

Real-World Dispensing Patterns of Mycophenolic Acid and Calcineurin Inhibitors Across Selected Immune-Mediated Disorders: A Retrospective Pharmacy-Registry Drug-Utilization Study (Review Article)

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ABSTRACT

Background: Mycophenolic acid (MPA) products and calcineurin inhibitors (CNIs) are used across a range of immune-mediated disorders, yet routine dispensing registers often lack the clinical detail needed to evaluate treatment appropriateness, effectiveness, or safety. **Objective:** To characterize encounter-level and patient-level dispensing patterns of MPA products and CNIs after exclusion of all records labeled nephrotic syndrome or systemic lupus erythematosus, and to identify data-quality priorities for future pharmacoepidemiologic surveillance. **Methods:** This retrospective repeated-encounter drug-utilization study analyzed eight consecutive monthly pharmacy spreadsheets. Eligible records required a patient identifier, sex, age, and a source-recorded diagnostic label. Diagnostic labels were preserved as recorded and were not independently adjudicated. Monthly activity was summarized at the dispensing-encounter level, whereas regimen patterns were summarized at the patient level using each patient's latest record from a month with complete CNI ascertainment. Analyses were descriptive. **Results:** The restricted dataset contained 73 dispensing encounters from 17 unique patients across 14 source-recorded diagnostic categories. Women accounted for 48 encounters (65.8%); mean age was 40.4 years (SD 15.3), and median age was 42 years (IQR 32–52). Pulmonary fibrosis was the most frequent recorded label (13 encounters; 17.8%), followed by autoimmune myasthenia (8; 11.0%) and multiple sclerosis recorded as “M.S” (7; 9.6%). Sixteen patients had a latest record from a month with complete CNI ascertainment: 12 (75.0%) had MPA-only recording and four (25.0%) had CNI-only recording; no concurrent MPA-CNI recording was identified. **Conclusions:** These data only describe pharmacy activity and do not demonstrate treatment efficacy, safety or adherence to guidelines. Future research on the registry will focus on standardizing diagnostic coding, obtaining comprehensive exposure data and clinically relevant variables for monitoring and outcomes.

Keywords: Drug utilization; mycophenolate; calcineurin inhibitor; immune-mediated disease; pharmacy registry; real-world data.

Article Information

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1. INTRODUCTION

Two drugs are available in the United States that contain MPA, which inhibits inosine monophosphate dehydrogenase, which slows the growth of lymphocytes: mycophenolate mofetil and enteric-coated mycophenolate sodium. Tacrolimus and cyclosporine help to suppress the activation of T cells by blocking a

protein called calcineurin. These mechanisms allow for use in transplantation and in certain autoimmune and inflammatory diseases, but the associated toxicity, monitoring needs and level of evidence is highly variable by indication (Allison & Eugui, 2000; Halloran, 2004).

The retained registry labels include pulmonary fibrosis, autoimmune myasthenia, demyelinating disorders, bullous disease, complement-mediated glomerular disease, Behcet disease, bone-marrow failure, rheumatoid disease and a number of general labels. The clinical evidence for MPA or CNI therapy is therefore indication specific, and cannot be deduced from a dispensing label alone. While current recommendations for NMOSD, rheumatoid arthritis, multiple sclerosis and aplastic anemia focus on disease specific treatment pathways and specialist selection (Tashkin et al., 2016; Narayanaswami et al., 2021; Kümpfel et al., 2024; Fraenkel et al., 2021), MPA is recommended as an option in systemic-sclerosis interstitial lung disease, selected C3 glomerulopathy, myasthenia gravis and pemphigus. However, with explicit definitions of the unit of analysis and diagnostic uncertainty, and the limits of exposure, routine pharmacy data can also yield valuable insights into the level of service activity.

This study therefore aimed to describe the distribution of source-recorded diagnostic labels and MPA/CNI dispensing activity after complete exclusion of nephrotic syndrome and systemic lupus erythematosus. A second aim was to distinguish encounter-level pharmacy activity from patient-level regimen-recording patterns and to use the observed data limitations to define a minimum dataset for future, more interpretable pharmacoepidemiologic surveillance.

2. METHODS

2.1 Design and data source

This was a retrospective, repeated-encounter drug-utilization study based on eight consecutive monthly spreadsheets from a single pharmacy dispensing register at Al-Sader Hospital Teaching in Najaf, Iraq covering [1\2026] to [8\2026]. Reporting was guided by STROBE principles (von Elm et al., 2007), and

the study was framed within the World Health Organization concept of drug-utilization research as the study of the distribution and use of medicines in society (World Health Organization, 2003). The dispensing encounter was the unit for monthly service-activity analyses; the individual patient was the unit for regimen-pattern analyses.

3 -Statistical analysis

Descriptive statistical methods were used to analyze data. Categorical variables such as the sex, categories of disease recorded, and the treatment groups (MPA and CNI) were summarized as frequencies and percentages. The continuous variables, especially the age, were presented as mean and SD and median and IQR as needed. The monthly dispensing activity was reported through three criteria: number of encounters, unique patients and user of treatment classes. Patient-level treatment-pattern analysis was performed using the newest of the fully completed CNI records to reduce the impact of repeated encounters. A log-linear count model was used to forecast the expected number of dispensings in the remaining 3 months (months 9–12) and 95% prediction intervals were constructed to account for model and sampling uncertainty. All estimates of the projected numbers were used as exploratory data for service and inventory planning purposes and were not regarded as clinical data.

4- RESULTS

After all specified exclusions, 73 dispensing encounters from 17 unique patients remained across 14 source-recorded diagnostic categories. Unless otherwise stated, percentages in encounter-level summaries use dispensing encounters as the denominator. Forty-eight encounters (65.8%) involved female patients. Mean age across encounters was 40.4 years (SD 15.3), median age was 42 years (IQR 32–52), and the observed age range was 3–66 years.

Table 1. Monthly encounter-level descriptive profile after the exclusions.

Month	Dispensing encounters	Unique patients	Female encounters	Median age	Encounters with MPA	Encounters with CNI*	MPA+CN I encounters
1	10	10	6	38.5	7	3	0
2	6	6	4	38.5	5	1	0
3	6	6	4	49	4	1	0
4	10	10	7	38.5	8	2	0
5	9	9	6	49	7	2	0
6	10	10	7	41.5	8	2	0
7	13	13	8	48	11	2	0
8	9	9	6	48	7	2	0

4.1 Source-recorded diagnostic labels and monthly counts

Pulmonary fibrosis accounted for the largest share of retained dispensing encounters (17.8%), followed by autoimmune myasthenia and the source label “M.S.” These frequencies

describe pharmacy activity associated with recorded labels, not the prevalence of the underlying diseases. Ambiguous source terminology was preserved rather than clinically reclassified.

Table 2. Number of dispensing encounters by source-recorded diagnostic label and month.

Source-recorded diagnostic label	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	Total	%
Pulmonary fibrosis	2	1	1	2	2	2	2	1	13	17.8 %
Autoimmune myasthenia	1	1	1	1	1	1	1	1	8	11.1%
Multiple sclerosis (source label: M.S)	1	1	0	1	1	1	1	1	7	9.6%
Spinal cord disorder (source label)	1	1	1	1	1	0	0	1	6	8.2%
Bullous disease	1	0	1	1	1	1	1	0	6	8.2%
C3 glomerulonephritis	0	0	0	1	1	1	1	1	5	6.8%
Rheumatism (source label)	1	0	0	0	0	1	2	1	5	6.8%
Immune-mediated soft-tissue inflammation (source label)	1	1	0	1	0	0	1	0	4	5.5%
Behcet disease	1	0	0	1	0	1	0	1	4	5.5%
Devic disease / NMOSD (source label)	0	1	0	1	1	0	1	0	4	5.5%
Muscle weakness (source label)	1	0	1	0	1	0	1	0	4	5.5%
Bone-marrow failure	0	0	0	0	0	1	1	1	3	4.1%
Hematologic disease (source label)	0	0	0	0	0	1	1	1	3	4.1%
Rheumatoid arthritis	0	0	1	0	0	0	0	0	1	1.4%

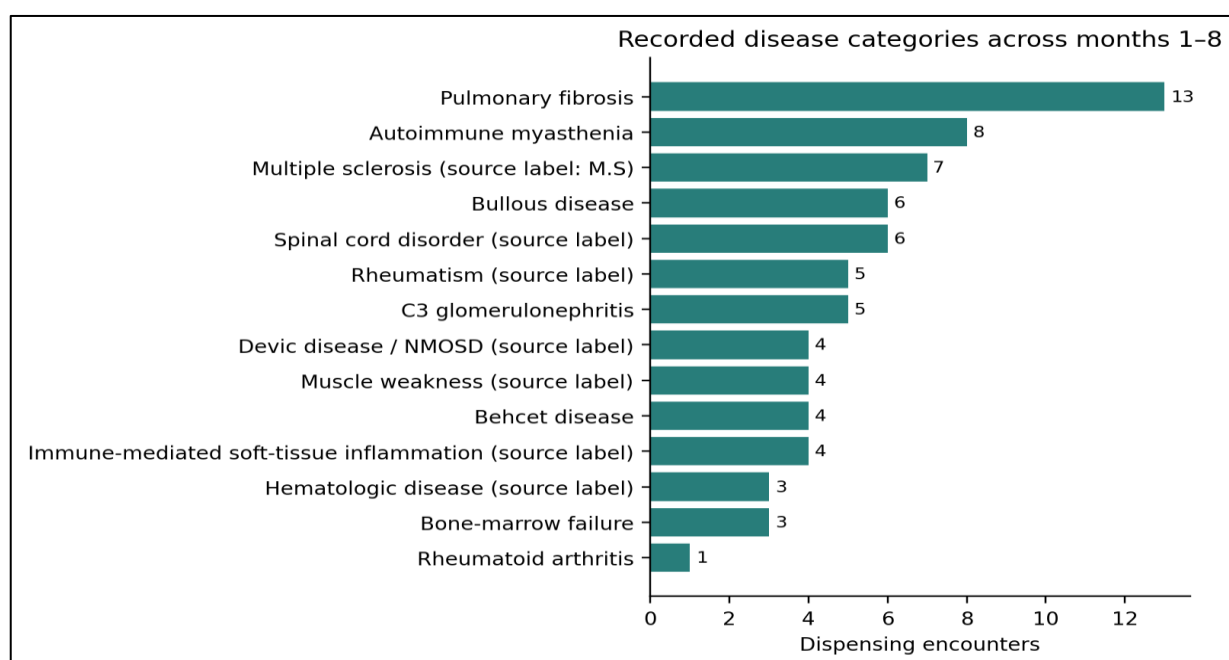


Figure 1. Distribution of source-recorded diagnostic labels across eligible dispensing encounters.

4.2 Patient-level regimen-recording patterns

Among the 16 patients with a latest observation from a month with complete CNI ascertainment, 12 (75.0%) had MPA-only recording and four (25.0%) had CNI-only recording; no patient had concurrent MPA and CNI recorded in the selected observation. These

16 patients comprised nine women and seven men, with a median age of 45 years. Because most diagnostic categories contributed only one patient, the table is descriptive and should not be interpreted as evidence of prescribing preference, comparative effectiveness, or guideline concordance.

Table 3. Latest complete patient-level regimen record by source-recorded diagnostic label

Source-recorded diagnostic label	MPA only	CNI only	MPA + CNI	Patients
Autoimmune myasthenia	1	0	0	1
Behcet disease	1	0	0	1
Bone-marrow failure	0	1	0	1
Bullous disease	1	0	0	1
C3 glomerulonephritis	1	0	0	1
Devic disease / NMOSD (source label)	1	0	0	1
Hematologic disease (source label)	1	0	0	1
Immune-mediated soft-tissue inflammation (source label)	1	0	0	1
Multiple sclerosis (source label: M.S)	1	0	0	1

MPA-only recording appeared across multiple source-recorded diagnostic labels, whereas CNI-only recording was identified in bone-marrow failure, spinal cord disorder, and subsets of pulmonary fibrosis and rheumatism. Given the very small numbers per category, these patterns should be read as a description of the registry rather than as disease-specific treatment estimates. The source data do not contain the clinical information needed to distinguish the effects of case mix, previous therapy, contraindications, medicine availability, clinician preference, or other specialist decisions.

5-DISCUSSION

5.2 Cornea and conjunctivitis disorders

The term pulmonary fibrosis is used in the source label and does not specify the cause of the condition, therefore, treatment appropriateness cannot be deduced from the register. Mycophenolate was also more tolerable than the oral cyclophosphamide and lung function was improved at 2 years compared with the control group with systemic-sclerosis-associated interstitial lung disease in Scleroderma Lung Study II (Tashkin et al., 2016). Later, the American Thoracic Society suggested the use of mycophenolate for systemic-sclerosis interstitial lung disease and highlighted phenotype-specific assessment (Raghu et al., 2024). The results obtained should not be extrapolated to idiopathic pulmonary fibrosis or to the label of registry, which has not been specified.

5.2 Autoimmune myasthenia

Evidence-based international consensus guidelines recommend mycophenolate, cyclosporine, and tacrolimus as nonsteroidal immunosuppressive treatments for MG, but they vary in their strength of recommendation and time to benefit (Sanders et al., 2016; Narayanaswami et al., 2021). There is historical randomized evidence for azathioprine when compared to some alternatives (Palace et al.,

1998). Given that this category is represented by only one patient in the patient-level analysis, the present registry cannot be used for comparing treatment strategies.

5.3 Bullous disease

For pemphigus vulgaris, international expert recommendations include corticosteroid-sparing immunosuppressants such as mycophenolate within individualized treatment pathways (Murrell et al., 2020). Rituximab produced higher sustained complete-remission rates than mycophenolate mofetil in a randomized trial, although adverse-event profiles and access remain clinically relevant (Werth et al., 2021). Because the source register records only “bullous disease,” the specific diagnosis and appropriateness of any individual regimen cannot be established.

5.4 C3 glomerulonephritis

C3 glomerulopathy is rare and heterogeneous. KDIGO guidance emphasizes clinical course, kidney biopsy, complement evaluation, and disease severity (KDIGO Glomerular Diseases Work Group, 2021). Retrospective cohorts suggest that mycophenolate with glucocorticoids may benefit selected patients, but response is variable and randomized evidence remains limited (Rabasco et al., 2015; Caravaca-Fontán et al., 2020). The registry therefore provides evidence of dispensing activity only, not confirmation that a disease-specific treatment pathway was followed.

5.5 Demyelinating disease: M.S and Devic disease/NMOSD

NMOSD is biologically and therapeutically distinct from multiple sclerosis; contemporary classification relies on clinical criteria together with AQP4-IgG and, where appropriate, MOG-IgG assessment (Wingerchuk et al., 2015). Current NEMOS recommendations emphasize relapse prevention with disease-specific biologic and immunosuppressive strategies, with older immunosuppressants remaining

context-dependent (Kümpfel et al., 2024). In multiple sclerosis, ECTRIMS/EAN guidance centers on approved disease-modifying therapies rather than routine MPA or CNI use (Montalban et al., 2018). Consequently, the registry terms “M.S” and “Device disease/NMOSD” require clinical validation before any judgment about treatment concordance.

5.6 Behcet disease, rheumatoid disease, and marrow failure

EULAR recommendations for Behcet syndrome tailor therapy to organ involvement rather than to a single universal immunosuppressive strategy (Hatemi et al., 2018). For rheumatoid arthritis, American College of Rheumatology guidance prioritizes conventional, biologic, and targeted synthetic disease-modifying antirheumatic drugs, with methotrexate commonly anchoring treatment (Fraenkel et al., 2021). In severe aplastic anemia, antithymocyte globulin plus cyclosporine remains an established immunosuppressive backbone, and addition of eltrombopag has improved hematologic outcomes in major studies (Townsend et al., 2017; Peffault de Latour et al., 2022). A generic source label such as “bone-marrow failure,” however, is insufficient to assign this evidence to an individual record.

5.7 Overall interpretation and study contribution

The principal contribution of this analysis is descriptive rather than comparative. At the encounter level, the register shows which source-recorded diagnostic labels generated pharmacy activity over eight months; at the patient level, it shows the latest recorded MPA/CNI regimen among patients with complete CNI ascertainment. Keeping these two units of analysis separate avoids treating repeated monthly attendance as independent

patients. The predominance of MPA recording may reflect case mix, medicine availability, specialist practice, or documentation patterns, but the register cannot determine which explanation is responsible because it lacks prescribed dose, treatment start date, co-therapy, laboratory monitoring, disease severity, adherence, adverse events, and clinical outcomes.

The patient-level summary reduces, but does not eliminate, bias from repeated attendance. One patient appeared only in month 3 and therefore lacked a latest observation with complete CNI ascertainment. Sparse disease-specific cells preclude reliable inferential comparisons. Accordingly, the most defensible use of these data is as a baseline for improving data quality and for planning future registry-based drug-utilization studies with clinically interpretable exposure and outcome measures.

5.8 Implications for registry design and future research

Future data collection should use standardized diagnostic coding (for example, ICD-10 or SNOMED CT) together with indication confirmation, drug strength and formulation, prescribed daily dose, quantity dispensed, days supplied, treatment start and stop dates, concomitant immunosuppression, relevant laboratory and physiological monitoring, therapeutic drug monitoring for CNIs, disease-specific response measures, adverse events, and a stable patient identifier. These elements would allow future work to move beyond simple dispensing counts toward interpretable exposure, persistence, safety, and outcome analyses. Data governance should include access control, data minimization, and documented ethics or service-evaluation oversight.

Table 4. Recommended minimum dataset for future immunosuppressant drug-utilization surveillance.

Domain	Minimum variable	Purpose
Patient	Stable anonymized patient identifier; age; sex	Separate repeated encounters and describe case mix
Indication	Validated diagnosis; ICD-10 or SNOMED CT code; organ involvement where relevant	Improve indication specificity and clinical interpretability
Medicine	Generic name; formulation; strength; quantity dispensed	Characterize the dispensed product accurately
Exposure	Prescribed dose; frequency; days supplied; start/stop dates	Estimate treatment intensity, duration, and persistence
Co-therapy	Concomitant immunosuppressants and corticosteroids	Interpret regimen complexity and treatment pathways
Monitoring	CBC; renal/hepatic function; blood pressure; CNI trough level where applicable	Assess monitoring completeness and safety context
Outcomes	Disease-specific response measures; adverse events; discontinuation reason	Support future effectiveness and safety analyses
Governance	Ethics/service-evaluation status; access controls; data-minimization procedures	Support reproducible and responsible registry use

6 .CONCLUSION

After complete exclusion of nephrotic syndrome and systemic lupus erythematosus, the registry contained 73 dispensing encounters from 17 unique patients across 14 source-recorded diagnostic categories. Pulmonary fibrosis generated the largest number of encounters, and MPA-only recording predominated in the latest complete patient-level observations.

The findings establish a transparent descriptive baseline for pharmacy-registry improvement, not evidence of treatment effectiveness, safety, or guideline concordance. Standardized diagnostic coding, complete medication-exposure data, and clinically relevant monitoring and outcome variables are essential before future registry studies can

support stronger pharmacoepidemiologic inference

7- RECOMMENDATION

- 1 .Identify and study cases over longer periods, such as two years or more.
- 2 .Expanding the database by establishing a central national registry that examines the pathological and demographic diversity of all cases .

REFERENCES

- Allison, A. C., & Eugui, E. M. (2000). Mycophenolate mofetil and its mechanisms of action. *Immunopharmacology*, 47(2–3), 85–118. [https://doi.org/10.1016/S0162-3109\(00\)00188-0](https://doi.org/10.1016/S0162-3109(00)00188-0)
- Caravaca-Fontán, F., Díaz-Encarnación, M. M., Cabello, V., Ariceta, G., Quintana, L. F., López-Mendoza, M., et al. (2020). Mycophenolate mofetil in C3 glomerulopathy and pathogenic drivers of the disease. *Clinical Journal of the American Society of Nephrology*, 15(9), 1287–1298. <https://doi.org/10.2215/CJN.15241219>
- Fraenkel, L., Bathon, J. M., England, B. R., St Clair, E. W., Arayssi, T., Carandang, K., et al. (2021). 2021 American College of Rheumatology guideline for the treatment of rheumatoid arthritis. *Arthritis & Rheumatology*, 73(7), 1108–1123. <https://doi.org/10.1002/art.41752>
- Halloran, P. F. (2004). Immunosuppressive drugs for kidney transplantation. *New England Journal of Medicine*, 351(26), 2715–2729. <https://doi.org/10.1056/NEJMra033540>
- Hatemi, G., Christensen, R., Bang, D., Bodaghi, B., Celik, A. F., Fortune, F., et al. (2018). 2018 update of the EULAR recommendations for the management of Behçet’s syndrome. *Annals of the Rheumatic Diseases*, 77(6), 808–818. <https://doi.org/10.1136/annrheumdis-2018-213225>
- KDIGO Glomerular Diseases Work Group. (2021). KDIGO 2021 clinical practice guideline for the management of glomerular diseases. *Kidney International*, 100(4S), S1–S276. <https://doi.org/10.1016/j.kint.2021.05.021>
- Kümpfel, T., Giglhuber, K., Aktas, O., Ayzenberg, I., Bellmann-Strobl, J., Häußler, V., et al. (2024). Update on the diagnosis and treatment of neuromyelitis optica spectrum disorders: Revised recommendations of the Neuromyelitis Optica Study Group (NEMOS). Part II. *Journal of Neurology*, 271, 141–176. <https://doi.org/10.1007/s00415-023-11910-z>
- Montalban, X., Gold, R., Thompson, A. J., Otero-Romero, S., Amato, M. P., Chandraratna, D., et al. (2018).ECTRIMS/EAN guideline on the pharmacological treatment of people with

- multiple sclerosis. *European Journal of Neurology*, 25(2), 215–237.
<https://doi.org/10.1111/ene.13536>
- Murrell, D. F., Peña, S., Joly, P., Marinovic, B., Hashimoto, T., Diaz, L. A., et al. (2020). Diagnosis and management of pemphigus: Recommendations of an international panel of experts. *Journal of the American Academy of Dermatology*, 82(3), 575–585.e1.
<https://doi.org/10.1016/j.jaad.2018.02.021>
 - Narayanaswami, P., Sanders, D. B., Wolfe, G., Benatar, M., Ciafaloni, E., Evoli, A., et al. (2021). International consensus guidance for management of myasthenia gravis: 2020 update. *Neurology*, 96(3), 114–122.
<https://doi.org/10.1212/WNL.00000000000011124>
 - Palace, J., Newsom-Davis, J., & Lecky, B. (1998). A randomized double-blind trial of prednisolone alone or with azathioprine in myasthenia gravis. *Neurology*, 50(6), 1778–1783.
<https://doi.org/10.1212/WNL.50.6.1778>
 - Peffault de Latour, R., Kulasekararaj, A., Iacobelli, S., Terwel, S. R., Cook, R., Griffin, M., et al. (2022). Eltrombopag added to immunosuppression in severe aplastic anemia. *New England Journal of Medicine*, 386(1), 11–23.
<https://doi.org/10.1056/NEJMoa2109965>
 - Rabasco, C., Caverio, T., Román, E., Rojas-Rivera, J., Olea, T., Espinosa, M., et al. (2015). Effectiveness of mycophenolate mofetil in C3 glomerulonephritis. *Kidney International*, 88(5), 1153–1160.
<https://doi.org/10.1038/ki.2015.227>
 - Raghu, G., Montesi, S. B., Silver, R. M., Hummers, L. K., Strek, M. E., Sylvester, K. W., et al. (2024). Treatment of systemic sclerosis–associated interstitial lung disease: Evidence-based recommendations. *American Journal of Respiratory and Critical Care Medicine*, 209(2), e21–e41.
<https://doi.org/10.1164/rccm.202306-1113ST>
 - Sanders, D. B., Wolfe, G. I., Benatar, M., Evoli, A., Gilhus, N. E., Illa, I., et al. (2016). International consensus guidance for management of myasthenia gravis. *Neurology*, 87(4), 419–425.
<https://doi.org/10.1212/WNL.00000000000002790>
 - Tashkin, D. P., Roth, M. D., Clements, P. J., Furst, D. E., Khanna, D., Kleerup, E.

- C., et al. (2016). Mycophenolate mofetil versus oral cyclophosphamide in scleroderma-related interstitial lung disease. *The Lancet Respiratory Medicine*, 4(9), 708–719. [https://doi.org/10.1016/S2213-2600\(16\)30152-7](https://doi.org/10.1016/S2213-2600(16)30152-7)
- Townsley, D. M., Scheinberg, P., Winkler, T., Desmond, R., Dumitriu, B., Rios, O., et al. (2017). Eltrombopag added to standard immunosuppression for aplastic anemia. *New England Journal of Medicine*, 376(16), 1540–1550. <https://doi.org/10.1056/NEJMoa1613878>
- von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., & Vandenbroucke, J. P. (2007). The STROBE statement. *PLOS Medicine*, 4(10), e296. <https://doi.org/10.1371/journal.pmed.0040296>
- Wingerchuk, D. M., Banwell, B., Bennett, J. L., Cabre, P., Carroll, W., Chitnis, T., et al. (2015). International consensus diagnostic criteria for neuromyelitis optica spectrum disorders. *Neurology*, 85(2), 177–189. <https://doi.org/10.1212/WNL.0000000000001729>
- Werth, V. P., Joly, P., Mimouni, D., Maverakis, E., Caux, F., Lehane, P., et al. (2021). Rituximab versus mycophenolate mofetil in patients with pemphigus vulgaris. *New England Journal of Medicine*, 384(24), 2295–2305. <https://doi.org/10.1056/NEJMoa2028564>
- World Health Organization. (2003). Introduction to drug utilization research. WHO International Working Group for Drug Statistics Methodology.