regularly.	November 1 2001- March 2002.	Open, observational, cross-sectional study.	Each patient demonstrated their inhalation technique with all used devices to the investigator with a placebo device.	Number of Errors vs Age	Better performance was associated to younger age (adjusted regression coefficient: 0.09 (95% CI -0.24 to 0.00),

								p<0.01.
						All observations of inhaler use were reported in accordance with a checklist for each inhaler based on the package inserts from the manufacturer. For each centre, a single trained observer evaluated the modalities of inhaler use. Factors associated with inhaler use were investigated using a multivariable logistic regression model.		
Wieshammer and Dreyhaupt (24)	224, ages 55.1 ± 20 years (range 6.1-84.5 years)	Aerolizer, Discus, Handihaler, and Turbuhaler	Newly referred outpatients reporting the use of 1 or several of the inhalers.	Unspecified	Observational, cross-sectional study.	Patients were asked to demonstrate their inhaler technique with an empty inhaler once. Technique was assessed by the same observer. The dependence of effective inhalation on age was investigated by logistic regression analysis.	Number of errors vs Age.	The error rate increased with age (p<0.01) for all devices analysed as whole, even after adjustment for severity of obstruction and type of training (p<0.05). Subgroup analyses showed a correlation between increased age (>60 years vs <60 years), and increased error rate with Discus (5.3 vs 43.8%, p<0.01, OR 0.07, 95% CI 0.02-0.33), and Turbuhaler (25.4 vs 46.0%, p<0.05, OR 0.40, 95% CI 0.18-0.90).

Melani et al. (5)	1664 (mean age 62 years)	MDI, Aerolizer, DIskus, Handihaler, and Turbuhaler	Outpatients attending one of 24 chest clinics throughout Italy, located at different latitudes and including highly urbanised as well as rural areas.	July-September 2008,	Observational, cross-sectional study.	Each patient demonstrated inhalation technique with all used devices using a placebo device. A single trained investigator evaluated the modalities of inhaler use; to standardise their findings, periodic meetings were held with all the participating observers. All observations of inhaler use were reported in accordance to a standardised device checklist. Statistical analysis was performed using generalised linear models (Stata 9), with Gaussian or binomial/logit tally.	Number of errors vs Age	After adjusting for different device, the risk of critical errors increased with age (OR 1.2 ±0.01, p=0.008).
Sadowksi et al. (25)	161 (mean age 56.90 years ± 18.59).	Handihaler, pMDI ± spacer, Turbuhaler, Diskus.	Patients attending eight study sites throughout northern Alberta, including 2 family medicine clinics, 2 specialty pulmonary clinics, and 4 community pharmacies in urban and rural settings.	2011-2013	Observational, cross-sectional study.	Participants were asked to demonstrate the technique of their specific device. For each step listed in the instructions for a particular device, research assistants recorded if the patient completed the step based on clinical observation. Checklists were compiled from	Number of errors vs Age.	Age was not identified as a significant predictor.

					educational resources provided by the bodies preparing national guidelines, as well as the COPD and Asthma Network of Alberta. These data were used to calculate effective use scores for each device using a scoring procedure.		