Estimation of health care costs as a function of disease severity in people with psoriatic arthritis in the UK

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Abstract

Objectives. The primary aim of this study was to estimate annual health care costs for biologic-naïve patients with PsA in the UK. The relationship between disease severity, defined by physical limitations, and costs was also explored.

Methods. This study utilized data from the British Society of Rheumatology Biologics Register (BSRBR) to develop a multivariate model estimating disease severity from parameters available in routine primary care data. The HAQ Disability Index was used to determine disease severity. This algorithm was then applied to routine data from The Health Improvement Network (THIN). Annual costs were estimated for drugs, contacts with a general practitioner and other health care professionals, tests, hospital outpatient attendances and inpatient admissions from a National Health Service perspective using official tariffs. The relationship between disease severity and health care costs was estimated using a generalized linear model.

Results. Three hundred and fifty-six cases with PsA were identified in the BSRBR and 4492 in THIN. Total mean annual health care costs ranged from £11 to £20,782 with a mean of £1446 (S.D. £1756). When costs were sub-grouped by the predicted HAQ score, the mean annual observed costs ranged from £548 per person for the least severely affected (HAQ <1.2) to £4832 for the most severely affected (HAQ >2.6). Prescription costs and secondary care episodes accounted for more than a third of total care costs each (38 and 34%, respectively). When the relationship between disease severity and costs was examined, estimated HAQ was found to be a significant predictor of total health care costs.

Conclusions. Treatment of people with PsA resulted in considerable financial costs and these costs varied markedly by disease severity.

Key words: Cost, Psoriatic arthritis, Disease severity, HAQ, British Society of Rheumatology Biologics Register, The Health Improvement Network.

Introduction

PsA is a chronic, systemic inflammatory arthritis, usually seronegative, associated with psoriasis [1]. PsA is a complex, multi-faceted disease with prominent involvement of peripheral diarthrodial joints, axial joints, peri-articular structures, and the skin and nails [2]. The course of PsA is unpredictable, ranging from a mild, non-destructive disease to a severe debilitating erosive arthropathy [3]. PsA usually develops in the 10 years following diagnosis of psoriasis. Although not always the case, the majority of patients with PsA develop skin symptoms before joint symptoms [4, 5].

The prevalence of psoriasis worldwide is thought to be between 0.3 and 3% depending on geographical region. Prevalence of psoriasis in the UK is ~1.5–2% [6], although the precise prevalence has not been established reliably [7–10]. A recent study from Sweden suggests that PsA occurs in 30% of patients with psoriasis [11] and in
Germany ~19% of psoriasis patients have a probable diagnosis of PsA [12]. In clinical studies of etanercept in psoriasis, 26% of patients also had PsA [13]. PsA has a debilitating impact on personal well-being, reducing significantly health-related quality of life [14–16]. The impact of the skin and joint problems of PsA are additive, with each independently causing disability [17]. Like RA, PsA results in joint damage, disability and increased mortality. In two large studies of patients with PsA, 40–57% had deforming erosive arthropathy, 17% had five or more deformed joints and 11–19% were disabled [18, 19]. PsA results in a higher risk of cardiovascular disease [20, 21] and decreased survival, with standardized mortality ratios of 1.6 for women and 1.7 for men [22]. Although PsA is a debilitating disease and this morbidity will obviously translate into considerable health care costs, no UK data exist characterizing the financial costs of treating PsA. Although limited studies in other countries have been conducted, their applicability to the UK health system is unknown [23]. The purpose of this study was to estimate treatment costs with respect to disease severity from routine general practice data. It was intended that these cost data could then be used in economic evaluations of PsA therapy where disease severity was modelled; the principle being that a shift in PsA disease severity may result in a corresponding change in treatment costs.

Methods

Since PsA disease severity is not recorded in any consistent and objective way in routine primary care, it was necessary to first model disease severity using parameters that were recorded in the available primary care data source. In this regard, the summary score of the HAQ Disability Index [24] was used to represent disease severity. The eight categories of function assessed by the disability index are: (i) dressing and grooming; (ii) arising; (iii) eating; (iv) walking; (v) hygiene; (vi) reach; (vii) grip; and (viii) common daily activities. For each of these categories, patients report the amount of difficulty they have in performing two or three specific activities. The HAQ Disability Index is sensitive to change and is a good predictor of future disability and costs, and has been shown to be reliable and valid in different languages and contexts [25]. In PsA it is correlated with disease activity and is an accepted outcome measure of physical function in clinical trials [26] and recommended as a routine assessment [27].

This relationship could then be applied to the primary care data to characterize people by disease severity. Their costs would be estimated directly by characterizing primary care consultations and their profile of prescribed drugs, clinical investigations, hospital admissions and hospital outpatient encounters. The model of disease severity was developed with data from the British Society of Rheumatology Biologics Register (BSRBR) [28]. Treatment costs—for all treatments—were estimated using data from The Health Improvement Network (THIN) [29].

Data sources: the BSRBR

The BSRBR tracks the progress of patients with severe rheumatic conditions who are taking anti-TNF-α therapy. All consultant rheumatologists in the UK who have prescribed anti-TNF therapy participate in the register. Both patients and rheumatology health professionals complete BSRBR questionnaires on a 6-monthly basis. At baseline, patients eligible for anti-TNF-α therapy undergo detailed clinical assessment by a consultant rheumatologist who completes a standard clinical pro forma that includes the disease activity score-28 (DAS-28) [30]. At this stage patients complete a quality-of-life instrument, the short form 36 (SF-36); an assessment of daily activities questionnaire, the HAQ; and a health utility scale, the EuroQol 5-dimensions (EQ-5D) index [31]. Patient and consultant instruments are completed at 6-monthly intervals for 3 years followed by annual consultant instruments for 2 years. The data utilized here were extracted from the BSRBR on 10 May 2009 and covered the period from 2002 to July 2006, and for only those patients who received etanercept. Cases were selected, who were biologic naïve at recruitment, where the indication for starting etanercept was PsA and where baseline HAQ had been measured on or before the day of commencing biologic therapy.

Data sources: routine primary care data (THIN)

The cost component of this study involved the evaluation of people treated in UK general practices participating in THIN [29]. Created in 2002, THIN includes data from ~300 UK practices. Patients in THIN are similar in age, gender and geographical characteristics to the general UK population [29]. THIN includes records on 4.78 million patients, of which 2.26 million are currently active. Approximately 3% of patients are lost annually due to leaving a practice or death. The data are collected in a non-interventional way from the daily record-keeping of physicians. The records are anonymized at the collection stage so that the researchers have access to only encrypted identifiers for the physician’s office and the patient. The database contains information on all past and current medical diagnoses (recorded by using Read codes) and prescribed medications [coded using the British National Formulary (BNF) taxonomy]. THIN also includes laboratory values and other clinical investigations, the results of which are electronically captured, as well as many aspects of physical examinations. The current data extract included records up to March 2007, and ethical approval for the study was granted by Cambridge Multicentre Research Ethics Committee.

Patients were initially selected from THIN if they had any diagnosis of PsA in their medical records and were biologic naïve. Cases were excluded if they had ~6 months’ wash-in from the first date of any prescription to the date of first PsA diagnosis, and also if there was <12 months’ observation from the date of first PsA diagnosis to the last date of any prescription. This allowed us to verify drug treatment history.
Development of a statistical model of PsA disease severity (BSRBR)

A series of potential covariates was extracted to use in the severity model, including gender, age at initiation of biologic therapy, years of disease duration, ESR, number of current non-DMARD drugs and number of historic DMARD drugs to which the patient had been exposed. The number of DMARD treatments was characterized in detail (current and historic in separate counts) as a count of any of the following drug therapies: MTX, SFZ, LEF, gold, HCQ, penicillamine, AZA, ciclosporin, cyclophosphamide, minocycline and tacrolimus. Baseline HAQ was used to determine PsA severity and was selected from the patient follow-up table as the earliest known valid score before commencing biologic therapy.

Application of the PsA severity model within THIN

In addition to other common covariates such as age and sex, the number of DMARDs (current and historic) was recorded as a count of the number of different generic DMARD drugs prescribed between the date of first PsA diagnosis and the data-censoring point. DMARDs were defined by the BNF chapter code 10.01.03.00 (‘Drugs that suppress the rheumatic disease process’). The number of current non-DMARD drugs was recorded as a count of the number of different pharmacologically active products prescribed in the final 6 months before data censoring. A product was counted as a current drug if it had been prescribed three or more times within this period. For a sub-group of cases, ESR had been measured at least once in their final year of observation.

Estimation of treatment costs (THIN)

All costs were the sum of those observable in the final 12 months’ case history giving an annual total as given by the following:

Prescriptions costs: each prescription was attributed an estimated cost by applying the net ingredient cost per prescription from 1998 to 2008 [32, 33]. Where necessary, the year-specific net ingredient cost of each BNF catalogue entry was adjusted to 2007 prices using the Her Majesty’s Treasury gross domestic product deflator index [34].

Primary care contacts: the number of contacts with either general practitioners (GPs) or nurses was determined based upon the type of contact reported in the medical history on any given day during the period of observation. Of the 51 possible contact types, 31 were classifiable into one of 10 cost centres, derived from the ‘Unit costs of health and social care 2007’ [35].

Investigations: a look-up table of medical investigations was generated from events recorded in the final year of observation before the data censor for each case, classifying 269 investigations into 1 of 20 tariff codes detailed in the UK Department of Health Indicative Tariffs for diagnostics [36].

Acute hospital inpatient care: an inpatient episode was judged to have occurred where the location descriptor for an entry in the medical history was recorded as either hospital admission or discharge. Read codes associated with this event on the same day were mapped to either an International Classification of Disease version 10 (ICD-10) diagnostic code or an Office of Population Censuses and Surveys’s Classification of Operations and Procedures version 4 (OPCS-4) procedure code using five-character Read code mapping tables published by the National Health Service (NHS) [37]. Those admissions with either valid diagnostic or procedure codes were then assigned a Health Resource Group (HRG) code using the HRG v3.5 Grouper software (Department of Health, London, UK) [38]. Admissions were then assigned either a non-elective or elective admission tariff [39] depending on whether the descriptor type indicated a new event or follow-up, respectively. Admissions with no diagnostic or procedural codes were assigned an average elective or non-elective cost.

Outpatient appointments: a combination of ICD-10 diagnoses and specialty codes was used to assign each appointment to one of the indicative outpatient tariffs for first or follow-up consultations [39]. Outpatient appointments with no diagnostic or specialty information codes were assigned an average first or follow-up cost. Accident and Emergency (A&E) attendances were also accounted for at a single published cost per event [39].

Statistical analysis

General linear modelling was used to develop a regression model for predicting HAQ scores in THIN using the available baseline covariates in BSRBR common to both data sets. With baseline HAQ as the dependent variable, all available covariates were tested singly at first to identify candidates for inclusion in a multivariate model. A manual forward inclusion method was used to sequentially add significant covariates to the model. The criterion for retaining a covariate common to both data sets in the optimized multivariate model was parameter significance of ≤0.05. The relationship between predicted HAQ scores and total annual health care costs was explored by means of a generalized linear model using a Poisson distribution assuming a log link. Potential explanatory variables included gender, HAQ, age and two-way interactions between these. The optimal generalized model was selected using the modified park test in accordance with the Manning and Mullahy criterion [40] for the appropriate distribution, while a log link was selected as commonly used for analysing cost data. The goodness of fit for models was assessed using standard statistics (mean, s.d. and range) while the predictive ability was assessed using the mean error, mean absolute error (MAE) and root mean squared error (RMSE). The predictive ability of the model obtained was assessed using the individual-level data and, when predicting mean values for cohorts sub-grouped by disease severity, on the predicted HAQ scores.
Results

Baseline characteristics: BSRBR

Three hundred and fifty-six cases with PsA were recorded in the BSRBR (Table 1). Of these, 296 (83%) were biologic naïve and had a baseline HAQ score. The sample was roughly gender balanced (52% female) with an average age at biologic treatment initiation of 46.7 years (s.d. 10.8 years) (Table 1). Before initiating biologics, these cases had been previously treated with a median of 3 DMARD drugs [interquartile range (IQR) 2–4] and a median disease duration of 11 years (IQR 6–18 years). Cases were generated with a median of 3 concurrent non-DMARD drugs (IQR 2–5). The average baseline HAQ was 1.786 (S.D. 0.637), mean DAS-28 was 6.09 (S.D. 1.17) and median ESR was 33 (IQR 20–58).

Baseline characteristics: THIN

There were 4492 cases in THIN with a diagnosis of PsA (Table 1). Selecting only those with at least 6 months’ data before the first date of PsA diagnosis and at least 12 months of observations thereafter left a cohort of 2526 (56%) cases. These cases had a similar gender balance to the BSRBR sample, but were somewhat older with a mean age of 55 years (s.d. 14.9 years). They had been exposed to fewer DMARD therapies [median 1 (IQR 0–1)] and also received fewer current non-DMARD drugs [median 2 (IQR 0–5)]. A smaller subset of 750 cases had an ESR measurement in their final year of observation and had broadly similar characteristics to the parent sample. Their ESR was generally lower than the BSRBR cases with a median of 13 (IQR 7–26).

PsA severity model

In univariate analysis, gender, age, DAS-28, ESR, number of DMARDs (current and historic) and number of current non-DMARD drugs were all found to be significant predictors of HAQ score. The parameter significance of disease duration was outside the a priori threshold and therefore excluded from further testing. In stepwise multivariate general linear model modelling, baseline age failed to reach parameter significance in the presence of gender, the number of DMARDs and the number of current non-DMARDs, and was excluded from further testing. Removing all non-significant parameters, several optimized model options were tested. The model with widest applicability to the THIN data set included gender, with the number of DMARDs and the number of current non-DMARDs included as continuous covariates (Table 2). The estimatable HAQ range using this model was 1.187–2.362. Using ESR as an additional covariate gave marginally improved performance over the core three-variable model and a wider estimatable HAQ of 1.047–3.000.

Total costs

As typically seen in health care, the cost data are heavily skewed with a minority of patients incurring substantially higher annual costs. The total annual health care costs ranged from £11 to £20 782 with a mean of £1446 (s.d. £1756) and a median of £962 (IQR £463–£1774). When costs were sub-grouped by age, costs were significantly different (P < 0.001) for patients aged ≤50 years (£1094) and patients aged >50 years (£1660).

Prescription costs and secondary care episodes accounted for more than one-third of total care costs each (38 and 34%, respectively; Fig. 1). The average annual cost of prescribed medications per person per year was £544 (s.d. £636), although a negatively skewed distribution meant the median was somewhat lower at £359 (IQR £11 to £3 905).

**Table 1** Baseline characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>BSRBR</th>
<th>THIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>296</td>
<td>2526</td>
</tr>
<tr>
<td>Males, n (%)</td>
<td>141 (48)</td>
<td>1234 (49)</td>
</tr>
<tr>
<td>Females, n (%)</td>
<td>155 (52)</td>
<td>1292 (51)</td>
</tr>
<tr>
<td>Age, mean (s.d.), years</td>
<td>46.7 (10.8)</td>
<td>55.5 (14.9)</td>
</tr>
<tr>
<td>Number of prior DMARDs, median (IQR)</td>
<td>3 (2–4)</td>
<td>1 (0–1)</td>
</tr>
<tr>
<td>Number of current non-DMARDs, median (IQR)</td>
<td>3 (2–5)</td>
<td>2 (0–5)</td>
</tr>
<tr>
<td>HAQ, mean (s.d.)</td>
<td>1.786 (0.637)</td>
<td>–</td>
</tr>
<tr>
<td>BMI, mean (s.d.), kg/m²</td>
<td>29.5 (7.1)</td>
<td>–</td>
</tr>
<tr>
<td>DAS-28, mean (s.d.)</td>
<td>6.09 (1.17)</td>
<td>–</td>
</tr>
<tr>
<td>Disease duration, median (IQR), years</td>
<td>11 (6–18)</td>
<td>–</td>
</tr>
<tr>
<td>ESR, mm/h</td>
<td>33 (20–58)</td>
<td>–</td>
</tr>
</tbody>
</table>

**Table 2** HAQ regression models

<table>
<thead>
<tr>
<th>Parameter</th>
<th>β</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.42</td>
<td>1.22, 1.63</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Male gender</td>
<td>–0.32</td>
<td>–0.45, –0.19</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of DMARDs</td>
<td>0.06</td>
<td>0.02, 0.11</td>
<td>0.009</td>
</tr>
<tr>
<td>Number of other drugs</td>
<td>0.08</td>
<td>0.06, 0.11</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

R² = 0.227 (adjusted R² = 0.219).
Secondary care episode costs were highly negatively skewed as the difference between central tendencies shows: mean £497 (s.d. £1343) and median £88 (IQR £0–£440). Consultations with the GP cost on average £226 per year [S.D. £232; median £170 (IQR £68–£306)], while the mean annual cost of clinical investigations was £135 [S.D. £206; median £53 (IQR £0–£178)].

Total cost by PsA disease severity

As previously described, the HAQ was predicted in the THIN data set using the estimated regression model from the BSRBR. The predicted HAQ in the THIN data set ranged between 1.11 and 2.73 with a mean of 1.58 (0.33). The predicted HAQ covered a large proportion of the HAQ scale but did not cover the full HAQ range (0–3). Approximately 82% of patients in the THIN data set had a predicted HAQ score of < 2, and 2% had a HAQ score of ≥ 2.5. When costs were sub-grouped by HAQ score, costs were significantly lower (P < 0.05) for patients with a HAQ < 2 (£1252) compared with patients with a HAQ score of > 2 U (£2947).

The results of the regression exploring the relationship between disease severity (HAQ) and annual costs are presented in Table 3. The optimal generalized linear model included HAQ, age and the interaction term HAQ * age as explanatory variables. Gender was not included as costs were not significantly different between males and females (P = 0.123). Comparing the summary statistics for the individual patient-level predictions, the mean predicted costs are close to the observed values: £1446 (£804) vs £1446 (£1756). Predicted costs were in the range £358–£6274, compared with £11–£20 782 for the observed costs. Regarding the goodness of fit, the MAE was £850 and the RMSE was £1571. When sub-grouping according to HAQ score (Table 4 and Fig. 2), the mean observed costs range from £548 for the least severely affected (HAQ ≤ 1.2) to £4832 for the most severely affected (HAQ > 2.6). These are comparable to the corresponding predicted values: £662 and £5771. The MAEs and RMSE in the predicted values (£261 and £361) were reasonable when compared with the overall mean cost (£1446).

Discussion

To our knowledge, this study is the first describing health care costs associated with PsA in the UK from an NHS

**Table 3** Generalized linear model of annual health care costs observed in THIN (assuming Poisson distribution with a log link)

<table>
<thead>
<tr>
<th>Covariates</th>
<th>β</th>
<th>s.e.</th>
<th>z</th>
<th>P-value</th>
<th>95% CI for β Lower, Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAQ</td>
<td>2.048</td>
<td>0.006</td>
<td>342.5</td>
<td>&lt;0.001</td>
<td>2.037, 2.060</td>
</tr>
<tr>
<td>Age, years</td>
<td>0.026</td>
<td>0.000</td>
<td>147.0</td>
<td>&lt;0.001</td>
<td>0.025, 0.027</td>
</tr>
<tr>
<td>Age * HAQ</td>
<td>-0.012</td>
<td>0.000</td>
<td>-120.2</td>
<td>&lt;0.001</td>
<td>-0.012, -0.012</td>
</tr>
<tr>
<td>Intercept</td>
<td>3.537</td>
<td>0.010</td>
<td>340.8</td>
<td>&lt;0.001</td>
<td>3.516, 3.557</td>
</tr>
<tr>
<td>Number of observations</td>
<td>2526</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-1226.802</td>
<td></td>
<td>51.06</td>
<td>&lt;0.001</td>
<td>-1226.802, -1226.802</td>
</tr>
<tr>
<td>AIC</td>
<td>971.343</td>
<td></td>
<td>63.08</td>
<td>&lt;0.001</td>
<td>971.343, 971.343</td>
</tr>
<tr>
<td>BIC</td>
<td>2 412 079</td>
<td></td>
<td>128.48</td>
<td>&lt;0.001</td>
<td>2 412 079, 2 412 079</td>
</tr>
</tbody>
</table>

AIC: Akaike’s information criterion; BIC: Schwarz’s information criterion.

**Table 4** Mean costs sub-grouped by HAQ band

<table>
<thead>
<tr>
<th>HAQ mid-point</th>
<th>Age, years</th>
<th>Observed cost, £</th>
<th>Estimated cost, £</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.14</td>
<td>48.7</td>
<td>548</td>
<td>662</td>
</tr>
<tr>
<td>1.30</td>
<td>52.9</td>
<td>1120</td>
<td>875</td>
</tr>
<tr>
<td>1.49</td>
<td>52.3</td>
<td>995</td>
<td>1139</td>
</tr>
<tr>
<td>1.70</td>
<td>57.9</td>
<td>1652</td>
<td>1557</td>
</tr>
<tr>
<td>1.89</td>
<td>63.3</td>
<td>2351</td>
<td>2075</td>
</tr>
<tr>
<td>2.09</td>
<td>63.7</td>
<td>2484</td>
<td>2683</td>
</tr>
<tr>
<td>2.29</td>
<td>65.2</td>
<td>3186</td>
<td>3449</td>
</tr>
<tr>
<td>2.47</td>
<td>66.3</td>
<td>4285</td>
<td>4361</td>
</tr>
<tr>
<td>2.65</td>
<td>54.9</td>
<td>4832</td>
<td>5771</td>
</tr>
</tbody>
</table>

Model predictive ability: ME £124; MAE £261; and RMSE £361. ME: mean error.
perspective among biologic-naive patients. The health care costs estimated from the THIN data set can be considered representative of the costs associated with PsA in the UK. The mean annual health care cost associated with PsA was estimated to be £1446 (s.d. £1756) per person. Prescription costs and secondary care episodes accounted for more than one-third of total care costs each.

When costs were sub-grouped by predicted HAQ score, they were significantly lower ($P < 0.05$) for patients with a HAQ of $\leq 2$ (£1252) compared with patients with a HAQ score of $>2$ units (£2947). For comparison, the annual cost associated with RA in the UK was ~£579.94 for patients with a HAQ of between 1 and 2 and £1673.41 for RA patients with a HAQ $>2$ units [41]. Our study suggests that the economic burden associated with PsA may be more important compared with RA. This may be attributable to differences in methods, the various cost included, or the requirement to predict the HAQ in the THIN data set. Costs in our study may also be overestimated given the inclusion of health care costs associated with comorbidities. In Germany and Hungary, health care costs for RA were found to be superior to the cost associated with PsA using a similar methodology for calculating health care costs for both PsA and RA [42, 43]. Our estimate was also compared with the cost of PsA observed in other European countries. In Germany for example, the mean direct annual costs associated with PsA was estimated to be €3156 (£2875). When health care costs were sub-grouped by HAQ band, costs were estimated to be €2331 (£2124), €4461 (£4064) and €5721 (£5212) for PsA patients with a HAQ score $<1.2$; between 1.2 and 1.7; and $>1.7$; respectively [42]. In Hungary, the mean annual cost among 172 PsA patients not treated by biologics was estimated to be €1681 (£1531) [43].

The observed estimates of the cost of care in this study are limited by the scope of the data recorded by physicians in their routine record-keeping. Our study only included costs associated with prescriptions, secondary care, investigations, GP (surgery, home or telephone consultations) and nurse (community or practice nurse). The use of registry data may also be associated with limitations. For example, the hospital data are likely to be underestimated because of underreporting of both outpatient attendances and inpatient admissions. Furthermore, this study did not separate health care costs related directly or not to PsA.

Costs were estimated from an NHS perspective, and only health care costs were included in this analysis. Other studies conducted in PsA have shown that the economic burden of PsA in terms of use of social care and reduced employment can be important [42, 43]. Consequently, this study only reports part of the picture of costs associated with PsA and represents an underestimation of the total costs associated with this disease.

The relationship between the predicted disease severity and total annual health care costs was also explored. The approach used presented a few limitations. First, it was necessary to predict the HAQ in the THIN data set using a separate regression model from the BSRBR. It is unclear how results from this model are applicable to the THIN data set given differences in patient’s characteristics, especially in the number of prior and current DMARDs. In addition, any model that utilizes two predictive elements will always be open to criticism due to potential multiplication of the variances; however, in this instance lack of a suitable single data source made this approach necessary.

Secondly, the absence of quantitative dermatology data from both BSRBR and THIN is a limitation of the study; however, other than clinical trial data we are not aware of any routine clinical practice data in which clinical dermatology severity is recorded. Thirdly, when the model was used to predict HAQ in the THIN data set, the HAQ score ranged between 1.11 and 2.73 for a mean of ~1.58 (0.33). The predicted HAQ did not cover the full HAQ range (0–3),
which may have an implication when constructing a model to predict costs across the full HAQ range. Given that the relationship between HAQ and costs was explored using a generalized linear model (exponential model), the errors in predicted values at the more severe end of the disease range could be substantial (Fig. 2).

However, comparing the summary statistics for the individual patient-level predictions, the mean predicted annual costs are close to the observed values. When sub-grouping according to HAQ score (Table 4 and Fig. 2), the mean observed costs were comparable with predicted costs with an RMSE of £361.

This study provides information about direct health care use associated with PsA and the possible relationship between disease severity and costs. As shown in previous studies conducted in PsA in other European countries, PsA is shown to be a debilitating disease with costs increasing exponentially as disease severity increases [42, 43]. The recent introduction of anti-TNF in the UK would, therefore, have contributed to a reduction in the burden associated with PsA. In this study, although our data cover a 10-year period between 1996 and 2006, the majority of our observations (85%) (i.e. final year prior to censorship) document only a 2-year period from 2004 to 2006, because the majority are active cases censored only by the 2007 mid-year horizon of our THIN subset. A meaningful comparison of health care costs before the marketing authorization of etanercept for PsA in December 2002 is therefore not feasible, given the small number of cases available before this date. Equally a within-subject cost analysis for biologic-treated cases before and after initiation of their biologic was not feasible, given that only a handful (<10) of such patients were observed. These cases were specifically excluded to leave a sample of biologic-naïve patients.

Costs were also limited to health care costs, and further studies should be conducted to capture the total costs associated with PsA including social care cost and reduced employment, which are shown to be considerable in other countries. Finally, further research is also needed to capture more accurately the relationship between disease severity and direct health care costs given the necessarily complex method used in this study.

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**References**


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