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Clinical science

Predictors of DAPSA28 remission in patients with psoriatic arthritis initiating a first TNF inhibitor: results from 13 European registries

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Abstract

Objectives: In bio-naïve patients with PsA initiating a TNF inhibitor (TNFi), we aimed to identify baseline predictors of Disease Activity index for PsA in 28 joints (DAPSA28) remission (primary objective) and DAPSA28 moderate response at 6 months, as well as drug retention at 12 months across 13 European registries.

Methods: Baseline demographic and clinical characteristics were retrieved and the three outcomes investigated per registry and in pooled data, using logistic regression analyses on multiply imputed data. In the pooled cohort, selected predictors that were either consistently positive or negative across all three outcomes were defined as common predictors.

Results: In the pooled cohort ($n = 13\,369$), 6-month proportions of remission, moderate response and 12-month drug retention were 25%, 34% and 63% in patients with available data ($n = 6954$, $n = 5275$ and $n = 13\,369$, respectively). Five common baseline predictors of remission, moderate response and 12-month drug retention were identified across all three outcomes. The odds ratios (95% CIs) for DAPSA28 remission were: age, per year: 0.97 (0.96–0.98); disease duration, years (<2 years as reference): 2–3 years: 1.20 (0.89–1.60), 4–9 years: 1.42 (1.09–1.84), ≥10 years: 1.66 (1.26–2.20); men *vs* women: 1.85 (1.54–2.23); CRP of >10 *vs* ≤10 mg/l: 1.52 (1.22–1.89) and 1 mm increase in patient fatigue score: 0.99 (0.98–0.99).

Conclusion: Baseline predictors of remission, response and adherence to TNFi therapy were identified, of which five were common for all three outcomes, indicating that the predictors emerging from our pooled cohort may be considered generalizable from country level to disease level.

Keywords: PsA, first TNF-inhibitor, predictors, DAPSA28, drug retention, real-world evidence

Rheumatology key messages

- This real-world study across 13 European countries presents data on 13 369 patients with psoriatic arthritis.
- Baseline predictors of remission, response and drug-retention following treatment with a first TNFi were identified.
- There was consistency of predictors across registries and treatment outcomes, suggesting generalizability from country level to disease level.

Introduction

TNF inhibitors (TNFis) have contributed to major improvements in clinical outcomes and quality of life for patients with PsA. However, many patients treated with TNFis fail to achieve the recommended treatment target of remission or, alternatively, low disease activity [1, 2].

As the palette of treatment options continues to increase, understanding baseline determinants of a good response to TNFis is important for clinicians and patients in their shared decision-making.

Several possible baseline predictors of treatment response in PsA have been investigated in individual countries or regions, including demographic, clinical, patient-reported and life-style characteristics, but no consistent pattern of predictors has emerged from the studies [3–17]. Cross-country differences in baseline characteristics of PsA patients initiating TNFi treatment have been reported in a previous study from the EuroSpA collaboration [2], and such differences may have contributed to the inconsistencies in observed predictors of a treatment response across studies from individual countries.

In addition to differences in patient characteristics, a wide range of outcome measures has been applied [3–17], possibly reflecting the different views on how best to capture the full spectrum of PsA with its various clinical manifestations [18]. In 2017, an international task force proposed the Disease Activity index for PSoriatic Arthritis (DAPSA) [19] for disease activity assessment in PsA [20]. The DAPSA includes a 66/68 swollen/tender joint count, which, however, is not always performed in routine clinical settings. Therefore, the modified DAPSA28, based on a 28-joint count, has been developed and compared with the original DAPSA and found valid [21]. The authors suggested that DAPSA28 might be an alternative if the full DAPSA was missing in registry studies [21]. While treatment responses according to DAPSA28 have been reported previously for 14 261 European patients with PsA initiating a TNFi [2], predictors of such a response using DAPSA28 as an outcome have not been investigated in a real-world cohort.

Thus, in this study of PsA patients starting their first TNFi, the primary aim was to identify baseline predictors of DAPSA28 remission after 6 months' treatment. Secondary aims were to identify baseline predictors of achieving DAPSA28 moderate response after 6 months and baseline predictors of 12-month drug retention.

Methods

Data sources

This study included secondary use of data on patients registered with a PsA diagnosis from 13 European registries: ATTRA (Czech Republic), DANBIO (Denmark), ROB-FIN (Finland), ICEBIO (Iceland), GISEA (Italy), NOR-DMARD (Norway), Reuma.pt (Portugal), RRBR (Romania), biorx.si (Slovenia), BIOBADASER (Spain), SRQ (Sweden), SCQM (Switzerland) and TURKBIO (Turkey). In all registries, data are collected prospectively as part of routine clinical practice. Based on a predefined study protocol, anonymized data were uploaded by individual registries onto a secure central server.

Patients and visits

Patients were included if they had a registered clinical diagnosis of PsA, were aged ≥18 years at diagnosis, and had initiated

a first TNFi treatment at some point between diagnosis and 90 years of age, with a start date between 1 January 2009 and 31 December 2018. The baseline visit was defined as a registered visit within the period 30 days before to 30 days after the registered date of TNFi treatment start (i.e. baseline date), with priority given to visits before treatment start. The 6-month visit was defined as the one closest in time to 180 days within a range of 90–270 days after the baseline date. Baseline patient characteristics included demography, clinical measures, treatment, and patient-reported outcomes (Table 1).

End points

The primary end point was DAPSA28 remission (i.e. DAPSA28 of ≤4) at 6 months after initiation of the first TNFi [21]. Secondary end points were (1) DAPSA28 moderate response at 6 months (here defined as a 75% improvement from the baseline DAPSA28, similar to the corresponding response definition for the original DAPSA score, as no validated definition for DAPSA28 moderate response is available [22]) and (2) 12-month drug retention.

Patients with no available 6-month DAPSA28 data were classified as having achieved DAPSA28 remission and DAPSA28 moderate response, respectively, if they fulfilled both of the following two criteria: (1) they had stopped the TNFi before 6 months and no subsequent biologic (b) or targeted synthetic (ts) DMARD was started within 6 months from the previous treatment start, and (2) if the clinician had stated 'remission' as the reason for discontinuation (Fig. 1a and b). Patients who stopped the TNFi during the first 6 months due to lack of effect, were considered as not having achieved DAPSA28 remission or DAPSA28 moderate response. Patients discontinuing treatment due to adverse events, other reasons, or no stated reason, were not included in the analyses.

Twelve-month drug retention was defined as the proportion of patients with a treatment duration of ≥52 weeks. Treatment duration was defined as the number of weeks between the registered date of treatment start and the registered stop date. If the same drug was restarted within 3 months of a registered stop date, and no other treatment was recorded in between, the treatment periods were considered as one. Switching to a biosimilar of the same drug was disregarded. A treatment without a registered stop date was assumed to have been discontinued if a new b or ts DMARD treatment was recorded in the registry, and the stop date was then defined as the date of next treatment start. If no new treatment had been registered, a stop date was entered 12 months after the last registered visit. In the remaining observations, the stop date was defined as the date of data extraction, date of death, or end of registry follow-up, whichever came first.

Ethics

All participating registries obtained necessary approvals from relevant authorities prior to data transfer to the EuroSpA coordinating centre. This study was designed, implemented and reported in accordance with the Guidelines for Good Pharmacoepidemiology Practices (GPP) of the International Society for Pharmacoepidemiology (ISPE 2008), the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines [23] and the ethical principles laid down in the Declaration of Helsinki.

Statistics

The statistical approach used for the current study has previously been applied in a cohort of patients with axial SpA and is summarized below [24].

Descriptive analyses of the baseline patient characteristics were performed per registry, in the pooled cohort, and additionally for patients with and without available data on DAPSA28 remission and moderate response at 6 months (in the pooled cohort only).

Logistic regression analyses were used to identify baseline variables associated with the primary and secondary end points. Regression models were applied separately per registry and in the pooled cohort. Events-per-variable (EPV) was used to evaluate the sample size within the logistic regression models. Likelihood ratio tests were used to assess all models. Results of the multivariable models are presented as odds ratio (OR) with 95% or 85% CIs, see below.

Independent variables

Sex, smoking status (current *vs* previous/never), use of concomitant conventional synthetic (cs) DMARDs, CRP (≤10 *vs* >10 mg/l) and year of TNFi start (2009–2014 *vs* 2015–2018) were included as categorical variables. Age at treatment start, time since diagnosis, BMI, 28 tender and swollen joint counts, physician global score, HAQ [25], and patient pain and fatigue scores were included as continuous variables. Age at diagnosis, ESR and patient global score were not included in the models, as they were considered to represent an overlap with time since diagnosis, CRP, and patient pain and fatigue scores, respectively. For further details on the independent variables, see Tables 2–5.

Missing data

Patients with no registration of concomitant csDMARDs were considered not to be using such drugs. For all remaining independent baseline variables, multiple imputation by chained equations (MICE) was applied in a pooled dataset containing all registries (30 imputed datasets).

Variable selection

Variable selection in multiply imputed data for each end point followed. First, variable selection was performed separately in each of the 30 imputed datasets; the final model included the predictors that appeared in at least half of the models. Once the set of predictors was selected, the model was fitted to all imputed datasets and the model estimates were pooled according to Rubin's rules [24, 26].

Analyses in individual registries

To compare the selected predictors across registries, prediction models were first applied in each registry. A significance level of 0.157 was chosen due to small EPV values in some registries, corresponding to an 85% CI [27]. The individual registry regression analyses were evaluated for consistency of selected predictors by visual inspection to determine whether pooling of the data was feasible.

Analyses in the pooled cohort

The pooled dataset was split into a derivation cohort and a validation cohort for each of the three end points, ensuring that 50% of patients from each registry went into each cohort, respectively. Registries with EPV ≥ 1 in the derivation

Table 1. Baseline characteristics of PsA patients starting a first TNFi, pooled and stratified by registry

Country	All	Czech Republic	Denmark	Finland	Iceland	Italy	Norway	Portugal	Romania	Slovenia	Spain	Sweden	Switzerland	Turkey
Registry	**Pooled**	**ATTRA**	**DANBIO**	**ROB-FIN**	**ICEBIO**	**GISEA**	**NOR-DMARD**	**Reuma.pt**	**RRBR**	**Biorx.si**	**BIOBADASER**	**SRQ**	**SCQM**	**TURKBIO**
Number of patients, *n*	13369	718	2090	234	306	1591	717	675	86	367	445	5225	628	287
Demography and diagnosis														
Age at treatment start, years	49 (40–58)	49 (40–57)	48 (39–56)	48 (40–56)	50 (39–59)	51 (42–59)	47 (39–57)	49 (40–57)	52 (47–61)	51 (43–57)	50 (40–57)	50 (40–59)	50 (40–58)	41 (34–51)
Age at diagnosis, years	43 (34–52)	40 (31–49)	43 (34–52)	40 (30–48)	43 (32–53)	45 (36–54)	41 (32–51)	42 (33–51)	47 (39–55)	43 (35–51)	45 (36–53)	43 (34–53)	44 (35–54)	36 (29–45)
Time since diagnosis, years	3 (1–8)	6 (2–12)	3 (1–7)	5 (2–11)	4 (1–9)	3 (1–7)	3 (1–9)	4 (2–8)	4 (2–6)	5 (2–10)	3 (1–7)	3 (1–8)	2 (1–6)	3 (1–7)
Men, *n* (%)	6385 (48%)	386 (54%)	928 (44%)	118 (50%)	126 (41%)	733 (46%)	345 (48%)	338 (50%)	37 (43%)	194 (53%)	227 (51%)	2552 (49%)	293 (47%)	108 (38%)
BMI, kg/m^2	27.0 (24.1–30.5)	28.1 (24.9–32.0)	27.2 (23.9–30.5)	27.8 (25.2–31.4)	30.1 (26.8–34.4)	26.2 (23.5–29.4)	NA	26.5 (24.0–29.4)	28.5 (25.5–31.8)	26.6 (23.8–29.7)	27.1 (24.2–30.7)	NA	26.5 (23.5–29.8)	28.1 (25.3–31.2)
Current smokers, *n* (%)	1865 (17%)	89 (16%)	582 (29%)	14 (12%)	26 (15%)	67 (8%)	131 (22%)	74 (16%)	4 (5%)	54 (15%)	98 (23%)	528 (12%)	127 (24%)	71 (26%)
Fulfilling the CASPAR criteria, *n* (%)	2497 (93%)	675 (95%)	284 (96%)	NA	47 (94%)	71 (96%)	NA	455 (89%)	79 (92%)	364 (99%)	NA	NA	502 (87%)	20 (87%)
Clinical measures														
Swollen joint count (28)	2 (0–5)	7 (3–10)	1 (0–3)	2 (1–5)	4 (2–6)	1 (0–3)	1 (0–3)	3 (1–6)	–	6 (3–9)	2 (1–4)	2 (0–5)	2 (0–4)	2 (0–4)
Swollen joint count (66)	3 (1–7)	9 (5–12)	3 (0–6)	3 (1–6)	–	1 (0–4)	NA	4 (1–8)	–	NA	NA	3 (1–6)	3 (1–6)	–
Tender joint count (28)	4 (1–9)	10 (5–13)	4 (1–8)	3 (1–6)	4 (2–6)	3 (1–8)	2 (1–6)	4 (2–9)	–	8 (4–12)	3 (1–6)	4 (2–8)	3 (1–7)	4 (1–8)
Tender joint count (68)	7 (3–12)	12 (8–19)	8 (4–14)	4 (2–9)	–	4 (2–10)	NA	7 (3–13)	–	NA	NA	6 (3–11)	6 (2–11)	–
CRP, mg/l	6 (3–14)	15 (6–28)	5 (2–12)	6 (3–13)	8 (3–15)	NA	5 (2–11)	8 (4–19)	–	7 (3–16)	NA	5 (2–12)	5 (2–10)	9 (3–17)
ESR, mm/h	15 (7–29)	30 (17–45)	NA	14 (5–24)	NA	15 (8–30)	12 (6–22)	24 (11–42)	–	24 (12–40)	17 (7–34)	12 (6–24)	11 (6–20)	NA
Physician global score (mm)	40 (25–60)	65 (50–80)	25 (15–40)	38 (26–51)	56 (41–70)	50 (30–70)	30 (21–40)	50 (36–65)	–	60 (40–70)	NA	40 (30–50)	40 (30–60)	31 (20–62)
DAPSA28, units	25 (17–37)	41 (30–52)	23 (16–34)	21 (16–33)	28 (21–34)	NA	17 (12–26)	28 (19–40)	–	38 (26–51)	NA	24 (17–35)	19 (13–29)	26 (17–34)
DAPSA (original), units	25 (18–35)	36 (27–43)	26 (19–36)	21 (15–29)	–	NA	NA	26 (19–37)	–	NA	NA	23 (17–31)	21 (15–32)	–
DAS28-CRP, units	4.2 (3.3–5.0)	5.2 (4.6–5.8)	4.0 (3.1–4.8)	3.9 (3.2–4.7)	4.3 (3.9–4.9)	NA	3.5 (2.7–4.3)	4.3 (3.6–5.2)	–	5.0 (4.1–5.6)	NA	4.1 (3.3–4.8)	3.6 (2.7–4.5)	4.2 (3.2–4.9)
Treatment														
n (%)														
Infliximab	2251 (17%)	99 (14%)	576 (28%)	56 (24%)	188 (61%)	114 (7%)	91 (13%)	52 (8%)	8 (9%)	26 (7%)	39 (9%)	907 (17%)	64 (10%)	31 (11%)
Etanercept	4654 (35%)	126 (18%)	495 (24%)	60 (26%)	67 (22%)	657 (41%)	211 (29%)	270 (40%)	18 (21%)	63 (17%)	170 (38%)	2290 (44%)	147 (23%)	80 (28%)
Adalimumab	3987 (30%)	352 (49%)	626 (30%)	87 (37%)	9 (3%)	614 (39%)	87 (12%)	198 (29%)	41 (48%)	172 (47%)	132 (30%)	1312 (25%)	243 (39%)	114 (40%)
Certolizumab pegol	847 (6%)	47 (7%)	208 (10%)	6 (3%)	0 (0%)	28 (2%)	190 (26%)	12 (2%)	0 (0%)	31 (8%)	38 (9%)	248 (5%)	16 (3%)	23 (8%)
Golimumab	1630 (12%)	94 (13%)	185 (9%)	25 (11%)	42 (14%)	178 (11%)	138 (19%)	143 (21%)	19 (22%)	75 (20%)	66 (15%)	468 (9%)	158 (25%)	39 (14%)
TNFi start year[a], *n* (%)														
2009–2014	7541 (56%)	344 (48%)	1231 (59%)	179 (76%)	144 (47%)	1254 (79%)	469 (65%)	336 (50%)	0 (0%)	219 (60%)	95 (21%)	2708 (52%)	452 (72%)	110 (38%)
2015–2018	5828 (44%)	374 (52%)	859 (41%)	55 (24%)	162 (53%)	337 (21%)	248 (35%)	339 (50%)	86 (100%)	148 (40%)	350 (79%)	2517 (48%)	176 (28%)	177 (62%)
Concomitant csDMARD (%)[b]	7832 (59%)	588 (82%)	1311 (63%)	190 (81%)	129 (42%)	916 (58%)	529 (74%)	463 (69%)	85 (99%)	285 (78%)	323 (73%)	2539 (49%)	361 (57%)	113 (39%)
Patient-reported outcomes (PROs)														
Patient pain score (mm)	61 (42–77)	70 (50–80)	63 (43–78)	54 (36–72)	67 (50–78)	60 (50–80)	48 (29–65)	60 (48–80)	–	70 (56–80)	NA	61 (43–75)	60 (40–70)	75 (55–80)
Patient fatigue score (mm)	65 (41–80)	65 (50–80)	70 (50–84)	NA	70 (50–80)	NA	45 (15–70)	NA	NA	NA	NA	64 (41–78)	–	70 (50–75)
Patient global score (mm)	64 (45–80)	70 (58–80)	72 (52–87)	51 (31–70)	74 (54–85)	60 (50–80)	51 (31–70)	64 (48–80)	–	70 (60–80)	60 (50–80)	60 (42–75)	60 (40–80)	70 (54–75)
HAQ (units)	0.9 (0.5–1.4)	1.2 (0.9–1.6)	1.0 (0.6–1.5)	0.9 (0.5–1.4)	1.2 (0.8–1.5)	1.0 (0.4–1.5)	0.5 (0.2–0.9)	1.1 (0.5–1.5)	–	1.1 (0.5–1.6)	NA	0.9 (0.5–1.2)	0.8 (0.4–1.1)	0.8 (0.6–0.9)
Comorbidities and conditions associated with PsA														
Psoriasis	1904 (83%)	NA	378 (100%)	203 (87%)	NA	NA	NA	311 (61%)	41 (48%)	328 (89%)	–	NA	529 (89%)	90 (100%)
Uveitis	63 (3%)	NA	NA	10 (4%)	NA	NA	NA	1 (0%)	0 (0%)	6 (2%)	14 (3%)	NA	32 (5%)	NA
IBD	148 (8%)	NA	–	7 (3%)	NA	92 (100%)	NA	0 (0%)	0 (0%)	2 (1%)	NA	NA	22 (4%)	–
Cardiovascular disease	898 (26%)	262 (36%)	–	67 (29%)	NA	123 (100%)	108 (23%)	9 (2%)	43 (50%)	116 (32%)	18 (5%)	NA	108 (24%)	–
Diabetes	396 (12%)	57 (8%)	–	16 (7%)	NA	119 (100%)	27 (6%)	27 (5%)	14 (16%)	27 (7%)	34 (9%)	NA	27 (6%)	–
Kidney	92 (3%)	7 (1%)	NA	0 (0%)	NA	–	7 (1%)	8 (2%)	7 (8%)	4 (1%)	1 (0%)	NA	9 (3%)	NA

Data are as observed, median (interquartile range) or percentage. Percentages are calculated based on the number of patients with available data, unless stated otherwise. Cells are marked with '–' if based on <50 patients.

[a] 2009 was chosen because the first three biologic DMARDs (bDMARDs) (adalimumab, etanercept and infliximab) were all well-established treatment options across the European countries from that year. 2015 was chosen as secukinumab was approved as the first non-TNFi bDMARD treatment option that year.

[b] Patients with no registration of concomitant use of csDMARDs were considered to not be using such drugs; all data are thus considered available.

NA: not available; CASPAR: ClASsification criteria for Psoriatic ARthritis; DAPSA28: Disease Activity index for PSoriatic Arthritis in 28 joints; DAPSA (original): based on 66/68 joints; DAS28-CRP: disease activity score in 28 joints based on CRP; HLA-B27: HLA subtypes B*2701–2759; TNFi: TNF inhibitor; csDMARD: conventional synthetic DMARD.

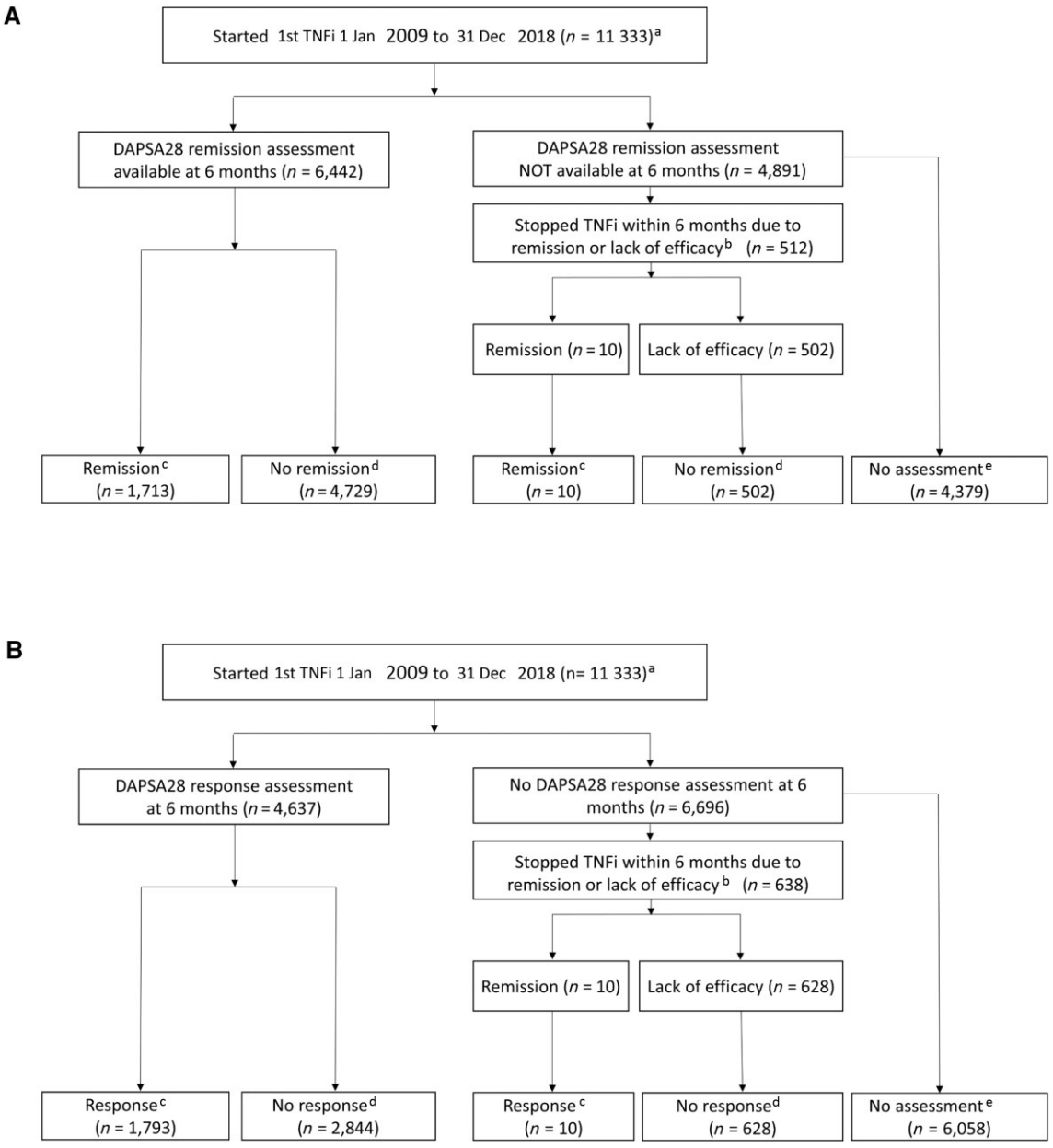

Figure 1. Classification of patients starting their first TNF-inhibitor with regards to DAPSA28 remission (A) and DAPSA28 moderate response (B) at 6 months. [a]Excluding Italy and Spain due to no available CRP. [b]According to the opinion of the clinician. [c]Remission: $n = 1723$ (panel A)/response: $n = 1803$ (panel B). [d]No remission: $n = 5231$ (panel A)/no response: $n = 3472$ (panel B). [e]Including patients stopping TNFi after 6 months for any reason, patients stopping TNFi within 6 months for other reasons, and patients continuing on TNFi but without an assessment. TNFi: TNF inhibitor; DAPSA28: Disease Activity index for PSoriatic Arthritis in 28 joints

cohort were pooled. Age, sex and registry were a priori forced into the models, and continuous variables were categorized if the assumption of linearity was violated. A significance level of 0.05 and a corresponding 95% CI was applied. Selected predictors that were either consistently positive or negative across all three outcomes, were defined as common predictors. The performance of the final multivariable models was evaluated in the validation cohorts by calculating the area under the receiver operating curve (AUROC) [28].

Additional analyses

In addition, we assessed whether differences in per registry proportions for DAPSA28 remission, moderate response and drug retention impacted the identified predictors, by stratifying the pooled cohort into three ordered levels based on visual inspection of the distribution of the outcomes in the registries. Prediction models were applied to each stratum, adjusting for registry using a variable selection process similar to the analyses in individual registries.

Finally, as DAPSA is the gold standard in the assessment of PsA patients, we conducted a prediction analysis in a subset with available remission and response criteria based on 66/68 joint counts, i.e. applying DAPSA remission (≤ 4) and DAPSA moderate response (75% improvement from baseline) as outcomes and substituting the 28 joint counts with 66/68 joint counts as predictors [22]. R version 4.1.0 was used for the statistical analyses.

Results

Cohorts

Across the 13 registries, 13 369 PsA patients had started a first TNFi treatment during the study period. Baseline patient characteristics by registry and pooled are shown in Table 1, with corresponding information on data availability in Supplementary Table S1, available at *Rheumatology* online. Numerical baseline differences between patients with *vs* without 6-month follow-up data were only seen for concomitant csDMARDs (Supplementary Table S2, available at *Rheumatology* online).

DAPSA28 remission and moderate response

Of the 13 registries, 11 collected data on DAPSA28 ($n = 11\,333$) (Table 1). A total of 6442 (57%) patients had a DAPSA28 assessment at the 6-month follow-up visit after initiating their first TNFi, with 1713 (27%) of these having achieved DAPSA28 remission. Of the 4891 patients with no DAPSA28 assessment at 6 months (43%), 512 were instead classified according to their discontinuation reason prior to 6 months follow-up (Fig. 1a). In total, 1723 of 6954 patients (25%) were classified as having achieved DAPSA28 remission at 6 months. Proportions of DAPSA28 remission ranged from 18% to 34% across registries (Table 2). Corresponding results for DAPSA28 moderate response are presented in Fig. 1b and Table 3.

Drug retention

All patients initiating a first TNFi were included in the drug retention analyses. Thereof, 8461 (63%) were still on treatment at 12 months, with proportions ranging from 54% to 76% across registries (Table 4).

Prediction analyses in individual registries

Eleven registries fulfilled the EPV criteria and were eligible for prediction analyses of the primary end point DAPSA28 remission at 6 months. Male sex was identified as a predictor in 9 registries (positive in 8 and negative in 1), while negative predictors included older age at treatment start (9 registries), higher tender joint count (7 registries), and higher BMI, patient pain and fatigue scores in 5 registries. The remaining baseline variables were found predictive in less than half of the eligible registries in which the variable was available, see Table 2 and Supplementary Table S3, available at *Rheumatology* online, for presentation of ORs.

Eleven and 13 registries, respectively, were eligible for analyses of the secondary end points 6-month DAPSA28 moderate response and 12-month drug retention. Higher swollen joint count was identified as a positive predictor of DAPSA28 moderate response in 8 registries and CRP of >10 mg/l in 6 registries. Negative predictors included older age at treatment start (6 registries) and current smoking, higher BMI and higher patient fatigue score (5 registries). Male sex and longer disease duration were positive predictors of 12-month drug retention in 10 and 8 registries, respectively, while TNFi start year 2015–2018 was a negative predictor in 10 registries. A concomitant csDMARD was a positive predictor in 6 registries and a negative predictor in 1 registry. The remaining baseline variables were found predictive in less than half of the registries in which the variable was available, see Tables 3–4 and Supplementary Tables S4 and S5, available at *Rheumatology* online, for presentation of ORs.

Prediction analyses in the pooled cohort

The consistency of predictors in the regression analyses per registry was found to justify pooling the data (Tables 2–4). Common baseline predictors across all three outcomes (6-month DAPSA28 remission/6-month DAPSA28 moderate response/12-month drug retention) in the derivation cohort were: male sex, longer disease duration, higher CRP (positive predictors); older age at treatment start, higher fatigue score (negative predictors) (Table 5).

A higher pain score was a negative predictor of DAPSA28 remission and 12-month drug retention but a positive predictor of DAPSA28 moderate response (Table 5).

The performance of the final models as assessed by the AUROC in the validation cohort was estimated to 0.75 (DAPSA28 remission), 0.73 (DAPSA28 moderate response) and 0.64 (12-month drug retention), i.e. the models were able to correctly predict remission in 75%, moderate response in 73% and 12-month drug retention in 64% of patients (Table 5).

In the pooled analyses stratified according to the proportion of patients achieving DAPSA28 remission, DAPSA28 moderate response and 12-month drug retention, the common predictors identified in the pooled unstratified analyses (positive: male sex, longer disease duration, higher CRP; negative: older age at treatment start and higher patient fatigue score) were identified in at least 2 of 3 strata across the three outcomes (Supplementary Table S6, available at *Rheumatology* online).

In the additional analyses with DAPSA remission and moderate response as outcomes, fewer data were available compared with the DAPSA28 analyses (Supplementary Tables S1 and S7, available at *Rheumatology* online). Baseline differences between patients with *vs* without 6-month follow-up DAPSA were comparable with those seen in the DAPSA28 analyses, as were the predictors in the regression analyses per registry (data not shown). In the prediction models on pooled data, we identified the same predictors as for DAPSA28. In addition, the 66 swollen joint count was a common positive predictor, which is in contrast to the DAPSA28 analyses, in which the 28 swollen joint count was not identified as a common predictor (Supplementary Table S7, available at *Rheumatology* online).

Discussion

In this study, we identified five common baseline predictors of TNFi treatment response and retention, for the first time applying the DAPSA28 as an end point in a large-scale prediction analysis across 13 European countries through the EuroSpA collaboration.

The main findings were that male sex, longer disease duration and higher CRP were positive predictors of DAPSA28 remission and DAPSA28 moderate response at 6 months and of drug retention after 12 months, while older age at treatment start and a higher patient fatigue score were negative predictors.

In the EuroSpA collaboration, we have previously shown how baseline characteristics and treatment outcomes differ across European countries, possibly illustrating different prescription practices and access to therapy [2]. To analyse whether cross-country differences might contribute to inconsistencies in baseline predictors of treatment response across

Table 2. Summary of predictors of DAPSA28 remission after 6 months of treatment with the first TNFi per registry[a] for registries with EPV per available independent variables ≥1

Country	Czech Republic	Denmark	Finland	Iceland	Norway	Portugal	Romania	Slovenia	Sweden	Switzerland	Turkey	Row sum[b]
Registry	**ATTRA**	**DANBIO**	**ROB-FIN**	**ICEBIO**	**NOR-DMARD**	**Reuma.pt**	**RRBR**	**Biorx.si**	**SRQ**	**SCQM**	**TURKBIO**	
Patients with DAPSA28 remission assessment, *n*	480	1496	113	177	546	383	82	287	3074	157	159	
DAPSA28 remission, *n* (%)	127 (27)	344 (23)	35 (31)	45 (25)	163 (30)	102 (27)	17 (21)	51 (18)	748 (24)	37 (24)	54 (34)	
EPV per available IVs	9.1	24.6	2.7	3.2	12.5	7.8	1.7	3.9	57.5	2.6	3.9	
Age at treatment start, years	–	–	–		–	–		–	–	–	–	9
Men	+	+	+	+	+	+	–		+		+	9
Time since diagnosis, years	+	+			+		+		+			5
BMI, kg/m^2	–	–			NA	–	–		NA	–		5
Current smokers		–								–		2
Concomitant csDMARD							Constant					0
1st TNFi start, year (2015–2018)[c]		+					Constant			+		2
CRP > 10 mg/l[d]	+	+					Constant		+			3
Patient pain score, mm		–	–	–	–	–					+	6
Patient fatigue score, mm		–	NA		–	NA	NA	NA	–	–	–	5
Physician global score, mm	–		+						–			3
HAQ, units	–	–		–				–	–			5
Swollen joint count (28)					+				+			2
Tender joint count (28)		–	–	–	–			–	–	–		7
Sum of independent predictors[e]	7	11	5	4	7	4	3	3	9	6	4	
Total number of available IVs[f]	14	14	13	14	13	13	10	13	13	14	14	

Baseline variables that are identified as predictors in at least half of registries in which the variable is available are highlighted in bold.

[a] Italy and Spain excluded due to no available CRP.

[b] Number of times a variable is selected as a predictor.

[c] TNFi initiation since 1 January 1 2009 was chosen as the start of data collection, as the first three bDMARDs (adalimumab, etanercept and infliximab) were then well-established treatment options across the European countries. 2015 was chosen as the separator between the time periods, as secukinumab was approved as the first non-TNFi bDMARD treatment option that year.

[d] The CRP cut-off was decided based on the various detection limits used across registries.

[e] Sum of predictors selected per cohort.

[f] Number of independent variables (after excluding NA and constant variables).

DAPSA28: Disease Activity index for PSoriatic Arthritis in 28 joints; EPV: events-per-variable; IVs: independent variables; csDMARD: conventional synthetic DMARD; TNFi: TNF inhibitor; +: odds ratio (OR) > 1; –: OR < 1; constant: dichotomous variable, where only one category was available in the registry; NA: variable not delivered by the registry.

Table 3. Summary of predictors of DAPSA28 moderate response after 6 months of treatment with the first TNFi per registry[a] for registries with EPV per available independent variables ≥1

Country	Czech Republic	Denmark	Finland	Iceland	Norway	Portugal	Romania	Slovenia	Sweden	Switzerland	Turkey	Row sum[b]
Registry	**ATTRA**	**DANBIO**	**ROB-FIN**	**ICEBIO**	**NOR-DMARD**	**Reuma.pt**	**RRBR**	**Biorx.si**	**SRQ**	**SCQM**	**TURKBIO**	
Patients with DAPSA28 response assessment, *n*	462	1172	84	68	472	268	20	275	2205	116	133	
DAPSA28 moderate response, *n* (%)	265 (57)	317 (27)	34 (41)	13 (19)	143 (30)	106 (40)	11 (55)	124 (45)	711 (32)	17 (15)	62 (47)	
EPV per available IVs	15.5	22.6	2.6	0.9	11	8.2	1	9.5	54.7	1.2	4.4	
Age at treatment start, years	–	–	–		–			–	–			6
Men		+			+	+			+			4
Time since diagnosis, years	+	+	+						+			4
BMI, kg/m^2	–	–			NA	–		–	NA	–		5
Current smokers		–	–				Constant	–	–	–		5
Concomitant csDMARD							Constant		+			1
1st TNFi start, year (2015–2018)[c]	+						Constant					1
CRP > 10 mg/l[d]	+	+			+	+	Constant	+	+			6
Patient pain score, mm		+				–			+		+	4
Patient fatigue score, mm		–	NA		–	NA	NA	NA	–	–	–	5
Physician global score, mm	–					–		+				3
HAQ, units	–	–			–			–	–			5
Swollen joint count (28)	+	+			+	+	+		+	+	+	8
Tender joint count (28)		+						+				2
Sum of independent predictors[e]	8	11	3	0	6	6	1	7	10	4	3	
Total number of available IVs[f]	14	14	13	14	13	13	9	13	13	14	14	

Baseline variables that are selected as predictors in at least half of registries in which the variable is available are highlighted in bold.

[a] Italy and Spain excluded due to no available CRP.

[b] Number of times a variable is selected as a predictor.

[c] TNFi initiation since 1 January 2009 was chosen as the start of data collection, as the first three bDMARDs (adalimumab, etanercept and infliximab) were then well-established treatment options across the European countries. 2015 was chosen as the separator between the time periods, as secukinumab was approved as the first non-TNFi bDMARD treatment option that year.

[d] The CRP cut-off was decided based on the various detection limits used across registries.

[e] Sum of predictors selected per cohort.

[f] Number of independent variables (after excluding NA and constant variables).

DAPSA28: Disease Activity index for PSoriatic Arthritis in 28 joints; EPV: events-per-variable; IVs: independent variables; csDMARD: conventional synthetic DMARD; TNFi: TNF inhibitor; +: odds ratio (OR) > 1; –: OR < 1; constant: dichotomous variable, where only one category was available in the registry; NA: variable not delivered by the registry.

Table 4. Summary of predictors of 12-month drug retention on the first TNFi per registry for registries with EPV per available independent variables ≥1

Country	Czech Republic	Denmark	Finland	Iceland	Italy	Norway	Portugal	Romania	Slovenia	Spain	Sweden	Switzerland	Turkey	Row sum[a]
Registry	**ATTRA**	**DANBIO**	**ROB-FIN**	**ICEBIO**	**GISEA**	**NOR-DMARD**	**Reuma.pt**	**RRBR**	**Biorx.si**	**BIOBADASER**	**SRQ**	**SCQM**	**TURKBIO**	
Number of patients	718	2090	234	306	1591	717	675	86	367	445	5225	628	287	
12-months drug retention, *n* (%)	504 (70)	1225 (59)	150 (64)	206 (67)	861 (54)	389 (54)	512 (76)	63 (73)	231 (63)	281 (63)	3468 (66)	387 (62)	184 (64)	
EPV per available IVs	15.3	61.8	6.5	7.1	60.9	25.2	12.5	1.9	10.5	18.2	135.2	17.2	7.4	
Age at treatment start, years					–	–			–	–	–		–	6
Men	+	+	+			+	+		+	+	+	+	+	10
Time since diagnosis, years	+	+		+	–		+		+	+	+	+		9
BMI, kg/m^2			+		+	NA			–		NA			3
Current smokers				–			–	+			–		–	5
Concomitant csDMARD	+	+	–			+	+			+		+		7
1st TNFi start, year (2015–2018)[b]	–	–		–	–	–	–	Constant	–	–		–	–	10
CRP > 10 mg/l[c]		+			NA	+	+			NA	+		+	5
Patient pain score, mm			–	–		–	–			NA	–			5
Patient fatigue score, mm		–	NA		NA	+	NA	NA	NA	NA	–			3
Physician global score, mm	+									NA				1
HAQ, units										NA				0
Swollen joint count (28)	+				–						+			3
Tender joint count (28)	–	–									–	–	–	5
Sum of independent predictors[d]	7	7	4	4	5	7	7	1	5	5	9	5	6	
Total number of available IVs[e]	14	14	13	14	12	13	13	12	13	9	13	14	14	

Baseline variables that are selected as predictors in at least half of registries in which the variable is available are highlighted in bold.

[a] Number of times a variable is selected as a predictor.

[b] TNFi initiation since 1 January 2009 was chosen as the start of data collection, as the first three bDMARDs (adalimumab, etanercept and infliximab) were then well-established treatment options across the European countries. 2015 was chosen as the separator between the time periods, as secukinumab was approved as the first non-TNFi bDMARD treatment option that year.

[c] The CRP cut-off was decided based on the various detection limits used across registries.

[d] Sum of predictors selected per cohort.

[e] Number of independent variables (after excluding NA and constant variables).

EPV: events-per-variable; IVs: independent variables; csDMARD: conventional synthetic DMARD; TNFi: TNF inhibitor; +: odds ratio (OR) > 1; –: OR < 1; constant: dichotomous variable, where only one category was available in the registry; NA: variable not delivered by the registry.

Table 5. Univariable and final multivariable analyses for predicting DAPSA28 remission and DAPSA28 moderate response at 6 months and 12-month drug retention on the first TNFi in pooled data (derivation cohorts) for registries with EPV≥1

	Prediction of DAPSA28 remission ($n = 3435$)		Prediction of DAPSA28 moderate response ($n = 2537$)		Prediction of 12–month drug retention ($n = 6642$)	
Patients achieving the outcome, *n* (%)	836 (24%)		860 (34%)		4170 (63%)	
	Univariable	Multivariable	Univariable	Multivariable	Univariable	Multivariable
	OR (95% CI)		OR (95% CI)		OR (95% CI)	
Age at treatment start, years	0.97 (0.97–0.98)	0.97 (0.96–0.98)	0.98 (0.97–0.99)		0.99 (0.99–1.00)	0.99 (0.99–1.00)
Men	2.43 (2.07–2.86)	1.85 (1.54–2.23)	1.96 (1.66–2.31)	1.71 (1.42–2.06)	1.66 (1.50–1.84)	1.47 (1.32–1.63)
Time since diagnosis, years	1.01 (1.00–1.02)		1.02 (1.01–1.04)	1.03 (1.01–1.04)	1.02 (1.01–1.03)	
BMI, kg/m^2	0.97 (0.94–0.99)	0.98 (0.95–1.00)	0.97 (0.95–0.99)	0.97 (0.95–0.99)	1.00 (0.98–1.01)	
Current smokers	0.69 (0.54–0.87)	0.74 (0.57–0.96)	0.82 (0.65–1.04)		0.73 (0.63–0.84)	0.77 (0.66–0.89)
Concomitant csDMARD	1.15 (0.98–1.35)		1.40 (1.17–1.68)	1.23 (1.01–1.50)	1.11 (1.00–1.22)	
1st TNFi start, year (2015–2018)[a]	1.19 (1.01–1.39)		1.21 (1.02–1.42)		0.73 (0.66–0.81)	0.65 (0.58–0.72)
CRP > 10 mg/l[b]	1.32 (1.09–1.58)	1.52 (1.22–1.89)	1.93 (1.62–2.29)	1.61 (1.33–1.95)	1.22 (1.07–1.39)	1.24 (1.08–1.43)
Patient pain score, mm	0.98 (0.97–0.98)		0.99 (0.99–1.00)	1.01 (1.00–1.01)	0.99 (0.99–0.99)	0.99 (0.99–1.00)
Patient fatigue score, mm	0.98 (0.97–0.98)	0.99 (0.98–0.99)	0.99 (0.98–0.99)	0.99 (0.98–0.99)	0.99 (0.99–0.99)	1.00 (0.99–1.00)
Physician global score, mm	0.99 (0.98–0.99)	0.99 (0.98–1.00)	1.01 (1.00–1.01)		1.00 (1.00–1.00)	
HAQ, units	0.32 (0.27–0.38)	0.57 (0.45–0.71)	0.73 (0.63–0.84)	0.75 (0.61–0.91)	0.79 (0.72–0.87)	
Swollen joint count (28)	0.97 (0.94–0.99)	1.05 (1.01–1.08)	1.08 (1.06–1.10)		1.00 (0.98–1.01)	
Tender joint count (28)	0.92 (0.90–0.93)		1.02 (1.00–1.03)		0.97 (0.96–0.98)	0.97 (0.96–0.99)
Age at treatment start, years (41–49)[c]				0.72 (0.56–0.92)		
Age at treatment start, years (50–57)				0.46 (0.36–0.60)		
Age at treatment start, years (58–84)				0.48 (0.37–0.63)		
Time since diagnosis, years (2nd quartile)[c]		1.20 (0.89–1.60)				1.12 (0.95–1.31)
Time since diagnosis, years (3rd quartile)		1.42 (1.09–1.84)				1.29 (1.11–1.50)
Time since diagnosis, years (4th quartile)		1.66 (1.26–2.20)				1.43 (1.21–1.69)
Patient pain score, mm (44–61)		0.64 (0.49–0.83)				
Patient pain score, mm (62–75)		0.77 (0.58–1.04)				
Patient pain score, mm (76–100)		0.80 (0.55–1.16)				
Swollen joint count (2–4)[c]				1.73 (1.38–2.16)		
Swollen joint count (5–28)				2.22 (1.74–2.84)		
Tender joint count (3–4)[c]		0.87 (0.66–1.15)				
Tender joint count (5–8)		0.60 (0.45–0.80)				
Tender joint count (9–28)		0.52 (0.36–0.74)				
AUROC (95% CI)[d]		0.75 (0.73–0.77)		0.73 (0.70–0.75)		0.64 (0.62–0.65)

Baseline variables that are common predictors across all outcomes are highlighted in bold. Registries with EPV≥1 in derivation cohort, considering all independent variables, were included in all models (RRBR excluded from all analyses; ICEBIO and SCQM excluded from DAPSA28 response analyses).

[a] TNFi initiation since 1 January 2009 was chosen as the start of data collection, as the first three bDMARDs (adalimumab, etanercept and infliximab) were then well-established treatment options across the European countries. 2015 was chosen as the separator between the time periods, as secukinumab was approved as the first non-TNFi bDMARD treatment option that year.

[b] The CRP cut-off was decided based on the various detection limits used across registries.

[c] Continuous independent variables were categorized if linearity assumption was violated. Cut-offs for time since diagnosis in DAPSA28 remission: 2nd quartile (2–3 years), 3rd quartile (4–9 years) and 4th quartile (10–56 years); 12-month drug retention: 2nd quartile (2–3 years), 3rd quartile (4–8 years) and 4th quartile (9–56 years).

[d] AUROC was calculated in derivation cohort.

EPV: events-per-variable; DAPSA28: Disease Activity index for PSoriatic Arthritis in 28 joints; TNFi: TNF inhibitor; OR: odds ratio; csDMARD: conventional synthetic DMARD; AUROC: area under the receiver operating curve.

registries, we also stratified the pooled cohort by the proportion of patients achieving DAPSA28 remission, moderate response and 12-month drug retention, respectively, and identified baseline predictors for each stratum. We found that, although the identified baseline predictors across strata and end points were not identical to the per-registry and unstratified pooled analyses, no major differences emerged. This suggests that despite the known and unknown differences across the individual countries, pooling of the cohorts to allow large-scale analyses seems an acceptable approach. Thereby, the baseline predictors emerging from our pooled analyses may be considered generalizable from the country-level to disease-level.

We found that starting a TNFi from 2015–2018 *vs* 2009–2014 reduced the chance of 12-month drug retention. This observed decrease in treatment retention over time may be explained by the emerging options for switching to another TNFi or a drug with a different mode of action, should the treatment target not be met. In support of this argument, a recent study on time trends in treatment response in European patients with PsA has indicated considerably longer drug retention rates prior to 2009 [29].

A major strength of this study was the availability of similar clinical variables from 13 different European registries, allowing for the inclusion of the largest number of patients with PsA to date in a thorough analysis of baseline predictors of treatment response to TNFis. In previous similar studies, various outcome measures and baseline characteristics have been investigated; however, few consistent predictors have emerged across the studies [3–7, 13, 14, 16, 17]. Similarly, a meta-analysis from 2015 including 4034 patients with PsA identified several possible but no consistent predictors, which was ascribed to variation in the study design and heterogeneity in the treatment response measures used in the included studies [15].

In agreement with our findings, male sex has been suggested as a predictor for a good treatment response in other studies of patients with PsA [4, 6, 9, 10, 13, 14]. Similarly, our study adds weight to findings from previous smaller studies that have reported younger age at treatment start to be associated with better treatment responses [9, 10, 30]. On the other hand, we found a positive association between longer disease duration at TNFi treatment start and both drug retention and treatment response. The patients with longer disease duration in our cohort had earlier onset PsA, which might also have contributed to the better outcomes, as there is evidence pointing towards a more aggressive disease course in PsA with onset later in life [31]. Smaller studies have reported contradictory results regarding disease duration [16, 17, 32].

Higher CRP at baseline was, in our study, predictive of a good treatment response. In contrast, although CRP was included in many previous studies, it only predicted a good treatment response in a minority [3, 9, 12, 17]. Across those studies, the baseline level of inflammation, as assessed by the CRP, was generally low, and the room for improvement therefore limited, which may potentially explain why this signal was not previously detected. It could also be an indication that many aspects besides inflammation play a role in this heterogeneous disease entity.

Baseline patient pain and fatigue scores were consistently associated with all treatment outcomes in our pooled cohort, with fatigue as a consistently negative predictor and pain as a negative predictor of remission and drug retention but a positive predictor of DAPSA28 moderate response. Previous smaller studies have not found any clear pattern of associations between patient scores and treatment outcomes, but some have reported that worse scores at baseline predicted poorer outcomes [4, 5, 9, 11–17]. There is emerging evidence suggesting that the fatigue and pain experienced by patients may not be fully explained by the rheumatic disease. For example, in a study of fatigue in PsA, inflammation, disease duration and chronic pain only explained two-thirds of the experienced fatigue [33]; moreover, pain experienced by patients may be modulated by the concept of pain catastrophizing, a negative cognitive–affective response to anticipated or actual pain [34, 35]. Our findings may reflect such underlying mechanisms. Nevertheless, our findings suggest that the patient perspective is important for predicting the success of therapies; however, further investigation into the concept of patient assessments is warranted.

Functional disability measured by HAQ has previously been associated with poor outcomes in RA [36, 37], but our results only showed a negative association with remission/response and not with drug retention. We find that the setting may not have been suitable for detecting such associations. For example, our patients have a relatively short disease duration, and a high HAQ score may thus partly reflect reversible disease activity. In addition, drug retention is not a strictly clinical outcome measure and may be impacted by various factors not related to the disease status itself, i.e. treatment guidelines, access to the drug, etc.

Previously, other data on the use of csDMARDs in combination with TNFis suggested no additional effect of combination therapy on treatment response, but a possible beneficial effect on treatment retention [7, 12, 15, 38–40]. We have previously reported improved clinical response rates when combining adalimumab and infliximab but not etanercept with a csDMARD in PsA [41]. In the current study, we were unable to replicate these findings, as we analysed TNFis as one group; however, our findings are in agreement with previous studies regarding drug retention.

Cardiovascular risk factors, such as smoking and obesity, are overrepresented in patients with PsA compared with the general population [42, 43], but the role of such factors during treatment with TNFi is unclear. In a few previous studies, smoking and obesity were associated with a poorer treatment response [4, 7, 13], while others found no such effect [10, 14, 16]. In our pooled cohort, smoking was a negative predictor of DAPSA28 remission and drug retention, but was not associated with DAPSA28 moderate response. Smoking was, however, negatively associated with DAPSA28 moderate response in half of the registries. Variation in smoking habits across countries, in addition to heterogeneity in the data collection, may play a role in the differences observed between the per registy and pooled analyses. BMI showed a similar tendency in our data, in line with our recent findings from a study on predictors of treatment response in axial SpA [24].

Limitations to our study include its observational nature, which does not allow any causal conclusions to be drawn, and the lack of an endorsed PsA data collection framework limits generalizability of findings to this patient group. In addition, issues with data availability prompted us to use DAPSA28 over DAPSA although the latter is the gold standard in assessing PsA. We were, however, reassured in finding largely similar predictors in the subset of patients with available DAPSA scores. Selection bias based on availability of the

DAPSA28 outcome cannot be ruled out; however, baseline characteristics for patients with and without available DAPSA28 scores at follow-up were largely similar, and we therefore consider our findings to be generalizable.

In addition, we have previously discussed other limitations, including the unbalanced sizes of the registries and missing data, which also apply to this study [24]; moreover, we were not able to include psoriasis and other relevant comorbidities in the prediction models due to a lack of good quality data. Finally, we primarily investigated predictors of short- and medium-term outcomes, which is a limited window for a disease like PsA, which can have fluctuating disease activity over time. An aim for future studies could be to investigate the maintenance of treatment responses within a longer timeframe, including all available visits regardless of pre-specified time-windows.

The performance of the final models was found acceptable for DAPSA28 remission and DAPSA28 moderate response but poor for 12-month drug retention. This suggests that additional factors such as, e.g. socio-economic parameters, comorbidities and biomarkers (imaging and serological), are still needed for better prediction of treatment retention and response.

In conclusion, baseline predictors of remission, response and drug retention in European patients with PsA treated with a first TNFi were identified, five of which were common across the outcomes. The consistency of predictors across registries and treatment outcomes, despite heterogeneity in patient characteristics and treatment practices, indicate that the baseline predictors emerging from our pooled analyses may be considered generalizable from country-level to disease-level.

Supplementary material

Supplementary material is available at *Rheumatology* online.

Data availability

The data in this article were collected in the individual registries and made available for secondary use through the EuroSpA Research Collaboration Network (https://eurospa.eu/registries). Relevant patient level data may be made available on reasonable request to the corresponding author, but will require approval from all contributing registries.

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No trend toward increased AE rates over time (pooled PsA, AS, PsO):†[6]

AEs of select interest (EAIR per 100 PY)	1 year	2 years	3 years	4 years	5 years	6 years	Cumulative rate
Serious infections Cases	2.0 n=149	1.7 n=475	0.7 n=649	1.3 n=1,841	1.3 n=2,285	1.1 n=2,226	1.3 n=8,719
Malignant or unspecified tumours Cases	0.2 n=15	0.2 n=50	0.2 n=225	0.3 n=422	0.3 n=520	0.3 n=573	0.3 n=1,896
MACE Cases	0.2 n=15	0.1 n=39	0.2 n=151	0.2 n=238	0.2 n=264	0.1 n=287	0.2 n=1,031
Total IBD Cases	0.2 n=12	0.2 n=46	0.2 n=185	0.3 n=340	0.2 n=312	0.1 n=261	0.2 n=1,291
Exposure (PY)	7450	28,549	93,744	137,325	182,024	212,636	680,470

No trend towards increased rates of malignancy, MACE or IBD over time[6]

The most frequently reported adverse reactions are upper respiratory tract infections (17.1%) (most frequently nasopharyngitis, rhinitis).[1,2] Refer to the prescribing information for a summary of adverse events.

Adapted from Novartis Data on File. 2021.[6]

Refer to the Cosentyx Summary of Product Characteristics for full details, dosing and administration, including special populations.

Cosentyx® (secukinumab) licensed indications in rheumatology: Cosentyx, alone or in combination with methotrexate, is indicated for the treatment of active **psoriatic arthritis** in adult patients when the response to previous disease-modifying anti-rheumatic drug therapy has been inadequate; active **ankylosing spondylitis** in adults who have responded inadequately to conventional therapy; active **non-radiographic axial spondyloarthritis** with objective signs of inflammation as indicated by elevated C-reactive protein and/or magnetic resonance imaging evidence in adults who have responded inadequately to non-steroidal anti-inflammatory drugs; active **enthesitis-related arthritis** in patients 6 years and older (alone or in combination with methotrexate) whose disease has responded inadequately to, or who cannot tolerate conventional therapy; active **juvenile psoriatic arthritis** in patients 6 years or older (alone or in combination with methotrexate) whose disease has responded inadequately to, or who cannot tolerate, conventional therapy.[1,2]

Prescribing information, adverse event reporting and full indication can be found on the next page.

*Patients prescribed Cosentyx for any indication since launch.

†Successive time periods of PSUR shown with cumulative rate: 26 Dec 2014 to 25 Dec 2015; 26 Dec 2015 to 25 Dec 2016; 26 Dec 2016 to 25 Dec 2017; 26 Dec 2017 to 25 Dec 2018: 26 Dec 2018 to 25 Dec 2019; 26 Dec 2019 to 25 Dec 2020.[6]

Abbreviations: AE, adverse event; AS, ankylosing spondylitis; EIAR, exposure-adjusted incidence rate; HCP, healthcare professional; IBD, inflammatory bowel disease; MACE, major adverse cardiac event; PsA, psoriatic arthritis; PsO, plaque psoriasis; PY, patient year.

References: 1. Cosentyx® (secukinumab) GB Summary of Product Characteristics; **2.** Cosentyx® (secukinumab) NI Summary of Product Characteristics; **3.** European Medicines Agency. European public assessment report. Available at: https://www.ema.europa.eu/en/documents/overview/cosentyx-epar-medicine-overview_en.pdf [Accessed February 2024]; **4.** Novartis Data on File. Secukinumab – Sec008. 2023; **5.** Novartis. Novartis Cosentyx® positive 16-week PREVENT results advance potential new indication for patients with axial spondyloarthritis. Available at: https://www.novartis.com/news/media-releases/novartis-cosentyx-positive-16-week-prevent-results-advance-potential-new-indication-patients-axial-spondyloarthritis [Accessed February 2024]; **6.** Novartis data on file. Cosentyx Periodic Safety Update Report (PSUR); 26 December 2019 – 25 December 2020. 22 February 2021; **7.** Deodhar A, et al. Arthritis Res Ther 2019;21(1):111.

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Cosentyx® (secukinumab) Northern Ireland Prescribing Information.

Please refer to the Summary of Product Characteristics (SmPC) before prescribing.

Indications: Treatment of: moderate to severe plaque psoriasis in adults, children and adolescents from the age of 6 years who are candidates for systemic therapy; active psoriatic arthritis in adults (alone or in combination with methotrexate) who have responded inadequately to disease-modifying anti-rheumatic drug therapy; active ankylosing spondylitis in adults who have responded inadequately to conventional therapy; active non-radiographic axial spondyloarthritis (nr-axSpA) with objective signs of inflammation as indicated by elevated C-reactive protein (CRP) and/or magnetic resonance imaging (MRI) evidence in adults who have responded inadequately to non-steroidal anti-inflammatory drugs; active enthesitis-related arthritis and juvenile psoriatic arthritis in patients 6 years and older (alone or in combination with methotrexate) whose disease has responded inadequately to, or who cannot tolerate, conventional therapy; active moderate to severe hidradenitis suppurativa (acne inversa) in adults with an inadequate response to conventional systemic HS therapy. **Presentations:** Cosentyx 150 mg solution for injection in pre-filled pen; Cosentyx 300 mg solution for injection in pre-filled pen. **Dosage & Administration:** Administered by subcutaneous injection at weeks 0, 1, 2, 3 and 4, followed by monthly maintenance dosing. Consider discontinuation if no response after 16 weeks of treatment. Each 150 mg dose is given as one injection of 150 mg. Each 300 mg dose is given as two injections of 150 mg or one injection of 300 mg. If possible avoid areas of the skin showing psoriasis. *Plaque Psoriasis:* Adult recommended dose is 300 mg monthly. Based on clinical response, a maintenance dose of 300 mg every 2 weeks may provide additional benefit for patients with a body weight of 90 kg or higher. Adolescents and children from the age of 6 years: if weight ≥ 50 kg, recommended dose is 150 mg (may be increased to 300 mg as some patients may derive additional benefit from the higher dose). If weight < 50 kg, recommended dose is 75 mg. However, 150mg solution for injection in pre-filled pen is not indicated for administration of this dose and no suitable alternative formulation is available. *Psoriatic Arthritis:* For patients with concomitant moderate to severe plaque psoriasis see adult plaque psoriasis recommendation. For patients who are anti-TNFα inadequate responders, the recommended dose is 300 mg, 150 mg in other patients. Can be increased to 300 mg based on clinical response. *Ankylosing Spondylitis:* Recommended dose 150 mg. Can be increased to 300 mg based on clinical response. *nr-axSpA:* Recommended dose 150 mg. *Enthesitis-related arthritis and juvenile psoriatic arthritis:* From the age of 6 years, if weight ≥ 50 kg, recommended dose is 150 mg. If weight < 50 kg, recommended dose is 75 mg. However, 150mg solution for injection in pre-filled pen is not indicated for administration of this dose and no suitable alternative formulation is available. *Hidradenitis suppurativa:* Recommended dose is 300 mg monthly. Based on clinical response, the maintenance dose can be increased to 300 mg every 2 weeks. **Contraindications:** Hypersensitivity to the active substance or excipients. Clinically important, active infection. **Warnings & Precautions:** *Infections:* Potential to increase risk of infections; serious infections have been observed. Caution in patients with chronic infection or history of recurrent infection. Advise patients to seek medical advice if signs/symptoms of infection occur. Monitor patients with serious infection closely and do not administer Cosentyx until the infection resolves. Non-serious mucocutaneous candida infections were more frequently reported for secukinumab than placebo in the psoriasis clinical studies. Should not be given to patients with active tuberculosis (TB). Consider anti-tuberculosis therapy before starting Cosentyx in patients with latent TB. *Inflammatory bowel disease (including Crohn's disease and ulcerative colitis):* New cases or exacerbations of inflammatory bowel disease have been reported with secukinumab. Secukinumab, is not recommended in patients with inflammatory bowel disease. If a patient develops signs and symptoms of inflammatory bowel disease or experiences an exacerbation of pre-existing inflammatory bowel disease, secukinumab should be discontinued and appropriate medical management should be initiated. *Hypersensitivity reactions:* Rare cases of anaphylactic reactions have been observed. If an anaphylactic or serious allergic reactions occur, discontinue immediately and initiate appropriate therapy. *Vaccinations:* Do not give live vaccines concurrently with Cosentyx; inactivated or non-live vaccinations may be given. Paediatric patients should receive all age appropriate immunisations before treatment with Cosentyx. *Latex-Sensitive Individuals:* The removable needle cap of the 150mg pre-filled pen contains a derivative of natural rubber latex. *Concomitant immunosuppressive therapy:* Combination with immunosuppressants, including biologics, or phototherapy has not been evaluated in psoriasis studies. Cosentyx was given concomitantly with methotrexate, sulfasalazine and/or corticosteroids in arthritis studies. Caution when considering concomitant use of other immunosuppressants. **Interactions:** Live vaccines should not be given concurrently with secukinumab. No interaction between Cosentyx and midazolam (CYP3A4 substrate) seen in adult psoriasis study. No interaction between Cosentyx and methotrexate and/or corticosteroids seen in arthritis studies. **Fertility, pregnancy and lactation:** *Women of childbearing potential:* Use an effective method of contraception during and for at least 20 weeks after treatment. *Pregnancy:* Preferably avoid use of Cosentyx in pregnancy. *Breast feeding:* It is not known if secukinumab is excreted in human breast milk. A clinical decision should be made on continuation of breast feeding during Cosentyx treatment (and up to 20 weeks after discontinuation) based on benefit of breast feeding to the child and benefit of Cosentyx therapy to the woman. *Fertility:* Effect on human fertility not evaluated. **Adverse Reactions**: *Very Common* (≥1/10): Upper respiratory tract infection. *Common* (≥1/100 to <1/10): Oral herpes, headache, rhinorrhoea, diarrhoea, nausea, fatigue. *Uncommon (≥1/1,000 to <1/100):* Oral candidiasis, lower respiratory tract infections, neutropenia, inflammatory bowel disease. *Rare (≥1/10,000 to <1/1,000)*: anaphylactic reactions, exfoliative dermatitis (psoriasis patients), hypersensitivity vasculitis. *Not known:* Mucosal and cutaneous candidiasis (including oesophageal candidiasis). *Infections:* Most infections were non-serious and mild to moderate upper respiratory tract infections, e.g. nasopharyngitis, and did not necessitate treatment discontinuation. There was an increase in mucosal and cutaneous (including oesophageal) candidiasis, but cases were mild or moderate in severity, non-serious, responsive to standard treatment and did not necessitate treatment discontinuation. Serious infections occurred in a small proportion of patients (0.015 serious infections reported per patient year of follow up). *Neutropenia:* Neutropenia was more frequent with secukinumab than placebo, but most cases were mild, transient and reversible. Rare cases of neutropenia CTCAE Grade 4 were reported. *Hypersensitivity reactions*: Urticaria and rare cases of anaphylactic reactions were seen. *Immunogenicity:* Less than 1% of patients treated with Cosentyx developed antibodies to secukinumab up to 52 weeks of treatment. *Other Adverse Effects:* The list of adverse events is not exhaustive, please consult the SmPC for a detailed listing of all adverse events before prescribing. **Legal Category:** POM. **MA Number & List Price:** EU/1/14/980/005 - 150 mg pre-filled pen x2 £1,218.78; EU/1/14/980/010 – 300 mg pre-filled pen x 1 £1218.78. **PI Last Revised:** May 2023. Full prescribing information, (SmPC) is available from: Novartis Pharmaceuticals UK Limited, 2nd Floor, The WestWorks Building, White City Place, 195 Wood Lane, London, W12 7FQ. Telephone: (01276) 692255.

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Adverse Event Reporting:

Adverse events should be reported. Reporting forms and information can be found at www.mhra.gov.uk/yellowcard. Adverse events should also be reported to Novartis via uk.patientsafety@novartis.com or online through the pharmacovigilance intake (PVI) tool at www.novartis.com/report

If you have a question about the product, please contact Medical Information on 01276 698370 or by email at medinfo.uk@novartis.com

Cosentyx® (secukinumab) Great Britain Prescribing Information.

Please refer to the Summary of Product Characteristics (SmPC) before prescribing.

Indications: Treatment of: moderate to severe plaque psoriasis in adults, children and adolescents from the age of 6 years who are candidates for systemic therapy; active psoriatic arthritis in adults (alone or in combination with methotrexate) who have responded inadequately to disease-modifying anti-rheumatic drug therapy; active ankylosing spondylitis in adults who have responded inadequately to conventional therapy; active non-radiographic axial spondyloarthritis (nr-axSpA) with objective signs of inflammation as indicated by elevated C-reactive protein (CRP) and/or magnetic resonance imaging (MRI) evidence in adults who have responded inadequately to non-steroidal anti-inflammatory drugs; active enthesitis-related arthritis and juvenile psoriatic arthritis in patients 6 years and older (alone or in combination with methotrexate) whose disease has responded inadequately to, or who cannot tolerate, conventional therapy; active moderate to severe hidradenitis suppurativa (acne inversa) in adults with an inadequate response to conventional systemic HS therapy. **Presentations:** Cosentyx 75 mg solution for injection in pre-filled syringe; Cosentyx 150 mg solution for injection in pre-filled syringe; Cosentyx 150 mg solution for injection in pre-filled pen; Cosentyx 300 mg solution for injection in pre-filled pen. **Dosage & Administration:** Administered by subcutaneous injection at weeks 0, 1, 2, 3 and 4, followed by monthly maintenance dosing. 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For patients who are anti-TNFα inadequate responders, the recommended dose is 300 mg, 150 mg in other patients. Can be increased to 300 mg based on clinical response. *Ankylosing Spondylitis:* Recommended dose 150 mg. Can be increased to 300 mg based on clinical response. *nr-axSpA:* Recommended dose 150 mg. *Enthesitis-related arthritis and juvenile psoriatic arthritis:* From the age of 6 years, if weight ≥ 50 kg, recommended dose is 150 mg. If weight < 50 kg, recommended dose is 75 mg. *Hidradenitis suppurativa:* Recommended dose is 300 mg monthly. Based on clinical response, the maintenance dose can be increased to 300 mg every 2 weeks. **Contraindications:** Hypersensitivity to the active substance or excipients. Clinically important, active infection. **Warnings & Precautions:** *Infections:* Potential to increase risk of infections; serious infections have been observed. Caution in patients with chronic infection or history of recurrent infection. Advise patients to seek medical advice if signs/symptoms of infection occur. Monitor patients with serious infection closely and do not administer Cosentyx until the infection resolves. Non-serious mucocutaneous candida infections were more frequently reported for secukinumab in the psoriasis clinical studies. Should not be given to patients with active tuberculosis (TB). Consider anti-tuberculosis therapy before starting Cosentyx in patients with latent TB. *Inflammatory bowel disease (including Crohn's disease and ulcerative colitis):* New cases or exacerbations of inflammatory bowel disease have been reported with secukinumab. Secukinumab, is not recommended in patients with inflammatory bowel disease. If a patient develops signs and symptoms of inflammatory bowel disease or experiences an exacerbation of pre-existing inflammatory bowel disease, secukinumab should be discontinued and appropriate medical management should be initiated. *Hypersensitivity reactions*: Rare cases of anaphylactic reactions have been observed. If an anaphylactic or serious allergic reactions occur, discontinue immediately and initiate appropriate therapy. *Vaccinations:* Do not give live vaccines concurrently with Cosentyx; inactivated or non-live vaccinations may be given. Paediatric patients should receive all age appropriate immunisations before treatment with Cosentyx. *Latex-Sensitive Individuals*: The removable needle cap of the 75mg and 150 mg pre-filled syringe and 150mg pre-filled pen contains a derivative of natural rubber latex. *Concomitant immunosuppressive therapy:* Combination with immunosuppressants, including biologics, or phototherapy has not been evaluated in psoriasis studies. Cosentyx was given concomitantly with methotrexate, sulfasalazine and/or corticosteroids in arthritis studies. Caution when considering concomitant use of other immunosuppressants. **Interactions:** Live vaccines should not be given concurrently with secukinumab. No interaction between Cosentyx and midazolam (CYP3A4 substrate) seen in adult psoriasis study. No interaction between Cosentyx and methotrexate and/or corticosteroids seen in arthritis studies. **Fertility, pregnancy and lactation:** *Women of childbearing potential:* Use an effective method of contraception during and for at least 20 weeks after treatment. *Pregnancy:* Preferably avoid use of Cosentyx in pregnancy. *Breast feeding:* It is not known if secukinumab is excreted in human breast milk. A clinical decision should be made on continuation of breast feeding during Cosentyx treatment (and up to 20 weeks after discontinuation) based on benefit of breast feeding to the child and benefit of Cosentyx therapy to the woman. *Fertility:* Effect on human fertility not evaluated. **Adverse Reactions**: *Very Common (≥1/10):* Upper respiratory tract infection. *Common (≥1/100 to <1/10):* Oral herpes, headache, rhinorrhoea, diarrhoea, nausea, fatigue. *Uncommon (≥1/1,000 to <1/100):* Oral candidiasis, lower respiratory tract infections, neutropenia, inflammatory bowel disease. *Rare (≥1/10,000 to <1/1,000)*: anaphylactic reactions, exfoliative dermatitis (psoriasis patients), hypersensitivity vasculitis. *Not known:* Mucosal and cutaneous candidiasis (including oesophageal candidiasis). *Infections:* Most infections were non-serious and mild to moderate upper respiratory tract infections, e.g. nasopharyngitis, and did not necessitate treatment discontinuation. There was an increase in mucosal and cutaneous (including oesophageal) candidiasis, but cases were mild or moderate in severity, non-serious, responsive to standard treatment and did not necessitate treatment discontinuation. Serious infections occurred in a small proportion of patients (0.015 serious infections reported per patient year of follow up). *Neutropenia:* Neutropenia was more frequent with secukinumab than placebo, but most cases were mild, transient and reversible. Rare cases of neutropenia CTCAE Grade 4 were reported. *Hypersensitivity reactions*: Urticaria and rare cases of anaphylactic reactions were seen. *Immunogenicity:* Less than 1% of patients treated with Cosentyx developed antibodies to secukinumab up to 52 weeks of treatment. *Other Adverse Effects:* The list of adverse events is not exhaustive, please consult the SmPC for a detailed listing of all adverse events before prescribing. **Legal Category:** POM. **MA Number & List Price:** PLGB 00101/1205 – 75 mg pre-filled syringe x 1 - £304.70; PLGB 00101/1029 - 150 mg pre-filled pen x2 £1,218.78; PLGB 00101/1030 - 150 mg pre-filled syringe x2 £1,218.78; PLGB 00101/1198 – 300 mg pre-filled pen x 1 £1218.78. **PI Last Revised:** June 2023. Full prescribing information, (SmPC) is available from: Novartis Pharmaceuticals UK Limited, 2nd Floor, The WestWorks Building, White City Place, 195 Wood Lane, London, W12 7FQ. Telephone: (01276) 692255.

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Adverse Event Reporting:

Adverse events should be reported. Reporting forms and information can be found at www.mhra.gov.uk/yellowcard. Adverse events should also be reported to Novartis via uk.patientsafety@novartis.com or online through the pharmacovigilance intake (PVI) tool at www.novartis.com/report.

If you have a question about the product, please contact Medical Information on 01276 698370 or by email at medinfo.uk@novartis.com