Observational Study

Medicine

OPEN

Burden of glucocorticoid use in commercially insured adults with generalized myasthenia gravis in the United States

A retrospective claims-based analysis

Nicholas J. Silvestri, MD, FAAN[a], Jenny Y. Park, PharmD, MS[b,*], Elizabeth Serra, MScPH[c], Patrick Gagnon-Sanschagrin, MS[c], Annie Guérin, MS[c], Blanca Canales, PharmD[b], Kristina R. Patterson, MD, PhD[b], Andrea Meyers, PhD[b], Tuan Vu, MD[d]

Abstract

Generalized myasthenia gravis (gMG) is a chronic autoimmune condition characterized by muscle weakness. If frontline treatments inadequately manage symptoms, patients may require use of glucocorticoids (GC); however, long-term use of GCs is associated with toxicities. Few studies have examined the incidence of GC-related toxicities and economic burden among patients with gMG. This study aims to describe GC toxicities, healthcare resource utilization, and costs among US adults with gMG, stratified by level of GC use. Adults with gMG were identified using IQVIA PharMetrics® Plus data and classified into 2 mutually exclusive cohorts based on GC use during the most recent 12 months of health plan enrollment (study period): "no GC use" (no GC fills) or "any GC use" (≥1 GC fill). The "any GC use" cohort was stratified into "≥5 mg/d" (mean prednisone equivalent daily dose ≥5 mg) and "≥10 mg/d" (mean prednisone equivalent daily dose ≥10 mg) subgroups. GC use, incident GC toxicities, and all-cause healthcare resource utilization and costs were described during the study period for each cohort and subgroup. Among 8833 patients with gMG, 5076 (57.5%) had no GC use and 3757 (42.5%) had any GC use (≥5 mg/d: 1537 [40.9%]; ≥10 mg/d: 860 [22.9%]). Use of nonsteroidal immunosuppressants was higher among patients with GC use than those without (37.6% any GC use vs 19.6% no GC use). Incident GC toxicities were higher in patients with any GC use than those without (61.9% vs 52.3%). Common acute toxicities included nausea and vomiting, pneumonia, fungal infections, sepsis, and urinary tract infection; chronic toxicities were dyslipidemia, sleep disturbances, obesity, cardiac arrhythmias, and hypertension. Annual all-cause costs were >2x higher among patients with any GC use than those with no GC use ($76,381 vs $35,309). GC acute and chronic toxicities and costs tended to increase with increasing GC use. Since claims data do not contain reasons for diagnoses, toxicities could not be confirmed to be related to GC use. Additionally, results may be confounded by disease severity or concomitant medications. Effective GC-sparing treatments are needed to mitigate the clinical and economic burden of GC use in adults with gMG.

Abbreviations: AANEM = American Association of Neuromuscular and Electrodiagnostic Medicine, CCI = Charlson Comorbidity Index, ER = emergency room, GC = glucocorticoid, gMG = generalized myasthenia gravis, HIPAA = Health Insurance Portability and Accountability Act, HRU = healthcare resource utilization, ICD-10-CM = International Classification of Diseases, Tenth Revision, Clinical Modification, IP = inpatient, MG = myasthenia gravis, OP = outpatient, PEDD = prednisone equivalent daily dose, PLEX = plasma exchange, SAS = statistical analysis system, SD = standard deviation, SLE = systemic lupus erythematosus, US = United States, USD = United States dollar.

Keywords: burden, generalized myasthenia gravis, glucocorticoid, healthcare costs, healthcare resource utilization, toxicity

This study was funded by Amgen Inc. The study sponsor was involved in several aspects of the research, including the study design, interpretation of data, and writing of the manuscript.

NJS has received consulting fees from Amgen Inc, argenx SE, Alexion Pharmaceuticals, Inc., EMD Serono Inc., Immunovant, Inc., Johnson & Johnson, and UCB. JYP, BC, KRP, and AM are employees and stockholders of Amgen Inc. ES, PGS, and AG are employees of Analysis Group ULC, a consulting company that has provided paid consulting services to Amgen Inc, which funded the development and conduct of this study and manuscript. TV is the USF Site Principal Investigator for MG clinical trials sponsored by Alexion/AstraZeneca Rare Disease, Amgen, argenx, Cartesian Therapeutics, COUR, Dianthus Therapeutics, EMD Serono, Immunovant, Johnson & Johnson, NMD Pharma, Regeneron, and UCB. TV has also served as a speaker for Alexion/AstraZeneca Rare Disease, argenx, Johnson & Johnson, and CSL Behring and has served on advisory boards and/or performed consulting work for Alexion/AstraZeneca Rare Disease, argenx, Amgen, Dianthus Therapeutics, Johnson & Johnson, ImmunAbs, and NMD Pharma.

The data that support the findings of this study are available from a third party, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are available from the authors upon reasonable request and with permission of the third party.

The study was considered exempt research under 45 CFR § 46.104(d)(4) as it involved only the secondary use of data that were de-identified in compliance with the Health Insurance Portability and Accountability Act (HIPAA), specifically, 45 CFR § 164.514.

Part of the material in this manuscript was presented at the American Association of Neuromuscular & Electrodiagnostic Medicine (AANEM) Annual Meeting held October 15 to 18, 2024 in Savannah, GA, US as a poster presentation.

Supplemental Digital Content is available for this article.

[a] Department of Neurology, University at Buffalo Jacobs School of Medicine and Biomedical Sciences, University at Buffalo, Buffalo, NY, [b] Amgen Inc, Thousand Oaks, CA, [c] Analysis Group ULC, Montréal, Québec, Canada, [d] Department of Neurology, University of South Florida, Tampa, FL.

1. Introduction

Myasthenia gravis (MG) is a chronic autoimmune condition characterized by fatigable weakness of skeletal muscles due to impaired signal transmission at the neuromuscular junction.[1,2] In 2021, approximately 82,715 adults were living with MG in the United States (US), resulting in an estimated prevalence of 320 cases per million people.[3] The primary manifestation of MG is fluctuating and fatigable muscle weakness affecting ocular, bulbar, limb, and respiratory muscles.[4] Approximately 15% of patients experience only ocular symptoms (ocular MG), while the remaining 85% have generalized weakness (generalized MG or gMG).[4]

Management of gMG aims to achieve complete remission or at least "minimal manifestation status," wherein the patient has no symptoms or functional limitations from gMG but may still experience some muscle weakness, with minimal or no side effects of treatment.[5,6] Treatment guidelines recommend initial treatment with an acetylcholinesterase inhibitor, such as pyridostigmine.[6] If symptoms are not well-controlled with acetylcholinesterase inhibitors, immunosuppressive therapy is often required, with systemic glucocorticoids (GCs) typically serving as the first-line immunosuppressant.[5,6] Long-term use of GCs is often required for symptom control. However, long-term use of GCs is associated with potentially serious toxicities, including weight gain, cataracts, hypertension, diabetes, osteoporosis, infections, and neuropsychiatric symptoms,[1,5] which may substantially impact patients' overall health and quality of life.[7] To minimize the risk of toxicities, patients are advised to gradually taper GCs to the lowest possible maintenance dose upon achieving treatment goals. Nevertheless, more than half of patients do not achieve a satisfactory response after 2 years of low-dose prednisone monotherapy.[8] As a result, there is a growing need for alternative treatments that can provide effective disease control with fewer adverse effects. Nonsteroidal immunosuppressants are recommended for patients who have experienced GC toxicities or an inadequate response to GCs alone, but these agents may have additional side effects or delayed onset of action.[5,6] In cases of severe, treatment-refractory gMG, immunoglobulins or biologic agents may be considered, offering potential benefits in efficacy or tolerability.[6,9]

In addition to clinical burden, patients with gMG experience considerable economic impact.[8,10] A recent real-world analysis found that total monthly healthcare costs among patients with gMG were nearly 4-times higher than those of matched individuals without MG, primarily driven by hospitalization costs.[10] Additionally, long-term immunosuppression with GCs is associated with safety issues that may further impact clinical and socioeconomic outcomes.[8] Given that GCs remain a mainstay of immunosuppressive treatment in gMG management,[1,5] there is a need for an assessment of their true clinical burden and economic costs in real-world clinical practice. This study was conducted to describe incident GC toxicities, healthcare resource utilization (HRU), and healthcare costs among adults with gMG in the US, stratified by level of GC use.

2. Methods

2.1. Data source

The IQVIA PharMetrics® Plus data from October 1, 2015 to December 31, 2022 were used for this study. The database is representative of the commercially insured US national population under 65 years of age. It includes fully adjudicated, integrated medical and pharmacy claims data for over 215 million enrollees, including a longitudinal view of inpatient (IP) and outpatient (OP) services, prescription and office/OP-administered drugs, costs, and detailed enrollment information. All GC treatments submitted for reimbursement purposes are captured.

The study was considered exempt research under 45 CFR § 46.104(d)(4) as it involved only the secondary use of data that were de-identified in compliance with the Health Insurance Portability and Accountability Act (HIPAA), specifically, 45 CFR § 164.514.

2.2. Study design and sample selection

A retrospective cohort design was used for this study. The index date was defined as the most recent calendar date on or after the first gMG diagnosis, followed by 12 months of continuous health plan enrollment. The baseline and study periods were defined as the 12 months before and after the index date, respectively. As gMG is a chronic and fluctuating condition,[1] this approach was used to capture a representative snapshot of patients with gMG at different points in their disease and treatment journeys, and accordingly, generate representative estimates of the clinical and economic burden of the prevalent gMG population.

To assess GC use among patients with gMG, prescription fills of relevant systemic (i.e., oral, intravenous, and injection) GCs (prednisone, prednisolone, methylprednisolone, and dexamethasone) were identified during the study period and converted to their prednisone equivalent daily dose (PEDD). PEDD was calculated as cumulative prednisone equivalent dose divided by the length of the study period (i.e., 365 days) for each patient.[11–13]

Patients were included in the study if they met the following eligibility criteria, based on those used by Phillips et al:[14] had ≥2 diagnoses for MG (International Classification of Diseases, Tenth Revision, Clinical Modification [ICD-10-CM] G70.0x, G70.2) ≥30 days apart; had ≥1 MG diagnosis by a provider other than an ophthalmologist/optometrist; had ≥24 months of continuous commercial health plan enrollment, with ≥12 months after their first observed MG diagnosis; and were ≥18 years of age as of the index date.

Patients included in the study were classified into the following 2 mutually exclusive cohorts based on GC use during the study period: "no GC use" cohort, comprising patients with no GC fills; and "any GC use" cohort, comprising patients with ≥1 GC fill. The any GC use cohort was further stratified into the "≥5 mg/d" subgroup (mean PEDD ≥5 mg during the study period) and the "≥10 mg/d" subgroup (mean PEDD ≥10 mg during the study period).

2.3. Study measures and statistical analyses

Patient demographic characteristics were evaluated as of the index date and included age, sex, region of residence, primary health plan type, and index year. Patient clinical characteristics were assessed during the study period and included Charlson Comorbidity Index and gMG-related treatments. All

* Correspondence: Jenny Y. Park, Amgen Inc, 1 Amgen Center Drive, Thousand Oaks 91320, CA (e-mail: ypark07@amgen.com).

How to cite this article: Silvestri NJ, Park JY, Serra E, Gagnon-Sanschagrin P, Guérin A, Canales B, Patterson KR, Meyers A, Vu T. Burden of glucocorticoid use in commercially insured adults with generalized myasthenia gravis in the United States: A retrospective claims-based analysis. Medicine 2026;105:12(e47979).

Received: 5 November 2025 / Received in final form: 5 February 2026 / Accepted: 18 February 2026

http://dx.doi.org/10.1097/MD.0000000000047979

characteristics were measured separately for the no GC use and any GC use cohorts, including the ≥5 mg/d and ≥10 mg/d subgroups.

Patients were considered to have an incident GC toxicity if they had ≥1 claim with a diagnosis for the toxicity during the study period and no such claim during the baseline period. Incident GC toxicities were described for the any GC use cohort and the ≥5 mg/d and ≥10 mg/d subgroups, separately. Toxicities were reported individually and grouped as acute versus chronic. The list of relevant toxicities was informed by prior literature (see Table S1, Supplemental Digital Content, https://links.lww.com/MD/R550 for the complete list of toxicities and associated definitions).[15,16]

Annual all-cause HRU and healthcare costs during the study period were described separately for the no GC use and any GC use cohorts, as well as the ≥5 mg/d and ≥10 mg/d subgroups. HRU components included OP, emergency room (ER), and IP visits. Total healthcare costs were reported in 2022 US dollars (USD) and included medical (OP, ER, IP) and pharmacy costs from the payers' perspective.

Means, medians, and standard deviations were reported for continuous variables, while frequencies and percentages were reported for categorical variables. Incident GC toxicity frequencies in the any GC use cohort and subgroups were compared to those of the no GC use cohort using unadjusted Chi-square tests. For all other measures, no statistical comparisons were conducted; differences reported in this study are numerical. Analyses were conducted using statistical analysis system Enterprise Guide, Version 7.1 (Statistical Analysis System, Cary).

3. Results

3.1. Patient demographic characteristics

A total of 8833 patients were included in the study, including 5076 (57.5%) with no GC use and 3757 (42.5%) with any GC use during the study period (Fig. 1). Among patients in the any GC use cohort, 1537 (40.9%) had a mean PEDD ≥5 mg and 860 (22.9%) had a mean PEDD ≥10 mg. Patient demographic characteristics were generally consistent across the cohorts and subgroups. Mean age was similar with patients aged 52.8 years in the no GC use cohort and 53.5 years in the any GC use cohort (≥5 mg/d: 53.7 years; ≥10 mg/d: 53.2 years). However, there was a trend of decreasing proportion of female patients with increasing GC use (Table 1).

3.2. GC use and patient clinical characteristics

Over the 12-month study period, the mean PEDD was 6.6 mg among patients in the any GC use cohort, 13.8 mg among patients in the ≥5 mg/d subgroup, and 19.2 mg among patients in the ≥10 mg/d subgroup.

Patients in the any GC use cohort had a higher mean Charlson Comorbidity Index score than those in the no GC use cohort (1.1 vs 0.7, respectively), which increased incrementally with mean PEDD ≥5 mg (1.2) and mean PEDD ≥10 mg (1.3; Table 2).

The use of nonsteroidal immunosuppressants, immunoglobulins, and biologics increased with increasing levels of GC use. Mycophenolate mofetil and azathioprine were the most commonly prescribed among these treatments. Mycophenolate mofetil was used by 9.6% of patients in the no GC use cohort, 20.3% in the any GC use cohort, 28.2% in the ≥5 mg/d subgroup, and 31.4% in the ≥10 mg/d subgroup. Similarly, azathioprine use increased from 8.4% in the no GC use cohort to 14.3% in the any GC use cohort, 20.2% in the ≥5 mg/d subgroup, and 20.9% in the ≥10 mg/d subgroup.

3.3. Incident GC toxicities

During the study period, incident GC toxicities were more common among patients in the any GC use cohort than the no GC use cohort (61.9% vs 52.3% with ≥1 toxicity), with a trend of increasing incidence with increasing GC use (≥5 mg/d: 62.9%; ≥10 mg/d: 67.3%; all $P < .001$; Fig. 2A; Table S1, Supplemental Digital Content, https://links.lww.com/MD/R550). Additionally, a greater proportion of patients with any GC use than no GC use had ≥3 incident GC toxicities (16.5% vs 9.5%), with this proportion rising with mean PEDD ≥5 mg (18.9%) and mean PEDD ≥10 mg (22.8%; all $P < .001$).

Both acute and chronic incident GC toxicities were more common in the any GC use cohort than the no GC use cohort (acute: 28.5% vs 19.1%; chronic: 51.9% vs 43.8%; both $P < .001$), with rates increasing with higher GC use (Fig. 2A; Table S1, Supplemental Digital Content, https://links.lww.com/MD/R550). The most common acute toxicities in the ≥10 mg/d subgroup were nausea and vomiting (no GC use: 5.3%; any GC use: 7.5%;

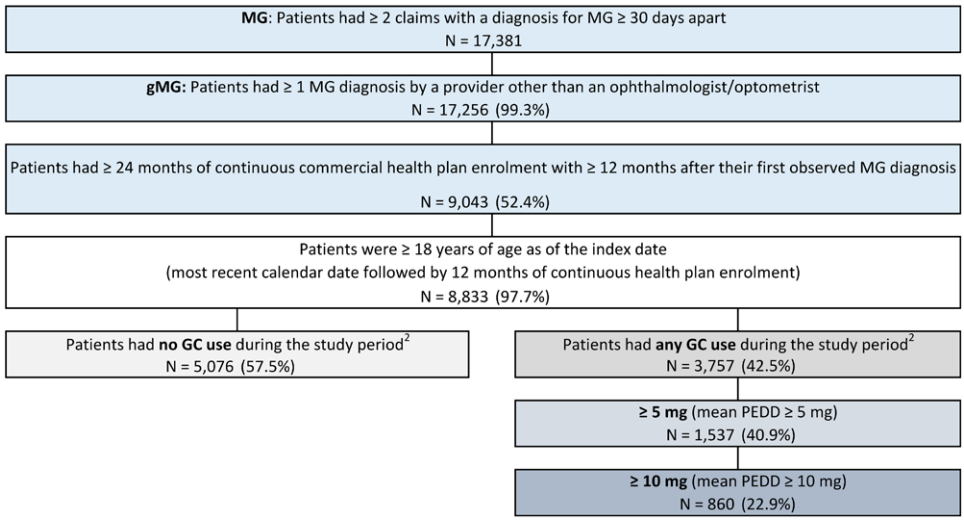

Figure 1. Sample selection.[1] 1. Sample selection criteria were based on Phillips et al, 2022.[14] 2. GCs were identified from pharmacy claims during the study period and included prednisone, prednisolone, methylprednisolone, and dexamethasone. GC = glucocorticoid, gMG = generalized myasthenia gravis, MG = myasthenia gravis, PEDD = prednisone equivalent daily dose.

Table 1

Patient demographic characteristics.

Demographic characteristics*	No GC use, N = 5076	Any GC use, N = 3757	≥5 mg/d subgroup†, N = 1537	≥10 mg/d subgroup‡, N = 860
Age, mean ± SD (median)	52.8 ± 13.2 (56.0)	53.5 ± 12.2 (56.0)	53.7 ± 12.4 (57.0)	53.2 ± 12.4 (56.0)
Female, N (%)	2938 (57.9%)	2022 (53.8%)	680 (44.2%)	361 (42.0%)
Region of residence, N (%)				
South	2413 (47.5%)	1891 (50.3%)	719 (46.8%)	414 (48.1%)
Midwest	1058 (20.8%)	827 (22.0%)	368 (23.9%)	202 (23.5%)
Northeast	901 (17.8%)	611 (16.3%)	251 (16.3%)	137 (15.9%)
West	698 (13.8%)	421 (11.2%)	196 (12.8%)	106 (12.3%)
Unknown	6 (0.1%)	7 (0.2%)	3 (0.2%)	1 (0.1%)
Primary health plan type, N (%)				
Preferred Provider Organization	3880 (76.4%)	2899 (77.2%)	1178 (76.6%)	653 (75.9%)
Health Maintenance Organization	697 (13.7%)	513 (13.7%)	221 (14.4%)	131 (15.2%)
Point of service	341 (6.7%)	232 (6.2%)	97 (6.3%)	55 (6.4%)
Consumer Directed Health Care	112 (2.2%)	88 (2.3%)	29 (1.9%)	14 (1.6%)
Indemnity/traditional	44 (0.9%)	25 (0.7%)	12 (0.8%)	7 (0.8%)
Other/unknown	2 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Index year, N (%)				
2016	234 (4.6%)	179 (4.8%)	89 (5.8%)	51 (5.9%)
2017	453 (8.9%)	340 (9.0%)	168 (10.9%)	104 (12.1%)
2018	491 (9.7%)	380 (10.1%)	154 (10.0%)	83 (9.7%)
2019	427 (8.4%)	328 (8.7%)	152 (9.9%)	77 (9.0%)
2020	815 (16.1%)	547 (14.6%)	248 (16.1%)	139 (16.2%)
2021	2656 (52.3%)	1983 (52.8%)	726 (47.2%)	406 (47.2%)

GC = glucocorticoid, PEDD = prednisone equivalent daily dose, SD = standard deviation.

*Patient characteristics were assessed as of the index date.

†Defined as mean PEDD ≥5 mg.

‡Defined as mean PEDD ≥10 mg.

≥5 mg/d: 7.8%; ≥10 mg/d: 9.9%), pneumonia (no GC use: 2.0%; any GC use: 5.2%; ≥5 mg/d: 6.7%; ≥10 mg/d: 8.8%), and fungal infections (no GC use: 3.8%; any GC use: 6.2%; ≥5 mg/d: 6.4%; ≥10 mg/d: 8.7%; all $P < .001$; Fig. 2B; Table S1, Supplemental Digital Content, https://links.lww.com/MD/R550). The most common chronic toxicities in the ≥10 mg/d subgroup were dyslipidemia (no GC use: 8.9%; any GC use: 10.9%; ≥5 mg/d: 12.0%; ≥10 mg/d: 12.8%), sleep disturbances (no GC use: 6.8%; any GC use: 9.5%; ≥5 mg/d: 10.6%; ≥10 mg/d: 11.7%), and obesity (no GC use: 7.6%; any GC use: 10.3%; ≥5 mg/d: 10.6%; ≥10 mg/d: 11.2%; all $P < .01$; Fig. 2C; Table S1, Supplemental Digital Content, https://links.lww.com/MD/R550).

3.4. Healthcare resource utilization

During the study period, patients with any GC use had higher HRU than those with no GC use, including a higher mean number of OP visits (32.1 vs 21.0) and higher rates of ER visits (43.7% vs 29.6% with ≥1 ER visit) and IP admissions (18.2% vs 8.9% with ≥1 IP admission; Fig. 3). A trend of increasing HRU with increasing GC use was observed for mean number of OP visits (≥5 mg/d: 35.6; ≥10 mg/d: 38.9) and rate of IP admissions (≥5 mg/d: 24.5%; ≥10 mg/d: 30.8%).

3.5. Healthcare costs

Patients with any GC use incurred approximately double the annual all-cause healthcare costs relative to those with no GC use ($76,381 vs $35,309), which was driven by higher OP ($46,865 vs $21,078), IP ($14,300 vs $5772), and pharmacy costs ($13,442 vs $7454; Fig. 4). A trend of increasing costs with increasing GC use was observed overall (≥5 mg/d: $108,762; ≥10 mg/d: $129,170) and across all cost categories.

4. Discussion

In this retrospective, claims-based study, nearly half of prevalent patients with gMG received treatment with GCs during a 1-year follow-up period. Among these patients, more than 40% were in the ≥10 mg/d subgroup, with a mean PEDD of 19.2 mg. Current MG clinical guidelines suggest initiation of nonsteroidal immunosuppressants as a steroid-sparing option; however, this study found that increased use of nonsteroidal immunosuppressants was correlated with higher levels of GC use. Concordant with expectations, patients with higher GC use had significantly more incident GC toxicities, with rates increasing alongside increasing GC use. Additionally, HRU and healthcare costs were also higher among patients who used GCs relative to those who did not, with the highest HRU and costs observed in patients with a mean PEDD ≥5 mg or ≥10 mg.

While the risk of toxicities associated with GC use is well-recognized in patients with gMG,[1,5] there is scarce prior literature describing the level of GC use and risk of relevant toxicities in patients with gMG. Johnson et al conducted a retrospective, single-center study of patients with gMG treated with systemic GCs for ≥1 year and found that weight gain was among the most commonly reported toxicities,[17] which is consistent with the observation of incident obesity in the present study. Additionally, Johnson et al reported that GC toxicities were generally more frequent in patients receiving >30 mg of GCs per day than those receiving ≤30 mg per day, as determined by the last dose recorded in patients' medical charts.[17] While the dosage measurements and thresholds used were different, these findings nonetheless corroborate findings in the current study describing the increased incidence of GC toxicities in patients with higher GC use. The most common acute toxicities found in this study included nausea and vomiting, pneumonia, fungal infections, sepsis, and urinary tract infection while chronic toxicities were dyslipidemia, sleep disturbances, obesity, cardiac arrhythmias, and hypertension.

Similar to GC toxicities, the empirical association between varying levels of GC use and HRU and healthcare costs in patients with gMG are not well-characterized in the literature. In a claims-based analysis of patients with gMG or ocular MG receiving second-line therapy, multivariable analysis showed that a GC dose of ≥40 mg/d was associated with significantly higher healthcare costs compared to < 40 mg/d.[18]

Table 2

Patient clinical characteristics.

Clinical characteristics*	No GC use, N = 5076	Any GC use, N = 3757	≥5 mg/d subgroup†, N = 1537	≥10 mg/d subgroup‡, N = 860
CCI, mean ± SD (median)	0.7 ± 1.4 (0.0)	1.1 ± 1.8 (0.0)	1.2 ± 2.0 (0.0)	1.3 ± 2.1 (0.0)
Treatments, N (%)				
GCs	0 (0.0%)	3757 (100.0%)	1537 (100.0%)	860 (100.0%)
Prednisone	0 (0.0%)	3126 (83.2%)	1517 (98.7%)	851 (99.0%)
Methylprednisolone	0 (0.0%)	818 (21.8%)	98 (6.4%)	48 (5.6%)
Dexamethasone	0 (0.0%)	254 (6.8%)	56 (3.6%)	29 (3.4%)
Prednisolone	0 (0.0%)	7 (0.2%)	3 (0.2%)	0 (0.0%)
Acetylcholinesterase inhibitors	2032 (40.0%)	2110 (56.2%)	1059 (68.9%)	628 (73.0%)
Pyridostigmine	2016 (39.7%)	2093 (55.7%)	1055 (68.6%)	624 (72.6%)
Neostigmine	25 (0.5%)	28 (0.7%)	8 (0.5%)	5 (0.6%)
Ambenonium chloride	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Nonsteroidal immunosuppressants	994 (19.6%)	1414 (37.6%)	778 (50.6%)	462 (53.7%)
Mycophenolate mofetil	486 (9.6%)	761 (20.3%)	434 (28.2%)	270 (31.4%)
Azathioprine	426 (8.4%)	538 (14.3%)	310 (20.2%)	180 (20.9%)
Methotrexate	77 (1.5%)	124 (3.3%)	49 (3.2%)	27 (3.1%)
Tacrolimus	22 (0.4%)	35 (0.9%)	21 (1.4%)	12 (1.4%)
Cyclosporine	13 (0.3%)	30 (0.8%)	16 (1.0%)	7 (0.8%)
Cyclophosphamide	2 (0.0%)	14 (0.4%)	9 (0.6%)	4 (0.5%)
Immunoglobulin	342 (6.7%)	590 (15.7%)	349 (22.7%)	237 (27.6%)
Intravenous immunoglobulin	328 (6.5%)	563 (15.0%)	339 (22.1%)	231 (26.9%)
Subcutaneous immunoglobulin	120 (2.4%)	235 (6.3%)	138 (9.0%)	97 (11.3%)
Biologic therapies	139 (2.7%)	271 (7.2%)	157 (10.2%)	105 (12.2%)
Rituximab	65 (1.3%)	118 (3.1%)	60 (3.9%)	34 (4.0%)
Eculizumab	63 (1.2%)	117 (3.1%)	77 (5.0%)	57 (6.6%)
Efgartigimod	12 (0.2%)	53 (1.4%)	30 (2.0%)	20 (2.3%)
Ravulizumab	8 (0.2%)	20 (0.5%)	9 (0.6%)	7 (0.8%)
Mechanical ventilation	52 (1.0%)	103 (2.7%)	64 (4.2%)	49 (5.7%)
PLEX	49 (1.0%)	139 (3.7%)	105 (6.8%)	73 (8.5%)
Thymectomy	18 (0.4%)	54 (1.4%)	43 (2.8%)	30 (3.5%)

CCI = Charlson comorbidity index, GC = glucocorticoid, PEDD = prednisone equivalent daily dose, PLEX = plasma exchange, SD = standard deviation.

*Clinical characteristics were assessed during the study period.

†Defined as mean PEDD ≥5 mg.

‡Defined as mean PEDD ≥10 mg.

Indeed, patients receiving ≥40 mg/d incurred $79,752 (2019 USD) in mean MG-related total healthcare costs over the 2-year follow-up period.[18] Although these MG-related healthcare costs are not directly comparable to the all-cause costs evaluated in the present study, the consistent trends observed in both studies highlight a large economic burden seen among patients using higher levels of GC.

High GC use has also been shown to be associated with a heightened risk of GC toxicities and elevated HRU and healthcare costs in other immune-mediated conditions, such as systemic lupus erythematosus and immunoglobulin G4-related disease.[11,15,19,20] Notably, DerSarkissian et al evaluated GC toxicities and economic burden among patients with systemic lupus erythematosus who used or did not use GCs, and suggested that the high HRU and costs observed in those with GC use may be partly due to the risk of GC toxicities.[11] More specifically, patients at risk of developing toxicities may require more frequent monitoring, and additional medical visits or hospitalization may be needed if toxicities develop.[11]

As clinical guidelines recommend long-term immunosuppression for most patients with gMG,[6] the cumulative toxicities associated with GC use, as well as HRU and healthcare costs, may impose a substantial burden over a patient's lifetime. Moreover, although not evaluated in the present study, prior literature has shown that GC use is also associated with a large burden on quality of life.[7] In an analysis of online public domain conversations describing perspectives of patients with MG, those treated with GCs expressed a high degree of negativity towards their condition, which was driven by concerns regarding toxicities and lack of effectiveness.[7] The use of nonsteroidal immunosuppressants has been recommended as an approach to manage and reduce GC toxicities and allow for GC tapering.[6,9] However, despite this guideline recommendation, patients with a mean PEDD ≥5 mg in this study also had higher use of nonsteroidal immunosuppressants, suggesting that use of nonsteroidal immunosuppressants may be correlated with reduced GC use in real-world clinical practice. As such, there is an unmet need for more effective and well-tolerated treatment options for gMG that may reduce patient reliance on GCs.

The International Consensus Guidance for the Management of Glucocorticoid Related Complications in Neuromuscular Disease state that despite the introduction of novel immune therapies for the treatment of autoimmune diseases such as MG, GCs remain a mainstay of treatment; therefore, specific strategies to minimize acute and chronic adverse events from GC use are necessary. Considering the negative impacts of GCs observed in this and prior studies, the introduction of effective GC-sparing treatments to the gMG treatment landscape may provide multifaceted benefits for both patients and healthcare systems alike.[21] A limited number of recent trials have evaluated GC-sparing effects of approved gMG biologic treatments. The BeatMG trial examined the potential GC-sparing effects of rituximab, a B cell-targeted therapy, and found no significant difference in the proportion of patients achieving a ≥75% reduction in daily prednisone dose between the rituximab and placebo arms.[22] Conversely, the recent phase 3 MINT trial evaluated the efficacy of inebilizumab, a CD19 directed B cell depleter for patients with AChR + and MuSK + gMG.[23] Participants receiving inebilizumab experienced improved function and reduced disease severity due to gMG alongside successful protocol-prescribed prednisone tapering to 5 mg/d.[23]

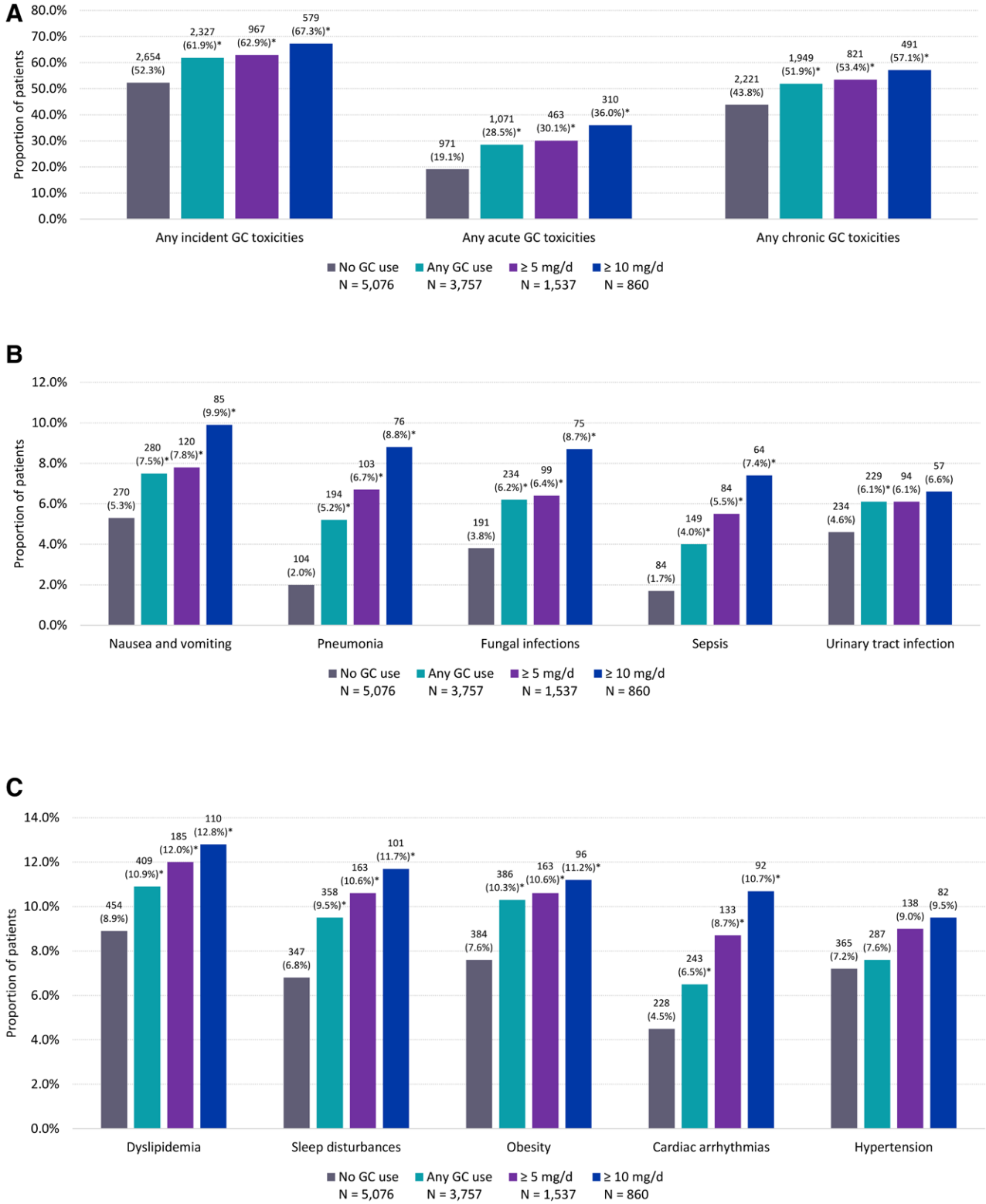

Figure 2. Patients with (A) any incident GC toxicities, (B) top 5[1] acute GC toxicities, and (C) top 5[1] chronic GC toxicities. * Significance denoted at $P < .01$ (compared to no GC use cohort). [1] The top 5 acute and chronic GC toxicities were selected based on frequencies of individual toxicities in the ≥10 mg/d subgroup. GC = glucocorticoid.

4.1. Limitations

Some limitations should be considered in the interpretation of these study findings. Due to the lack of an ICD code that distinguishes gMG from ocular MG (G070.00 is used for both), provider specialty was used to differentiate gMG from ocular MG. Furthermore, the analyses did not adjust for indicators of disease severity and are descriptive in nature. Additionally, because treatment-related adverse events cannot be directly identified from claims data, diagnosis codes were used to identify medical events that may have been related to GC toxicities;

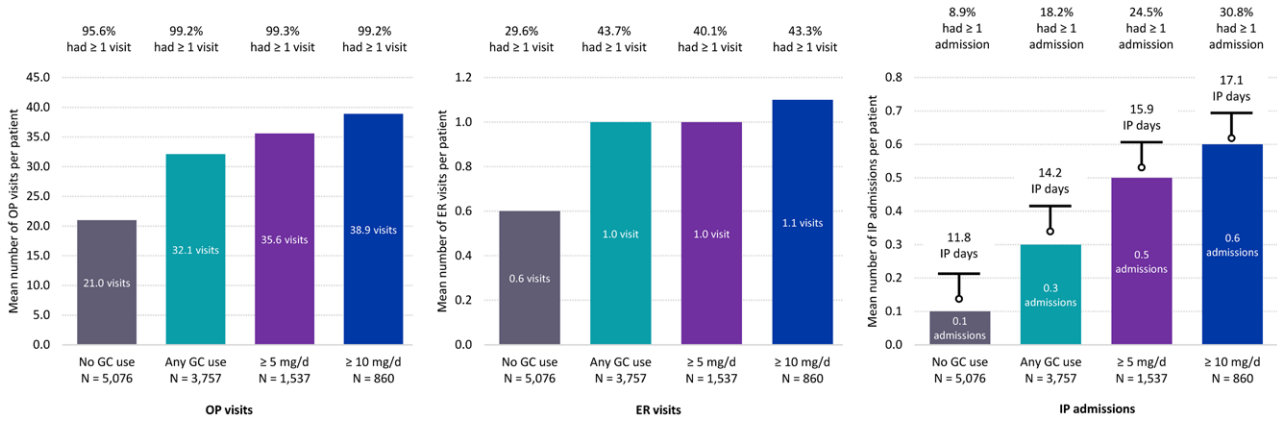

Figure 3. Annual, all-cause HRU. ER = emergency room, GC = glucocorticoid, HRU = healthcare resource utilization, IP = inpatient, OP = outpatient.

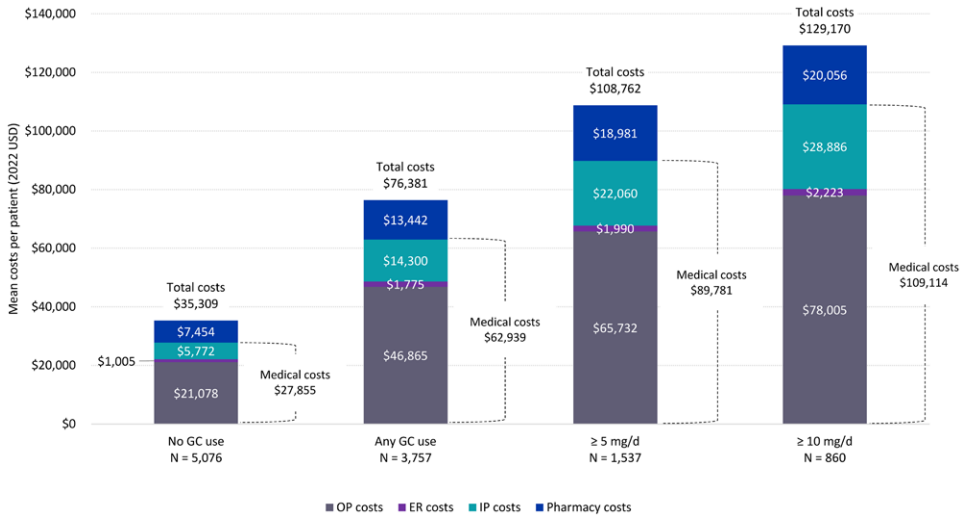

Figure 4. Average annual, all-cause healthcare costs. ER = emergency room, GC = glucocorticoid, IP = inpatient, OP = outpatient, USD = United States dollar.

as such, the observed diagnoses could be not confirmed to be treatment-related. Further, the present study did not examine temporal relationships between observed GC use and observed GC toxicities during the study period, thus inference should not be made on the relative timing of events using these findings. This study included commercially insured patients and thus may not be representative of the overall adult gMG population in the US, including patients with other or no health insurance coverage. Lastly, limitations inherent to retrospective claims database analyses apply, including the risk of data omissions, coding errors, and the presence of rule-out diagnoses.

5. Conclusions

The findings of this study demonstrate the considerable clinical and economic burden of GC use in patients with gMG in real-world clinical practice. Concordant with the established risks of GC use, patients with higher GC use experienced increased incidence of acute and chronic GC toxicities, elevated HRU and healthcare costs, and more frequent use of nonsteroidal immunosuppressants. There is an unmet need for effective disease-modifying treatments to mitigate GC exposure for improved gMG management and patient outcomes. The introduction of effective alternative treatment options with more favorable safety profiles may help to alleviate the adverse clinical and economic impacts of elevated GC use among patients with gMG.

Acknowledgments

Medical writing assistance was provided by professional medical writer, Christine Tam, MWC, an employee of Analysis Group ULC, a consulting company that has provided paid consulting services to Amgen Inc, which funded the development and conduct of this study and manuscript.

Author contributions

Conceptualization: Nicholas J. Silvestri, Jenny Y. Park, Elizabeth Serra, Patrick Gagnon-Sanschagrin, Annie Guérin, Blanca Canales, Kristina R. Patterson, Andrea Meyers, Tuan Vu.
Formal analysis: Elizabeth Serra, Patrick Gagnon-Sanschagrin, Annie Guérin.
Investigation: Nicholas J. Silvestri, Jenny Y. Park, Elizabeth Serra, Patrick Gagnon-Sanschagrin, Annie Guérin, Blanca Canales, Kristina R. Patterson, Andrea Meyers, Tuan Vu.
Methodology: Nicholas J. Silvestri, Jenny Y. Park, Elizabeth Serra, Patrick Gagnon-Sanschagrin, Annie Guérin, Blanca Canales, Kristina R. Patterson, Andrea Meyers, Tuan Vu.
Validation: Elizabeth Serra, Patrick Gagnon-Sanschagrin, Annie Guérin.
Writing – review & editing: Nicholas J. Silvestri, Jenny Y. Park, Elizabeth Serra, Patrick Gagnon-Sanschagrin, Annie Guérin, Blanca Canales, Kristina R. Patterson, Andrea Meyers, Tuan Vu.

References

[1] Menon D, Bril V. Pharmacotherapy of generalized myasthenia gravis with special emphasis on newer biologicals. Drugs. 2022;82:865–87.
[2] Mishra AK, Varma A. Myasthenia gravis: a systematic review. Cureus. 2023;15:e50017.
[3] Ye Y, Murdock DJ, Chen C, Liedtke W, Knox CA. Epidemiology of myasthenia gravis in the United States. Front Neurol. 2024;15:1339167.
[4] Gilhus NE, Tzartos S, Evoli A, Palace J, Burns TM, Verschuuren JJGM. Myasthenia gravis. Nat Rev Dis Primers. 2019;5:30.
[5] Alhaidar MK, Abumurad S, Soliven B, Rezania K. Current treatment of myasthenia gravis. J Clin Med. 2022;11:1597.
[6] Sanders DB, Wolfe GI, Benatar M, et al. International consensus guidance for management of myasthenia gravis: executive summary. Neurology. 2016;87:419–25.
[7] Anderson A, Pesa J, Choudhry Z, et al. Patient perceptions of disease burden and treatment of myasthenia gravis based on sentiment analysis of digital conversations. Sci Rep. 2024;14:7271.
[8] Sacca F, Salort-Campana E, Jacob S, Cortes-Vicente E, Schneider-Gold C. Refocusing generalized myasthenia gravis: patient burden, disease profiles, and the role of evolving therapy. Eur J Neurol. 2024;31:e16180.
[9] Narayanaswami P, Sanders DB, Wolfe G, et al. International consensus guidance for management of myasthenia gravis: 2020 update. Neurology. 2021;96:114–22.
[10] Zhdanava M, Pesa J, Boonmak P, et al. Economic burden of generalized myasthenia gravis (MG) in the United States and the impact of common comorbidities and acute MG-events. Curr Med Res Opin. 2024;40:1145–53.
[11] DerSarkissian M, Gu YM, Duh MS, et al. Clinical and economic burden in patients with systemic lupus erythematosus during the first year after initiating oral corticosteroids: a retrospective US database study. ACR Open Rheumatol. 2023;5:318–28.
[12] Kabadi S, Yeaw J, Bacani AK, et al. Healthcare resource utilization and costs associated with long-term corticosteroid exposure in patients with systemic lupus erythematosus. Lupus. 2018;27:1799–809.
[13] Schultz NM, Penson DF, Wilson S, et al. Adverse events associated with cumulative corticosteroid use in patients with castration-resistant prostate cancer: an administrative claims analysis. Drug Saf. 2020;43:23–33.
[14] Phillips G, Abreu C, Goyal A, et al. Real-world healthcare resource utilization and cost burden assessment for adults with generalized myasthenia gravis in the United States. Front Neurol. 2021;12:809999.
[15] Chen HL, Shen LJ, Hsu PN, Shen CY, Hall SA, Hsiao FY. Cumulative burden of glucocorticoid-related adverse events in patients with systemic lupus erythematosus: findings from a 12-year longitudinal study. J Rheumatol. 2018;45:83–9.
[16] Yasir M, Goyal A, Sonthalia S. Corticosteroid adverse effects. In: StatPearls. StatPearls Publishing; 2026. https://www.ncbi.nlm.nih.gov/books/NBK531462/. Accessed July 18, 2024.
[17] Johnson S, Katyal N, Narula N, Govindarajan R. Adverse side effects associated with corticosteroid therapy: a study in 39 patients with generalized myasthenia gravis. Med Sci Monit. 2021;27:e933296.
[18] Ting A, Story T, Lecomte C, Estrin A, Syed S, Lee E. A real-world analysis of factors associated with high healthcare resource utilization and costs in patients with myasthenia gravis receiving second-line treatment. J Neurol Sci. 2023;445:120531.
[19] Wu Q, Chang J, Chen H, et al. Efficacy between high and medium doses of glucocorticoid therapy in remission induction of IgG4-related diseases: a preliminary randomized controlled trial. Int J Rheum Dis. 2017;20:639–46.
[20] Wallace ZS, Park JY, Serra E, et al. Burden of glucocorticoid use and risk of toxicities among patients with immunoglobulin-G4-related disease: a retrospective US-based claims study. Rheumatol Ther. 2025;12:547–60.
[21] Bacher C, Narayanswami P, Bromberg M, et al. International consensus guidance for the management of glucocorticoid related complications in neuromuscular disease. Muscle Nerve. 2025;71:309–16.
[22] Nowak RJ, Coffey CS, Goldstein JM, et al; NeuroNEXT NN103 BeatMG Study Team. Phase 2 trial of rituximab in acetylcholine receptor antibody-positive generalized myasthenia gravis: the BeatMG Study. Neurology. 2022;98:e376–89.
[23] Nowak RJ, Benatar M, Ciafaloni E, et al. A phase 3 trial of inebilizumab in generalized myasthenia gravis. N Engl J Med. 2025;392:2309–20.