





## ORIGINAL RESEARCH

# Infection profile of immune-modulatory drugs used in autoimmune diseases: analysis of summary of product characteristic data

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## ABSTRACT

**Objective** Serious infection remains a concern when prescribing immune-modulatory drugs for immune-mediated inflammatory diseases. The 'summary of product characteristics' (SmPCs) provide information on adverse events for example, infections, from clinical trials and postmarketing pharmacovigilance.

This review aimed to compare infection frequency, site and type across immune-modulatory drugs, reported in SmPCs.

**Methods** The Electronic Medicines Compendium was searched for commonly prescribed immune-modulatory drugs used for: rheumatoid arthritis, spondyloarthritis, connective tissue disease, autoimmune vasculitis, autoinflammatory syndromes, inflammatory bowel disease, psoriasis, multiple sclerosis and/or other rarer conditions.

Information was extracted on infection frequency, site and organisms. Frequency was recorded as per the SmPCs: very common ( $\geq 1/10$ ); common ( $\geq 1/100$  to  $< 1/10$ ); uncommon ( $\geq 1/1,000$  to  $< 1/100$ ); rare ( $\geq 1/10,000$  to  $< 1/1,000$ ); very rare ( $< 1/10,000$ ).

**Results** 39 drugs were included, across 20 indications: 9 conventional synthetic disease-modifying anti-rheumatic drugs (csDMARDs), 6 targeted synthetic DMARDs, 24 biologic (b)DMARDs.

Twelve infection sites were recorded. Minimal/no site information was available for most csDMARDs, certolizumab pegol and rituximab. Upper respiratory tract was the most common site, especially with bDMARDs. Lower respiratory, ear/nose/throat and urinary tract infections were moderately common, with clustering within drug groups.

Data for 27 pathogens were recorded, majority viruses, with herpes simplex and zoster and influenza most frequent. Variable/absent reporting was noted for opportunistic and certain high-prevalence infections for example, Epstein-Barr.

**Conclusion** Our findings show differences between drugs and can aid treatment decisions alongside real-world safety data. However, data are likely skewed by trial selection criteria and varying number of trials per drug and highlight the need for robust postmarketing pharmacovigilance.

## WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Serious infection is a concern when prescribing immune-modulatory drugs for immune-mediated inflammatory diseases.
- ⇒ The European Medicines Agency 'summary of product characteristics' (SmPCs) data provide information on adverse events including infections; however, no comparison has been undertaken on reported infection frequencies across SmPCs for immune modulators.

## WHAT THIS STUDY ADDS

- ⇒ We undertook a summary analysis of the SmPCs using a novel methodological approach to help clinicians visualise infection risk patterns across treatment strategies.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE AND/OR POLICY

- ⇒ Our findings can be used to visualise differences between drug infection risk profiles and aid treatment decisions and highlight the need for robust postmarketing pharmacovigilance studies with real-world safety data.

## INTRODUCTION

Serious infection remains a risk in people with immune-mediated inflammatory diseases (IMIDs). One of the great challenges of contemporary disease care is balancing risk and benefit of immune-modulatory therapies. For most patients, these drugs provide a safe and effective method of disease control.<sup>1</sup> Advances in targeted therapies for autoimmune diseases have been accompanied by a growing awareness of the potential to change infection risk.

Quantifying the risk of serious infection can be challenging, as they are relatively rare events. Primary clinical trials are not



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scrutinised and long-term extension data rarely focus on safety. We instead rely on real-world data such as registries. An example is the increased risk of serious infection in patients taking inhibitors of tumour necrosis factor (TNFis), demonstrated through studies of registry data in rheumatoid arthritis (RA), psoriasis and inflammatory bowel disease (IBD).<sup>2-5</sup> Similar infection risks have also been shown with non-TNFi biologics, such as rituximab and tocilizumab, the latter being associated with serious bacterial skin and soft tissue infections.<sup>6,7</sup>

However, registry data are undermined by channeling bias and unmeasured confounding. Examining trial and long-term extension data combined would provide more power and overcome concerns around bias and confounding.

The European Medicines Agency (EMA) publishes a 'summary of product characteristics' (SmPC) for each drug on the European market, produced by the drug manufacturer. Stringent guidelines exist on the format and content of SmPCs.<sup>8,9</sup> EMA requires patient-level data from both clinical trials and long-term extension data to be submitted and reviewed. Data informing risk are also gathered from spontaneous reporting, directly by regulators or indirectly via the marketing authorisation holder. Altogether these inform risk profiling, as detailed in the SmPCs, through estimated event rates.<sup>8</sup> Information within the SmPCs is reviewed regularly (at least annually) and updated as and when new data becomes available. SmPCs are a crucial source of safety information for prescribers. However, to our knowledge, there has to date been no comparison undertaken on infection risk in immune-modulatory drug use, across SmPCs. Immune-modulatory drugs encompass conventional synthetic (cs), biologic (b) and targeted-synthetic (ts) disease-modifying antirheumatic drugs (DMARDs).

We sought to undertake a summary analysis of the SmPCs using a novel methodological approach to help clinicians visualise infection risk patterns across treatment strategies.

The rationale for this work was to be able to compare the information, provided by regulators, as detailed in the SmPCs. SmPCs follow a common format and requirements, enabling comparability across agents.

## METHODS

The search question was as follows: What is the frequency and nature of infection in patients with IMIDs taking immunomodulatory medication, as reported in the SmPC literature?

### Participants

An SmPC for a given drug was included if the drug is licensed in Europe for the treatment of an IMID. This comprised rheumatic diseases such as: inflammatory arthritis (including RA, axial spondyloarthritis, psoriatic arthritis), gout, connective tissue disease (eg, systemic lupus erythematosus, scleroderma, dermatomyositis),

autoimmune vasculitis, autoinflammatory syndromes, juvenile idiopathic arthritis. Non-rheumatic diseases included: IBD (Crohn's and ulcerative colitis), psoriasis, multiple sclerosis and other rarer conditions.

### Intervention

The intervention is the use of an immune-modulatory drug for the treatment of IMIDs. Information on infections as an adverse event secondary to the use of the drug, as described in the SmPC, was extracted and analysed.

### Comparator

A comparator or control is not directly relevant to this review, although patients with an IMID and not taking the immune-modulatory drugs under study could be considered as such.

### Outcomes

Infection risk and frequency based on each immunomodulatory drug under study were recorded, described by infection site (eg, respiratory, urinary tract, skin, etc) and by type (eg, bacterial, viral, fungal, etc).

### Study selection, data extraction and synthesis

The Electronic Medicines Compendium (EMC) was searched for the most commonly used immune-modulatory drugs in the treatment of IMIDs. The search and data extraction were performed on 28 September 2020.

Drugs were selected and agreed by all authors. Full length SmPC documents were manually searched for relevant information on infection risk and frequency, which was subsequently extracted from the Special warnings and precautions for use section and Undesirable effects section. The Special warnings and precautions for use section includes data on serious adverse reactions, including infections, and consideration of at-risk groups. The Undesirable effects section contains details of infections from clinical trials, postauthorisation safety studies and spontaneous reporting, in which there is at least a reasonable possibility that these are as a consequence of the medicinal product. It is important to note that decisions on what is included in the SmPC can be subjective and may be the result of a consensus decision determined by the relevant committee on evaluation of the available data. In addition to in-depth data and description of these adverse events, details on frequency of subtypes of event (eg, site and type of infection) were extracted.

Twenty-five per cent of included SmPCs were screened and extracted by a second reviewer, using a purpose-built data extraction table. Disagreements were discussed until a consensus was agreed, with a third reviewer involved as needed. No papers, or additional data or supplementary material were required from authors.

Information on frequency of infection was recorded as per the convention in the SmPC documentation: very common ( $\geq 1/10$ ); common ( $\geq 1/100$  to  $< 1/10$ ); uncommon ( $\geq 1/1000$  to  $< 1/100$ ); rare ( $\geq 1/10\ 000$  to  $< 1/1000$ ); very rare ( $< 1/10\ 000$ ).<sup>8</sup> Of note, not all 'very

rare' infections may be included in a given SmPC—the threshold for inclusion may be subjective and be based, for example, on clinical importance of the infection. Any additional information was recorded within the extraction table with adequate referencing to the relevant SmPC. Information, where available, on infection site (eg, respiratory, skin, etc), type (eg, bacterial, viral, etc) and individual pathogenic organisms was also extracted.

## RESULTS

In total, 39 drugs were identified, used across 20 indications, including 9 csDMARDs, 6 tsDMARDs (4 Janus kinase inhibitors, 2 sphingosine 1-phosphate receptor modulators) and 24 bDMARDs (17 cytokine-targeted and 7 cell-targeted). All drugs are listed by DMARD category in [table 1](#). All included SmPCs had been updated within 18 months of the search date.

All SmPCs had areas of missing or unavailable data (ie, not reported within the SmPCs), possibly due to the rarity of events or rarest events not being reported. For infection sites, this was most marked for cladribine, upadacitinib, certolizumab pegol, ravulizumab, natalizumab and dupilumab, which reported frequency of infection for a maximum of two sites. All drugs had large amounts of missing or unavailable data for frequencies of infection with pathogen groups (eg, bacteria, fungi), aside from viruses, where there were no missing data. With regards individual organisms, a large amount of missing data was noted for most pathogens, especially opportunistic infections, again due to low frequency of events. Infections were more likely to be listed by site than organism.

Twelve sites of infection were recorded. Minimal or no site information was available for most csDMARDs and siponimod, certolizumab pegol and rituximab. [Figure 1](#) shows the most common sites of infection listed by drug group. Upper respiratory tract was the most common site of infection, especially with bDMARDs. Lower respiratory, ear/nose/throat (including sinusitis) and urinary tract infections (UTIs) were moderately common, with clustering within drug groups, especially TNFis. No drugs reported the risk of cardiac infections. The eye, musculoskeletal, neurological oral and reproductive tract sites were the least commonly reported sites of infection.

Infection data for 27 distinct pathogens were recorded, the majority viruses, especially with bDMARD use. [Online supplemental figure 1](#) shows the most common pathogen subtypes by drug (where information was available). Specifically, herpes simplex and zoster were the most frequently listed pathogens (mainly with bDMARDs and tsDMARDs, most classed as 'common' in frequency), followed by influenza virus (common to very common with the use of several drugs across all categories; very common with the use of fingolimod, canakinumab, infliximab and ocrelizumab). Common non-viral causes of infection were candida and tinea species.

Variable or absent reporting was noted for opportunistic infections and certain viruses with high prevalence

in the general population, for example, Epstein-Barr. Infection frequencies for several opportunistic infections were reported, with variable amounts of missing data. Frequencies of infection with fungi—especially candida and tinea species—had the least missing data. Infection frequency for mycobacterium tuberculosis (TB) was reported for 8 of the 39 drugs. Frequencies for other mycobacterial infections, including mycobacterium avium complex, were available for five drugs. Other opportunistic infections, including histoplasma, blastomyces and aspergillus had frequencies reported for three or fewer drugs. The full list of frequencies of infections with the individual pathogens, by drug, is found in [figure 2](#). Cells are left blank where there is no mention of the infection within the SmPC. Colours denote the frequency reported within the SmPC, including where it is reported as 'unknown'.

## DISCUSSION

The SmPC literature reports differences in infection risk, by site and pathogen, between immune-modulatory drugs, although accounting for the lack of standardisation of reporting. The findings can be used to visualise risk estimates, in a format that is easily and quickly legible. However, some of the patterns we have shown lack face validity to clinicians familiar with real-world safety data. Reasons for this include that the data are likely skewed in some cases by trial selection criteria, varying number of trials per drug, and quirks of individual study-reporting methodologies. In addition, data used to build SmPCs may fail to capture risk of rare infections, which may be detected in observational studies and real-world data.

To our knowledge, this is the first review comparing infection risk profile of immune-modulatory drugs, as detailed in the SmPCs. Previous studies have sought to compare other aspects of drug information reporting, such as drug interactions and contraindications in conditions other than the IMIDs.<sup>10–12</sup> Similar to our findings, these also identified inconsistencies in reporting, especially when compared with real-world data, and potentially misleading information due to absent or contradictory information. All studies highlight the need to consult other sources prior to prescribing, and not relying solely on SmPC literature, for example, outcomes from observational studies from large-scale datasets.

The lack of reporting on rarer events, missing or unavailable data may in part be due to a lack of use of spontaneous adverse event reporting systems, such as the MHRA yellow card system, especially after a drug has been on the market for a period of time, leading to the Weber effect.<sup>13</sup> This is the phenomenon of increased reporting of adverse events for new drugs in their first years of approval. The EMA guidance on the production of SmPCs requires information on adverse events to comprise both trial and real-world data.<sup>8,9</sup> SmPCs for newer drugs are, therefore, likely to have their adverse event profile based on trial data, whereas older drugs are

**Table 1** Summary of immune-modulatory drugs included in this analysis, including date of last update to the summary of product characteristic (SmPC) document at the time of the search and data extraction

Drug	Mode of action	IMID licensed indication(s)	Mode of administration	Date of last SmPC update at time of search
<b>csDMARDs</b>				
Azathioprine	Purine synthesis inhibitor	Crohn's, UC, RA	Oral	03 December 2019
Ciclosporin	Calcineurin inhibitor	UC, RA, PsO, atopic dermatitis	Oral	10 March 2020
Cladribine	Purine analogue	MS	Oral	21 January 2020
Interferon beta	Unknown	MS	SC, IM	23 October 2019
Leflunomide	Pyrimidine synthesis inhibitor	RA, PsA	Oral	15 August 2017
Methotrexate	Dihydrofolate reductase inhibitor	Crohn's, RA, PsO	Oral, SC, IM	23 January 2020
Mycophenolate mofetil	Inosine-5'-monophosphate dehydrogenase inhibitor	Nil IMID	Oral	25 November 2020
Sulfasalazine	Unknown	Crohn's, UC, RA	Oral	15 October 2019
Teriflunomide	Dihydro-orotate dehydrogenase inhibitor	MS	Oral	18 September 2020
<b>tsDMARDs</b>				
Baricitinib	JAK1 and JAK2; limited inhibition of TYK2)	RA	Oral	26 November 2019
Filgotinib	JAK1	RA	Oral	24 September 2020
Tofacitinib	JAK3 and JAK1; some affinity for JAK2; limited affinity for TYK2	RA	Oral	06 February 2020
Upadacitinib	JAK1	RA	Oral	01 April 2020
Fingolimod	Sphingosine 1-phosphate receptor modulator	MS	Oral	16 January 2020
Siponimod	Sphingosine 1-phosphate receptor modulator	MS	Oral	24 April 2020
<b>bDMARDs</b>				
<i>Cytokine/enzyme-targeted</i>				
Adalimumab	TNF $\alpha$ inhibitor	Crohn's, UC, RA, PsO, axSpA, nr-axSpA	SC	04 September 2020
Anakinra	IL-1 receptor antagonist	RA, CAPS, Still's	SC	28 May 2020
Canakinumab	IL-1 $\beta$ inhibitor	Gout, autoimmune syndromes, Still's	SC	13 March 2020
Certolizumab pegol	TNF $\alpha$ inhibitor	RA, PsO, axSpA, PsA	SC	12 August 2020
Dupilumab	IL-4 receptor antagonist	Mod-severe atopic dermatitis, severe asthma	SC	26 September 2017
Eculizumab	C5 complement inhibitor	PNH	IV	29 June 2020
Etanercept	TNF $\alpha$ inhibitor	RA, PsO, PsA, AS, nr-axSpA	SC	14 September 2020
Golimumab	TNF $\alpha$ inhibitor	UC, RA, PsO, AS, nr-axSpA	SC, IV	12 May 2020
Guselkumab	IL-23 inhibitor	PsO	SC, IV	29 June 2020
Infliximab	TNF $\alpha$ inhibitor	Crohn's, UC, RA, AS, PsA, PsO	SC, IV	28 October 2019

Continued

**Table 1** Continued

Drug	Mode of action	IMID licensed indication(s)	Mode of administration	Date of last SmPC update at time of search
Ixekizumab	IL-17A inhibitor	PsO, PsA	SC	16 July 2020
Mitoxantrone	Type II topoisomerase inhibitor	nil IMID	IV	07 January 2020
Ravulizumab	C5 complement inhibitor	PNH	IV	28 September 2020
Sarilumab	IL-6 receptor antagonist	RA	SC	23 June 2017
Secukinumab	IL-17A inhibitor	AS, PsA, PsO	SC	19 August 2020
Tocilizumab	IL-6 receptor antagonist	RA, GCA	IV	02 September 2020
Ustekinumab	IL-12/23 inhibitor	Crohn's, UC, PsO, PsA	SC	27 February 2020
<i>Cell-targeted</i>				
Abatacept	CTLA-4 inhibitor	RA, PsA	SC, IV	10 June 2020
Alemtuzumab	CD52 antagonist	MS	IV	16 September 2020
Belimumab	B-cell activating factor	SLE	IV	28 September 2020
Natalizumab	$\alpha 4\beta 1$ integrin inhibitor	MS	IV	12 May 2020
Ocrelizumab	CD20 inhibitor	MS	IV	01 June 2020
Rituximab	CD20 inhibitor	RA, autoimmune vasculitis, pemphigus vulgaris	IV	08 April 2020
Vedolizumab	$\alpha 4\beta 7$ integrin inhibitor	Crohn's, UC	SC, IV	15 May 2020

UC= ulcerative colitis; PsO= psoriasis; PsA= psoriatic arthritis; MS= multiple sclerosis; CAPS= cryopyrin-associated periodic syndrome; AxSpA= axial spondyloarthritis; SLE= systemic lupus erythematosus  
 IMID, immune-mediated inflammatory disease; JAK, Janus kinase; RA, rheumatoid arthritis; TNF, tumour necrosis factor.

more likely to have a greater real-world evidence base. Nonetheless, rarer infections may also be more likely to be reported with newer drugs such as tsDMARDs and IL-17 inhibitors, in comparison to drugs which have been on the market for longer and there is, therefore, awareness and management of risk, for example, TNF inhibitors and tuberculosis.

With regards to sites of infection, upper respiratory tract infections (URTIs) were noted to be common with all drugs, except cladribine, indicating this is a poor discriminator for drug choice. In contrast, UTIs varied much more in frequency, with less frequent reporting for classes such as IL-17 inhibitors. There is also within-drug variation in the frequency of infections at different sites, for example, for abatacept, gastrointestinal infections are classed as rare, compared with ENT and URTI, which are very common. This is insightful as no studies to date have examined infection risk by site for a single drug. Abatacept overall appears to be associated with infections at all sites. The SmPC data would, therefore, suggest that it is not a good drug for patients at risk of infection. However, this is in contrast to registry data, which has generally reported a good infection safety profile compared with other biologics such as the commonly used TNF-inhibitors, although the EMA SmPC guidance stipulates that these data should be used in the production of SmPCs.<sup>7 14 15</sup> The SmPC may report a greater number of infection sites for abatacept compared

with other bDMARDs due to variations in trial data and reporting between drugs. This is a good example of the discordance between SmPCs and real-world registry data, which will be familiar to clinicians prescribing biologic drugs in clinical practice. It is also important to note that target populations for patients taking abatacept may be different to those taking TNFi (eg, RA vs psoriasis and IBD), and this will affect infection rates—in this example, infection rates are overall higher in RA compared with psoriasis and IBD. This reflects a limitation of the SmPCs, in that adverse events are not segregated by disease.

Variable or absent reporting was noted for most of the biologic DMARDs. This may be due to missing or unavailable data or due to number of patients being too low for very rare events to have occurred. It may also be the case that even if an event did occur, it simply was not reported in the SmPC document. Rituximab is a commonly used medication for the management of IMIDs such as RA and ANCA vasculitis. However, SmPC literature, based on pharmacovigilance data, was only able to provide information on respiratory tract infections and few organisms. In contrast, real-world registry data have been able to assess incidence ratios of infections, serious infections and hospitalisations with the use of this drug, as well as of individual infections.<sup>7 16</sup> The same is true of other drugs with sparse infection frequency reporting in the SmPCs, such as abatacept, tocilizumab and anakinra.<sup>7 17</sup> Interpretation of the SmPC data requires the user to appreciate

Drug & pathogen type		BACTERIA	FUNGI	PARASITES	PROTOZOA	VIRUSES	
Conventional synthetic drugs	Azathioprine	●	●			●	
	Cladribine					●	
	Mycophenolate mofetil		●			●	
	Teriflunomide					●	
Targeted synthetic drugs	Janus kinase	Baricitinib				●	
		Filgotinib				●	
		Tofacitinib					●
		Upadacitinib					●
	Sphingosine 1-phosphate receptor	Fingolimod					●
Biologic drugs	TNF $\alpha$	Adalimumab	●	●			●
		Certolizumab	●	●			●
		Etanercept	●	●		●	●
		Golimumab	●	●		●	●
		Infliximab	●	●	●		●
	IL-6	Tocilizumab					●
	IL-17	Ixekizumab					●
		Secukinumab		●			●
	IL-12/23	Ustekinumab					●
	IL-23	Guselkumab					●
	Complement C5	Eculizumab		●			●
	Other cytokine/enzyme target	Canakinumab					●
	Cell-targeted	Abatacept					●
		Alemtuzumab	●				●
Belimumab		●				●	
Ocrelizumab						●	
Rituximab		●	●			●	
Vedolizumab			●			●	

**Figure 1** Summary of common sites of infection for immune-modulatory drugs. Key: red = very common; orange = common; yellow = uncommon; green = rare; blank = no information available. Drugs with no frequencies reported for specific infection sites not included (azathioprine, ciclosporin, interferon beta, leflunomide, methotrexate, sulfasalazine, siponimod, certolizumab pegol, dupilumab).

that these could represent with no data or few data. For newer drugs, this is most likely explained by no or few events. For older drugs, it is likely to be due to true missing data, due to historical reporting methods in clinical trials and postmarketing pharmacovigilance. Of note, only two drugs, tofacitinib and abatacept, report 'rare' sites of infections, for skin and gastrointestinal infections, respectively.

Reporting of infection frequencies within the table of adverse events in the SmPCs is not within the context of

individual IMIDs. Information within them, therefore, requires cautious interpretation or the details of trial data that can be found for some indications, but not all, within the document. For example, infections at all sites are reported as 'very common' for canakinumab, a drug used in the treatment of periodic fever syndromes. The reported infection profile may reflect the underlying disease state, rather than the side-effect of the drug.

There is some face validity to the results described, for example, the risk of lower respiratory tract infections and



to choose drugs with less frequent infections, although being mindful that absent or rare events may indicate less reporting of infection, not necessarily low frequency. Similarly, for patients with a history of infection with a specific organism or opportunism, visualisation of organism data can help select drugs with a weaker signal for these infections. However, to have sufficient face validity for comparisons between SmPCs to alter care, the EMA would need to ensure more detailed information on source data within the tables in the SmPCs, especially with regard adverse events with drug use in different diseases. Ultimately, drug choice is individualised, dependent on both patient and clinician.

In conclusion, the SmPC literature is an important source of information on infection frequency, including on individual types and infectious organism. Our comparison of SmPCs across immune-modulatory drugs shows striking patterns, including the similarities and differences in infection, which can be used to guide prescribing decisions in this high-risk population. However, we have also highlighted the need for robust postmarketing pharmacovigilance studies, and the importance of using SmPC data alongside other sources when assessing infection risk.

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#### REFERENCES

- Rutherford AI, Subesinghe S, Hyrich KL, *et al*. Serious infection across biologic-treated patients with rheumatoid arthritis: results from the British Society for rheumatology biologics register for rheumatoid arthritis. *Ann Rheum Dis* 2018;77:annrheumdis-2017-212825.
- Askling J, Forell CM, Brandt L, *et al*. Time-dependent increase in risk of hospitalisation with infection among Swedish RA patients treated with TNF antagonists. *Ann Rheum Dis* 2007;66:1339-44.
- Galloway JB, Hyrich KL, Mercer LK, *et al*. Anti-TNF therapy is associated with an increased risk of serious infections in patients with rheumatoid arthritis especially in the first 6 months of treatment: updated results from the British Society for rheumatology biologics register with special emphasis on risks in the elderly. *Rheumatology* 2011;50:124-31.
- Nyboe Andersen N, Pasternak B, Friis-Møller N, *et al*. Association between tumour necrosis factor- $\alpha$  inhibitors and risk of serious infections in people with inflammatory bowel disease: nationwide Danish cohort study. *BMJ* 2015;350:h2809.
- Shah ED, Farida JP, Siegel CA, *et al*. Risk for overall infection with anti-TNF and Anti-integrin agents used in IBD: a systematic review and meta-analysis. *Inflamm Bowel Dis* 2017;23:570-7.
- Pawar A, Desai RJ, Solomon DH, *et al*. Risk of serious infections in tocilizumab versus other biologic drugs in patients with rheumatoid arthritis: a multidatabase cohort study. *Ann Rheum Dis* 2019;78:456-64.
- Grøn KL, Glinthorpe B, Nørgaard M, *et al*. Overall infection risk in rheumatoid arthritis during treatment with abatacept, rituximab and tocilizumab; an observational cohort study. *Rheumatology* 2020;59:1949-56.
- A guideline on summary of product characteristics module 1.3 summary of product characteristics, 2008
- Medicines Agency E. Section 4.8 undesirable effects
- Bergk V, Haefeli WE, Gasse C, *et al*. Information deficits in the summary of product characteristics preclude an optimal management of drug interactions: a comparison with evidence from the literature. *Eur J Clin Pharmacol* 2005;61:327-35.
- Pfistermeister B, Saß A, Criegee-Rieck M, *et al*. Inconsistencies and misleading information in officially approved prescribing information from three major drug markets. *Clin Pharmacol Ther* 2014;96:616-24.
- Savill N, Bushe CJ. A systematic review of the safety information contained within the summaries of product characteristics of medications licensed in the United Kingdom for attention deficit hyperactivity disorder. how does the safety prescribing advice compare with national guidance? *Child Adolesc Psychiatry Ment Health* 2012;6:2.
- Weber JCP. *Epidemiology in the United Kingdom of adverse drug reactions from non-steroidal anti-inflammatory drugs, 1987*: 27-35. [https://link.springer.com/chapter/10.1007/978-94-010-9772-7\\_2](https://link.springer.com/chapter/10.1007/978-94-010-9772-7_2)
- Salliot C, Dougados M, Gossec L. Risk of serious infections during rituximab, abatacept and anakinra treatments for rheumatoid arthritis: meta-analyses of randomised placebo-controlled trials. *Ann Rheum Dis* 2009;68:25-32.
- Chen SK, Liao KP, Liu J, *et al*. Risk of hospitalized infection and initiation of abatacept versus tumor necrosis factor inhibitors among patients with rheumatoid arthritis: a propensity score-matched cohort study. *Arthritis Care Res* 2020;72:9-17.
- Tony H-P, Burmester G, Schulze-Koops H, *et al*. Safety and clinical outcomes of rituximab therapy in patients with different autoimmune diseases: experience from a national registry (GRAID). *Arthritis Res Ther* 2011;13:R75-14.
- Galloway JB, Hyrich KL, Mercer LK, *et al*. The risk of serious infections in patients receiving anakinra for rheumatoid arthritis: results from the British Society for rheumatology biologics register. *Rheumatology* 2011;50:1341-2.
- Galloway JB, Mercer LK, Moseley A, *et al*. Risk of skin and soft tissue infections (including shingles) in patients exposed to anti-tumour necrosis factor therapy: results from the British Society for rheumatology biologics register. *Ann Rheum Dis* 2013;72:229-34.