Persistence and Effectiveness of Non-Biologic Systemic Therapies for Moderate-Severe Psoriasis in Adults: a Systematic Review

Citation for published version (APA):
Mason, K., Williams, S., Yiu, Z., McElhone, K., Ashcroft, D., Kleyn, C., Jabbar-Lopez, Z. K., Owen, C. M., Reynolds, N. J., Smith, C. H., Wilson, N., Warren, R., & Griffiths, CEM. (2019). Persistence and Effectiveness of Non-Biologic Systemic Therapies for Moderate-Severe Psoriasis in Adults: a Systematic Review. *Br J Dermatol*, *181*(2), 256-264. https://doi.org/10.1111/bjd.17625, https://doi.org/10.1111/bjd.17625

Citing this paper

General rights

Takedown policy

DR KAYLEIGH JANETTE MASON (Orcid ID : 0000-0002-5419-0669)

DR ZENAS ZEE NGAI YIU (Orcid ID : 0000-0002-1831-074X)

DR CATHERINE H. SMITH (Orcid ID : 0000-0003-1895-6070)

Article type   : Systematic Review

Persistence and Effectiveness of Non-Biologic Systemic Therapies for Moderate-Severe Psoriasis in Adults: a Systematic Review

Running head: Persistence and Effectiveness of Systemic Therapies for Psoriasis

Authors: K.J. Mason[1], S. Williams[1], Z.Z.N. Yiu[1,2], K. McElhone[1], D.M. Ashcroft[2], C.E.Kleyn[1], Z.K. Jabbar-Lopez[3], C.M. Owen[4], N.J. Reynolds[5,6], C.H. Smith[3], N. Wilson[7], R.B. Warren[1], C.E.M. Griffiths[1]

Affiliations:

1. Dermatology Centre, Salford Royal NHS Foundation Trust, The University of Manchester, Manchester Academic Health Science Centre, NIHR Manchester Biomedical Research Centre, Manchester, UK

2. Centre for Pharmacoepidemiology and Drug Safety, School of Health Sciences, The University of Manchester, Manchester, UK

3. St John's Institute of Dermatology, Guy's and St Thomas' NHS Foundation Trust and King's College London, London, UK

4. Royal Blackburn Hospital, East Lancashire Hospitals NHS Trust, Blackburn, UK

5. Institute of Cellular Medicine , Faculty of Medical Sciences, Newcastle University, UK

6. Department of Dermatology, Royal Victoria Infirmary, Newcastle-upon-Tyne, UK

7. Institute of Health Sciences, Faculty of Medical Sciences, Newcastle University

Corresponding author: Kayleigh J Mason

Address: BADBIR, Rutherford House (Unit 1), Manchester Science Partnerships, 40 Pencroft Way, Manchester, M15 6SZ, UK

Telephone: +44 161 306 1908

Email address: kayleigh.mason@manchester.ac.uk

Authors SW, ZZNY, ZKJL, CMO, and NW declare no conflict of interest.

What's already known about this topic?

- Research examining acitretin, ciclosporin, fumaric acid esters (FAE) and methotrexate for the treatment of moderate-severe psoriasis has focussed on safety and efficacy in randomised controlled trials

- The persistence and effectiveness of acitretin, ciclosporin, FAE and methotrexate since the introduction of biologic therapies in real-world clinical practice is poorly understood.

What does this study add?

- This systematic review examines the persistence and effectiveness of methotrexate, acitretin, ciclosporin and FAE for moderate-severe psoriasis.

- Data on the persistence and effectiveness of systemic therapies are lacking, particularly for acitretin and ciclosporin.

- The definitions of persistence and reporting of effectiveness are inconsistent.

- Further good quality observational studies are needed to explore the real-world persistence and effectiveness of systemic treatments used for psoriasis.

Summary

Background: The persistence and effectiveness of systemic therapies for moderate-severe psoriasis in current clinical practice are poorly characterised.

Objectives: To systematically review observational studies investigating the persistence and effectiveness of acitretin, ciclosporin, fumaric acid esters (FAE) and methotrexate involving at least 100 adult patients with moderate-severe psoriasis, exposed to therapy for ≥3 months.

Methods: Medline, Embase, the Cochrane Library and PubMed were searched from 01/01/2007 to 01/11/2017 for observational studies reporting on persistence (therapy duration or the proportion of patients discontinuing therapy during follow-up) or effectiveness (improvements in Psoriasis Area and Severity Index [PASI] or Physician Global Assessment [PGA]).

Results: Of 411 identified studies, 8 involving 4624 psoriasis patients were included. Variations in the definitions and analyses of persistence and effectiveness outcomes prevented a meta-analysis being conducted. One prospective multicentre study reported drug survival probabilities of 23% (ciclosporin), 42% (acitretin) and 50% (methotrexate) at 1 year. Effectiveness outcomes were not reported for either acitretin or cidosporin. The persistence and effectiveness of FAE and methotrexate were better characterised, but mean discontinuation times ranged from 28-50 months (FAE) and 7.7-22.3 months (methotrexate). At 12 months' follow-up, three studies reported 76% (FAE), 53% (methotrexate) and 59% (methotrexate) of patients achieved ≥75% reduction in PASI and one reported 76% of FAE-exposed patients achieved a markedly improved/clear PGA.

Conclusions: The comparative persistence and effectiveness of acitretin, ciclosporin, FAE and methotrexate in real-world clinical practice in the past decade cannot be well-described due to the inconsistency of the methods used.

Systematic review registration number: PROSPERO; CRD42018099771

Introduction

Psoriasis is a chronic inflammatory skin disorder which impairs both physical and psychological health[1]. Treatment options for patients with psoriasis depend on disease severity, comorbidities and patient choice and include topical, photo- and systemic therapies (including biologics and small molecules)[2,3]. More severe psoriasis frequently requires lifelong management, therefore counselling patients on the likelihood of medium-long-term disease control is important when discussing treatment choice.

In the UK, guidance provided by the National Institute for Health and Care Excellence (NICE) suggests the use of non-biologic, non-small molecule systemic therapies for the treatment of moderate-severe psoriasis that cannot be controlled with topical or phototherapies[3]. Methotrexate is recommended as first-line therapy, with cidosporin advised in the short term and for women considering conception. Acitretin may be considered if methotrexate and cidosporin are contraindicated or ineffective[3].

Most of the available evidence related to systemic therapies is derived from randomised controlled trials (RCTs). These remain the gold standard of investigating new therapies as participant randomisation to receive active or comparator treatments and high internal validity facilitate causal inference of the efficacy and/or safety of the therapy under investigation between the trial arms. However, most RCTs are not fully representative of real-world clinical practice and are powered for efficacy outcomes rather than safety. Due to their relatively small sample sizes, short follow-up periods and strict inclusion criteria, RCTs may have low external validity. Two studies have demonstrated that psoriasis patients identified as ineligible for biologic RCTs are at least twice as likely to experience serious adverse events when compared to eligible patients[4,5]. Attrition with longer-term RCTs or open-label extension studies may render the interpretation of safety data difficult due to the resulting bias in the sample studied. Post-marketing observational research is complementary to pre-licensing trials to enable the exploration of the persistence (duration of time from initiating to discontinuing therapy[6]) and effectiveness (response to therapy observed within real-world conditions accounting for factors that may influence the therapy's performance[7]) of psoriasis therapies in clinical practice. Discontinuation of systemic therapy is common in clinical practice, hence long-term data collection is critical to investigating therapeutic outcomes[8,9]. The British Association of Dermatologists Biologics and Immunomodulators Register (BADBIR) is a well-established prospective pharmacovigilance register of patients diagnosed with psoriasis and treated with all forms of systemic therapy[10]. Observational data collected by registers such as BADBIR will provide important evidence for the persistence and effectiveness of systemic psoriasis therapies in real-world clinical practice.

We conducted a systematic review of the persistence and effectiveness of four commonly used non-biologic, non-small molecule systemic psoriasis therapies in observational studies over the past decade. The aim was to summarise and evaluate observational studies (involving ≥100 subjects) investigating the persistence and/or effectiveness of acitretin, ciclosporin, fumaric acid esters (FAE) or methotrexate in adult patients with moderate-severe psoriasis.

Materials and methods

Literature Search

A literature search was completed utilising Embase, MEDLINE, PubMed and the Cochrane Library. Searches were limited to humans and publications dated from 1st January 2007 to 1st November 2017 to account for research published within the past decade as the introduction of biologic therapies has influenced systemic treatment prescribing. The full search strategy and complete study protocol is included within the Supplementary Materials (S1).

Inclusion Criteria

Longitudinal observational studies were eligible for review, including retrospective and prospective cohort studies. Study populations were to include: ≥100 patients; age >18 years; diagnosis of moderate-severe psoriasis; treatment with acitretin, ciclosporin, FAE or methotrexate; and follow-up time ≥3 months. A recent systematic review of observational studies in psoriasis patients specified a minimum of 100 patients prescribed each therapy to increase statistical power, therefore the same requirement was applied in this review[11].

Disease severity was ascertained through the inclusion criteria for each study (e.g. patients with moderate-severe psoriasis) or baseline measures of severity indicating moderate-severe diagnoses (Psoriasis Area and Severity Index [PASI] >10, Body Surface Area [BSA] >10% and/or Dermatology Life Quality Index [DLQI] >10). Studies where >50% of patients were diagnosed with psoriatic arthritis were excluded, as well as studies with pooled cohorts of patients receiving systemic therapies. Case-reports, RCTs and reviews were excluded.

Studies investigating persistence were included if therapy survival probabilities, mean or median time to therapy discontinuation, or the proportion of patients discontinuing therapy within the study follow-up period were reported. Studies investigating effectiveness were included if the absolute change in PASI, the proportion of patients achieving PASI50, PASI75 or PASI90 at ≥3 months (50%, 75% and 90% reductions in PASI, respectively), improvements in Physician Global Assessment (PGA) at ≥3 months, or the proportion of patients discontinuing therapy due to ineffectiveness were reported.

Study Selection

After the removal of duplicates, titles and abstracts were independently screened by two reviewers (SW and KJM). The remaining articles were read in full with data extracted by one reviewer (SW) and corroborated by the second (KJM); any articles found to meet the exclusion criteria were removed. Reference lists of reviews were also hand searched to identify additional publications.

Data Extraction

The study characteristics extracted from each included article were: author; study design and time period; therapies studied; number of patients per therapy; mean age; sex; mean disease duration; the proportion of patients with psoriatic arthritis; the mean baseline PASI and DLQI; and the proportion of patients using combination therapy. The outcomes of interest were extracted into a separate table along with the number of patients at each follow-up, where possible.

Quality Assessment

Two reviewers (SW and KJM) determined the quality of the included observational studies using the Newcastle-Ottawa Quality Assessment Scale for Cohort Studies[12]. There are 9 items included in the scale with four items under "Selection" and four items under "Outcome" scored a maximum of one star each, with the final "Comparability of Cohorts" item scored a maximum of two stars. Definitions and ratings of the biases are provided within the supplementary materials (S2).

This review is reported according to the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) guidelines and is registered with PROSPERO (CRD42018099771; date 19th June, 2018).

Results

The initial search produced 656 articles with 411 remaining after de-duplication (n=245; Figure 1). After excluding 335 articles by title screening, 76 abstracts remained. Fifty seven articles were excluded by abstract. Two additional articles were found through hand-searching the reference lists of the included studies, with 21 articles read in full and assessed for eligibility. Of the 13 articles excluded, three studies were removed by title or abstract due to having a cohort of <100 patients (Supplementary Materials S3)[13-15] and 10 articles were excluded for ineligibility (detailed in

Supplementary Materials S4)[16-25]; no studies were excluded based on outcome definition alone. The remaining eight articles were included in the systematic review (Table 1).

Study Characteristics

Acitretin, ciclosporin and methotrexate were included in one study[26], FAE and methotrexate in one study[27], methotrexate in two studies[28,29] and FAE in four[30-33] (Table 1). Four studies were retrospective and performed at a single centre [27,28,30,31] with four multicentre studies, three of which were prospective[26,29,33] and one retrospective[32]. All 8 studies were European with follow-up conducted from 2003-2014 and published in 2009-2017.

One study only reported the number of treatment cycles instead of the number of patients (158 cycles of FAE; 174 cycles of methotrexate)[27] and one study reported the baseline characteristics for the entire cohort instead of patients registering to each therapy[29]. Four studies reported the proportions of patients with no previous exposure to systemic psoriasis therapy (incident users) [26,28,31,32]. Two of these four studies investigated FAE and reported 60%[31] and 81%[32] of the cohort as incident users, one study reported 67% of a methotrexate cohort as incident users[28] and one study reported the proportions of incident users of acitretin, ciclosporin and methotrexate as 54%, 46% and 51%, respectively[26]. One article reported the number of first-line treatment cycles for FAE (n=116, 73%) and methotrexate (n=70, 40%) as opposed to the number of systemic-naïve patients[27].

Seven of the eight articles examined therapy discontinuation time[26-29,31-33] with six also reporting the proportion of patients discontinuing therapy[26-28,31-33](Table 2). All eight studies reported effectiveness outcomes (Table 2) with six studies reporting the proportion of patients discontinuing therapy due to ineffectiveness [26-28,31-33], with the other two studies reporting the mean PASI, PASI75 and PASI90[29] and PASI50, PASI75 and PASI90 at 3, 6 and 12 month time points[30].

Persistence

Davila-Seijo et al. reported the probability of drug survival at one year of 42.3% for acitretin (95% confidence interval [CI] 36.9%-47.6%), 23.3% for ciclosporin (95% CI 19.0%-27.8%) and 50.3% for methotrexate (95% CI 46.3%–54.2%), with median discontinuation times of 0.72, 0.45 and 1.01

years, respectively (Table 2)[26]. Over the 5 year study period 34%, 26% and 30% patients discontinuing acitretin, ciclosporin and methotrexate, respectively, did so for ineffectiveness (Table 2) with 14%, 18% and 17% discontinuing for adverse events[26].

One study reported mean treatment durations of 35.6 months (95% CI 27.8-43.5) and 22.3 months (95% CI 17.6-27.1) for FAE and methotrexate, respectively; the most common reasons for discontinuation during the 5 year study period were adverse events followed by ineffectiveness (42% and 21% for FAE; 22% and 21% for methotrexate; Table 2)[27]. Two studies reported the mean duration of FAE therapy as 28 months (range 1 week – 106 months)[31] and 50 months (no range)[32] with another two studies reporting mean durations of methotrexate therapy of 17.2 months (standard deviation 13.6)[28] and 7.7 months (range 0-36 months[29]; Table 2). The most common reasons for discontinuation among studies reporting the proportion of patients discontinuing FAE were adverse events (46% over 4 years[31]; 43% over 1 year[33]) and ineffectiveness (22% over 36 months[32]), and adverse events for methotrexate (22% over 48 weeks[28]; Table 2).

Effectiveness

Mean PASI at baseline and 12 months was reported by two studies; Walker et al. reported mean PASI of 16.83 and 5.61, respectively, for patients receiving FAE[33] while Maul et al. reported mean PASI of 11.4 and 2.2, respectively, for patients receiving methotrexate[29] (Table 2). Two studies reported 76% FAE patients on therapy at one year achieved PASI75[30] and PGA markedly improved or clear[32], with two studies reporting 53%[28] and 59%[29] methotrexate patients remaining on therapy at 1 year achieving PASI75 (Table 2). Two studies also reported discontinuations due to ineffectiveness for FAE (40% over 4 years[31]; 11% over 1 year[33]) and one for methotrexate (21% over 48 weeks[28]; Table 2). Effectiveness outcomes with PASI or PGA were not reported for cicdosporin or acitretin.

Quality Assessment

Two studies were rated as "high quality"[26,27] (scored >7) with the remaining 6 studies rated "medium quality"[28-33] (scored 4-6). None of the 6 studies rated as "medium quality" adjusted for age, sex, or any other confounding factors in their persistence or effectiveness analyses[28-33]. A meta-analysis was not conducted due to the diverse study designs, outcome definitions and analytical approaches used (Table 3).

Discussion

This systematic review found that when used in the treatment of moderate-severe plaque psoriasis the probability of drug survival at one year was 23% for ciclosporin, 42% for acitretin and 50% for methotrexate[26]. Discontinuations due to adverse events (42% FAE and 22% methotrexate[27]; 46% FAE[31]; 43% FAE[33]; 22% methotrexate[28]) were more common for FAE than methotrexate. There were mixed results for discontinuations due to ineffectiveness (44% acitretin, 21% ciclosporin and 33% methotrexate[26]; 22% FAE[32]). No studies reported effectiveness outcomes for acitretin or ciclosporin. The persistence and effectiveness of FAE and methotrexate were better characterised, but mean discontinuation times ranged from 28-50 months (FAE[27,31,32]) and 7.7-22.3 months (methotrexate[26-29]). Proportions of patients achieving PASI75 at 12 months were reported for FAE (76%[30]) and methotrexate (53%[28] and 59%[29]), with 76% FAE patients achieving a PGA of markedly improved/clear at 12 months[32].

A significant limitation to the current literature investigating the persistence of systemic therapy is the lack of survival analyses. Survival analyses are essential when using observational methods to explore drug persistence because without them, differing lengths of follow-up will not be accounted for. NICE recommends that ciclosporin use should not exceed one year unless patients have severe and/or unstable disease and biologic therapy is contra-indicated. As ciclosporin is usually prescribed for short durations, the lack of long-term persistence should not be viewed as a proxy for poor safety or ineffectiveness of this therapy[3]. Of the 8 studies identified, one conducted a survival analysis on the time to drug discontinuation for patients using each systemic therapy[26]. Three additional studies also conducted survival analyses; however, one pooled all systemic therapies into a systemic cohort[29], the second reported treatment courses rather than patients [27], and the third study did not provide the definition for discontinuation used in the survival analysis[28], making the results difficult to interpret.

A further limitation to the studies exploring therapy persistence is the inconsistent definition of drug discontinuation. Of the 7 studies reporting therapy persistence, 4 did not provide any definition of drug discontinuation[29,31-33]. One study defined discontinuation as "a suspension of medication" due to a range of possibilities, however it did not specify what a "suspension" was or a time-frame[28]. Two studies provided a sufficient definition of a discontinuation, providing a time-frame for how long patients were not using therapy[26,27]. Due to the lack of, and difference in, a definition of

discontinuation, it is difficult to ascertain whether short-term breaks in therapy have been accounted for. Definition of drug discontinuation and time-frames are particularly important when interpreting ciclosporin survival, as this is generally given for short periods of time.

Many of the included studies lack complete reporting and analysis of baseline characteristics. Evidence shows there are differences in the prescribing patterns of psoriasis therapies for different patients[34] while the definition of moderate-severe psoriasis remains inconsistent resulting in a range of baseline severities used between countries and healthcare systems. It would therefore be beneficial to assess the baseline characteristics of the therapy cohorts separately to identify differences between them. One study pooled the characteristics of the different therapy cohorts[29] and 5 studies did not report 3 or more of the baseline measurements listed [27,28,30,32,33]. This lack of detail makes the quality assessment both within and between studies more difficult.

There is little acknowledgment of prevalent user bias throughout the current literature. A prevalent user can be defined as a patient who previously used the therapy of interest before the start of the study follow-up, then restarted the same therapy during the study period[35]. The inclusion of such patients within an analysis can bias results as they may have been exposed to a specific therapy previously and could be prescribed this again due to a previous positive response, or they could be exposed to a new therapy if their initial treatment failed. One study reported the proportion of incident users within the entire cohort and one reported the proportion of treatment courses which were first-line[27], whilst only 4 studies provided the proportions of incident users for individual therapies[26,28,31,32]. It would be beneficial to conduct sensitivity analyses with and without prevalent users to identify whether prevalent user bias is present. The discontinuation of previous therapy could also influence the disease severity recorded prior to initiating a new one, particularly if there are minimal washout periods or overlaps between them. By reporting both the aggregate estimates and estimates stratified by therapy, we can better understand whether previous therapy exposure affects drug persistence or effectiveness. Another factor that influences the persistence or effectiveness of therapies is medication adherence. Patients with psoriasis registering to BADBIR on acitretin, ciclosporin, FAE or methotrexate were almost twice as likely to be non-adherent (29.2%) when compared to patients receiving etanercept or adalimumab (16.4%; p<0,001)[36]. Medication adherence should be assessed when investigating treatment response, particularly whether non-adherence is intentional (e.g. medication perceived to be ineffective) or unintentional (e.g. lower persistence related to habit strength).

The results of this review reflect the contemporary evidence for the persistence and effectiveness of systemic psoriasis therapies within the real-world environment. Since performing our database search, one conference abstract has been published as a manuscript; the authors performed a single centre, retrospective study of 626 psoriasis patients receiving FAE monotherapy demonstrated a median duration of therapy of 1.7 years, with 188 (30%) patients discontinuing therapy[37]. The introduction of biologic and small molecule therapies in the past decade are likely to have influenced the persistence of acitretin, ciclosporin, FAE, and methotrexate in clinical practice, which is yet to be addressed in the literature. Future analyses should stratify by year of initiation to account for changes in the prescribing environment and thus the persistence of these therapies over time. The complexity of studying persistence and effectiveness of therapy in clinical practice is highlighted by the varying results, study cohorts and methods of reporting. The inconsistent methods of reporting prevented a meta-analysis from being conducted. There was also the potential to introduce bias via the outcome definition specified in the protocol for this systematic review. Although no studies were excluded based on outcome definition alone (Supplementary Materials, Table S4), future reviews of this topic should consider the use of a more robust definition to minimise the risk of excluding a study that used a different but relevant outcome definition.

In conclusion, this systematic review highlights how evidence for the persistence and effectiveness of systemic therapies for psoriasis in clinical practice is lacking. There are few studies exploring acitretin or ciclosporin and those which have examined FAE or methotrexate are difficult to compare due to incomplete reporting of baseline characteristics, insufficient survival analyses and differing definitions of drug discontinuation. There is therefore a need for good quality observational research, with an additional need for uniform methods of analysis and reporting to allow for meta-analyses.

References

1. Dubertret L, Mrowietz U, Ranki A, et al. European patient perspectives on the impact of psoriasis: the EUROPSO patient membership survey. *The British journal of dermatology.* 2006;155(4):729-736.

2. Strober BE, Siu K, Menon K. Conventional systemic agents for psoriasis. A systematic review. *The Journal of Rheumatology.* 2006;33(7):1442-1446.

3. Psoriasis: assessment and management. [Clinical guideline]. 2017. Accessed 11th May 2018, 2018.

4. Mason KJ, Barker J, Smith CH, et al. Comparison of Drug Discontinuation, Effectiveness, and Safety Between Clinical Trial Eligible and Ineligible Patients in BADBIR. *JAMA Dermatol.* 2018.

5. Garcia-Doval I, Carretero G, Vanaclocha F, et al. Risk of serious adverse events associated with biologic and nonbiologic psoriasis systemic therapy: patients ineligible vs eligible for randomized controlled trials. *Arch Dermatol.* 2012;148(4):463-470.

6. Cramer JA, Roy A, Burrell A, et al. Medication compliance and persistence: terminology and definitions. *Value in health : the journal of the International Society for Pharmacoeconomics and Outcomes Research.* 2008;11(1):44-47.

7. Singal AG, Higgins PD, Waljee AK. A primer on effectiveness and efficacy trials. *Clinical and translational gastroenterology.* 2014;5:e45.

8. Barbosa CD, Balp MM, Kulich K, Germain N, Rofail D. A literature review to explore the link between treatment satisfaction and adherence, compliance, and persistence. *Patient preference and adherence.* 2012;6:39-48.

9. Freeman K, Marum M, Bottomley JM, Auland M, Jackson P, Ryttov J. A psoriasis-specific model to support decision making in practice UK-experience. *Current Medical Research and Opinion.* 2011;27(1):205-223.

10. Burden AD, Warren RB, Kleyn CE, et al. The British Association of Dermatologists' Biologic Interventions Register (BADBIR): Design, methodology and objectives. *British Journal of Dermatology.* 2012;166(3):545-554.

11. Langham S, Langham J, Goertz HP, Ratcliffe M. Large-scale, prospective, observational studies in patients with psoriasis and psoriatic arthritis: A systematic and critical review. *BMC medical research methodology.* 2011;11:32.

12. Wells GA, Shea B, O'Connell D, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. 2018.

13. Wain EM, Darling MI, Pleass RD, Barker JNWN, Smith CH. Treatment of severe, recalcitrant, chronic plaque psoriasis with fumaric acid esters: A prospective study. *British Journal of Dermatology.* 2010;162(2):427-434.

14. Borghi A, Corazza M, Bertoldi AM, Caroppo F, Virgili A. Low-dose acitretin in treatment of plaque-type psoriasis: descriptive study of efficacy and safety. *Acta Derm Venereol.* 2015;95(3):332-336.

15. Borghi A, Corazza M, Mantovani L, Bertoldi AM, Giari S, Virgili A. Prolonged cyclosporine treatment of severe or recalcitrant psoriasis: descriptive study in a series of 20 patients. *International Journal of Dermatology.* 2012;51(12):1512-1516.

16. Calara PS, Norlin JM, Althin R, Carlsson KS, Schmitt-Egenolf M. Healthcare Provider Type and Switch to Biologics in Psoriasis: Evidence from Real-World Practice. *BioDrugs.* 2016;30(2):145-151.

17. Christophers E, Segaert S, Milligan G, Molta CT, Boggs R. Clinical improvement and satisfaction with biologic therapy in patients with severe plaque psoriasis: results of a European cross-sectional observational study. *Journal of Dermatological Treatment.* 2013;24(3):193-198.

18. Gelfand JM, Wan J, Callis Duffin K, et al. Comparative effectiveness of commonly used systemic treatments or phototherapy for moderate to severe plaque psoriasis in the clinical practice setting. *Archives of Dermatology.* 2012;148(4):487-494.

19. Jungo P, Maul JT, Djamei V, et al. Superiority in Quality of Life Improvement of Biologics over Conventional Systemic Drugs in a Swiss Real-Life Psoriasis Registry. *Dermatology.* 2017;232(6):655-663.

20. Norlin JM, Carlsson KS, Persson U, Schmitt-Egenolf M. Register-Based Evaluation of Relative Effectiveness of New Therapies: Biologics Versus Conventional Agents in Treatment of Psoriasis in Sweden. *BioDrugs.* 2015;29(6):389-398.

21. Norlin JM, Steen Carlsson K, Persson U, Schmitt-Egenolf M. Switch to biological agent in psoriasis significantly improved clinical and patient-reported outcomes in real-world practice. *Dermatology.* 2012;225(4):326-332.

22. Lambert J, Ghislain PD, Cauwe B, Van den Enden M. Treatment patterns in moderate-to-severe plaque psoriasis: results from a Belgian cross-sectional study (DISCOVER). *Journal of Dermatological Treatment.* 2017;28(5):394-400.

23. Yeung H, Wan J, Van Voorhees AS, et al. Patient-reported reasons for the discontinuation of commonly used treatments for moderate to severe psoriasis. *Journal of the American Academy of Dermatology.* 2013;68(1):64-72.

24. Shear N, Dobson-Belaire W, Tey G, Reidel K, Liu FF, Khan Z. Psoriasis treatment progression and biologic utilization: A Canadian retrospective study. *Journal of the American Academy of Dermatology.* 2015;1):AB246.

25. Svedbom A, Dalen J, Mamolo C, Cappelleri JC, Petersson IF, Stahle M. Treatment patterns with topicals, traditional systemics and biologics in psoriasis - a Swedish database analysis. *Journal of the European Academy of Dermatology and Venereology : JEADV.* 2015;29(2):215-223.

26. Davila-Seijo P, Dauden E, Carretero G, et al. Survival of classic and biological systemic drugs in psoriasis: results of the BIOBADADERM registry and critical analysis. *Journal of the european academy of dermatology and venereology : JEADV.* 2016;30(11):1942-1950. http://onlinelibrary.wiley.com/o/cochrane/clcentral/articles/750/CN-01247750/frame.html.

27. Arnold T, Schaarschmidt M-L, Herr R, Fischer JE, Goerdt S, Peitsch WK. Drug survival rates and reasons for drug discontinuation in psoriasis. *JDDG: Journal der Deutschen Dermatologischen Gesellschaft.* 2016;14(11):1089-1099.

28. Cabello Zurita C, Grau Perez M, Hernandez Fernandez CP, et al. Effectiveness and safety of Methotrexate in psoriasis: an eight-year experience with 218 patients. *Journal of Dermatological Treatment.* 2017;28(5):401-405.

29. Maul JT, Djamei V, Kolios AGA, et al. Efficacy and Survival of Systemic Psoriasis Treatments: An Analysis of the Swiss Registry SDNTT. *Dermatology.* 2017;232(6):640-647.

30. Inzinger M, Weger W, Heschl B, Salmhofer W, Quehenberger F, Wolf P. Methotrexate vs. fumaric acid esters in moderate-to-severe chronic plaque psoriasis: Data registry report on the efficacy under daily life conditions. *Journal of the European Academy of Dermatology and Venereology.* 2013;27(7):861-866.

31. Ismail N, Collins P, Rogers S, Kirby B, Lally A. Drug survival of fumaric acid esters for psoriasis: a retrospective study. *British Journal of Dermatology.* 2014;171(2):397-402.

32. Reich K, Thaci D, Mrowietz U, Kamps A, Neureither M, Luger T. Efficacy and safety of fumaric acid esters in the long-term treatment of psoriasis--a retrospective study (FUTURE). *J.* 2009;7(7):603-611.

33. Walker F, Adamczyk A, Kellerer C, et al. Fumaderm in daily practice for psoriasis: dosing, efficacy and quality of life. *British Journal of Dermatology.* 2014;171(5):1197-1205.

34. Davison NJ, Warren RB, Mason KJ, et al. Identification of factors that may influence the selection of first-line biological therapy for people with psoriasis: a prospective, multicentre cohort study. *The British journal of dermatology.* 2017;177(3):828-836.

35. Ray WA. Evaluating Medication Effects Outside of Clinical Trials: New-User Designs. *American Journal of Epidemiology.* 2003;158(9):915-920.

36. Thorneloe RJ, Griffiths CEM, Emsley R, et al. Intentional and Unintentional Medication Non-Adherence in Psoriasis: The Role of Patients' Medication Beliefs and Habit Strength. *The Journal of investigative dermatology.* 2018;138(4):785-794.

37. Dickel H, Bruckner T, Altmeyer P. Long-term real-life safety profile and effectiveness of fumaric acid esters in psoriasis patients: a single-centre, retrospective, observational study. *Journal of the European Academy of Dermatology and Venereology : JEADV.* 2018;32(10):1710-1727.

Table 1   The characteristics of the studies included in the systematic review.

Study	Design	Therapy	Baseline Characteristics	
Arnold et al.[26]	Retrospective, single centre, 2003-2014	FAE	n; 158 (treatment courses) Mean age (SD); 50.4 years (15.2) Mean disease duration; 19.9 years Mean PASI (SD); 13.0 (7.8) Baseline DLQI not provided	116 courses first-line systemic therapy % female; 33.9 % PsA; 15.8 Combination therapies not provided
		MTX	n; 174 (treatment courses) Mean age (SD); 51.7 years (12.6) Mean disease duration; 18.3 years Mean PASI (SD); 12.3 (7.0) Baseline DLQI not provided	70 courses first-line systemic therapy % female; 42.5 % PsA; 48.3 Combination therapies not provided
Cabello et al.[27]	Retrospective, single centre, 2007-2014	MTX	n; 218 Mean age (SD); 45.8 years (15) Disease duration not provided Mean PASI (SD); 7.4 (6.7) Mean DLQI (SD); 8.2 (5.1)	% systemic naïve; 67 % female not provided % PsA not provided Combination therapies; 87% monotherapy, 13% receiving another systemic treatment
Davila-Seijo et al.[25]	Prospective, multicentre (BIOBADADERM), 2008-2013, (Median follow-up (range); 3.3 years (0-5.1))	ACI	n; 340 Mean age (SD); 55 years (15) Mean disease duration (SD); 16 years (16) Mean PASI (SD); 9 (6) DLQI not provided	% systemic naïve; 54 % female; 31 % PsA; 5 Combination therapies; 2 cycles MTX, 3 cycles CsA
		CIC	n; 356 Mean age (SD); 43 years (14) Mean disease duration (SD); 15 years (12) Mean PASI (SD); 13 (9) DLQI not provided	% systemic naïve; 46 % female; 49 % PsA; 7 Combination therapies; 5 cycles MTX, 5 cycles ACI
		MTX	n; 638 Mean age (SD); 49 years (15) Mean disease duration (SD); 16 years (13) Mean PASI (SD); 9 (6) Baseline DLQI not provided	% systemic naïve; 51 % female; 45 % PsA; 12 Combination therapies; 11 cycles CsA, 8 cycles ACI

Inzinger et al.[29]	Retrospective, single centre (PsoRA), 2004-2011	FAE	n; 200 Mean age (SD); 40.4 years (13.3) Mean disease duration (SD); 17.3 years (12.4) Mean PASI (SD); 11.6 (5) Baseline DLQI not provided	% systemic naïve not provided % female not provided % PsA not provided Combination therapies not provided
Ismail et al.[30]	Retrospective, single centre, 2003-2012	FAE	n; 249 Mean age (range); 44.5 years (17-82) Disease duration not provided Mean PASI (range); 9.2 (0-22.2) Mean DLQ (range); 13.4 (0-27)	% systemic naïve; 60 % female; 36 % PsA; 10.0 Combination therapies; 5% in combination; n=4 CsA, 3 ACI, 3 infliximab, 2 etanercept, 1 adalimumab
Maul et al.[28]	Prospective, multicentre (SDNTT), 2011-2014	MTX	*Baseline characteristics provided only for total systemic cohort (MTX 119, FAE 27, CsA 6, Retinoid 6)* n; 158 Mean age; 47.1 years Mean disease duration; 14.4 years Mean PASI (SD, range); 9.2 (6.1; 0.0-32.4) Mean DLQI (SD, range); 10.7 (6.6; 0.0-27.0)	% systemic naïve not provided % female; 31.6 % PsA; 10.8 Combination therapies not provided
Reich et al.[31]	Retrospective, multicentre (FUTURE), dates not provided	FAE	n; 984 Mean age (SD, range); 50.5 years (13.18, 15-105) Mean disease duration (range); 21.9 years (13.32, 0-75) Baseline PASI and DLQI not provided	% systemic naïve; 80.6 % female; 41.8 % PsA; 8.3 Combination therapies not provided
Walker et al.[32]	Prospective, multicentre (74 private practices and 4 hospitals in Germany)	FAE	n; 249 Mean age (range); 49.7 years (18-89) Disease duration not provided Mean PASI; 16.83 Mean DLQI; 9.95	% systemic naïve not provided % female; 44 % PsA not provided Combination therapies; 35.4% concomitant medication, psoriasis treatments not provided

Abbreviations: Acitretin (ACI); ciclosporin (CsA); fumaric acid esters (FAE); methotrexate (MTX); psoralen ultraviolet A (PUVA); ultraviolet B (UVB); standard deviation (SD); psoriatic arthritis (PsA); Psoriasis Area and Severity Index (PASI); Physician Global Assessment (PGA); Dermatology Life Quality Index (DLQI); Psoriasis Register Austria (PsoRA); Swiss Dermatology Network for Targeted Therapies (SDNTT); Dermatology Clinical Effectiveness Research Network (DCERN)

Table 2   Summary of evidence

Drug (reference)	Number of Patients	Results
Persistence		
Probability of drug survival at 12 months		
ACI[25]	340	42.3% (95% CI 36.9%-47.6%)
CsA[25]	356	23.3% (95% CI 19.0%-27.8%)
MTX[25]	638	50.3% (95% CI 46.3%–54.2%)
Therapy discontinuation time		
ACI[25]	340	Median; 0.72 years (no range)
CsA[25]	356	Median; 0.45 years (no range)
FAE[26]	158 *	Mean; 35.6 months (95% CI 27.8-43.5)
FAE[30]	249	Mean; 28 months (1 week-106 months)
FAE[31]	984	Mean; 50 months (no range)
MTX[25]	638	Median; 1.01 years (no range)
MTX[26]	174 *	Mean; 22.3 months (95% CI 17.6-27.1)
MTX[27]	218	Mean; 17.2 months (SD; 13.6)
MTX[28]	119	Mean; 7.7 months (range 0-36)
Proportion of patients discontinuing therapy, n (%); discontinuations due to adverse events, n (%)		
ACI[25]	340	281 (83%) over 5 years; 40 (14%)
CsA[25]	356	329 (92%) over 5 years; 58 (18%)
FAE[26]	158 *	108 (68%) over 5 years; 45 (42%)
FAE[30]	249	146 (59%) over 4 years; 67 (46%)
FAE[31]	984	213 (22%) over 36 months; 18 (17%)
FAE[32]	249	104 (42%) over 1 year; 45 (43%)
MTX[25]	638	456 (72%) over 5 years; 79 (17%)
MTX[26]	174 *	129 (74%) over 5 years; 52 (40%)
MTX[27]	218	112 (51%) over 48 weeks; 25 (22%)
Effectiveness		
Mean PASI Values		
FAE[32]	Baseline: 249 12 months: 145	16.83 5.61
MTX[28]	Baseline: 119 3 months: 80 6 months: 55 12 months: 28	11.4 3.3 2.2 2.2
Proportion of patients achieving improvements in disease severity: n (%)		
FAE[29]	3 months: 115	PASI50; 87 (76%) PASI75; 54 (47%) PASI90; 10 (9%)
	6 months: 73	PASI50; 60 (82%) PASI75; 46 (63%) PASI90; 20 (27%)
	12 months: 41	PASI50; 37 (90%) PASI75; 31 (76%) PASI90; 14 (34%)
FAE (PGA markedly	3 months: 953 6 months: 941	294 (30.8%) 630 (67.0%)

improved/clear)[31]	12 months: 936	713 (76.2%)
	24 months: 901	701 (77.8%)
	36 months: 566	465 (82.1%)
	>36 months: 566	473 (83.6%)
MTX[27]	Not provided for separate time points	PASI75: Week 12; 32.5% Week 16; 34.4% Week 24; 44.7% Week 36; 50.0% Week 48; 52.8%
MTX[28]	3 months: 81	PASI75; 30 (37%) PASI90; 11 (13.6%)
	6 months: 56	PASI75; 30 (53.6%) PASI90; 16 (28.6%)
	12 months: 29	PASI75; 17 (58.6%) PASI90; 13 (44.8%)
Proportion of therapy discontinuations due to ineffectiveness: n (%)		
ACI[25]	281 †	96 (34.2%) over 5 years
CsA[25]	329 †	86 (26.1%) over 5 years
FAE[26]	108 †	33 (20.9%) over 5 years
FAE[30]	146 †	59 (40%) over 4 years
FAE[31]	103 †	58 (56.3%) over 36 months
FAE[32]	76 †	8 (11.1%) over 1 year
MTX[25]	456 †	137 (30.0%) over 5 years
MTX[26]	129 †	37 (21.3%) over 5 years
MTX[27]	112 †	24 (21.1%) over 48 weeks

Abbreviations: Acitretin (ACI); ciclosporin (CsA); fumaric acid esters (FAE); methotrexate (MTX); 95% CI (95% confidence interval); Psoriasis Area and Severity Index (PASI); Physician Global Assessment (PGA); * treatment courses; † number discontinuing therapy.

Table 3   Newcastle-Ottawa Quality Assessment Scale for Cohort Studies

Reference	Arnold et al.[26]	Cabello et al.[27]	Davila-Seijo et al.[25]	Inzinger et al.[29]	Ismail et al.[30]	Maul et al.[28]	Reich et al.[31]	Walker et al.[32]
Selection (maximum one star per item)								
Representativeness of exposed cohort	(b) *	(b) *	(a) *	(b) *	(b) *	(a) *	(a) *	(a) *
Selection of non-exposed cohort	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ascertainment of exposure	(a) *	(a) *	(a) *	(a) *	(a) *	(b) *	(b) *	(b) *
Outcome not present at baseline	(a) *	(a) *	(a) *	(a) *	(a) *	(a) *	(a) *	(a) *
Comparability of cohorts (maximum two stars)								
Matching	(a+b) **	0	(a) *	0	0	0	0	0
Outcome (maximum one star per item)								
Assessment of outcome	(b) *	(b) *	(b) *	(b) *	(b) *	(b) *	(b) *	(b) *
Length of follow-up	(a) *	(a) *	(a) *	(a) *	(a) *	(a) *	(a) *	(a) *
Adequacy of follow-up	(d)	(d)	(b) *	(b) *	(b) *	(a) *	(a) *	(c)
Total score	7	5	7	6	6	6	6	5