Medication beliefs, adherence, and outcomes in people with asthma: The importance of treatment beliefs in understanding inhaled corticosteroid nonadherence—a retrospective analysis of a real-world data set

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Background: Poor adherence to inhaled corticosteroids (ICSs) increases asthma morbidity and mortality and is influenced by patients' treatment beliefs. This study maps patients' beliefs about ICSs across 6 countries examining variations in beliefs, and their relationship with adherence and outcomes.

Objective: We sought to explore the relationship between patient treatment beliefs, and adherence and outcomes in asthma across 6 countries.

Methods: Patients 18 years or older with asthma, receiving ICS alone or in combination with a long-acting β2-agonist, were included from a point-in-time paper survey of patients with asthma in Europe and the United States. Clinical characteristics, such as adherence and asthma control, were collected by self- and physician-report. Patients completed the Beliefs about Medicines Questionnaire, adapted for ICSs. Relationships between patient treatment beliefs, adherence, and outcomes were examined using regression analyses.

Results: Data from 1312 patients were analyzed. Patients were from Germany (24%), the United States (21%), France (21%), Spain (16%), Italy (10%), and the United Kingdom (9%). Most had physician-reported mild-intermittent asthma (87%), and mean age was 40 ± 15.5 years. There was considerable variation in necessity beliefs between countries, with respondents in Italy having more doubts about treatment necessity and respondents in Spain showing higher concerns. Patients with doubts about ICS necessity and high concerns had lower self-reported (necessity: $\chi^2(2) = 34.31$, $P < .001$; concerns: $\chi^2(2) = 20.98$, $P < .001$) and physician-reported adherence (necessity: $\chi^2(2) = 11.70$, $P = .003$; concerns: $\chi^2(2) = 34.45$, $P < .001$). Patients with high necessity beliefs ($F(2, 483) = 3.33$; $P = .037$) and high concerns ($F(2,483) = 23.46$; $P < .001$) reported poorer control. Physician estimates of adherence did not correlate well with patient self-report ($\rho = 0.178$, $P < .001$).

Conclusions: ICS necessity beliefs and concerns were associated with adherence and asthma control. This has implications for the design of adherence interventions. (J Allergy Clin Immunol Global 2023;2:51-60.)

Key words: *Asthma, beliefs, adherence, control, real-world data*

Asthma is one of the most common long-term conditions in the world, affecting 339 million people globally.[1,2] Despite the availability of effective management options, such as the availability of inhaled corticosteroids (ICSs), asthma control remains poor for a significant number of people.[1] A key factor contributing to poor control is suboptimal treatment adherence, which is associated with increased asthma exacerbations, hospitalizations, and death.[3,4] Average ICS adherence rates reported in the literature range from 30% to 70%,[5,6] and adherence has frequently been declared a priority that should be promoted by both health professionals and patients to improve asthma management.[7,8] In

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Abbreviations used
ACT: Asthma Control Test
ICS: Inhaled corticosteroid

the United Kingdom, the National Review of Asthma Deaths reported that two-thirds of asthma deaths in the UK sample could have been prevented, with inadequate medication use resulting from poor medication adherence as a key contributing yet avoidable factor for asthma deaths.[9]

The reasons for poor medication adherence are complex[10] and vary both within and between individuals over time.[11] The National Institute for Health and Care Excellence (NICE) medicine adherence guidelines recommend approaching variations in adherence from the patient perspective by understanding the influence of adherence determinants on patient motivation and ability.[8,11-13] Both motivation and ability can be driven by intentional and unintentional processes.[14] A key factor influencing motivation to adhere is patients' beliefs about treatment. A recent meta-analysis of 94 peer-reviewed studies across 18 countries and 24 long-term conditions including asthma showed that nonadherence is strongly related to patients' personal beliefs about treatment, in particular doubts about personal need for the treatment and concerns about potential harm.[15]

Beliefs about the treatment are associated and influenced by beliefs about the disease. One study of inner-city mostly non-White patients with asthma found that due to the often asymptomatic nature of asthma, more than half incorrectly think that their asthma is present only when they have acute exacerbations.[16] This can decrease an individual's perceived personal need for maintenance asthma treatment, leading to poor adherence to regular ICSs.[17] Concerns about medication, such as about side effects and long-term effects, also contribute to poor adherence in asthma.[18] To improve ICS adherence, it is therefore important to understand patients' treatment beliefs and attitudes toward their medication. Previous studies have identified that different attitudinal subgroups exist in people with asthma, based on their treatment beliefs and illness perceptions, each with different levels of adherence.[19,20] The findings from a study that explored illness beliefs and adherence found that illness beliefs do not add to the identification of low adherers. Regardless of illness beliefs, the accepting cluster (high necessity beliefs, low concerns) displayed high percentages of adherent patients with asthma, whereas the remaining 3 subgroups revealed large numbers of low adherers.[21]

This is the first study to provide an extensive profile of the distribution of necessity beliefs and concerns about ICSs in a large, real-world sample of patients with asthma. The article aims to provide data on the pattern of medication beliefs in the population and their association with adherence and asthma outcomes. Because of the size of the data set, with patients from 5 Western European countries and the United States, we also explored the differences in belief patterns between countries.

METHODS

Survey design

This study used the Asthma Disease-Specific Programme, a point-in-time paper survey conducted on a near-yearly basis by Adelphi Real World that collects information from physicians and their patients with asthma who are presenting for routine care. A full description of Asthma Disease-Specific Programme survey methods has previously been published.[22] The survey was conducted as a market research survey adhering to the International Chamber of Commerce/European Society for Opinion and Marketing Research (ICC/ESOMAR) international code on market and social research. Ethical approval was not sought and is not necessary as laid out by the code of conduct.[23] Before volunteering to complete a questionnaire, patients were asked to provide informed consent. The program instructions describe the purpose of the survey, why the respondent had been selected, and who might have access to the aggregated and anonymized data set compiled.

Data collection

Data collection took place across Europe (in Germany, France, Spain, Italy, and the United Kingdom) and the United States. The eligible physician sample was based on qualifying physicians agreeing to participate in the survey after being contacted randomly from public lists of health care professionals based on quotas set by specialty and geographical spread. Physicians had to have completed their medical training in the past 5 to 35 years, were personally responsible for treating patients with asthma, and saw 3 or more patients with asthma per month. Physicians completed patient forms on their next 6 consecutive patients aged 12 years or older with a confirmed diagnosis of asthma, regardless of the reason for their visit.

Physicians invited qualifying patients to complete a patient self-completion form that was independently completed by consenting patients. Both physicians and patients were assigned unique identification numbers that allowed linkage of physician- and patient-completed forms. Local research agency partners of Adelphi Real World were responsible for data collection.

Patient information collected

The physician and patient questionnaires collected detailed information on demographic and clinical characteristics, including, but not limited to, symptoms, exacerbations, comorbidities, health care resource utilization, asthma control, comorbidities, and adherence from a physician and patient perspective. The patient- completed form also included an asthma-specific version of the validated Beliefs about Medicines Questionnaire,[24] which included 5 treatment necessity and 6 treatment concern-related statements (Table I). Each country received its own previously validated translated version of the Beliefs about Medicines Questionnaire in its local language. Patients rated the extent to which they agreed or disagreed with a statement on a 5-point Likert scale, with higher scores indicating higher necessity and higher concerns on each respective subscale. Internal consistency measured by Cronbach alpha was good for both Necessity and Concerns scales ($\alpha = 0.81$ and $\alpha = 0.82$, respectively).

Treatment adherence data were collected on a 5-point scale in relation to the question "Now please think of your preventer or controller inhaler, how often do you use this medication per week?" (response options: never, only when I feel I need to, 1 or 2 days a week, 3 or 4 days a week, 5 or 6 days a week, everyday). Physician report of adherence was collected on a 5-point Likert scale from "not at all adherent" to "completely adherent." Similarly, asthma control was measured in patients using the Asthma Control Test (ACT),[25] and by physician-report scored on a 3-point scale as controlled, partly controlled, or uncontrolled. Completion of the physician and patient forms took approximately 15 to 20 minutes per patient, and physicians were financially compensated for survey participation at fair market rates. Physicians were not able to see their patients' responses to the questionnaires.

Study population

Patients with asthma who completed a patient self-completion, including the Beliefs about Medicines Questionnaire, and receiving single inhaler maintenance treatment in the form of an ICS or a fixed-dose combination ICS/long-acting β_2-agonist were identified from the data set.

Data analysis

Cross-sectional data were analyzed using STATA 14 (StataCorp, College Station, Tex). Items on each scale were assigned a score ranging from 1 to 5

TABLE I. Characteristics of included patients (n = 1312 overall, n may be <1312 in certain cases due to missing data)

Characteristic	N (%)
Country	1312
Germany	319 (24.3)
France	272 (20.7)
USA	269 (20.5)
Spain	210 (16.0)
Italy	128 (9.8)
UK	114 (8.7)
Ethnicity	1312
White/Caucasian	1159 (88.3)
Hispanic	44 (3.4)
African American	40 (3.0)
Afro-Caribbean	28 (2.1)
Asian—other	22 (1.7)
Other	10 (0.8)
Asian—Indian subcontinent	9 (0.7)
Health provider who recruited the participant	1312
Primary care provider	592 (45.1)
Pulmonologist (or equivalent)	500 (38.1)
Allergist	220 (16.8)
Sex	1311
Male	554 (42.3)
Female	757 (57.7)
Current severity of patients' asthma condition (physician-perception)	1303
Intermittent	534 (41.0)
Mild persistent	594 (45.6)
Moderate persistent	167 (12.8)
Severe persistent	8 (0.6)
ACT scores	1295
5-16 (very poorly controlled asthma)	118 (9.1)
16-19 (not well-controlled asthma)	252 (19.5)
20-25 (well-controlled asthma)	925 (71.4)
Level of control of asthma in past 4 wk (physician-perception)	1304
Controlled	964 (73.9)
Partly controlled	271 (20.8)
Uncontrolled	69 (5.3)

according to the 5-point Likert scale, from Strongly disagree (1) to Strongly agree (5), with scoring for some items that were negatively worded being reversed. Scoring was dichotomized for frequency analyses: 0 = Uncertain/Disagree/Strongly disagree, 1 = Agree/Strongly agree. Necessity and Concerns scores were obtained by averaging the scores of individual items. Descriptive statistics were produced, including means and SDs for numeric variables and frequencies (%) for categorical variables. Statistical comparisons for outcomes between categorized Necessity and/or Concerns groups were conducted using standard statistical tests: Mann-Whitney/Kruskal-Wallis test for numeric variables such as Necessity and Concerns scores, which are treated as ordinal, and Fisher exact or chi-square test for categorical variables. A Bonferroni adjustment was applied to account for multiple pairwise comparisons between countries though not for analysis over all countries.

Regression analysis was used to determine the relationship between the mean Necessity and Concerns scores, and adherence and asthma control. In addition, models were run that include terms for country, and interaction terms for country with necessity and concerns.

Logistic regression was used for modeling binary outcomes, and linear regression was used for nonbinary outcomes. Restricted cubic spline transformations of the summary scales, with 3 knots each, were used to allow for possible nonlinear relationships, and SEs were adjusted to allow for possible intragroup correlation within reporting physician.

RESULTS

A total of 1312 patients (recruited by 484 physicians) met the inclusion criteria (see Table I). Patients were predominantly from Germany (24%), France (21%), and the United States (21%). Most patients had physician-reported mild-intermittent asthma (87%), and mean age was 40.8 ± 15.3 years with a mean body mass index of 25.7 ± 5.3 kg/m^2. There were no differences in age, sex, body mass index, or asthma severity between those respondents with and without self-completion study data (data not shown).

Descriptive analyses

Treatment beliefs. Overall, perceived personal necessity for ICSs was high, with more than half the patients agreeing to the inhaler protecting them from becoming worse (78%), and their health at present depending on the inhaler (64%). However, only a minority thought that without the ICS inhaler their life would be impossible (37%) (see Fig 1, *A*). More than one-third of patients reported being sometimes worried about long-term effects of their ICSs (40%) and becoming too dependent on their inhaler (36%). More than a quarter of patients reported being generally worried about using ICSs (28%) (see Fig 1, *B*).

Fig 2, *A* and *B*, shows the overall distribution of the 2 subscales—Necessity and Concerns scores. There was considerable variation in necessity beliefs (mean, 3.4 ± 0.8) and concerns (mean, 2.6 ± 0.7). Of the 1312 participants, nearly one-third had (n = 409; 31.2%) reported low necessity (ie, disagreed/strongly disagreed with the necessity scale items). A similar proportion (n = 358; 27.3%) reported high concerns (ie, agreed/strongly agreed with the concerns items).

Analysis according to the belief quadrants or attitudinal groups based on the Necessity and Concerns scores, of the 1312 patients, revealed that more than half the patients (53.1%) displayed suboptimal belief sets; 25.8% were classified as low necessity, low concern (indifferent), 22.0% as high necessity, low concern (ambivalent), and 5.3% showed the most problematic belief set of low necessity, high concern (sceptical; see Fig 3).

Adherence. About half (51%) the patients reported taking ICSs every day, and according to physician-report 43% were fully adherent. Patient and physician adherence estimates showed only a small correlation (spearman = 0.181; $P < .001$).

Asthma control. Physicians reported that nearly three-quarters (73.9%) of the 1304 patients with asthma had "controlled" asthma, with 20.8% and 5.3% reporting "partly controlled" and "uncontrolled asthma," respectively (Table I). In contrast, for patient-reported asthma control, 1295 respondents completed the ACT. Mean score was 21.0 ± 3.7, indicating generally well-controlled asthma.[26]

Associations between beliefs, adherence, and asthma control

Patients scoring high on the necessity scale and low on the concerns scale were consistently associated with the highest level of patient- and physician-reported adherence, whereas those patients scoring low on the necessity scale and high on the concern scale were consistently associated with the lowest level of patient- and physician-reported adherence (Table II). The differences in adherence across the quadrants remained significant when using the full breadth of the scale and when dichotomized

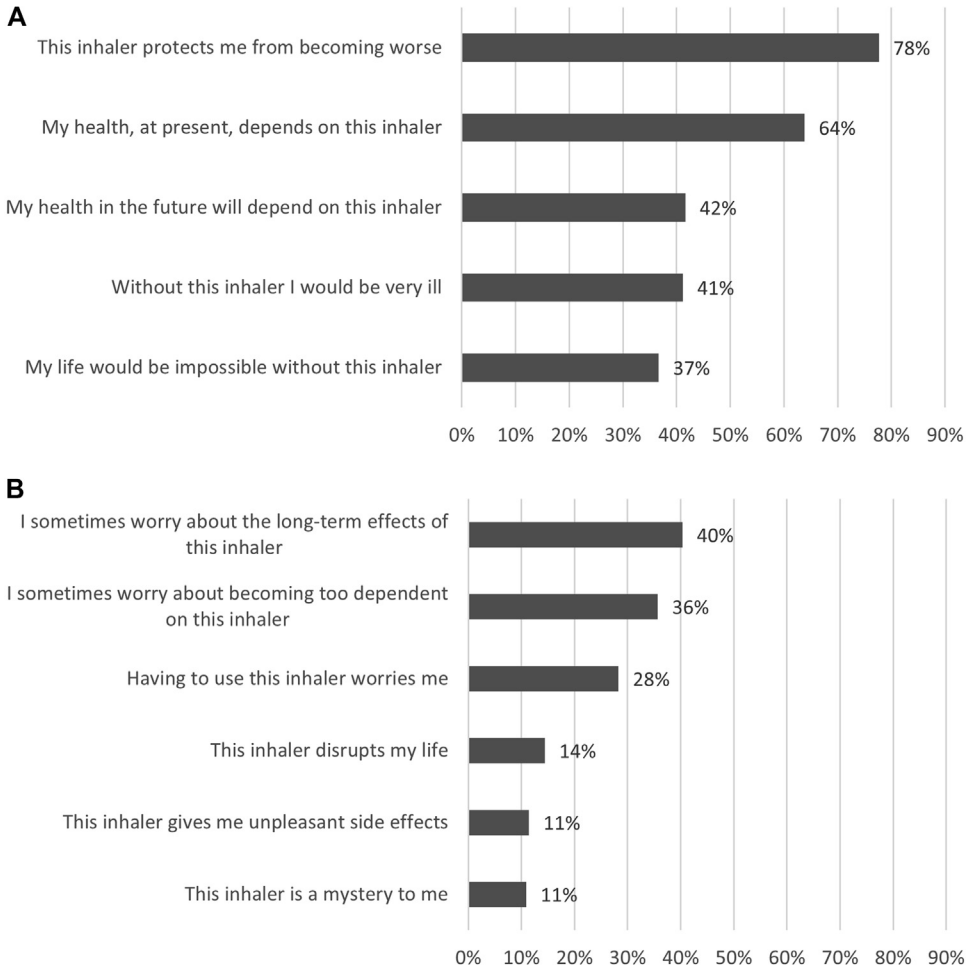

FIG 1. Frequency distribution showing proportion of patients agreeing with (**A**) Necessity items and (**B**) Concern items (N = 1312). *Note:* Scoring dichotomized: 0 = Uncertain/Disagree/Strongly disagree, 1 = Agree/Strongly agree.

into not everyday versus everyday (for patient-reported adherence), and not fully adherent to fully adherent (for physician-reported data). We also included exacerbations as an outcome/dependent variable, but there was no relationship with necessity or concerns (data not shown).

Regression analyses

Fig 4 shows the relationship between beliefs and adherence. Patients with doubts about ICS necessity and high concerns had significantly lower self-reported adherence (necessity: $\chi^2(2) = 43.57$, $P < .001$; concerns: $\chi^2(2) = 22.84$, $P = .002$). A similar relationship was observed with physician-reported adherence (necessity: $\chi^2(2) = 16.55$, $P = .021$; concerns: $\chi^2(2) = 38.19$, $P < .001$); however, as the contour regression plot shows, the relationship between patient- and physician-reported adherence and treatment beliefs differed. Fig 4, *A*, shows more gradual changes, whereas Fig 4, *B*, shows a greater area where lower adherence was expected—so for higher Concerns score, for example, physicians estimated lower adherence compared with patient-reported adherence. Although the nature of the relationships is different, both relationships are significant, with the top left (low Necessity, high Concerns) predicting lower adherence and the bottom right higher adherence (high Necessity, low Concerns).

Significant relationships were found between Necessity and Concerns scores and asthma control, as reported by both patients, via the ACT scores, and physician-reported scores (Fig 5). Patient ACT scores were higher in those with high necessity beliefs ($F(2, 479) = 3.50$; $P = .031$) and high concerns ($F(2, 479) = 22.06$; $P < .001$). Physicians reported poorer asthma control in patients with high concerns ($\chi^2(2) = 21.15$; $P < .001$), but there was no significant relationship with necessity ($\chi^2(2) = 1.24$; $P = .537$).

Higher patient self-reported adherence was associated with higher physician-rated asthma control ($\chi^2(1) = 4.1$; $P = .043$) but not with ACT scores. Comparatively, higher physician-reported adherence significantly predicted higher ACT scores ($F(1, 479) = 36.59$; $P < .0001$) and higher physician-rated control ($\chi^2(1) = 32.18$; $P < .0001$).

Health belief comparisons by demographic characteristics and asthma control

Significant differences in age between each of the attitudinal quadrants existed, with participants with high Necessity beliefs having a higher mean age than those with low Concerns. There

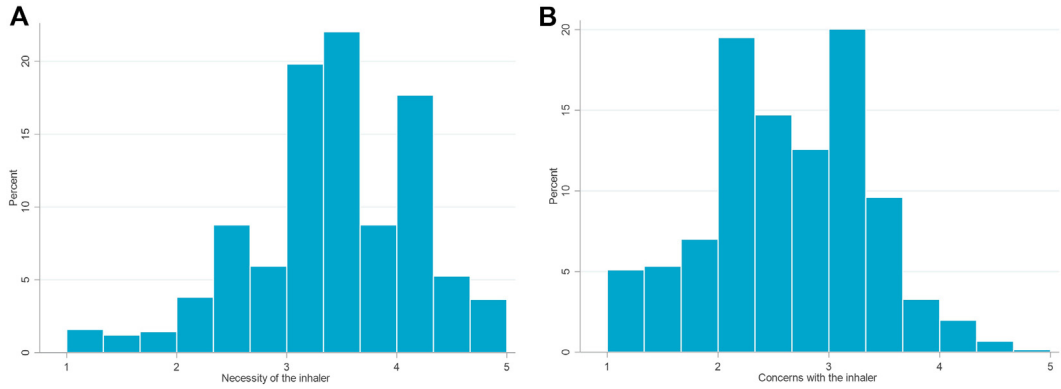

FIG 2. Overall frequency distribution of patient-reported (**A**) Necessity and (**B**) Concerns mean scores (N = 1312). *Note:* Higher scores represent higher necessity beliefs and higher concerns.

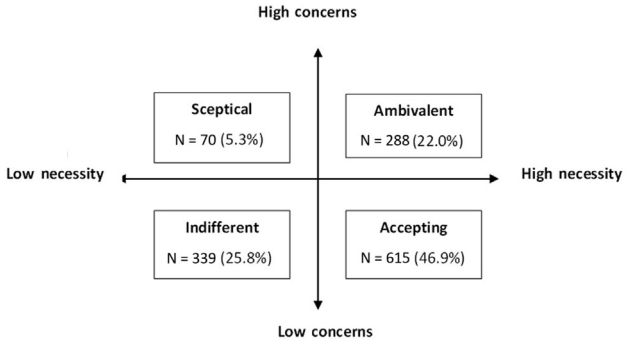

FIG 3. Proportion of patients with asthma allocated to each attitudinal group based on their Necessity and Concerns scores (N = 1312).

was a significant association between beliefs and asthma control ($P < .0001$) (Table III). There were also differences in the distribution of beliefs depending on the country of the respondent, with Germany having the highest proportion of participants reporting high Necessity beliefs, and low Concerns (Table IV), whereas more than a third of respondents (37.5%) within Italy had low Necessity beliefs and low Concerns. Other demographic characteristics were not significantly associated with beliefs.

There were significant differences in individual Necessity and Concerns beliefs between countries; however, median response and interquartile ranges tended to be similar (Table V; see Appendix A1 in this article's Online Repository at www.jaci-global.org). Overall, when comparing country responses for each individual Necessity or Concerns item, respondents in Italy reported significantly more doubts about the Necessity of their inhaler on at least 1 individual item compared with people in Germany (N2: $P = .002$; N3: $P < .001$; N4: $P < .001$), France (N3: $P = .083$; N4: $P < .001$) , the United Kingdom (N4: $P = .047$), and the United States (N3: $P = .007$; N4: $P = .023$). Surprisingly, the belief that the inhaler protects one from becoming worse was doubted more in France than in Italy (N5: $P = .004$).

Respondents in Spain showed significantly higher concerns on several items compared with Germany (C1: $P = .034$; C2: $P = .003$; C3: $P = .028$; C5: $P = .007$; C6: $P < .001$; C7: $P < .001$), Italy (C1: $P < .001$), the United Kingdom (C1: $P < .001$; C2: $P = .033$; C5: $P = .018$), and the United States (C1: $P < .001$; C6: $P < .001$; C7: $P < .001$). Concerns scores in France were significantly higher on the item "this inhaler is a mystery to me" compared with all other countries.

Regression analyses on associations between treatment beliefs and adherence showed few differences between countries (data not shown). Across countries, higher Necessity beliefs and lower Concerns continued to drive higher adherence. Interestingly, in France those with higher Necessity beliefs tended to be less adherent (odds ratio, 0.27; $P = .018$), whereas in Italy and the United States, those with higher concerns were more likely to be fully adherent according to patient self-reported adherence (odds ratio (Italy), 2.03, $P = .044$; odds ratio (US), 2.49, $P = .008$).

There were fewer differences across patients in the care of different physician specialties (primary care physicians, specialists, and allergists). None of the Necessity beliefs showed significant differences between physician specialities, but there were small differences in Concerns, with the items "Having to use this inhaler worries me" ($P = .0135$), "I sometimes worry about the long-term effects of this inhaler" ($P < .0001$), "This inhaler disrupts my life" ($P = .0343$), "I sometimes worry about becoming too dependent on this inhaler" ($P = .0111$), "I am concerned that this inhaler might become less effective if I use it regularly" ($P < .0001$), and "This inhaler gives me unpleasant side effects" ($P = .0032$) being significant (see Appendix A2 in this article's Online Repository at www.jaci-global.org).

Adherence and asthma control comparisons by country

In terms of between-country differences for physician- and patient-reported adherence and asthma control (see Appendix A3 in this article's Online Repository at www.jaci-global.org), patient-reported adherence was much lower in France than elsewhere, with 97% of respondents self-reporting their inhaler use as "not everyday," whereas physician-reported adherence was much higher in Germany and the United States, with more than 50% of respondents reporting full adherence. Overall mean ACT score differed by country, but in all countries the mean indicated well-controlled asthma with the mean score greater than 19, though the United Kingdom had the lowest overall mean ACT score (19.5) and Italy had the highest (21.9). Physician-reported control was highest in Germany, with 84% of respondents indicating "controlled" asthma, though rates in other countries

TABLE II. Measures of patient- and physician-reported adherence by quadrant

Patient-reported adherence, n (%) (n = 1293 due to missing data)						
Response	**Overall (n = 1293)**	**Low N Low C (n = 333)**	**Low N High C (n = 69)**	**High N Low C (n = 606)**	**High N High C (n = 285)**	***P* value**
No. missing	19	6	1	9	3	
Never	68 (5.3)	23 (6.9)	8 (11.6)	21 (3.5)	16 (5.6)	<.0001 (PC)
Only when I feel I need to	306 (23.7)	99 (29.7)	19 (27.5)	131 (21.6)	57 (20.0)	
1 or 2 d of the week	93 (7.2)	23 (6.9)	5 (7.2)	37 (6.1)	28 (9.8)	
3 or 4 d of the week	67 (5.2)	12 (3.6)	6 (8.7)	26 (4.3)	23 (8.1)	
5 or 6 d of the week	100 (7.7)	29 (8.7)	14 (20.3)	26 (4.3)	31 (10.9)	
Every day	659 (51.0)	147 (44.1)	17 (24.6)	365 (60.2)	130 (45.6)	
Not every day	634 (49.0)	186 (55.9)	52 (75.4)	241 (39.8)	155 (54.4)	<.0001 (PC)
Every day	659 (51.0)	147 (44.1)	17 (24.6)	365 (60.2)	130 (45.6)	
Physician-reported adherence, n (%) (n = 1302 due to missing data)						
	Overall (n = 1302)	**Low N Low C (n = 338)**	**Low N High C (n = 68)**	**High N Low C (n = 609)**	**High N High C (n = 287)**	***P* value**
No. missing	10	1	2	6	1	<.0001 (KW)
Not at all adherent	5 (0.4)	2 (0.6)	1 (1.5)	1 (0.2)	1 (0.3)	
Slightly adherent	44 (3.4)	11 (3.3)	10 (14.7)	12 (2.0)	11 (3.8)	
Moderately adherent	149 (11.4)	45 (13.3)	18 (26.5)	52 (8.5)	34 (11.8)	
Very adherent	549 (42.2)	128 (37.9)	20 (29.4)	261 (42.9)	140 (48.8)	
Fully adherent	555 (42.6)	152 (45.0)	19 (27.9)	283 (46.5)	101 (35.2)	
Not fully adherent	747 (57.4)	186 (55.0)	49 (72.1)	326 (53.5)	186 (64.8)	.0007 (PC)
Fully adherent	555 (42.6)	152 (45.0)	19 (27.9)	283 (46.5)	101 (35.2)	

Patient-reported compliance in relation to the question: How often do you use your preventer inhaler?
Physician-reported adherence related to the question: On the scale please indicate the extent to which the patient is adherent with their treatment regimen in terms of the number of times they take their treatment as prescribed.
KW, Kruskal-Wallis; *PC*, Pearson χ^2.

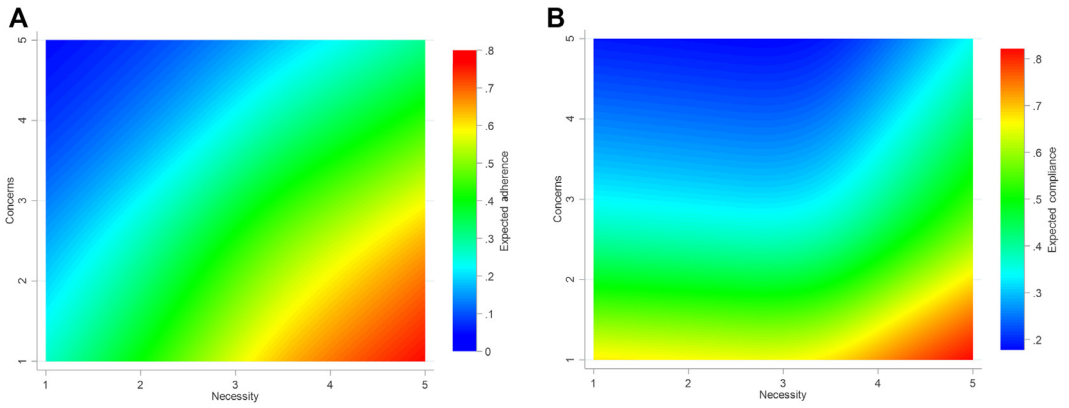

FIG 4. Contour regression plot of logistic regression of (**A**) patient-reported adherence (Necessity $P < .001$; Concerns $P = .002$) and (**B**) physician-reported adherence (Necessity $P = .021$; Concerns $P < .001$) vs Necessity and Concern scores. *Note:* Patient- and physician-reported adherence were dichotomized: Every day vs Not every day and Fully adherent vs Not fully adherent, respectively. Higher probabilities of high adherence are represented by the warmer colors (yellow/orange/red in order of increasing probability).

were generally similar, with approximately 70% reporting "controlled" asthma. Regressions on these outcomes show that when Necessity and Concerns are taken into account, there are few significant differences remaining for country variables (data not shown).

DISCUSSION

This study is one of the first to examine treatment beliefs of individuals with asthma in a large sample of participants across different countries. The aims of this study were to investigate and profile the treatment beliefs individuals with asthma hold about ICSs and to explore the relationship between treatment beliefs and adherence to ICSs. Differences in patient- and physician-reported adherence, and between countries, were explored.

The study findings revealed that a significant proportion of patients reported doubts about the necessity of their preventer inhaler, with doubts expressed about the general importance of their inhaler and its role in protecting them from becoming very ill. Although overall concerns about ICSs were reported in a smaller proportion of the sample, nearly half still

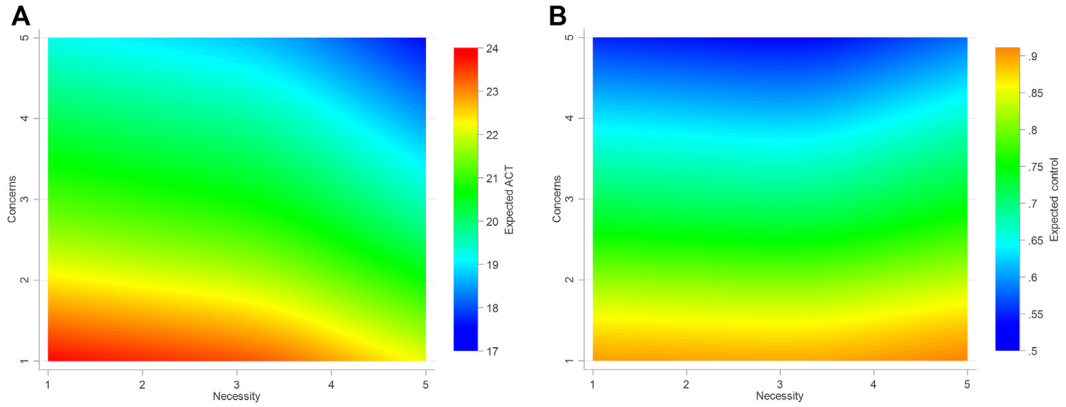

FIG 5. Contour regression plot of asthma control as measured by (**A**) patient-reported ACT score and (**B**) physician-reported asthma control vs Necessity and Concerns scores. *Note:* Higher expected ACT scores or physician-reported control as predicted by necessity beliefs and concerns are represented by the warmer colors (yellow/orange/red in order of increasing probability).

TABLE III. Patients' demographic characteristics and asthma control by beliefs quadrant

	Overall (n = 1312)	Low N Low C (n = 339)	Low N High C (n = 70)	High N Low C (n = 615)	High N High C (n = 288)	*P* value
Age (y)						
Mean ± SD	40.8 ± 15.3	38.3 ± 15.6	39.7 ± 14.4	41.3 ± 15.0	43.2 ± 15.4	.0002 (KW)
Sex, n (%)						
No. missing	1	0	1	0	0	
Male	554 (42.3)	148 (43.7)	42 (60.9)	246 (40.0)	118 (41.0)	.0091 (PC)
Female	757 (57.7)	191 (56.3)	27 (39.1)	369 (60.0)	170 (59.0)	
BMI (kg/m^2)						
No. missing	48	15	0	22	11	
Mean ± SD	25.7 ± 5.3	25.5 ± 5.1	25.4 ± 4.6	26.0 ± 5.5	25.7 ± 5.3	.6456 (KW)
ACT score						
No. missing	17	5	0	9	3	
Overall n	1295	334	70	606	285	
Mean ± SD	21.0 ± 3.7	21.9 ± 3.5	20.3 ± 3.4	21.1 ± 3.7	19.7 ± 3.8	<.0001 (KW)
ACT score ≤19 (uncontrolled asthma)	370 (28.6)	60 (18.0)	25 (35.7)	160 (26.4)	125 (43.9)	<.0001 (PC)
ACT score >19 (partly to well-controlled)	925 (71.4)	274 (82.0)	45 (64.3)	446 (73.6)	160 (56.1)	

ACT, Asthma Control Test; *BMI*, body mass index; *C*, Concerns; *KW*, Kruskal-Wallis; *N*, Necessity; *PC*, Pearson χ^2.

TABLE IV. Health beliefs breakdown by country

Health belief quadrant	Overall	France	Germany	Italy	Spain	UK	USA	*P* value
Overall n	1312	272	319	128	210	114	269	<.0001 (PC)
Low N Low C	339 (25.8)	56 (20.6)	70 (21.9)	48 (37.5)	50 (23.8)	37 (32.5)	78 (29.0)	
Low N High C	70 (5.3)	21 (7.7)	14 (4.4)	4 (3.1)	16 (7.6)	2 (1.8)	13 (4.8)	
High N Low C	615 (46.9)	117 (43.0)	172 (53.9)	55 (43.0)	86 (41.0)	52 (45.6)	133 (49.4)	
High N High C	288 (22.0)	78 (28.7)	63 (19.7)	21 (16.4)	58 (27.6)	23 (20.2)	45 (16.7)	

Values are n (%).
BMI, Body mass index; *C*, Concerns; *KW*, Kruskal-Wallis; *N*, Necessity; *PC*, Pearson χ^2.

expressed worries about the potential adverse long-term effects and concerns about becoming dependent on the inhaler. These findings are in line with findings from Lycett et al,[27] which highlighted that concerns about immediate and long-term side effects are prevalent in more than half the patients with asthma.

Overall only half the patients in the sample reported using their preventer inhaler every day, whereas physician-predicted adherence was even lower, at 42.6%. Previous reports of physician-reported adherence versus self-reported adherence highlight discordance in adherence estimates in more than half the cases.[28] Interestingly, a significant proportion of patients reported taking

TABLE V. Individual treatment beliefs breakdown by country

Item	Total	France	Germany	Italy	Spain	UK	USA	*P* value
Overall n	1312	272	319	128	210	114	269	
Necessity items								
N1. My health, at present, depends on this inhaler	4.0 (3.0-4.0)	4.0 (3.0-4.0)	4.0 (3.0-4.0)	4.0 (3.0-4.0)	4.0 (3.0-4.0)	4.0 (3.0-4.0)	4.0 (3.0-4.0)	.0352
N2. My life would be impossible without this inhaler	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (3.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	.0040
N3. Without this inhaler I would be very ill	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (3.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	.0003
N4. My health in the future will depend on this inhaler	3.0 (3.0-4.0)	3.0 (3.0-4.0)	3.0 (3.0-4.0)	3.0 (2.0-3.5)	3.0 (3.0-4.0)	3.0 (3.0-4.0)	3.0 (3.0-4.0)	<.0001
N5. This inhaler protects me from becoming worse	4.0 (4.0-4.0)	4.0 (3.0-4.0)	4.0 (4.0-4.0)	4.0 (4.0-5.0)	4.0 (4.0-4.0)	4.0 (4.0-4.0)	4.0 (3.0-4.0)	.0053
Concerns items								
C1. Having to use this inhaler worries me	2.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	2.0 (2.0-3.0)	3.0 (2.0-4.0)	2.0 (2.0-3.0)	2.0 (2.0-3.0)	<.0001
C2. I sometimes worry about the long-term effects of this inhaler	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	4.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	.0046
C3. This inhaler is a mystery to me	2.0 (2.0-3.0)	3.0 (2.0-3.0)	2.0 (1.0-3.0)	2.0 (1.0-3.0)	2.0 (2.0-3.0)	2.0 (2.0-3.0)	2.0 (2.0-3.0)	<.0001
C4. This inhaler disrupts my life	2.0 (2.0-3.0)	2.0 (2.0-3.0)	2.0 (2.0-3.0)	2.0 (1.0-2.0)	2.0 (2.0-3.0)	2.0 (2.0-3.0)	2.0 (1.0-2.0)	<.0001
C5. I sometimes worry about becoming too dependent on this inhaler	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	2.0 (2.0-4.0)	3.0 (2.0-4.0)	.0076
C6. I am concerned that this inhaler might become less effective if I use it regularly	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-3.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	<.0001
C7. This inhaler gives me unpleasant side effects	2.0 (2.0-3.0)	2.0 (2.0-3.0)	2.0 (2.0-3.0)	2.0 (1.0-3.0)	2.0 (2.0-3.0)	2.0 (2.0-3.0)	2.0 (2.0-3.0)	.0061

Values are median (interquartile range).
C, Concerns; *N*, Necessity.

their inhaler only when they felt they needed to, with a small proportion reporting never using their inhaler at all. The proportion of patients reporting taking their medication only when needed suggests that their poor adherence might be due to an intentional decision made about their medication-taking, such as adapting a symptom-based schedule rather than unintentional processes. This is in line with Halm's "no-symptoms, no asthma" description of treatment beliefs, where medication use in asthma is driven by the experience by symptoms.[16] Interestingly though, despite the proportion of patients reporting poor adherence, our self- and physician-reported figures for adherence are still higher than those reported by many other studies of adherence in asthma.[28,29] Our findings thus need to be considered in view of several factors that may have contributed to a higher adherence rate, for example, having a more motivated patient sample because patients were recruited by physicians when they presented for routine appointments with their physicians, and thus may represent a population that is more adherent with scheduled visits and potentially with medication than the general population. Because participants' adherence was self-reported in response to a single question item only, and not objectively measured, the adherence rates reported here from patient recall are likely to be higher. The study cohort also had generally well-controlled asthma, and medication adherence and beliefs may be less of a concern for this population and findings from this analysis may not apply to those with poorer asthma control.

As hypothesized, low patient-reported adherence was significantly associated with low necessity beliefs and high concerns about the treatment. This finding is consistent with previous studies across various chronic conditions on the importance of patients' treatment beliefs in treatment adherence.[15] Similarly, low physician-reported adherence was associated with beliefs in the same direction—that is, poor adherence was associated with low necessity belief scores and high concerns. However, the study found that patient-reported asthma control (ACT scores) was higher in those with high necessity beliefs and high concerns, which does not seem to align with the findings that high necessity beliefs and low concerns correlate with high medication adherence. This could be because the relationship between adherence and asthma control is not directly correlated across all individuals; it may be that some patients have inherently better asthma control regardless of adherence, because of their particular asthma phenotype. Good asthma control may also reinforce an individual's perceived need for treatment independently of their concerns about the treatment.

The creation of attitudinal groups based on patients' beliefs about ICSs provided further insight into the relationship of necessity beliefs and concerns with adherence. Nearly half the patients were categorized as being "accepting" of their treatment (ie, high necessity, low concerns), and this group displayed the smallest proportion of people with poor adherence. In line with preceding studies on other chronic conditions, patients in the sceptical category (ie, low necessity, high concerns) had the highest proportion of people with poor adherence.[30] Similar to previous literature, the percentage (5.3%) of the sample categorized as sceptical was relatively low[31]; most were accepting of treatment. The proportion of people with poor adherence in both the "ambivalent" and "indifferent" attitudinal groups was lower than that in the sceptical group, but also significantly higher than that in the accepting group. This underlines the importance to address patients' treatment beliefs and

to elicit both—doubts about the necessity and concerns about ICSs—to improve adherence.

More than two-thirds of patients reported high necessity for their ICSs, with less than a third reporting high concerns. Although there were significant differences between countries based on treatment beliefs, it remains questionable whether these differences were meaningful. Overall, individual necessity and concerns beliefs appeared to be fairly stable across countries—a finding that requires further research to understand how the context of the different health care systems and different cultural and societal effects may influence beliefs, given that the countries included in this sample represented only Western European / North American culture. Nevertheless, for example, a higher proportion of respondents from Germany had high Necessity beliefs and low Concerns about their treatment, whereas in Italy, more respondents had low Necessity and low Concerns. How these differences relate to adherence and outcomes was less clear, and differences may reflect how asthma care is delivered in different countries and/or how treatment is accessed or prescribed. In Italy, state-controlled hospitals are a predominant feature of the health system, whereas in other countries such as Germany, the private sector holds a larger share of service provision. In addition, a European Union study on satisfaction from health systems in the 15 European Union member states found that nearly 70% of people from Germany were fairly satisfied or very satisfied with their health system, compared with just over 16% in Italy.[32] It may be that these health system differences have the potential to influence beliefs, medication adherence, and asthma control, but further research to explore this hypothesis would be needed. In addition, there may be differences in culture that may lead to differences in beliefs and behavior that warrant exploration.

The study comprised a large sample of participants from 6 countries, making this one of the largest data sets of treatment beliefs in asthma and asthma outcomes. The data were however cross-sectional, making it difficult to infer causality particularly as treatment beliefs, adherence, and asthma control are likely to change with time and our study measured these only at a single time point. Further research is needed to explore our findings and understand how treatment beliefs and adherence change over time, and how this has an impact on asthma control, to inform the development of sustainable and effective adherence interventions. Because of the large number of countries and tests used in this study, the significant differences observed in this study need to be interpreted with some caution due to the risk of finding significance due to chance alone as a result of multiple testing. The self-report measures used were also not validated and as is the nature of self-report measures, the findings are subject to bias, which together may limit the validity of the results. Nevertheless, this early data provide key information as to the relationships that exist between treatment beliefs and asthma outcomes on a large scale globally, providing data to inform national and global strategies to improve asthma adherence.

Conclusions

In line with the literature, higher ICS necessity beliefs and lower concerns were associated with higher self- and physician-reported adherence. Higher concerns scores were associated with lower asthma control; interestingly, this was also true for higher necessity scores. Although cross-sectional data do not allow us to infer causality, this finding may suggest that having had an exacerbation/experiencing symptoms leads to a shift in necessity beliefs, suggesting a "no symptoms, no asthma" belief in those patients, which is in line with previous findings.[16,20] This has implications for intervention design to optimize ICS adherence. Longitudinal studies using objective adherence and asthma control measures are needed to further explore these relationships.

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