Research Article

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Treatment patterns of biologics in US patients with ankylosing spondylitis: descriptive analyses from a claims database

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Aim: Examine treatment patterns among patients with active ankylosing spondylitis (AS) treated with a TNF inhibitor (TNFi). **Patients & methods:** Patients with AS who initiated a TNFi between 1 January 2013, and 31 January 2015, were identified in the Optum Research Database. Outcomes included adherence, persistence, discontinuation and therapy modifications of the index TNFi during 12-month follow-up. **Results:** Of the 426 patients included, 40.6% persisted on the index TNFi for ≥12 months, 31.0% discontinued, 21.4% switched to a different TNFi, and 7.0% discontinued and then restarted. Of the 333 patients who persisted on their TNFi for >90 days, 44.7% received ≥1 add-on medication. **Conclusion:** A high proportion of patients with AS switched, discontinued or modified their TNFi therapy.

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Keywords: ankylosing spondylitis • biologics • treatment patterns

Ankylosing spondylitis (AS) is a chronic, immune-mediated rheumatic disease that can cause irreversible damage of the spine and peripheral joints [1]. Inflammation of the vertebrae results in structural changes in the axial skeleton, including bone growth and fusion [1]. Furthermore, as many as half of all patients with AS may develop arthritis in peripheral joints [2]. The prevalence of AS in the USA has been estimated to be between 0.2% and 0.5% [3,4]; although one study found the prevalence to be as high as 1% [5]. Several comorbidities, including uveitis, cardiac abnormalities, inflammatory bowel disease, psoriasis, stroke and fractures, are also associated with AS [5–9].

The Assessment of SpondyloArthritis International Society (ASAS), the European League Against Rheumatism (EULAR) and the American College of Rheumatology (ACR)/Spondylitis Association of American and Spondyloarthritis Research and Treatment Network (SPARTAN) all recommend NSAIDs as first-line treatment for active AS, followed by biologic therapy for patients who are nonresponsive to NSAIDs [10,11]. Biologic therapies, including TNF inhibitors (TNFis) and the anti-IL-17A monoclonal antibody secukinumab (approved for use after this study was completed); have been shown to be effective for the treatment of AS [12–19]. The TNFis (adalimumab, certolizumab pegol, etanercept, golimumab and infliximab) all appear to have comparable efficacy to one another and clinical response rates (ASAS20) range from 50 to 60% [19]. Patients who do not adequately respond to biologic therapy may switch to a different biologic or modify their therapy (escalate dose of biologic or add concomitant NSAIDs or opioids) [10,11]. Studies have shown that switching biologics may be effective if the initial biologic fails; however, the subsequent biologic may not be as effective [20,21].

Real-world studies examining biologic therapy use and treatment pattern in patients with AS, especially in the United States are limited. Furthermore, adherence to and persistence with biologic therapy in patients with AS is vital to achieve the optimal outcomes of pain relief, improved physical function and minimal joint damage. Recent studies examining treatment persistence with biologics in patients with AS have found that approximately 48% to 88% of patients with AS persisted on their biologic therapy for periods of 1–3 years [22–26]; however, new biologic therapies have been approved for AS since those studies were performed. Studies of dose escalation of biologic therapy in patients with AS are also limited [22,26,27] and to our knowledge, only one previous study

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has examined add-on therapies in patients receiving biologic therapy for AS and that study was limited to add-on conventional synthetic disease-modifying antirheumatic drugs (csDMARDs) [22]. Although studies are limited, a recent working group of patient organization representatives (for psoriatic arthritis and axial spondyloarthritis) and rheumatologists reported that reducing pain was an important treatment goal for patients [28]. Thus, more current real-world estimates of treatment patterns and therapy modifications including the use of add-on pain relief and anti-inflammatory medications are needed. The objective of this study was to examine treatment patterns and therapy modifications in US patients with active AS receiving biologic therapy.

Patients & methods

Data source

This US-based, retrospective and observational study used administrative pharmacy and medical claims data from 1 January 2012, to 30 April 2016, from the Optum Research Database. The Optum database includes commercial and Medicare Advantage health plan members. In 2015, data were available for approximately 13.5 million individuals with both medical and pharmacy benefit coverage. Pharmacy claims data are submitted electronically by the pharmacy when the prescriptions are filled and include drug name, dosage form, drug strength, fill date, days of supply, financial information, and de-identified patient and prescriber codes.

Study design & patient selection

Patients diagnosed with AS were included if they had ≥1 pharmacy fill or medical infusion for a biologic approved for the treatment of AS between 1 January 2013 and 31 January 2015. The index date was defined as the date of the first pharmacy fill or infusion of the index biologic during the identification period (2-year period used to identify patients for the study). For 12 months before the index date (baseline period) and 15 months following the index date, patients had to be continuously enroll in a commercial or Medicare Advantage health plan with medical and pharmacy benefits (Supplementary Figure 1). The 12-month baseline period was used to assess patient characteristics and demographics and the first 12 months of the 15-month follow-up period was used to assess outcomes including treatment persistence, treatment patterns and therapy modifications at the end of persistence. The final 3 months of the 15-month follow-up period were used to ascertain persistence/discontinuation at the end of the follow-up period. To reduce confounding, therapy modifications were identified only in patients who persisted on the index TNFi for >90 days; the add-on period was defined as the period from 90 days after the index date to either the end of persistence or 12 months after the index date (whichever came first).

To be included in this study, patients must have been aged ≥18 years at the index date and not have received treatment with the index TNFi during the 12 months before the index date. Patients who received a biologic therapy other than the index TNFi were not excluded from the study. In addition, patients were required to have ≥2 non-rule-out diagnoses of AS ≥30 days apart during the 1 year before through 1 year after the index date and ≥1 of the diagnoses must have been on or before the index date. Patients were identified using the International Classification of Diseases, Ninth and Tenth Revisions, Clinical Modification codes (ICD-9-CM code 720.0; ICD-10-CM code M45). Patients who had fills for two or more different TNFis on the same day during the 12-month baseline period through the 15-month follow-up period were excluded.

Study outcomes

Patient characteristics recorded at the index date included age, sex, insurance type and geographic region. A baseline comorbidity score (Quan-Charlson Comorbidity Index) was calculated based on the presence of diagnosis codes on medical claims in the baseline period [29,30]. Baseline comorbid conditions were defined using the Clinical Classifications Software managed by the Agency for Healthcare Research and Quality (AHRQ). Claims for Crohn disease, psoriasis and ulcerative colitis were recorded during the 12 months before and 12 months after the index date.

The TNFi treatment was identified on the index date and included adalimumab, certolizumab pegol, etanercept, golimumab and infliximab. Discontinuation of therapy was defined as a gap in therapy of >90 days. Duration of persistence with the index TNFi was measured in the 12-month follow-up period using claims for the index medication, inclusive of fills or infusions on the index date. Persistence with the index TNFi was measured as the number of days from the index date to discontinuation or switching to a different TNFi. The date of discontinuation was defined by the run-out-of-days' supply of the last prescription filled prior to the gap in therapy. For infused TNFis, a presumed day supply was created based on the expected infusion schedule described in the product label.

Duration of persistence was defined as the total length (in days) of persistence during the year of follow-up. Patients who were persistent with the index TNFi for 1 year were identified. Moreover, patients who did not persist with the TNFi for >3 months were identified. The efficacy of TNFis is generally not assessed in the first 3 months; therefore, discontinuing the treatment in <3 months likely indicates that treatment was changed for reasons other than efficacy (cost, adverse effect and other).

Among patients who did not persist for 1 year, postpersistence treatment patterns were identified. Patients were classified into the following groups: switched to a different TNFi; discontinued and restarted the index therapy; or discontinued the index therapy without switching or restarting. Patients who were identified as both switching and restarting in the 1 year postindex period were classified by whichever occurred first during the 15-month follow-up period. Among patients who switched to a different TNFi, the TNFi that the patient switched to was identified. The switch date was the date of the earliest claim indicating a switch after the index date. Adherence with the index TNFi was measured in the follow-up period using claims for the index medication, inclusive of fills or infusions on the index date. Adherence was measured as the proportion of days covered (PDC), calculated by the number of days covered by prescription claims for the index TNFi divided by 365 days.

For patients who were persistent with the index TNFi for >90 days, the following therapy modifications were identified: index TNFi dose escalation and add-on medications. For dose escalation, the average daily dose was calculated for each day of the patient's follow-up and patients who received >110% of the product label dose of their index TNFi for ≥90 continuous or intermittent days were considered to have meaningful dose escalation. The total number of days that a patient was treated with an average daily maintenance dose >110% of the recommended daily maintenance dose in the product label was calculated. Claims for add-on medications were identified during the 12-month baseline period and included NSAIDs, opioids, corticosteroids, csDMARDs, antidepressants, anxiolytics, sleeping aids and topical analgesics. For patients who persisted on their index TNFi therapy for >90 days, the initiation of add-on medications was identified from 90 days after index date until the end of persistence or 12 months postindex (add-on period).

Statistical analysis

All data were analyzed descriptively. Patient-level analyses included baseline demographics, number of patients initiating each TNFi and number of patients who switched treatments. Subgroup analyses by index TNFi reported the mean (standard deviation [SD]) duration of time (in days) patients persisted on each index TNFi, time to switch to a different TNFi, number of patients who initiated add-on medications and number of patients with dose escalation of the index TNFi.

Results

Demographics & baseline characteristics

A total of 426 patients with AS met the inclusion criteria and were included in the analyses (Figure 1). Approximately half of the patients (45.1%) initiated etanercept, followed by adalimumab (28.6%), golimumab (11.7%), infliximab (11.7%) and certolizumab pegol (2.8%) as their index TNFi (Table 1). The mean (SD) age was 45.1 (13.1) years and 45.8% were women. The largest percentage of patients were from the South (42.3%), followed by the Midwest (27.5%), West (22.3%) and Northeast (8.0%). The mean (SD) Quan-Charlson Comorbidity Index score was 0.69 (1.06) at baseline. The most common AHRQ comorbidities were nontraumatic joint disorders (97.0%); spondylosis, intervertebral disc disorders, other back problems (80.5%); and other connective tissue disease (54.6%).

Adherence, persistence & postpersistence treatment patterns

The mean (SD) and median (interquartile range; IQR) PDC was 0.56 (0.29) and 0.60 (0.30, 0.84), respectively, and the mean (SD) and median (IQR) duration of persistence with the index TNFi was 236 days (131) and 274 days (105, 365), respectively (Supplementary Table 1). Patients who initiated adalimumab had the longest mean duration of persistence (243 days). Patients who initiated etanercept had the shortest mean duration of persistence (192 days). Kaplan–Meier curves of persistence in the total number of patients and with each index TNFi are shown in Figure 2. Overall, only 40.6% of patients persisted with the index TNFi for ≥12 months (Figure 3A); golimumab had the highest rate of 12-month persistence (50.0%) and certolizumab pegol had the lowest rate of 12-month persistence (33.3%).

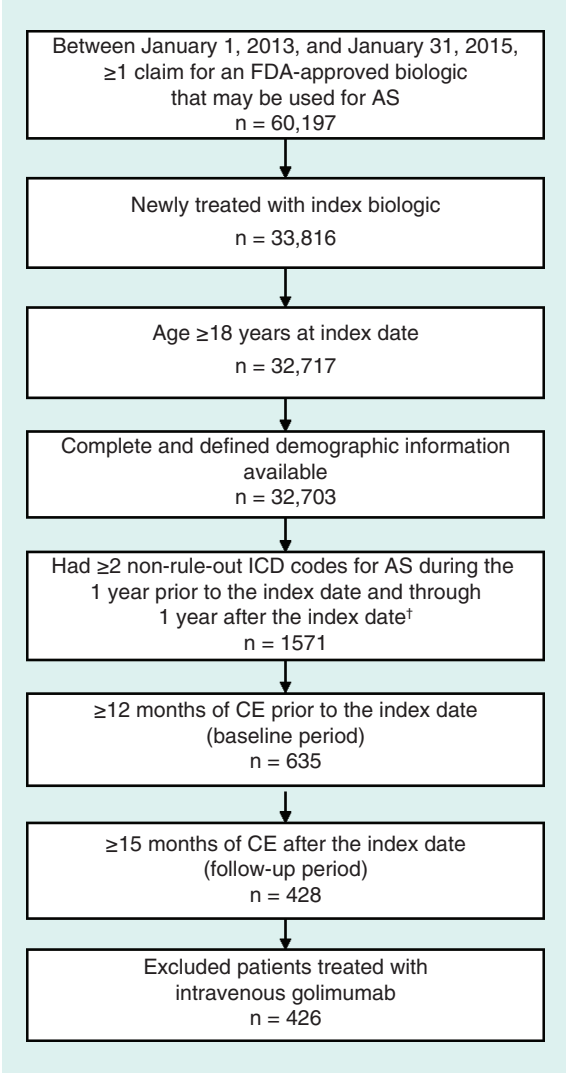

Figure 1. Patient attrition flow chart.
†The two ICD codes had to be ≥30 days apart and the first claim had to be on the index date or during the baseline period.
AS: Ankylosing spondylitis; CE: Continuous enrollment; ICD: International Classification of Disease.

A total of 59.4% of patients discontinued the index TNFi before 1 year: 31.0% discontinued the index TNFi without restarting or switching, 7.0% discontinued and then restarted the index TNFi and 21.4% switched from the index TNFi to a different TNFi (Figure 3B). Among the 91 patients who switched TNFi therapies, the mean (95% CI) time to switch was 179 days (161–198; Figure 4A). The most common TNFi therapy that patients were switched to was adalimumab (56.0%) followed by infliximab (17.6%; Figure 4B).

Therapy modifications among patients who persisted with the index TNFi for >90 days

Therapy modifications were identified in the 333 patients who persisted on the index TNFi for >90 days. During the 12-month baseline period (prior to the index date) a total of 90.7% of patients received any medication; 62.5% received NSAIDs, 55.3% corticosteroids, 29.4% csDMARDs and 19.5% opioids. During the add-on period (90 days postindex until the end of persistence or 12 months postindex), 44.7% of patients initiated ≥1 add-on medication (no use during the first 90 days after the index date; Table 2). The most commonly initiated add-on medications were corticosteroids (16.8%) followed by opioids (12.9%), NSAIDs (10.2%) and antidepressants (7.2%). Infliximab, which is administered intravenously (iv.), had the highest rate of patients initiating an add-on medication (51.3%). Among patients using a subcutaneously (sc.)-administered index TNFi, 43.9% initiated an add-on medication: etanercept (44.7%), adalimumab (43.4%), golimumab (42.9%) and certolizumab pegol (37.5%).

Overall, 7.2% of patients had a dose escalation of the index TNFi. Notably, dose escalation was much higher in patients with an iv.-administered TNFi (infliximab; 38.5%) than in those with sc.-administered TNFis (adal-

Table 1. Baseline demographic and clinical characteristics.

Characteristic	Total (n = 426)	TNFi-sc.				TNFi-iv.
		Adalimumab (n = 122)	Certolizumab pegol (n = 12)	Etanercept (n = 192)	Golimumab (n = 50)	Infliximab (n = 50)
Age, mean (SD)	45.1 (13.1)	45.4 (13.2)	46.5 (10.9)	43.3 (12.8)	44.6 (10.1)	51.5 (15.3)
Female, n (%)	196 (45.8)	49 (40.2)	7 (58.3)	87 (45.3)	26 (50.0)	27 (54.0)
Baseline Quan-Charlson Score, mean (SD)	0.69 (1.06)	0.72 (1.04)	0.83 (0.83)	0.71 (1.22)	0.54 (0.65)	0.60 (0.88)
US region, n (%)						
– Northeast	34 (8.0)	11 (9.0)	1 (8.3)	15 (7.8)	4 (8.0)	3 (6.0)
– Midwest	117 (27.5)	36 (29.5)	5 (41.7)	42 (21.9)	14 (28.0)	20 (40.0)
– South	180 (42.3)	49 (40.2)	3 (25.0)	87 (45.3)	21 (42.0)	20 (40.0)
– West	95 (22.3)	26 (21.3)	3 (25.0)	48 (25.0)	11 (22.0)	7 (14.0)
Insurance type, n (%)						
– Commercial	380 (89.2)	105 (86.1)	11 (91.7)	176 (91.7)	50 (100.0)	38 (76.0)
– Medicare	46 (10.8)	17 (13.9)	1 (8.3)	16 (8.3)	0 (0.0)	12 (24.0)
AHRQ comorbidities, n (%)						
– Nontraumatic joint disorders	415 (97.4)	116 (95.1)	12 (100.0)	189 (98.4)	49 (98.0)	49 (98.0)
– Spondylosis, intervertebral disc disorders and other back problems	339 (79.6)	90 (73.8)	7 (58.3)	160 (83.3)	39 (78.0)	43 (86.0)
– Other connective tissue disease	241 (56.6)	67 (54.9)	10 (83.3)	110 (57.3)	24 (48.0)	30 (60.0)
– Immunizations and screening for infectious disease	226 (53.1)	71 (58.2)	6 (50.0)	102 (53.1)	19 (38.0)	28 (56.0)
– Eye disorders	178 (41.8)	60 (49.2)	4 (33.3)	67 (34.9)	23 (46.0)	24 (48.0)

AHRQ: Agency for Healthcare Research and Quality; iv.: Intravenous; sc.: Subcutaneous; SD: Standard deviation; TNFi: TNF inhibitor.

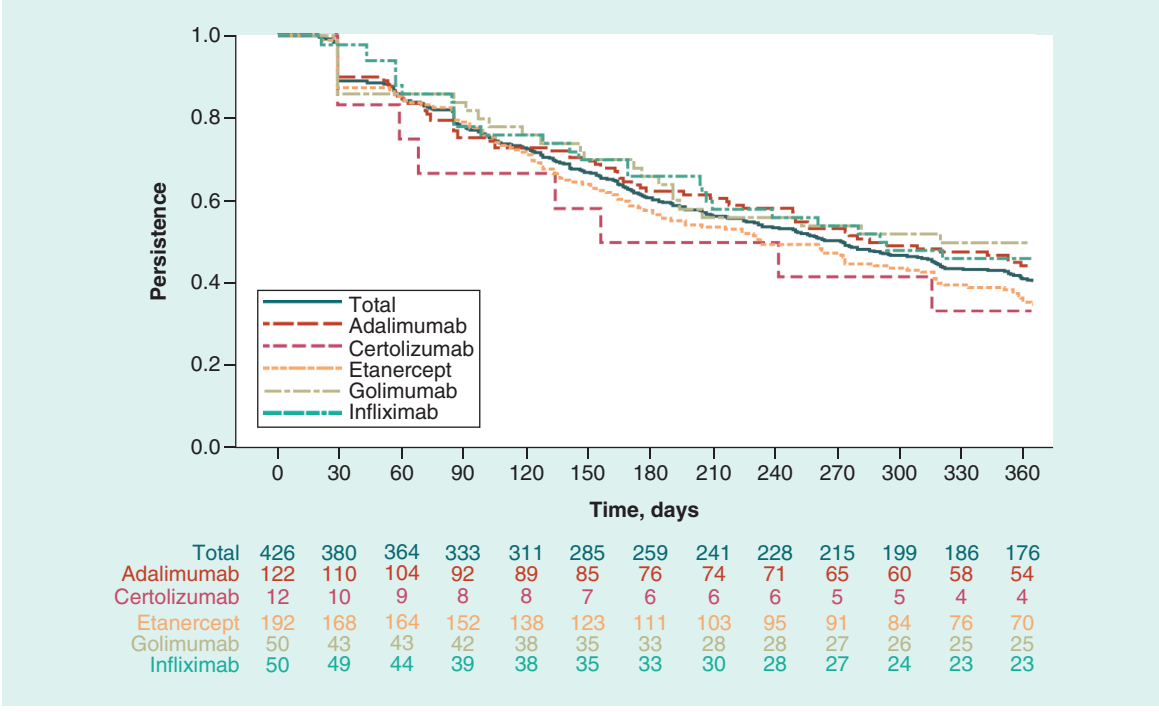

Figure 2. Kaplan–Meier curves of persistence with index TNF inhibitor therapies.

imumab, certolizumab pegol, etanercept and golimumab; 2.7%) in the immediate 12-month postindex period (Supplementary Figure 2). The mean (SD) number of days from index date to dose escalation was 223 days (66).

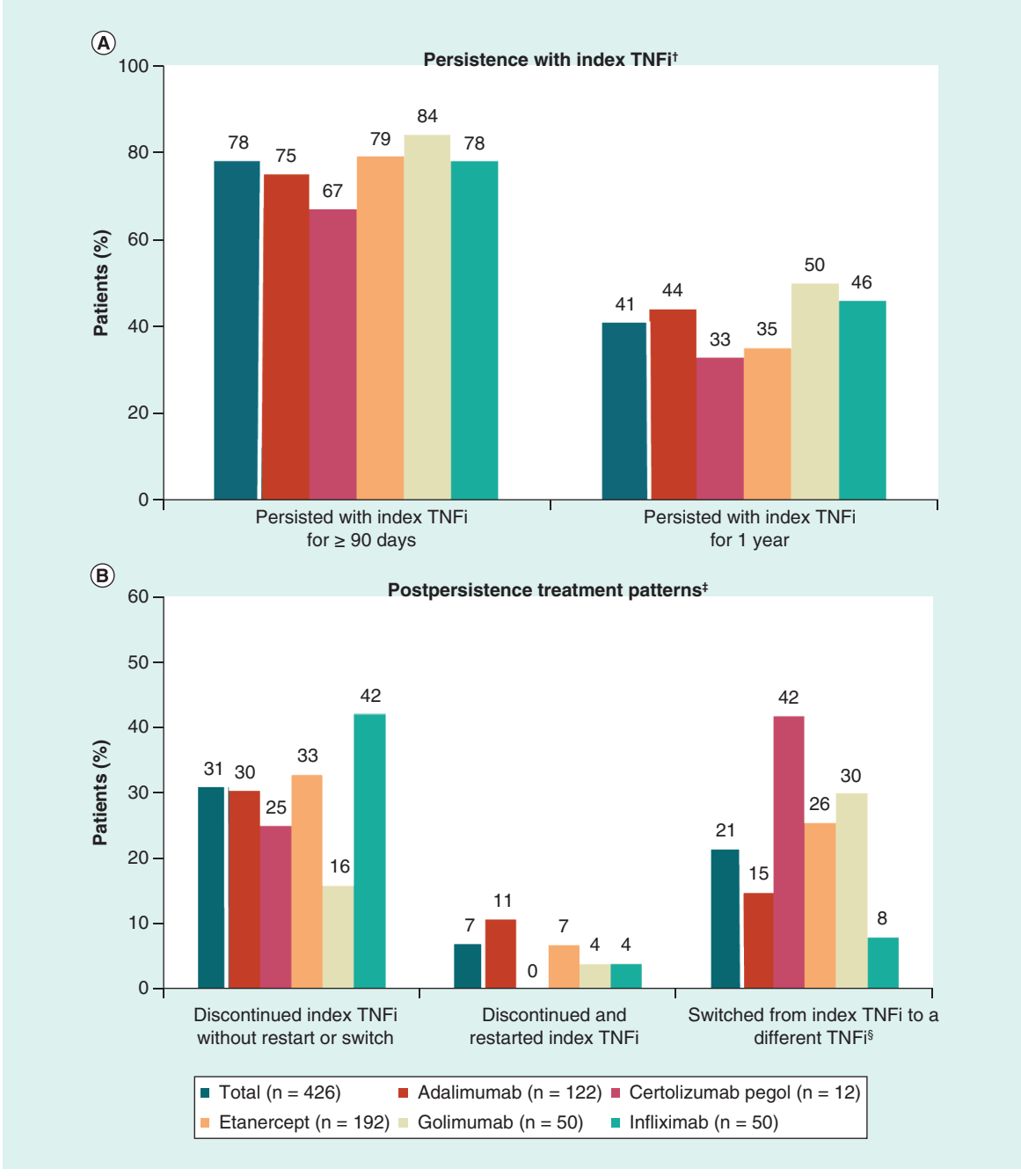

Figure 3. Persistence with index TNFi and postpersistence treatment patterns.
†During the 12-month follow-up period.
‡Among patients who discontinued during the 12-month follow-up period.
§Includes patients who discontinued the index TNFi and then switched to a different TNFi.
TNFi: TNF inhibitor.

The mean number of days above 110% of reference dose was 23.9 days (86.6 days for TNFi-iv. and 14.6 days for TNFi-sc.).

Discussion

Results of this descriptive, administrative claims-based study in the US highlight treatment patterns that are important for understanding real-world use of TNFis in patients with AS. The current study results are consistent

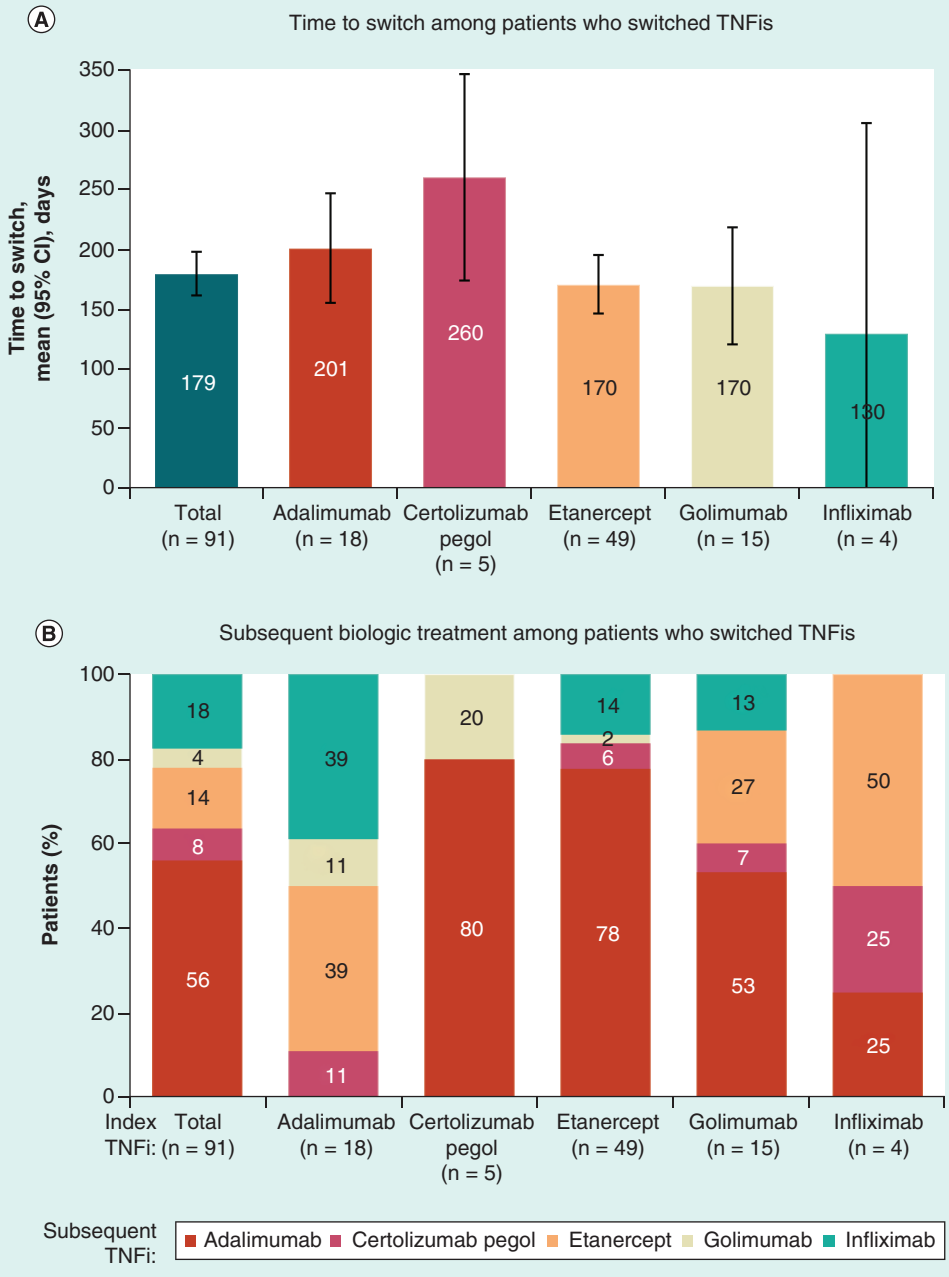

Figure 4. Time to switch and subsequent biologic treatment among patients who switched TNFis.
Includes patients who discontinued the index TNFi and then switched to a different TNFi.
TNFi: TNF inhibitor.

with previous studies that found that etanercept and adalimumab were the most frequently administered TNFis in patients with AS [22,24,31]. This may be because these drugs were among the first TNFis approved by the US FDA for the treatment of AS and because of formulary availability and insurance contracts. In the current study, golimumab had the highest rate of 90-day and 12-month persistence (84% and 50%, respectively) and certolizumab pegol had the lowest (67% and 33%); although these results should be interpreted with caution as only 12 patients were in the certolizumab pegol group. These observations contrast with the results of a study of patients with rheumatoid arthritis, psoriatic arthritis, psoriasis and AS in which persistence was highest among patients treated with infliximab (66–79%) and lowest among patients treated with golimumab (11–25%) [31].

Table 2. Add-on medications initiated from 90 days after the index date to the end of persistence or 12 months.

Add-on medication, n (%)	Total (n = 333)	TNFi-sc.				TNFi-iv.
		Adalimumab (n = 92)	Certolizumab pegol (n = 8)	Etanercept (n = 152)	Golimumab (n = 42)	Infliximab (n = 39)
Any medication	149 (44.7)	40 (43.4)	3 (37.5)	68 (44.7)	18 (42.9)	20 (51.3)
Corticosteroid	56 (16.8)	10 (10.9)	3 (37.5)	24 (15.8)	9 (21.4)	10 (25.6)
Opioid	43 (12.9)	13 (14.1)	0 (0.0)	21 (13.8)	5 (11.9)	4 (10.3)
NSAID	34 (10.2)	11 (12.0)	0 (0.0)	13 (8.6)	6 (14.3)	4 (10.3)
Antidepressant	24 (7.2)	6 (6.5)	2 (25.0)	13 (18.6)	1 (2.4)	2 (5.1)
Anxiolytic	23 (6.9)	4 (4.3)	0 (0.0)	11 (7.2)	3 (7.1)	5 (12.8)
csDMARD†	15 (4.5)	4 (4.3)	0 (0.0)	9 (5.9)	0 (0.0)	2 (5.1)
Topical analgesic	13 (3.9)	5 (5.4)	0 (0.0)	3 (2.0)	1 (2.4)	4 (10.3)
Sleeping aid	9 (2.7)	4 (4.3)	2 (25.0)	1 (0.7)	1 (2.4)	1 (2.6)

†Included auranofin, aurothioglucose, azathioprine, cyclosporine, gold sodium, hydroxychloroquine, leflunomide, methotrexate and sulfasalazine.
AS: Ankylosing spondylitis; csDMARD: Conventional synthetic disease-modifying antirheumatic drug; iv.: Intravenous; sc.: Subcutaneous; TNFi: Tumor necrosis factor inhibitor.

In the findings reported here, the discontinuation rate (31%) was similar to the discontinuation rate (34%) in a previous study of TNFis in patients with AS [23]; however, the rate of switching to a new TNFi (21%) fell between the results of previous studies (4–30%) [23,24,32]. Previous studies have confirmed that while switching to a second TNFi can be effective in AS, overall effectiveness may be somewhat lower [21,33,34].

The percentage of patients in this study who discontinued or switched TNFis (59.4%) was higher than in the previous studies [22–24,32]. Although the current study did not evaluate the reasons patients switched or discontinued TNFi therapy, previous studies have shown that approximately 30–36% of patients with AS, discontinued or switched biologic therapy because of adverse events [35,36] or lack of treatment effect [37]. Although no specific TNFi has been shown to be more effective than another in patients with AS [12,38], studies of TNFi treatment patterns provide better understanding of real-world use.

In addition to studies of biologic treatment patterns in patients with AS, more real-world studies examining add-on medication are needed. To our knowledge, the only study examining add-on medications in patients receiving TNFis for AS examined add-on csDMARDs only [22]. Notably, almost 40% of patients in this current study received medications for pain and inflammation. Evidence is lacking that analgesics (e.g., opioids) are effective in patients with AS; however; analgesics are recommended in patients who have an inadequate response to biologics [10]. Conversely, long-term treatment with systemic corticosteroids is not recommended for patients with AS [10,11]. Pain relief is an important treatment goal for patients with AS according to a recent working group [28] and more studies are needed to better understand why patients receiving TNFis require add-on corticosteroids, pain medications and csDMARDs. Inflammatory conditions known to overlap with AS, such as ulcerative colitis, Crohn disease and psoriasis, which may be reasons for the addition of some of these medications, were present in 6.1, 5.4 and 3.1% of patients in the 12 months before and 12 months after the index date in this study (Supplementary Table 2).

A larger proportion of patients receiving an iv.-administered TNFi (infliximab) had dose escalation than patients receiving an sc.-administered TNFi. These results were consistent with a previous study that found that patients with AS often required dose increases of infliximab [27]. Although the reasons for the more frequent dose escalations with infliximab are not entirely understood, possible reasons include specific dosing instructions, caution in administering the initial dose(s), increased flexibility of iv. infusion and insurance approval policies. In addition, the presence of anti-drug antibodies to infliximab may decrease its efficacy and as a result, some rheumatologists may increase the dose [39].

One limitation of this study was that only patients with commercial and Medicare Advantage insurance were included; therefore, the results may not be generalizable to all patients with AS, especially those with Medicaid, other insurance or no insurance. Moreover, due to the study design, diagnoses on claims could have been coded incorrectly or not coded at all and patients may have filled the medication but may not have used it as prescribed. Another limitation of this study is that the claims data do not include information about specific phenotypes, disease severity, or imaging results or reasons (e.g., inefficacy or intolerability) for discontinuing or modifying treatment. Further, this study could not consider the potential effects of rebates, discounts or other price concessions on

the choice of TNFi therapy, and utilization rates and switching may differ based on the TNFi options available in the formulary of each payer/employer group. The proportions of patients found to initiate and/or switch to each individual TNFi were likely influenced by insurance company policies requiring one TNFi to be used before another. Additionally, the retrospective nature of the study limits the analysis to patients who were diagnosed with AS during the 1-year period of study and because this study was limited to 1 year, long-term treatment patterns are unknown.

Conclusion

Using real-world data from a US administrative claims database, a high proportion of patients with AS were found to have either switched or discontinued their TNFi therapy during the 12 months of follow-up. Furthermore, approximately 45% of patients with AS initiated an add-on medication while receiving TNFi therapy. These findings provide an understanding of real-world treatment patterns of patients with AS and suggest that concomitant treatment options in addition to biologic therapy or alternate therapies for patients with AS are important. Inadequate control of symptoms may cause patients to discontinue biologic therapy, which can contribute to unfavorable outcomes. The importance of routinely evaluating patient symptom control and the need to better understand optimal therapy strategies necessitates further study in patients with AS.

Future perspective

Over the next 5–10 years, new monoclonal antibody therapies are expected to be approved for the treatment of AS; which will add to the currently approved TNFis and the anti-IL-17A monoclonal antibody secukinumab for the treatment of patients with AS. Therefore, characterizing patients with AS who discontinue biologic therapy and understanding the reasons for discontinuation will aid the development of treatment strategies to optimize patient outcomes. In addition, treatment guidelines should be developed to assist healthcare providers and patients in choosing appropriate biologic therapy for specific patient populations and to provide guidance on when and how to switch between biologic therapies. Lastly, incorporating patients' preferences and perspective when making treatment decisions should remain a high priority.

Summary points

- TNF inhibitors (TNFis) have been shown to be an effective treatment option for patients with moderate to severe ankylosing spondylitis (AS); however, some patients may have an inadequate response and/or biologics may lose effectiveness over time, both of which may lead to discontinuation.
- Add-on therapies and/or dose escalation of TNFis are often needed to achieve optimal outcomes among patients with chronic inflammatory diseases with inadequately controlled symptoms.
- The objective of this study was to examine adherence, persistence, discontinuation and dose escalation of the index biologic and initiation of add-on medication in patients with active AS who newly initiated treatment with a TNFi.
- This US-based retrospective observational study used administrative pharmacy and medical claims data from 1 January 2012 to 30 April 2016, from the Optum Research Database, which includes commercial and Medicare Advantage health plan members.
- A total of 426 patients with AS were included in the study; the mean standard deviation and median interquartile range proportion of days covered (treatment adherence) was 0.56 days (0.29) and 0.60 days (0.30, 0.84), respectively and the mean standard deviation and median interquartile range duration of persistence with the index TNFi was 236 days (131) and 274 days (105, 365), respectively.
- Only 40.6% persisted on their index TNFi for $\geq$12 months; 21.4% of patients switched to a different TNFi, 7.0% discontinued and restarted the index TNFi and 31.0% discontinued without switching or restarting.
- Of the 333 patients who continued their TNFi for >90 days, approximately 45% initiated an add-on therapy; the most commonly initiated add-on medications were corticosteroids (16.8%), followed by opioids (12.9%), nonsteroidal anti-inflammatory drugs (10.2%) and antidepressants (7.2%).
- The proportion of patients with TNFi dose escalation was substantially higher with an iv.-administered TNFi (38.5%) compared with an sc.-administered TNFi (2.7%).
- These study findings provide valuable information on real-world treatment modifications of TNFis in AS; further research is needed to better understand optimal therapy strategies and the impact of insufficient symptom control in patients with AS.

Supplementary data

To view the supplementary data that accompany this paper please visit the journal website at: www.futuremedicine.com/doi/suppl/10.2217/cer-2017-0076.

Financial & competing interests disclosure

J Walsh is a paid consultant for Novartis. O Adejoro was an employee of Optum during the time of the study and writing of the manuscript. B Chastek is an employee of Optum. Y Park is an employee of Novartis. O Adejoro's current affiliation is Eisai Inc., and he can be contacted at Olu.adejoro@eisai.com. The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

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Ethical conduct of research

Institutional review board approval was not required as this study is a retrospective analysis of existing claims data, with no patient intervention or interaction and no patient identifiable information is included in the claims dataset.

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