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Long-Term Treatment Patterns Among Patients With Psoriasis Treated With Ixekizumab or Adalimumab: A Real-World Study

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ABSTRACT

Background: There is a paucity of long-term real-world evidence comparing the effectiveness of ixekizumab (IXE) and adalimumab (ADA). We compared real-world treatment patterns of IXE-treated and ADA-treated patients with psoriasis over 24 months in the United States.

Methods: A retrospective observational study was conducted using IBM Watson Health MarketScan® databases. Adult patients with psoriasis having ≥1 claim for IXE or ADA from March 1, 2016 – October 31, 2019 were identified. Inverse probability of treatment weighting (IPTW) was used to address cohort imbalances. Cox proportional hazards models were used to estimate the risks of non-persistence, discontinuation, and switching. Logistic regression was used to estimate odds of high adherence. Persistence, adherence, discontinuation, reinitiation, and dosing and switching rates were also analyzed.

Results: The final cohorts comprised 475 IXE users and 3159 ADA users over 24 months. IXE users demonstrated higher adherence (36.3% vs 28.8%; *P*<0.001) and persistence rates (35.2% vs 28.8%; *P*=0.004), and a lower discontinuation rate (59.1% vs 65.3%; *P*=0.007) compared to ADA users. IXE users had a higher likelihood of being treatment-adherent compared to ADA users (OR=1.52, 95% CI: 1.24–1.87), a lower risk of non-persistence (HR=0.84, 95% CI: 0.75–0.95), and a lower risk of discontinuation (HR=0.83, 95% CI: 0.74–0.94), respectively. Switching rates were similar in both groups (31.2% vs 30.0%; *P*=0.608).

Conclusion: IXE users had better treatment adherence and persistence, and a lower risk of discontinuation compared to ADA users over 24 months. There was no difference in the risk of switching between IXE and ADA.

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INTRODUCTION

Psoriasis is a chronic systemic inflammatory condition characterized by erythematous, scaly plaques on the skin. It is associated with several comorbidities that impact quality of life, well-being, and life span of patients.[1,2] Currently available treatment options for moderate-to-severe plaque psoriasis include oral drugs, biologic therapies, and phototherapy.[3–5] Two commonly utilized biologics for psoriasis include adalimumab (ADA) and ixekizumab (IXE). ADA is a human monoclonal antibody that inhibits tumor necrosis factor-α (TNF-α).[6–8] IXE is a human monoclonal antibody that targets interleukin 17A (IL-17A).[6–8] Short-term Phase III studies have shown that 63–80% of patients receiving ADA and 87–90% of patients receiving IXE achieved 75% reduction in Psoriasis Area and Severity Index.[7–14] Both ADA and IXE have been separately shown in clinical trials to maintain long-term efficacy over 5 and 7 years, respectively.[15–16]

Long-term effectiveness of drugs, including ADA and IXE, in real-world settings is more difficult to assess. Data are limited and can be conflicting or contradictory to clinical trial findings.[12] Additionally, there are no long-term real-world studies comparing effectiveness of both medications. Previously, we compared real-world treatment pattern outcomes for IXE and ADA users with a variable length follow-up period of 14 and 16.5 months, respectively.[17] Here, we expanded the analyses and compared adherence, persistence, switching, discontinuation, and reinitiation outcomes between IXE and ADA users with psoriasis in real-world settings over 24 months.

MATERIALS AND METHODS

Study Design and Data Sources

A retrospective observational study was conducted in adult patients with psoriasis who were using either IXE or ADA

therapy. Data were collected using the IBM Watson Health MarketScan® Commercial Claims and Encounters (contains healthcare experiences of privately insured individuals), Medicare Supplemental and Coordination of Benefits (contains same information as commercial claims and encounters for individuals with Medicare Supplemental insurance paid by employers), and Early View Databases (captures same components of Commercial and Medicare Databases for services incurred as late as approximately 45 days before data release). The datasets comply with Health Insurance Portability and Accountability Act (HIPAA), 1996. This study did not involve the collection, use, or transmittal of individually identifiable data; therefore, Institutional Review Board (IRB) approval was not required.

Selection Criteria and Study Time Period

Adult patients were included if they had at least one inpatient claim or two non-diagnostic outpatient claims (at least 30 days apart) with psoriasis diagnosis between March 1, 2015 and October 31, 2019. International Classification of Diseases (ICD), 9th and 10th Revision, Clinical Modification (ICD-9-CM diagnosis code 696.1x or ICD-10-CM diagnosis codes L40.0–L40.4 or L40.8–L40.9) were used to identify records of patients with psoriasis. Patients were required to have ≥1 claim for the index drug of interest IXE or ADA between March 1, 2016 and October 31, 2019 with a psoriasis diagnosis on or before the date of the first claim of interest. The date of the first index drug claim set the index date and assigned patients to the IXE or ADA cohort. Patients were required to be ≥18 years of age at index date and continuously enrolled with medical and pharmacy benefits for at least 6 months before (pre-period) and 24 months after (post-period) the index date. Patients with index drug indications other than psoriasis (such as psoriatic arthritis for both IXE and ADA and ankylosing spondylitis, juvenile idiopathic arthritis, rheumatoid arthritis, Crohn's disease, ulcerative colitis, hidradenitis suppurativa, and uveitis for ADA) in the 6-month pre-period were excluded. Patients with index medications (ADA / IXE) within 90 days before the index date were also excluded. Patients were followed for 24 months starting from the index date.

Study Outcomes Definitions

Treatment adherence, persistence, discontinuation, reinitiation, dosing, and switching were assessed during a 24-month follow-up period. Adherence was measured by proportion of days covered (PDC) defined as the number of days with medication on hand during the follow-up period divided by the total number of days in the follow-up period. Mean PDC was reported, and high adherence was defined as PDC ≥80%. Patients were considered on persistent treatment if they had a <60-day gap between the end-of-day supply of the prior script to the next refill. The proportion of patients who stayed on persistent treatment during a 24-month follow-up period and time to non-persistence were captured and reported. Discontinuation was defined as having a gap of 90 days without any refill of the index drug after the days' supply of the previous script was exhausted. The proportion of patients who reached discontinuation during a 24-month follow-up period and time to discontinuation were reported. Among those who discontinued the index therapy, reinitiation was captured when the patients had ≤1 claim of index drug after the discontinuation date. The proportion of patients who reinitiated and time from discontinuation to reinitiation were reported. Switching was defined by starting a new biologic for psoriasis after discontinuing the index biologic. The proportion of patients who switched and time to switching were captured.

The average daily dose was reported for patients who had no index drug in the pre-period and had both the induction and maintenance period. Daily dosage was calculated as quantity multiplied by strength divided by days of supply. Quantity, strength, and days of supply were available in pharmacy claims billed by the National Drug Codes. When ADA was administered in doctor's office and billed by Healthcare Common Procedure Coding System codes, quantity was estimated based on the unit field recorded on the claim. If it was either missing or outside of the expected range (≤0 or >4), the paid amount on the claim divided by the wholesale acquisition cost was used as a proxy for quantity. A 14-day supply was assigned for each injection based on the recommended injection schedule for ADA.[18] The maintenance period started with the first claim after the induction period. The average daily dose for the induction and maintenance period for IXE and ADA were reported and compared to the expected daily dose based on dosing information in drug package inserts.[18,19]

Covariates

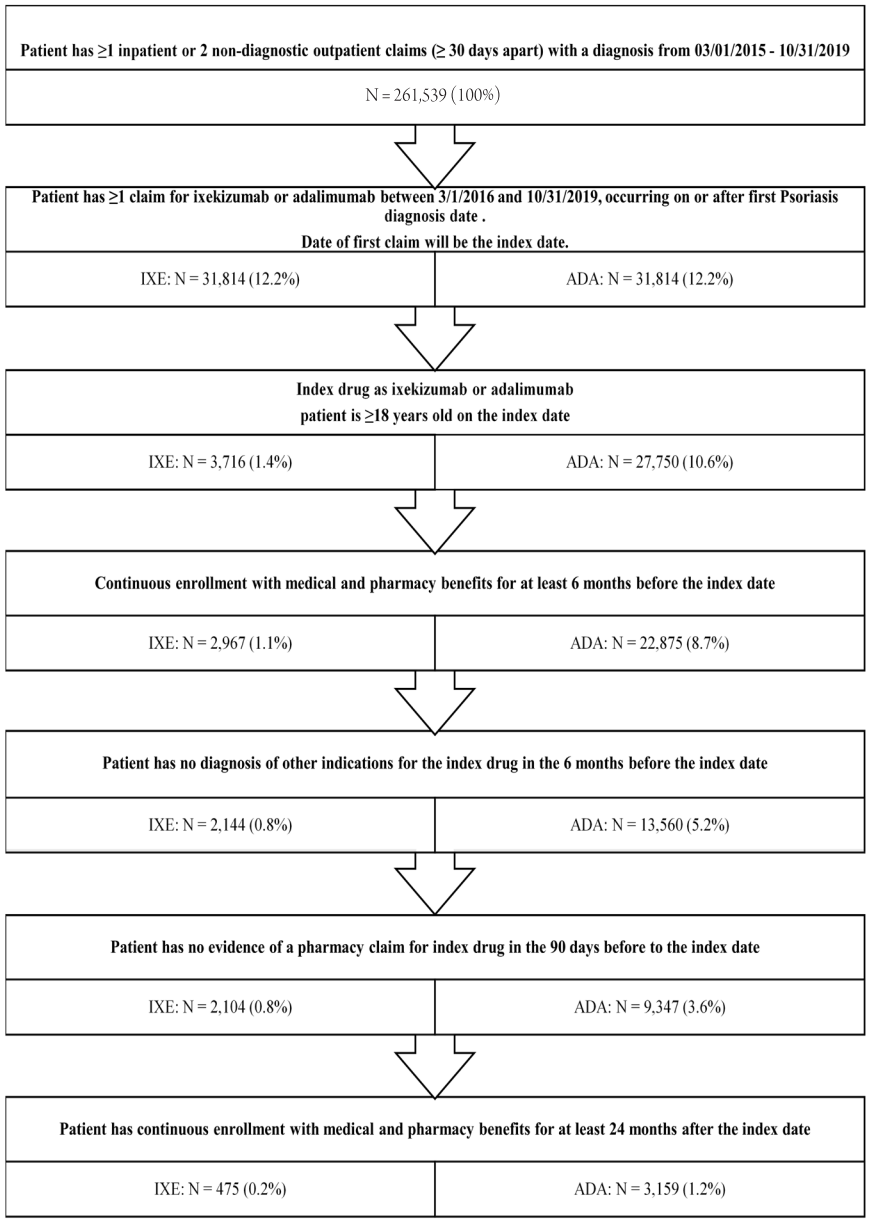
Baseline demographic and clinical variables (including age, gender, primary payer, health plan type, geographic region) were measured at the index date. Clinical variables Deyo Charlson Comorbidity Index (DCCI), Comorbid conditions (anxiety, coronary heart disease, depression, diabetes, hyperlipidemia, hypertension, obesity, other autoimmune disorders, osteoarthritis, peripheral vascular disease, and sleep apnea) were also included and measured at 6-months pre-index period. Pre-period use of biologics (ADA, brodalumab, certolizumab pegol, etanercept, guselkumab, infliximab, IXE, secukinumab, and ustekinumab), systemic drugs (apremilast, acitretin, systemic corticosteroids, cyclosporine, and methotrexate), topical drugs (coal tar, ketoconazole topical, and topical steroids), and non-pharmacologic treatments (phototherapy or laser treatments) were collected during the pre-index period. In addition, pre-period all-cause and psoriasis-related healthcare costs and comorbidity-related costs were collected.

Statistical Analysis

Categorical variables were presented as the count and proportion of patients in each category. Continuous variables were summarized by mean and standard deviation (SD).

Inverse probability of treatment weights (IPTW) was performed to address imbalances between two study groups. Propensity weights were estimated using logistic regression with IXE vs ADA as the dependent variable and baseline variables as covariates (Table 3). The cohorts were considered balanced on a given variable if the standardized difference (Std. Diff) was ≤0.1. Statistical tests for significance were conducted using chi-square test for categorical variables and pooled two sample t-tests for continuous variables for weighted outcomes. A priori *P* value of <0.05 was considered statistically significant. The weighted probabilities of persistence, discontinuation, and switching were estimated using Kaplan-Meier curves and weighted log-rank test. Cox proportional hazards models were employed to estimate the risks of non-persistence, discontinuation, and switching. Logistic regression was used to estimate the odds of high adherence (PDC≥80%). Covariates used in the IPTW model were included in regression models as well. Effect sizes, hazard ratio (HR), and odds ratios (OR) were presented along with 95% confidence intervals (CI). Descriptive analyses were conducted using WPS version 4.2 (World Programming System, United Kingdom); IPTW and multivariable analyses were conducted using R version 3.6.3 (R Foundation for Statistical Computing, Vienna, Austria).

FIGURE 1. Patient selection.



Abbreviations: ADA, adalimumab; IXE, ixekizumab.

TABLE 1.

Demographic and Baseline Characteristics Over 24 Months (unweighted and weighted results).

Variables	Before Weighting			After Weighting		
	IXE N=475	ADA N=3159	Std. Diff.	IXE	ADA	Std. Diff.
Age (mean, SD)	48.4 (11.0)	46.4 (12.1)	0.173	46.3 (11.5)	46.7 (12.1)	0.034
Male (%)	55.4%	56.6%	0.024	57.9%	56.3%	0.031
Commercial payer (%)	95.6%	96.7%	0.057	96.6%	96.5%	0.000
Pre-period DCCI index (mean, SD)	0.3 (0.9)	0.3 (0.8)	0.070	0.3 (0.9)	0.3 (0.8)	0.022
Pre-period comorbid conditions (%)						
Anxiety	5.9%	8.1%	0.088	8.3%	7.8%	0.016
Cerebrovascular disease	0.8%	0.9%	0.011	0.9%	1.0%	0.005
Coronary heart disease	3.4%	2.5%	0.053	2.0%	2.6%	0.042
Depression	5.7%	6.6%	0.040	5.5%	6.5%	0.043
Diabetes	14.9%	11.4%	0.106	11.0%	11.8%	0.027
Hyperlipidemia	21.5%	19.2%	0.057	21.2%	19.6%	0.041
Hypertension	25.5%	24.2%	0.028	24.7%	24.5%	0.006
Obesity	17.1%	13.6%	0.095	13.8%	14.0%	0.006
Osteoarthritis	6.1%	6.0%	0.005	7.2%	6.0%	0.045
Other autoimmune disorders	2.3%	1.8%	0.034	2.0%	1.9%	0.007
Pre-period treatments (%)						
Any biologics (biologic-experienced)	55.6%	28.6%	0.567	29.2%	32.1%	0.064
Any systemic agents/targeted oral therapies	41.1%	40.1%	0.019	36.1%	40.2%	0.083
Any topical agents	61.1%	58.8%	0.046	55.2%	59.1%	0.079
Phototherapy or laser treatments	4.2%	3.5%	0.040	3.0%	3.5%	0.028

Abbreviations: ADA, adalimumab; DCCI, Deyo Charlson comorbidity index; CDHP, consumer-directed health plan; EPO, exclusive provider organization; HDHP, high deductible health plan; HMO, health maintenance organization; IXE, ixekizumab; PPO, preferred provider organization; POS, point of service; SD, standard deviation; Std. Diff, standardized difference.

TABLE 2.

Weighted Treatment Pattern Outcomes: Adherence, Persistence (60-day gap), Discontinuation (90-day gap), and Reinitiation Over 24 Months.

	IXE	ADA	P value
Adherence			
PDC, mean (SD)	0.57 (0.31)	0.53 (0.31)	0.027
PDC≥80% (%)	36.3%	28.8%	<0.001
Persistence (60-day gap)			
Patients who were persistent at 24 months (%)	35.2%	28.8%	0.004
Number of days on persistent treatment (mean, SD)	402 (273)	375 (265)	0.033
Switching			
Patients who are switching to a different biologic	31.2%	30.0%	0.608
Number of days to switch (mean, SD)	355 (184)	326 (192)	0.073
Discontinuation (90-day gap)			
Patients who discontinued treatment (%)	(59.1%)	(65.3%)	0.007
Number of days to discontinuation (Mean, SD)	235 (160)	236 (162)	0.917
Re-initiation after discontinuation			
Patients who reinitiated treatment (%)	19.7%	19.0%	0.695
Number of days from discontinuation to reinitiation (mean, SD)	189 (94)	190 (107)	0.903

Abbreviations: ADA, adalimumab; IXE, ixekizumab; PDC; proportion of days covered; SD, standard deviation.

TABLE 3.

List of Covariates Used in the Multivariate Model Analysis
Covariate
Age
Log [Pre-period Psoriasis-related costs]
Sex
Payer
Plan type
Region
Pre-period CCI
Pre-period comorbidity-related costs
Pre-period anxiety
Pre-period coronary heart disease
Pre-period depression
Pre-period diabetes
Pre-period hyperlipidemia
Pre-period hypertension
Pre-period obesity
Pre-period other autoimmune disorders
Pre-period osteoarthritis
Pre-period peripheral vascular disease
Pre-period sleep apnea
Pre-period Psoriasis biologic use
Pre-period Psoriasis systemic agents/targeted oral therapies
Pre-period Psoriasis topical agents
Pre-period Phototherapy

RESULTS

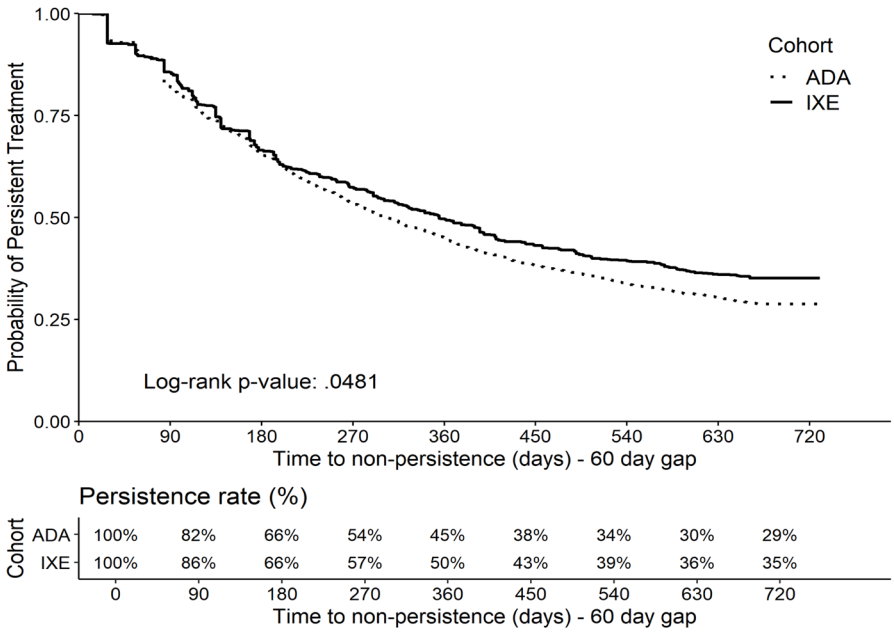
The final study cohorts consisted of 475 IXE and 3159 ADA users who fulfilled the eligibility criteria during the 24-month follow-up period (Figure 1). Table 1 presents pre- and post-weighting demographics and pre-period clinical characteristics. On average, IXE users were older than ADA users with an unweighted mean (SD) age of. 48.4 (11.0) vs 46.4 (12.1). Most patients had commercial payer coverage (95.6%–96.7%). Both IXE and ADA users had the same mean (SD) DCCI score of 0.3 (0.8) (Table 1).

The most common baseline comorbidities for IXE and ADA users were hypertension (25.5% vs 24.2%; Std. Diff=0.028), hyperlipidemia (21.5% vs 19.2%; Std. Diff=0.057), obesity (17.1% vs 13.6%; Std. Diff=0.095), diabetes (14.9% vs 11.4%; Std. Diff=0.106), and osteoarthritis (6.1% vs 6.0%; Std. Diff=0.034; Table 1). IXE users had a higher percentage of patients with prior use of biologics compared to ADA users (55.6% vs 28.6%; Std. Diff=0.567). Overall, the demographic and baseline characteristics, such as age, primary payer, insurance plan type, geographic region, and the pre-period DCCI, were balanced after weighting (Table 1).

Univariate Analyses

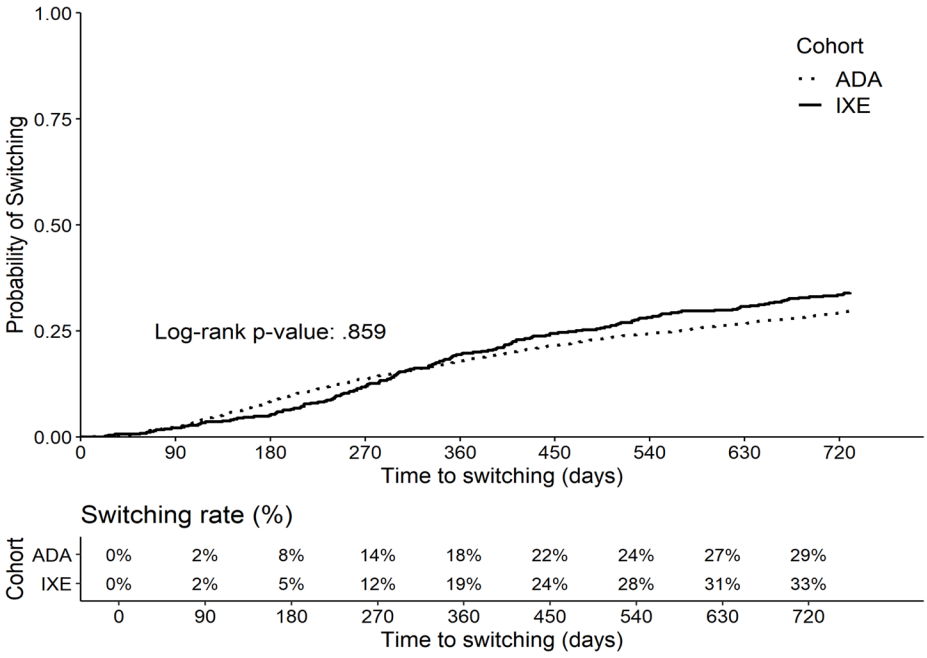
After weighting, IXE users had a significantly higher mean (SD) adherence compared to ADA users (0.57 [0.31] vs 0.53 [0.31]; *P*=0.027). A significantly greater proportion of IXE users had a PDC≥80% versus ADA users (36.3% vs 28.8%; *P*<0.001; Table 2). A significantly greater proportion of patients on IXE versus ADA were found to be persistent on treatment (35.2% vs 28.8%; *P*=0.004) during the 24-month follow-up period. Mean (SD) number of days on persistent treatment was also significantly higher in IXE users compared to ADA users (402 [273] vs 375 [265]; *P*=0.033). The probability of persistence over 24 months was significantly higher for IXE users compared to ADA users (*P*=0.048), as estimated using Kaplan-Meier curves (Figure 2). The median time to non-persistence was 355 days (95% CI: 301–410) for IXE and 302 days (95% CI: 286–321) for ADA.

FIGURE 2. Probability of persistence (60 days) over 24 months (IXE versus ADA).



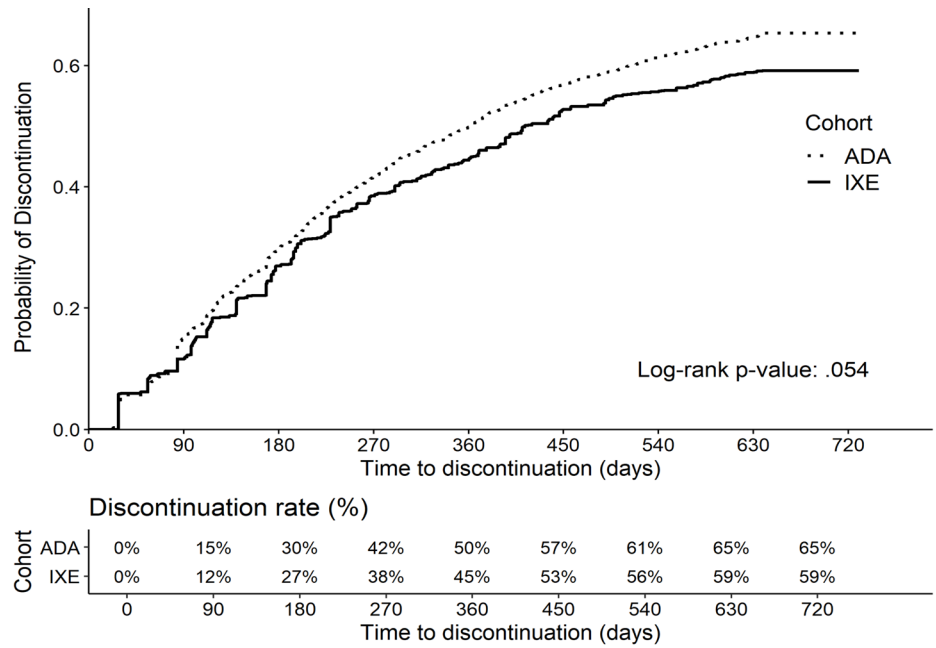
Abbreviations: ADA, adalimumab; IXE, ixekizumab.

FIGURE 3. Probability of switching over 24 months (IXE versus ADA).



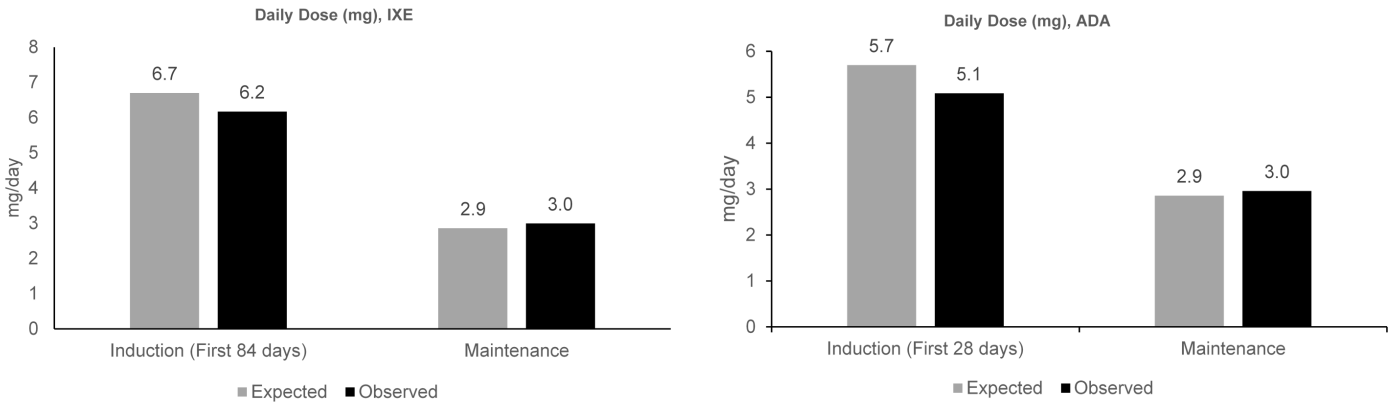
Abbreviations: ADA, adalimumab; IXE, ixekizumab.

FIGURE 4. Probability of discontinuation over 24 months (IXE versus ADA).



Abbreviations: ADA, adalimumab; IXE, ixekizumab.

FIGURE 5. Dosing over 24 months period in induction and maintenance phase (A) Daily Dose (mg) IXE (B) Daily Dose (mg), ADA.



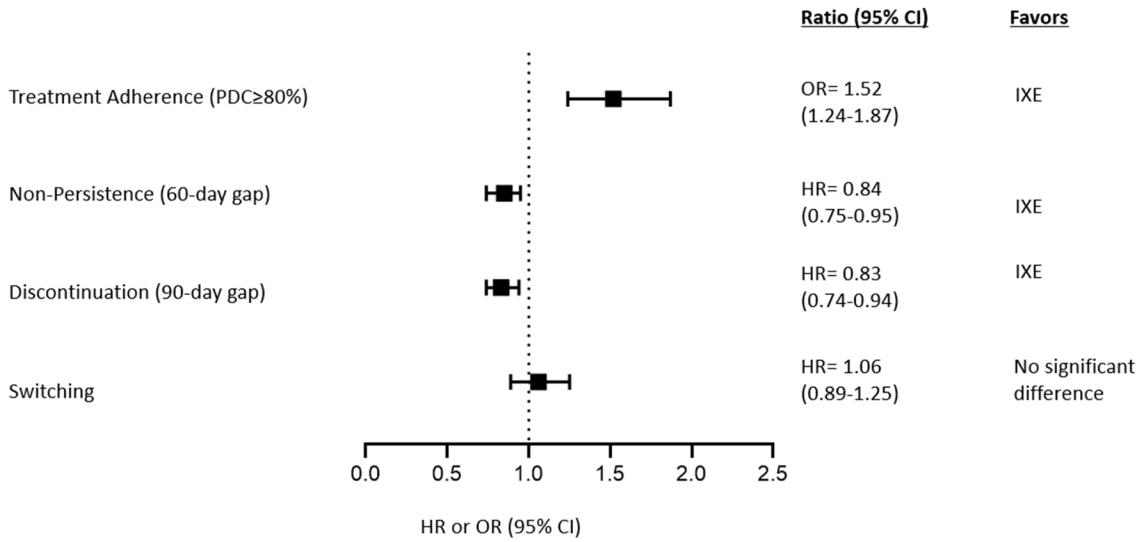
Dosing Calculation:
According to package insert, the induction period was considered as the first 84 days with a total of 560 mg for IXE and the first 7 days for ADA 80 mg.[18,19] For IXE, due to possible early refills or prescriptions consisting of multiple injections, the induction period was modified as either the first 84 days or when the cumulative strength multiplied by quantity ≥560 mg was achieved, whichever occurred first. For ADA, it was the first 7 days or when cumulative dose reached ≥80 mg, whichever came first. The maintenance period started with the first claim after the induction period.

IXE: Recommended induction dosing is 160 mg at week 0, then 80 mg every 2 weeks through week 12 (averaging to 6.1 mg/day). Recommended maintenance dosing is 80 mg every 4 weeks.

ADA: The expected weekly dosing including the induction dose is calculated for the first 4 weeks of treatment, which include the induction dose (80 mg at week 0) and first two maintenance doses (40 mg at week l, 40 mg, at week 3) due to most patients having 28 or more days' supply on their first claim. Recommended maintenance period dosing is 40 mg every other week (80 mg total every 4 weeks)

Abbreviations: IXE, ixekizumab; AD, adalimumab.

FIGURE 6. Risk of non-persistence, discontinuation, and switching, and odds of high treatment adherence between IXE and ADA users over 24 months.



Abbreviations: ADA, adalimumab; CI: confidence interval; HR:hazard ratio; IXE: ixekizumab; OR: odds ratio; PDC: proportion of days covered.

Post-weighting switching rates were similar between IXE users and ADA users (31.2% vs 30.0%; *P*=0.608). The mean number of days (SD) to first switch was similar between IXE and ADA users (355 [184] vs 326 [192]; *P*=0.073). There was no significant difference in the probability of switching over 24 months between IXE and ADA users (*P*=0.859), as estimated using Kaplan-Meier curves (Figure 3). IXE users had a significantly lower discontinuation rate compared to ADA users (59.1% vs 65.3%, *P*=0.007), whereas time to discontinuation was not significantly different (Table 2). The probability of discontinuation was not significant over 24 months between IXE and ADA users (*P*=0.054) (Figure 4). The median time to discontinuation was 370 days (95% CI: 370–493) for IXE and 362 days (95% CI: 341–378) for ADA users. The proportion of patients who reinitiated (19.7% vs. 19.0%, *P*=0.695) and the mean number of days from discontinuation to reinitiation were similar in both the groups (189 vs 190; *P*=0.903; Table 2).

Dosing

A total of 397 IXE users and 2347 ADA users were included in the dosing analysis. Based on the package insert for IXE, the average daily dosing during the induction period was 6.7 mg/day and maintenance period was 2.9 mg/day. In the current study, the observed daily dosing for IXE was similar in both induction (6.2 mg/day) and maintenance periods (3.0 mg/day; Figure 5). For ADA, the recommended average daily and maintenance dosings were 5.7 mg/day and 2.9 mg/day, respectively. The observed daily dosing for ADA was 5.1 mg/day and maintenance period was 3.0 mg/day (Figure 5). Based on these results, study patients utilized the index drugs as expected based on administration guidelines for psoriasis.

Multivariate Analysis

After multivariable adjustment, IXE users had over 52% higher odds of high treatment adherence measured by PDC ≥80% than ADA users (OR=1.52, 95% CI: 1.24–1.87). IXE users had 16% lower risk of non-persistence compared to ADA users (HR=0.84, 95% CI: 0.75–0.95). IXE users had a 17% lower risk of discontinuation compared to ADA users (HR=0.83, 95% CI:0.74–0.94; Figure 6). There was no significant difference in the risk of switching between both IXE and ADA users (HR=1.06, 95% CI: 0.89–1.25).

DISCUSSION

To our knowledge, this is the first administrative claims study that provides real-world comparative data on long-term treatment patterns of patients with psoriasis receiving either IXE or ADA in a US population. Our findings demonstrate that IXE users had higher adherence (36.3% vs 28.8%) and persistence rates (35.2% vs 28.8%) and lower discontinuation rates (59.1% vs 65.3%) compared with ADA users over a 24-month period. After adjusting for covariates in the multivariate analysis, IXE users had a lower risk for non-persistence and discontinuation and higher odds of having highly adherent treatment than ADA users. Our findings were similar to our earlier study, which was based on variable length of follow-up of 14 and 16.5 months.[17]

Though a shorter follow-up time, results in the prior study were relatively similar to current results. Compared to ADA users, IXE users had 19% lower risk of non-persistence ([HR=0.81, 95% CI: 0.69–0.95] vs current study [HR=0.84, 95% CI: 0.75–0.95]), and 26% lower risk of discontinuation ([HR=0.74, 95% CI: 0.62–0.88] vs. current study [HR=0.83, 95% CI: 0.74 –0.94]).[17] Unlike the previous study, IXE users in the current study had 52% greater odds of being highly adherent (PDC ≥80%) compared to ADA users ([OR=1.52, 95% CI: 1.24–1.87] vs previous [OR=1.22, 95% CI: 0.98–1.53]).[17] Also, in the current study, no significant difference was observed in the risk of switching between IXE and ADA users ([HR=1.06, 95% CI: 0.89–1.25] vs previous [HR=0.72, 95% CI: 0.57–0.91]).

Our findings regarding real-world use of ADA are consistent with the existing literature.[20–23] A study by Chastek et al showed that 40–42% of biologic-naïve patients who used commercial health plans in the US were persistent on their index drug ADA for one year.[20] ADA users had 45% discontinuation rate (allowing 60-day gap).[20] In another real-world study conducted in the Medicare population, treatment adherence and discontinuation rates for ADA were 40.7% and 43.4%, respectively.[21] In the current study, we found lower rates of adherence (28.8%) and persistence (28.8%) and higher discontinuation rates (65.3%) among ADA users. This could be attributed to the longer follow-up period. A recent real-world data study by Feldman et al that stratified ADA users with and without metabolic conditions reported discontinuation rates of 53.9% and 48.7%, respectively, for both groups.[22] The discontinuation rates were slightly lower than the current study (65.3%). The plausible reason could be that Feldman et al study disqualified discontinuation if the patient restarted treatment after reaching the allowable gap.[22] The combined rate of discontinuation and reinitiation was closer to the discontinuation rate in our study. The Feldman et al. study also reported rate of PDC ≥80% (27.6% vs 26.5%) for ADA users, which is similar to PDC rates reported for the ADA cohort in our current study.[22]

Clinicians are faced with an increasing range of biologic therapies for their patients with moderate-to-severe psoriasis. The treatment outcomes reported here serve as a proxy for real-world drug effectiveness and tolerability. In the absence of direct evidence from head-to-head trials, these real-world data (together with existing clinical trial data), help to provide clinicians with important information about long-term effectiveness, tolerability, and persistence of psoriasis drugs.[23,24] The long duration of follow-up is particularly relevant given the chronicity of psoriasis. Lastly, these real-world data on treatment patterns are relevant to payers in order to make informed decisions related to effectiveness of various biologics available for the treatment of psoriasis.[25,26]

LIMITATIONS

The study relied on diagnostic codes and pharmacy prescriptions in claims, which are subject to data coding limitations and data entry errors. Also, treatment pattern analyses were built on the assumption that patients took medications as prescribed, ie, there was no confirmation that patients took the medications as directed. Pre-period number of unique biologics (as a proxy for treatment resistance) and pre-period obesity were measured and included in multivariate models. IPTW and multivariable modeling were employed to address observable imbalances between patient cohorts, but residual differences not captured in claims may remain. Lastly, the chosen databases are limited to only those individuals with commercial health coverage or private Medicare supplemental coverage.

CONCLUSION

In summary, compared to ADA, IXE use for the treatment of psoriasis is associated with significantly better long-term persistence on therapy, a greater adherence to treatment, and a lower risk of treatment discontinuation in real-world settings. The results of this study supplement the data derived from randomized controlled trials for IXE and ADA to provide important information on their effectiveness in routine clinical practice and will help to inform decisions by both healthcare providers and payers in their treatment selection for patients with moderate-to-severe psoriasis.

DISCLOSURES

Dr Andrew Blauvelt has served as a scientific adviser and/or clinical study investigator for AbbVie, Abcentra, Aligos, Almirall, Amgen, Arcutis, Arena, Aslan, Athenex, Boehringer Ingelheim, Bristol-Myers Squibb, Dermavant, Eli Lilly and Company, Evommune, Forte, Galderma, Incyte, Janssen, Landos, Leo, Novartis, Pfizer, Rapt, Regeneron, Sanofi Genzyme, Sun Pharma, and UCB Pharma. Dr. Nianwen Shi, Dr Carolyn R. Lew, and Nicole M. Zimmerman are employees of IBM Watson Health that was compensated by Eli Lilly and Company for conducting this research. Dr Najwa Somani, Scott A. Kern, Dr Russel Burge, Terri Ridenour, Dr Baojin Zhu, and Dr Mwangi Murage are full-time employees and stockholders of Eli Lilly and Company.

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