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Original Research

Mapping EQ-5D-5L utility scores from the severe asthma questionnaire in the SHARP CRC registry

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ABSTRACT

Background: Severe asthma imposes a substantial burden on individuals' health-related quality of life (HRQoL), which might not be fully captured by generic instruments. The Severe Asthma Questionnaire (SAQ) is a validated disease-specific HRQoL instrument capturing the unique lived experience of people with severe asthma. However, the SAQ does not generate preference-based utility values required for health economic evaluations. This study aimed to develop and validate mapping algorithms from the SAQ to the EuroQol (EQ)-5D-5L, enabling estimation of utility values when EQ-5D data are unavailable.
Methods: We used baseline and 6-month data from the longitudinal, multicentre SHARP Burden of Asthma study, including adults with severe asthma across 7 European countries. Direct mapping (ordinary least squares and beta-mixture regression models) using the UK value set and indirect mapping (ordered probit regression models) were developed with baseline data to predict EQ-5D-5L utility values from SAQ scores. Performance was assessed via mean absolute error (MAE), root mean square error (RMSE), and R^2, with 6-month data used for validation.

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Results: Data from 327 patients were included. The beta-mixture model using SAQ subscales marginally outperformed the other models in the development set (MAE = 0.090, RMSE = 0.129, R^2 = 0.704), whereas in the validation set the ordered probit regression model showed the best predictive performance (MAE = 0.106, RMSE = 0.151, R^2 = 0.589).

Conclusions: Direct mapping with beta-mixture regression showed good overall performance, aligning with prior studies. Indirect mapping may be advantageous in settings requiring flexibility across EQ-5D-5L value sets. These findings demonstrate that EQ-5D-5L utility values can be reliably estimated from the SAQ, supporting use of the instrument in health-economic analyses.

Glossary

ALDVMM	adjusted limited dependent variable mixture models
AQLQ-S	Sydney Asthma Quality of Life Questionnaire
BoA	Burden of Asthma
BMI	body mass index
CRC	Clinical Research Collaboration
EQ-5D-5L	EuroQol five-dimensional five-level questionnaire
EQ-HWB	EuroQol Health and Wellbeing
FEV_1	forced expiratory volume in 1 s
HRQoL	health-related quality of life
MAE	mean absolute error
MAPS	MApping onto Preference-based measures reporting Standards
OCS	oral corticosteroids
OLS	ordinary least squares
QALY	quality-adjusted life-years
RMSE	root mean square error
R^2	explained variance
SAQ	Severe Asthma Questionnaire
SD	standard deviation
SE	standard error
SHARP	Severe Heterogeneous Asthma Research collaboration, Patient-centred
UK	United Kingdom

1. Introduction

Severe asthma is a heterogeneous, complex and chronic respiratory condition characterised by persistent symptoms, frequent severe exacerbations and intensive treatment requirements [1]. Although individuals with severe asthma comprise only 3–10% of the overall asthma population, they account for a disproportionately high share of asthma-related morbidity, healthcare utilisation, and costs [2–4]. Understanding and addressing the health-related quality of life (HRQoL) of people living with severe asthma is essential—not only in clinical care but also for informing healthcare policy and resource allocation.

While several asthma-specific HRQoL instruments exist [5–8], they generally fail to capture the unique challenges faced by people living with severe asthma [9]. These patients often experience an additional burden due to comorbidities, high treatment demands (e.g. long-term corticosteroid use) and the impact of frequent severe asthma exacerbations, all of which can profoundly affect not only the patients themselves but also their families and social networks.

To more accurately reflect the multifaceted impact of living with severe asthma on daily functioning and well-being, a novel questionnaire was recently developed and validated in collaboration with patients: the Severe Asthma Questionnaire (SAQ) [10]. The SAQ includes multiple subscales specifically designed to capture the lived experience of those with severe asthma.

Despite its clinical relevance within the severe asthma domain, the SAQ does not facilitate the direct calculation of utilities to determine quality-adjusted life-years (QALYs) – a key outcome for health economic evaluations [11]. This restricts the use of SAQ data in informing policy and decision-making contexts. At the same time, generic preference-based measures are frequently absent from clinical studies or routine clinical data collection, creating a disconnect between disease-specific outcomes and economic evaluations [7,12].

Mapping is a statistical approach that bridges this gap by linking disease-specific instruments like the SAQ to generic preference-based measures [12]. Among these, the EuroQol five-dimensional questionnaire (EQ-5D), particularly the five-level version (EQ-5D-5L), is the most widely used preference-based instrument for deriving health utility values [13]. When EQ-5D data are unavailable, mapping from instruments like the SAQ allows for the estimation of utilities.

This study aimed to develop and evaluate algorithms for both direct and indirect mapping from the SAQ to the EQ-5D-5L. These models may enable future estimation of utility values from SAQ data when EQ-5D values are unavailable, facilitating their use in health economic evaluations and policy decision-making for severe asthma care.

2. Methods

2.1. Study population and design

We obtained data from the Severe Heterogeneous Asthma Research collaboration Patient-centred (SHARP) Burden of Asthma (BoA) study – a multi-centre, longitudinal study aiming to assess the burden of living with severe asthma on HRQoL in a European population [14]. This study included adult (aged ≥18 years) patients with severe asthma from the United Kingdom (UK), Netherlands, Serbia, Portugal, Sweden, Slovenia and Lithuania. Patients were excluded if they had a condition, other than asthma, which substantially contributed to their respiratory symptoms (e.g., lung cancer, heart failure or severe COPD) according to their attending physician. Patients were followed for 12 months and patient-level data were collected between December 2022 and July 2025. Clinical and demographic data were obtained at baseline during clinical visit and registered via electronic case report forms (CASTOR EDC platform, Amsterdam, The Netherlands) by the physician. EQ-5D-5L data were additionally collected at baseline, 6 and 12 months and SAQ data were collected at baseline and monthly via the PatientCoach app or weblink (PatientCoach, Leiden University Medical Centre, Leiden, The Netherlands). EQ-5D-5L and SAQ data collected at baseline were used for the development set; data collected at 6 months for the validation set. For the purpose of this study, we used the final sample of observations reporting both HRQoL instruments (*i.e.* SAQ and EQ-5D-5L) at baseline and/or 6 months. As the SHARP BoA study is ongoing, not all participants had reached the 6-month follow-up at the time of analysis, resulting in a smaller validation cohort. Baseline characteristics of the total SHARP BoA study population are presented in Supplementary Table S1.

2.2. Instruments

2.2.1. Target instrument: EQ-5D-5L

The EQ-5D-5L is a generic, preference-based instrument to estimate health state utility for health-related quality of life. The EQ-5D-5L comprises five dimension (mobility; self-care; usual activities; pain/discomfort; anxiety/depression) with five levels of the perceived problems (1 = no problems; 2 = slight problems; 3 = moderate problems; 4 = severe problems; 5 = extreme problems). Responses to the EQ-5D-5L were translated into utilities using the UK value set which ranges from an index score of −0.285 in state 55555 (lower limit) to 1 in state 11111 (upper limit) [15]. Here, a utility value of 1 represents full health or perfect health, whereas a value of 0 represents death. Negative values represent health states considered worse than death. The questionnaire was available in all required languages for the current study.

2.2.2. Source instrument: SAQ

The SAQ is a validated measure of the health-related quality of life of people living with severe asthma [10]. The questionnaire comprises 17 items: 16 questions with response options on a seven-point Likert scale to form the averaged SAQ score (scores 1-7 with 1 = very difficult and 7 = no problem) and a single item with a 100-point Borg-type scale to form the SAQ-global score (scores 0-100 with 0 = no quality of life and 100 = perfect quality of life). Within the SAQ-global item, there are two additional questions relating to the best and worst months of the year. These two questions are not used for scoring purposes but provide additional clinical information. The content of the 16 questions contributing to the mean SAQ score fall into three subscales: (i) My Life: impact on life's activities – questions 1-7 and 14, (ii) My Mind: impact on emotional well-being – questions 8-11, (iii) My Body: impact of extra-pulmonary symptoms including those caused by side effects of treatment – questions 12-16. Subscale iii, my life, measures quality of life deficits that are typically found only in severe asthma compared to mild and moderate asthma, and has a limited representation in previous asthma-specific HRQoL questionnaires [9,16]. The SAQ has been translated and validated in eleven languages [17] and was available in all required languages for this study.

2.3. Statistical analysis

The accuracy of a mapping algorithm depends on the conceptual overlap between the source measure (SAQ) and the target measure (EQ-5D-5L). If there is little to no overlap in content, it is unlikely that the mapping can effectively capture the relationship between these measures, making it difficult to estimate health utilities reliably [18]. Hence, Spearman's rank correlation coefficients were estimated to assess the correlations between the EQ-5D-5L index scores and five domains, and the SAQ total scores and three subscales.

2.3.1. Model development

The development cohort consisted of all available EQ-5D-5L and SAQ data at baseline. We applied both direct and indirect mapping strategies to develop the mapping algorithm. In the direct approach, the EQ-5D-5L index values were estimated using ordinary least squares (OLS) regression and one-component beta-mixture regression models. OLS is a commonly reported regression model in mapping literature, relying on assumptions of normally distributed residuals with constant variance (homoscedasticity) [19]. We set the utilities predicted by OLS regression to be > 1 to one.

In addition to OLS regression, mixture models are increasingly being used for mapping due to their flexibility and ability to capture multimodality [12]. The beta-mixture regression model is a two-part model consisting of a multinomial logit model and a beta mixed model. The inclusion of the multinomial logit model allows for modelling observations at the boundaries and a mass of observations at full health [12] – a feature not handled well by a single beta distribution. We selected the beta-mixture model for this analysis, because beta-based mixture models were previously reported to marginally outperform adjusted limited dependent variable mixture models (ALDVMM) in a Sydney Asthma Quality of Life Questionnaire (AQLQ-S) mapping study [12].

In all direct mapping models, we evaluated the SAQ both as a total score and as separate subscale scores (My Life, My Body, My Mind). For each model type (OLS, beta-mixture), we compared two model specifications [1]: EQ-5D-5L utility regressed on the SAQ total score, and [2] EQ-5D-5L utility regressed on the three individual SAQ subscale scores (My Life, My Body, My Mind). This allowed us to assess whether the domain-level information provided better predictive accuracy than the total score alone.

In the indirect approach, ordered probit regression models were estimated for each domain of the EQ-5D-5L to predict the probabilities of a given response level. The expected EQ-5D-5L scores were subsequently computed using the probabilities of each of the possible 3125 (*i. e.* 5 levels across 5 domains, 5^5) health states and the UK EQ-5D-5L tariff [15]. Similar to the direct approach, we tested models using both the total SAQ score as a single predictor, as well as models including the individual SAQ subscales as separate predictors. This response mapping approach has previously been applied successfully in knee arthroplasty and breast cancer settings [20,21].

Statistical analyses were conducted using stata 16.1 (StataCorp LP, college station, Texas, USA) via the *regress*, *betamix* and *oprobit* commands.

2.3.2. Model validation

The validation cohort consisted of all available EQ-5D-5L and SAQ data collected at the 6-month follow-up. Previously developed mapping models—both direct and indirect approaches—were applied to this dataset without any model updating or recalibration. Predicted EQ-5D-5L values using the original model coefficients were compared to observed values to assess the generalisability of the mapping algorithms to data collected at a different time point.

2.3.3. Model performance

Preferred models were selected using several fit statistics: mean absolute error (MAE), (lowest) root mean square error (RMSE) and explained variance (R^2). MAE was computed as the mean of the absolute difference between the predicted and observed EQ-5D-5L utilities. RMSE was derived as the root square value of the mean squared differences between the predicted and observed EQ-5D-5L utilities. R^2 was calculated to assess the proportion of variance in the observed EQ-5D-5L utilities that was explained by the model predictions. The model with the lowest MAE and RMSE, along with the highest R^2, was deemed to have the best predictive performance compared to the other models. All models were ranked according to the three performance indicators.

The conduct and reporting of this mapping study followed the MApping onto Preference-based measures reporting Standards (MAPS) statement and corresponding 23-item checklist (Supplementary Table S2) [22,23].

3. Results

3.1. Patient characteristics

A total of 327 patients were included in the study, of which 55% were female (Table 1). The mean age was 55 years (SD 13) and the mean BMI was 29 kg/m^2 (SD 7). At baseline, 77% of patients were receiving biologic therapy for asthma management and 14% used OCS as maintenance therapy. The mean SAQ total score was 5.1 (SD 1.6) and the mean EQ-5D-5L score was 0.77 (SD 0.24). Fig. 1 shows the left-skewed distribution of the EQ-5D-5L and SAQ values at baseline in the development and validation set, with the majority of EQ-5D-5L values concentrated between 0.75 and 1.0.

3.2. Conceptual overlap

The Spearman correlation coefficients of the EQ-5D-5L index value and domains with the SAQ total score and subscales are presented in Table 2. All SAQ measures were positively correlated with the EQ-5D-5L index value (r ranging from 0.74 to 0.83), indicating that better asthma-specific quality of life is associated with higher EQ-5D-5L utilities. The SAQ My Life subscale (including questions on the impact on life's activities) showed the strongest correlation with the EQ-5D-5L usual activities (e.g. work, study, housework, family or leisure activities) dimension (r = −0.83). The Spearman correlation coefficients were statistically significant for all combinations of the EQ-5D-5L dimensions

Table 1
Baseline characteristics of the study population (N = 327).

	N	
Age (years)	325	55 (13)
Female	325	179 (55%)
Caucasian	325	316 (97%)
BMI (kg/m^2)	325	29 (6.9)
FEV_1 (% predicted)	315	79 (21)
FEV_1 (L)	321	2.4 (0.8)
Receiving biologics	324	251 (77%)
Prescribed maintenance OCS	324	46 (14%)
≥1 Exacerbations in the last 12 months requiring OCS	320	178 (56%)
Number of exacerbations in the last 12 months requiring OCS	320	1.8 (2.2)
Number of emergency department visits in the last 12 months	325	0.4 (0.8)
Number of hospital admissions in the last 12 months	325	0.2 (0.6)
ACQ-6 score	326	1.7 (1.3)
SAQ total score	327	5.1 (1.6)
EQ-5D-5L score	327	0.77 (0.24)

Data presented as mean (standard deviation) or number (percentages). Sample sizes vary as a function of data availability. *BMI, body mass index; EQ-5D-5L, EuroQol five-dimensional five-level questionnaire; FEV_1, forced expiratory volume in 1 s; OCS, oral corticosteroids; SAQ, Severe Asthma Questionnaire.*

and index value, and SAQ subscales. In general, we observed a high degree of conceptual overlap between the source (SAQ) and target instrument (EQ-5D-5L).

3.3. EQ-5D-5L utility score prediction and goodness-of-fit

The predictive performances of the OLS, beta-mixture and ordered probit regression models are reported in Table 3. All models showed close agreement between observed and predicted EQ-5D-5L utility values in the development set (N = 327). The observed mean EQ-5D-5L score was 0.766 (SD 0.239), and the predicted means from all mapping approaches were nearly identical, ranging from 0.764 to 0.766. Among the direct mapping models, beta-mixture using SAQ subscales performed best, achieving the lowest MAE (0.090) and RMSE (0.129), and the highest R^2 (0.704). The indirect ordered probit regression model with SAQ subscales scores showed similar performance (MAE = 0.091, RMSE = 0.130, R^2 = 0.699), while OLS regression slightly underperformed and frequently predicted values at the upper bound of 1, the maximum of full health, indicating poorer fit compared to the beta-mixture model. Visual inspection of predicted versus observed distributions confirmed reasonable model fit of the beta-mixture model, with most predictions falling within the central range of observed values (Fig. 2).

3.4. Validation and performance

Model performance was further evaluated in a validation set using 6-month follow-up data (N = 187). The observed mean EQ-5D-5L score was slightly higher than in the development (0.784 [SD 0.236] vs. 0.769 [SD 0.237]) (Table 3). Predicted means across all models were again nearly identical to the observed value, with predictions ranging from 0.777 to 0.779. In the validation set, the indirect ordered probit regression model with SAQ subscales performed marginally better than direct approaches (MAE = 0.106, RMSE = 0.151, R^2 = 0.589), though differences between models were modest.

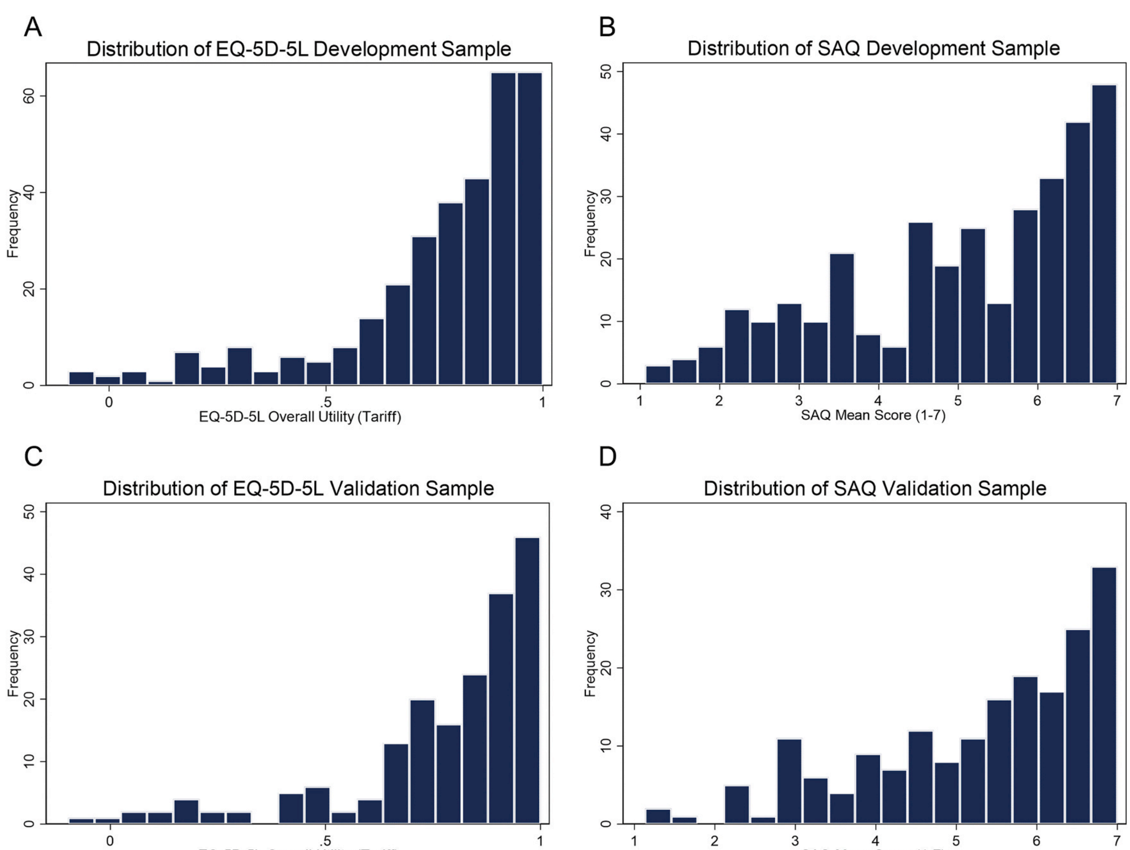

Fig. 1. Distribution of outcome measures across in the development (A-B) and validation (C-D) dataset. *EQ-5D-5L, EuroQol five-dimensional five-level questionnaire; SAQ, Severe Asthma Questionnaire.*

Table 2
Spearman's rank correlation coefficients of the EQ-5L-5L index value and dimensions, and the SAQ mean total score and subscales.

		EQ-5D-5L					
		Index value	Mobility	Selfcare	Usual activities	Pain/discomfort	Anxiety/depression
SAQ	**Mean**	0.83	−0.69	−0.61	−0.78	−0.57	−0.63
	My Life	0.82	−0.75	−0.63	−0.83	−0.58	−0.52
	My Mind	0.74	−0.52	−0.51	−0.64	−0.46	−0.74
	My Body	0.75	−0.61	−0.53	−0.68	−0.54	−0.62

Total sample correlations. All correlation coefficients were statistically significant at $p < 0.0001$. *EQ-5D-5L, EuroQol five-dimensional five-level questionnaire; SAQ, Severe Asthma Questionnaire.*

Table 3
Model performance of direct and indirect mapping approaches for the EQ-5D-5L in the development (N = 327) and validation (N = 187) set.

Regression model type	SAQ	Mean	SD	Min	Max	MAE	RMSE	R^2	Rank
Development									
Observed EQ-5D-5L		0.769	0.237	−0.094	1.000				
Direct									
Ordinary least squares	total score	0.768	0.193	0.271	1.000	0.095	0.137	0.667	**6**
	subscales	0.768	0.196	0.273	1.000	0.092	0.133	0.685	**3**
Beta-mixture	total score	0.767	0.178	0.184	0.955	0.092	0.133	0.683	**4**
	subscales	0.768	0.183	0.185	0.954	0.090	0.129	0.704	**1**
Indirect									
Ordered probit	total score	0.770	0.197	0.141	0.954	0.093	0.134	0.681	**5**
	subscales	0.770	0.198	0.151	0.959	0.091	0.130	0.699	**2**
Validation									
Observed EQ-5D-5L		0.784	0.236	−0.098	1.000				
Direct									
Ordinary least squares	total score	0.784	0.178	0.256	0.995	0.106	0.155	0.568	**5**
	subscales	0.784	0.180	0.265	0.996	0.106	0.153	0.577	**3**
Beta-mixture	total score	0.783	0.173	0.136	0.970	0.106	0.155	0.569	**4**
	subscales	0.783	0.173	0.141	0.969	0.105	0.153	0.578	**2**
Indirect									
Ordered probit	total score	0.784	0.191	0.060	0.954	0.109	0.158	0.554	**6**
	subscales	0.784	0.191	0.073	0.959	0.106	0.151	0.589	**1**

EQ-5D-5L, EuroQol five-dimensional five-level questionnaire; MAE, mean absolute error; RMSE, root mean square error.

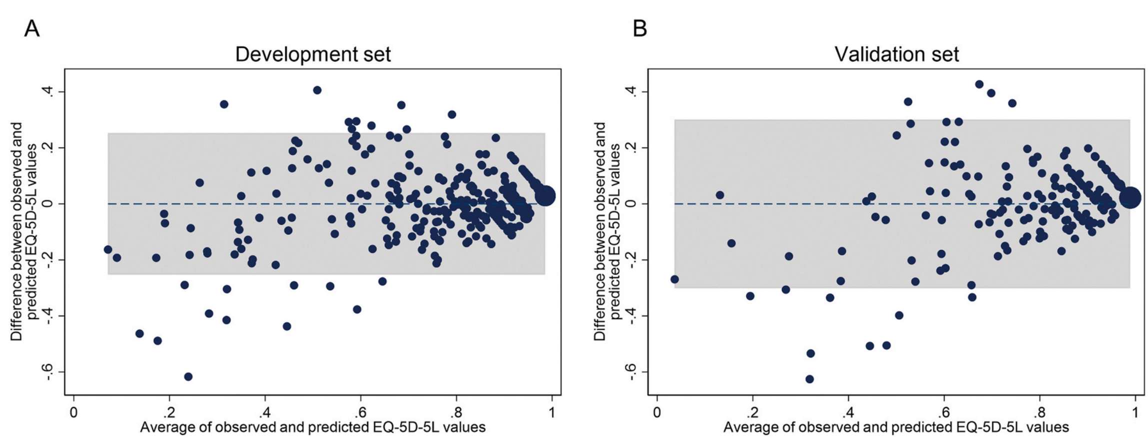

Fig. 2. Bland-Altman plot of the observed and predicted mean differences of EQ-5D-5L utility values in the development (A) and validation (B) set, using the beta-mixture regression model with SAQ subscales as dependent variables. *EQ-5D-5L, EuroQol five-dimensional five-level questionnaire; SAQ, Severe Asthma Questionnaire.*

3.5. Model coefficients

Coefficients of the best-performing beta-mixture regression model using SAQ subscales are presented in Table 4. Of the three SAQ subscales, only the My Life subscale significantly predicted EQ-5D-5L utilities (β = 0.425 [SE 0.050], p < 0.001). EQ-5D-5L utilities can be predicted by entering a patient's SAQ subscale scores into the mean equation shown in Table 4 (e.g., utility = −0.566 + 0.425 × My Life + 0.068 × My Mind + 0.037 × My Body); the model then applies the beta-mixture parameters reported in Supplementary Table S3 to generate the final predicted utility. For practical application, a tool for applying country-specific tariffs with the two-step procedure for indirect mapping is provided in the Supplement.

3.6. Prediction error distribution

The distribution of prediction errors across subsets of the EQ-5D-5L range is shown in Table 5. The beta-mixture model achieved the

Table 4
Coefficients (standard errors) for the best-fitting beta-mixture regression model in the development dataset (N = 327).

	Beta-mixture regression model	
	Coefficient (SE)	*p*-value
Mean equation (μ)		
SAQ My Life	0.425 (0.050)	<0.001
SAQ My Mind	0.068 (0.050)	0.17
SAQ My Body	0.037 (0.063)	0.55
Constant (intercept)	−0.566 (0.132)	<0.001
Calculation for application	EQ-5D-5L utility = −0.566 + 0.425 × (SAQ My Life) + 0.068 × (SAQ My Mind) + 0.037 × (SAQ My Body)	

Standard errors in parentheses. Additional model parameters are presented in the Online Repository (Supplementary Table S3). *SAQ, Severe Asthma Questionnaire; SE, standard error.*

Table 5
Distribution of prediction errors by observed EQ-5D-5L utility score in the best-fitting model (beta-mixture).

	Beta-mixture regression model
RMSE	
EQ-5D-5L < 0	0.269
0 ≤ *EQ-5D-5L* < 0.25	0.385
0.25 ≤ *EQ-5D-5L* < 0.5	0.220
0.5 ≤ *EQ-5D-5L* < 0.75	0.144
0.75 ≤ *EQ-5D-5L* ≤ 1	0.105
MAE	
EQ-5D-5L < 0	0.269
0 ≤ *EQ-5D-5L* < 0.25	0.343
0.25 ≤ *EQ-5D-5L* < 0.5	0.181
0.5 ≤ *EQ-5D-5L* < 0.75	0.114
0.75 ≤ *EQ-5D-5L* ≤ 1	0.073

Dependent variable: EQ-5D-5L; independent variables: SAQ subscales. *EQ-5D-5L, EuroQol five-dimensional five-level questionnaire; MAE, mean absolute error; RMSE, root mean square error.*

lowest MAE and RMSE for utilities between 0.75 and 1 (MAE = 0.073; RMSE = 0.105). Prediction accuracy decreased toward the lower end of the utility scale, with MAE = 0.343 and RMSE = 0.385 for scores between 0 and 0.25. This pattern indicates higher precision in predicting EQ-5D-5L utilities near the ceiling compared with lower health states.

4. Discussion

The SAQ is a disease-specific questionnaire designed to capture the unique and multifaceted impact of severe asthma on patients' lives. However, as it is not preference-based, it cannot be directly used to calculate utility values for health-economic evaluations. This study demonstrated that SAQ scores can be mapped onto EQ-5D-5L utility values, with performance comparable to that reported in other mapping studies. As a result, this enables existing SAQ datasets to be retrospectively leveraged to estimate utility values, substantially expanding the evidence base for economic analyses and supporting more patient-centred decision making in severe asthma.

This is the first study, to the best of our knowledge, estimating the association between the SAQ and EQ-5D-5L, which limits direct comparison with prior studies. Nevertheless, several mapping approaches have been proposed for the more commonly used standardised asthma quality of life questionnaire AQLQ-S [12,24]. Although not specific to severe asthma, the AQLQ-S assesses asthma symptoms and functional limitations of people living with asthma [8]. For example, Gray et al. analysed 852 observations across six countries and showed that EQ-5D-5L utility values can reliably be predicted from the AQLQ-S using beta-mixture regression, which outperformed linear models [12]. These findings support the plausibility of our results. Interestingly, unlike our findings with the SAQ, Gray and colleagues found that including the individual AQLQ-S dimension scores rather than the total score did not significantly improve their predictions, possibly reflecting the different conceptual frameworks, study populations and item structures between the AQLQ-S and the SAQ.

In line with external recommendations for mapping [25], we estimated health state utility values using several models: OLS regression, beta-mixture regression (direct mapping), and ordered probit regression (response mapping), using the SAQ total score or subscales. The beta-mixture regression model based on SAQ subscales demonstrated the best performance, with lowest MAE and MSE and highest R^2. However, prediction accuracy was not uniform across the EQ-5D-5L utility range [26]. In particular, errors were substantially larger at the lower end of the EQ-5D-5L scale, indicating less precise utility estimates for patients with the most severe health states. This is especially relevant since patients with low baseline utility often have the greatest potential for QoL gains. In such cases, mapping may underestimate or otherwise imprecisely estimate intervention benefits in this subgroup when used in health economic evaluations. The observed larger errors could be due to the limited number of patients with the most severe health states in our dataset, as most patients were receiving biologic therapy and had moderate to relatively good HRQoL. Overall, the performance of the preferred model was consistent with the range reported in other mapping studies [12,24,26].

Notably, the OLS models generated predictions clustered near the upper bound of 1, indicating linear specification limitations. Prior studies have shown that while linear regression can predict mean values of preference-based measures accurately, it exhibits bias at the distribution ends [27–29]. More flexible approaches, such as beta-mixture or ordered probit models, may therefore more accurately reflect and capture the ordered nature of health utility scores.

Beyond summary fit statistics, other comparisons between direct and indirect mapping approaches can be made. The two-step approach of indirect mapping provides the advantage of using different country-specific value sets. We provide a supplementary tool for calculating EQ-5D-5L utilities from SAQ subscale scores using the ordered probit regression coefficients, including tariffs for multiple countries. To illustrate its applicability, we applied the Dutch value set to the model coefficients. Prediction accuracy was comparable to the UK value set ordered probit regression model (MAE = 0.091, RMSE = 0.130, R^2 = 0.696), suggesting that the tool can reliably map SAQ scores to EQ-5D-5L utilities using value sets other than the UK.

By enabling EQ-5D-5L utility values estimation from SAQ scores, this study supports bridging the gap between disease-specific quality-of-life data and preference-based requirements for health economic analyses. The SAQ is particularly sensitive to domains like social functioning, emotional well-being, and the cumulative burden of symptoms and treatment—aspects that are often underrepresented in generic measures. Although we demonstrated correlations between EQ-5D-5L dimensions and SAQ subscales, differences in questionnaire item content limit the model fit, resulting in moderate explained variance. One potential approach to better capture these broader aspects of health is the use of extended preference-based instruments, such as the EuroQol Health and Wellbeing (EQ-HWB), a 25-item measure that covers additional domains such as energy, social relationships and cognition [30,31]. Nonetheless, the EQ-5D-5L remains the most widely used standard for economic evaluations, providing a practical and broadly applicable basis for mapping from disease-specific measures such as the SAQ.

Study strengths include the multinational dataset with observations from seven European countries and the real-world design reflecting routine clinical care. This is further supported by a high response rate of 71%, ensuring a broad representativeness of the target population. Another important strength is the use of a separate validation set, enhancing robustness and generalisability of our findings. Several limitations of this study should also be noted. First, comorbidities are common among adults with severe asthma and have been associated with poorer asthma-related outcomes [32]. While the SAQ specifically captures quality of life related to severe asthma, EQ-5D-5L utility values may also reflect the impact of coexisting conditions. As a result, the mapping may conflate asthma-related and non-asthma-related health effects. This may potentially underestimate utility in patients without comorbidity and overestimating it in those with substantial comorbidity. This limitation is particularly relevant in the SHARP BoA study, in which patients with respiratory conditions other than asthma that substantially contributed to their respiratory symptoms were excluded. In general, caution is advised when applying mapping algorithms in populations with different levels of comorbidity. Second, we were unable to validate our results on an external dataset due to lack of availability. Third, sociodemographic variables and interaction terms were not included as predictors, though their added value is usually modest. Moreover, relying solely on SAQ data enhances its generalisability and practical use, as it can be applied even when sociodemographic information is unavailable. Fourth, the temporal mismatch between instruments—EQ-5D-5L capturing health "today" *versus* SAQ assessing the past two weeks—may introduce noise into the mapping relationship. Finally, although the data included observations from multiple countries, we applied the UK tariff uniformly across all observations making the mapping specific to the UK setting. Indirect mapping partly addresses this by allowing the application of alternative tariffs, as illustrated in the Supplement with the Dutch value set. Nonetheless, the first stage of the response mapping model was still fitted on the UK tariff, which may introduce some residual bias.

It should be noted that mapping represents a second-best solution to directly collected EQ-5D values, as it inevitably introduces additional uncertainty. Whenever feasible, direct collection of EQ-5D-5L remains preferable. Nonetheless, our results show that EQ-5D-5L utilities can be estimated from SAQ subscale scores using a beta-mixture regression model when EQ-5D data are unavailable. The model is most applicable to adults with severe asthma whose SAQ scores resemble our development sample, and generalisability to other populations requires caution. Validation in independent datasets remains an important direction for future research.

5. Conclusion

This study showed that it is possible to estimate preference-based EQ-5D-5L health utility scores from the disease-specific SAQ. The performance of these models in populations that do not resemble our study population in terms of sociodemographic information or SAQ score distributions remains to be evaluated.

CRediT authorship contribution statement

Fleur L. Meulmeester: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **M. Elske van den Akker-Van Marle:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Lianne ten Have:** Writing – review & editing. **Joseph W. Lanario:** Writing – review & editing, Investigation. **Michael E. Hyland:** Writing – review & editing, Investigation. **Anne McGahey:** Writing – review & editing, Investigation. **Dominique Hamerlijnck:** Writing – review & editing. **Aruna T. Bansal:** Writing – review & editing. **Anneke ten Brinke:** Writing – review & editing, Investigation. **Kim de Jong:** Writing – review & editing. **Tania Wainwright:** Writing – review & editing, Investigation. **Joanna Tilley:** Writing – review & editing, Investigation. **Simon Doe:** Writing – review & editing, Investigation. **Kathleen Bayani:** Writing – review & editing, Investigation. **Valentyna Yasinska:** Writing – review & editing, Investigation. **Oksana Tenselius:** Writing – review & editing, Investigation. **Barbro Dahlén:** Writing – review & editing, Investigation. **Kristina Bieksiene:** Writing – review & editing, Investigation. **Jolita Palacionyte:** Writing – review & editing, Investigation. **Cláudia C. Loureiro:** Writing – review & editing, Investigation. **Maria G. da Cunha:** Writing – review & editing, Investigation. **Diogo Canhoto:** Writing – review & editing, Investigation. **Sanja Hromis:** Writing – review & editing, Investigation. **Sabina Škrgat:** Writing – review & editing, Investigation. **Ana Ž. Bertoncel:** Writing – review & editing, Investigation. **Peter Kopač:** Writing – review & editing, Investigation. **Mariana Paula-Rezelj:** Writing – review & editing, Investigation. **Matthew Masoli:** Writing – review & editing, Investigation, Data curation. **Jacob K. Sont:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Data sharing agreement

Statistical analyses are made available on GitHub whenever possible (https://github.com/flmeulmeester)

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Disclaimer

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Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT version GPT-5.1 in order to enhance readability and language of the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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Declaration of competing interest

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Appendix A. Supplementary data

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