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Incident glaucoma and ocular hypertension after periocular and intravitreal steroid injections: a claims-based analysis

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ABSTRACT

Background/aims This study aims to determine the incidence and risk of open-angle glaucoma or ocular hypertension (OHT) following ocular steroid injections using healthcare claims data.

Methods We retrospectively reviewed deidentified insurance claims data from the IBM MarketScan Database to identify 19 156 adult patients with no prior history of glaucoma who received ocular steroid injections between 2011 and 2020. Patient demographics and steroid treatment characteristics were collected. Postinjection glaucoma/OHT development was defined as a new diagnosis of glaucoma/OHT, initiation of glaucoma drops, and/or surgical or laser glaucoma treatment. Cox proportional hazards models were used to determine the risk of glaucoma/OHT development within 5 years after first steroid injection.

Results Overall, 3932 (20.5%) patients were diagnosed with new glaucoma/OHT, 3345 (17.5%) started glaucoma drops and 435 (2.27%) required a laser or surgical glaucoma procedure within 5 years of first steroid injection. Triamcinolone subconjunctival injections were associated with a lower risk of glaucoma/OHT development than retrobulbar or intravitreal steroid injections (p<0.001, HR 0.68, 95% CI 0.59 to 0.79), whereas the 0.59 mg fluocinolone acetonide intravitreal implant had the highest risk of glaucoma/OHT development (p=0.001, HR 2.01, 95% CI 1.34 to 3.02). The risk of glaucoma/OHT development was also higher for patients receiving multiple steroid injections (p<0.001), with the largest increase in risk occurring after three total steroid injections.

Conclusion Patients receiving ocular steroid injections are at risk of developing glaucoma/OHT, even with no prior glaucoma/OHT diagnosis or treatment. Patients should be closely monitored for the development of glaucoma following ocular steroid injections, particularly in the setting of intravitreal and/or repeated steroid administration.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Ocular hypertension and glaucoma are well-known potential complications of steroid administration. However, few studies have directly compared the risk of glaucoma development for different types of ocular steroid injections, and many prior studies on this topic have been limited to smaller clinic-based or hospital-based populations with limited follow-up periods.

WHAT THIS STUDY ADDS

⇒ This study uses a large repository of healthcare claims data to give a nationwide population perspective of the risk of new ocular hypertension and glaucoma in patients with no prior history of glaucoma who received ocular steroid injections. The study also highlights the rate of glaucoma treatment initiation—including intraocular pressure lowering drops, laser procedures and glaucoma surgeries—following ocular steroid injections. We demonstrate that patients receiving intravitreal steroid injections, sustained-release intravitreal steroid implants or multiple steroid injections over time are at significantly increased risk of developing ocular hypertension and glaucoma compared with patients receiving periocular steroid injections.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The findings of this study help to better characterise glaucoma and ocular hypertension risk in patients receiving ocular steroid injections and to highlight various clinical factors that may modulate the risk of glaucoma development and the need for glaucoma treatment in these patients. This information may be useful both for patients to better understand the potential risks of treatment with ocular steroid injections, and for clinicians to provide individualised patient counselling and monitoring over time.

INTRODUCTION

In recent decades, local administration of corticosteroids via periocular and intravitreal injections has become increasingly prevalent in the treatment of various exudative and inflammatory ocular conditions.[1] The use of sustained-release steroid delivery devices—including injectable 0.7 mg dexamethasone and 0.19 mg fluocinolone acetonide intravitreal implants (Ozurdex and Iluvien,

respectively) and surgically implantable 0.59 mg fluocinolone acetonide intravitreal tablets (Retisert)—has transformed the management of conditions such as macular oedema due to chronic non-infectious uveitis and various other etiologies.[1] Ocular hypertension (OHT) and glaucoma are well-recognised complications of steroid administration due to possible microstructure alterations in the trabecular meshwork that lead to increased aqueous outflow resistance and elevated intraocular pressure (IOP).[2 3] In some cases, steroid-induced glaucoma can be vision-threatening and require management with topical, laser or even surgical intervention.

Although the association between steroid administration and glaucoma development is well documented, few studies have directly compared the risk of glaucoma for different types and routes of periocular and intravitreal steroid injections.[4 5] Additionally, many previous studies on this topic have been confined to smaller clinic-based or hospital-based populations in which very large patient numbers and extended follow-up times have not been possible.[4–7] Therefore, the purpose of this study was to determine the rate of new glaucoma/OHT development following periocular and/or intravitreal steroid injections using a large, nationwide insurance claims database and to compare the risk of glaucoma/OHT development between different types and routes of ocular steroid injections. We also assessed the impact of demographic and clinical factors on the risk of developing postinjection glaucoma or OHT.

MATERIALS AND METHODS

Patients or the public were not involved in the design, conduct, reporting or dissemination plans of our research. The research adhered to the tenets of the Declaration of Helsinki and complied with the Health Insurance Portability and Accountability Act.

Data collection

We performed a 10-year retrospective review of the IBM MarketScan Database, which is composed of deidentified, patient-level healthcare claims data from both privately and publicly insured patients throughout the USA. The database contains more than 264 million individuals, 37 billion service records, 160 contributing employers and 40 contributing health plans. Available sociodemographic data included patient age and sex. Available clinical data included first dates of open-angle glaucoma and OHT diagnoses (based on International Classification of Diseases (ICD), 9th and 10th revision, codes), IOP-lowering eye-drops (based on National Drug Codes), laser and surgical glaucoma procedures (based on Current Procedural Terminology (CPT) codes), and types and routes of administration of steroid injections (based on Healthcare Common Procedure Coding System and CPT codes, respectively) (online supplemental table 1). Indications for steroid injections were also determined based on the ICD-9 or ICD-10 code associated with these procedures.

Study design

The study included all adult (age ≥18) patients who received periocular and/or intravitreal steroid injections between 1 January 2011 and 31 December 2020. To ensure that postinjection glaucoma/OHT development was an incident event, we excluded any patients with a prior history of glaucoma/OHT and/or glaucoma treatment within 2 years before their first steroid injection. Patients who were not examined by an eye care provider for at least 2 years prior to their first steroid injection were also excluded.

The main outcome measure was the development of postinjection glaucoma/OHT, which was defined as (1) a new diagnosis of open-angle glaucoma or OHT, (2) the initiation of IOP-lowering eye-drops and/or (3) laser or surgical glaucoma procedures. IOP-lowering eye-drops included alpha-agonists, beta-blockers, carbonic anhydrase inhibitors, prostaglandin analogues, nitric oxide donators and rho kinase inhibitors. Laser procedures included selective laser trabeculoplasty, argon laser trabeculoplasty and cyclophotocoagulation. Surgical procedures included minimally invasive glaucoma surgeries with or without glaucoma drainage devices and incisional glaucoma surgeries (such as trabeculectomy and tube shunt implantation).

Statistical analysis

Analyses were conducted at a patient—rather than eye—level due to lack of laterality data in ICD-9 coding. The proportion of patients who developed glaucoma after steroid injections was calculated and stratified by age, sex, indication for steroid injection and treatment characteristics (including steroid type, number of steroid injections and route of administration). A series of multivariable Cox proportional hazards models were used to determine the risk of glaucoma/OHT development within 5 years following the first steroid injection. In all models, the outcome was regressed against age, type of steroid administered, site of injection, indication for injection (such as scleritis, uveitis, diabetic retinopathy, retinal vein occlusion and macular degeneration), number of injections received and known risk factors for glaucoma (including diabetes mellitus, connective tissue disease, high myopia and history of penetrating keratoplasty).[8–12] Statistical significance was defined as a $p<0.05$.

RESULTS

Study cohort and demographics

A total of 50 112 patients in the IBM MarketScan Database received periocular and/or intravitreal steroid injections within the study period, and 19 156 patients (38.2%) met eligibility criteria for inclusion in the study (figure 1). At the time of first steroid injection, 1542 patients (8.04%) were 18–40 years, 10 059 patients (52.5%) were 41–64 years and 7555 patients (39.4%) were ≥65 years; 9153 patients (47.8%) were women and 10 003 patients (52.2%) were men (table 1). Overall, a total of 5141 patients (26.8%) developed a glaucoma/

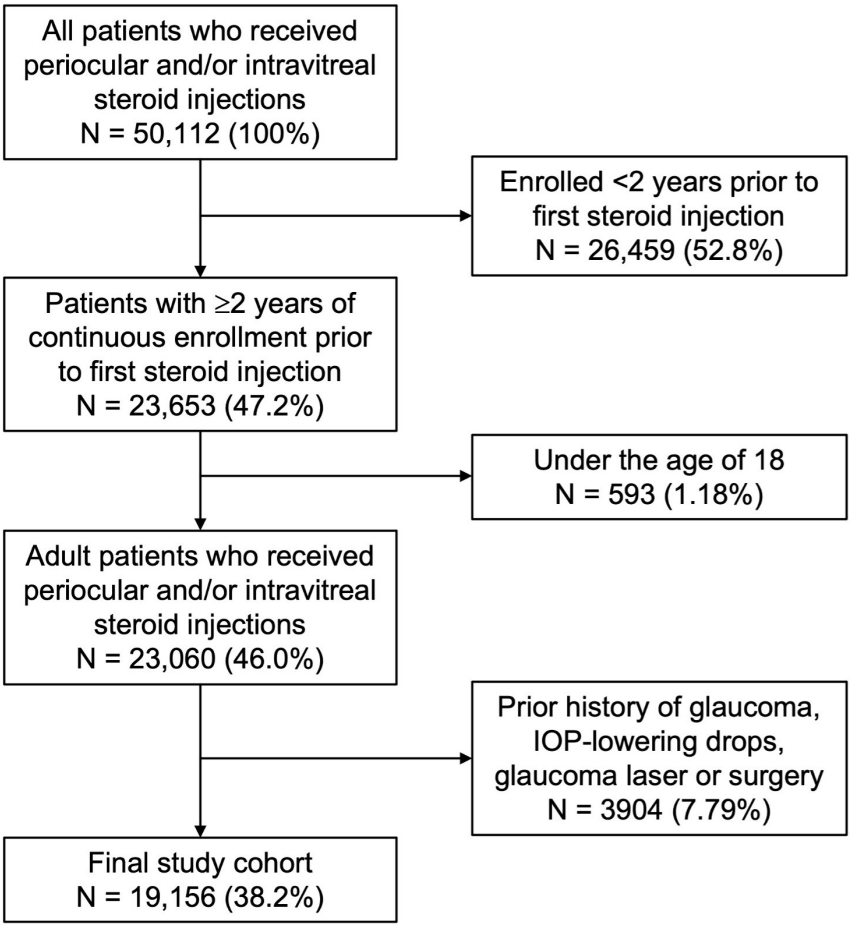

Figure 1 Study attrition diagram of eligible patients with no prior history of glaucoma/ocular hypertension who received periocular and/or intravitreal steroid injections. IOP, intraocular pressure.

OHT-related outcome within 5 years of their first steroid injection; specifically, 3932 (20.5%) were diagnosed with glaucoma or OHT, 3345 (17.5%) were started on IOP-lowering eye-drops, and 435 (2.27%) underwent a laser and/or surgical procedure to treat glaucoma. There was no significant association between age or sex and the risk of postinjection glaucoma/OHT development (p>0.05). Within the study cohort, diabetic retinopathy was the most common specified indication for receiving periocular and/or intravitreal steroid injections (n=4673, 20.8%), whereas scleritis was the least common indication (n=253, 1.13%). Patients receiving steroid injections to treat cystoid macular oedema associated with retinal vein occlusions had the highest risk of glaucoma/OHT development (p<0.001, HR 1.43, 95% CI 1.32 to 1.56).

Types of steroid injections

Six forms of ocular steroid administration were included in the study (table 1): triamcinolone subconjunctival injections (n=1780, 8.16%), triamcinolone retrobulbar (including anterior and posterior sub-Tenon) injections (n=6781, 31.1%), triamcinolone intravitreal injections (n=8985, 41.2%), dexamethasone intravitreal implants (Ozurdex; n=4022, 18.4%), 0.19 mg fluocinolone acetonide intravitreal implants (Iluvien; n=216, 0.99%) and 0.59 mg fluocinolone acetonide surgically placed intravitreal implants (Retisert; n=37, 0.17%). Due to the time period analysed, Yutiq (0.18 mg intravitreal fluocinolone acetonide) and Xipere (40 mg/mL suprachoroidal triamcinolone) were not included. Triamcinolone subconjunctival injections were associated with a significantly lower risk of glaucoma/OHT development compared with all other types of ocular steroid injections (p<0.001, HR 0.68, 95% CI 0.59 to 0.79), whereas Retisert intravitreal implants were associated with the highest risk of glaucoma/OHT development (p=0.001, HR 2.01, 95% CI 1.34 to 3.02; figure 2).

Quantity of steroid injections

The risk of glaucoma/OHT development was also determined relative to the total number of steroid injections received over time. A total of 11 376 patients (59.4%) received a single steroid injection within the study period, 3822 (20.0%) had 2 steroid injections, 1453 (7.59%) had 3 steroid injections and 2505 (13.1%) had ≥4 steroid injections. Patients who received multiple (>1) steroid injections had a significantly higher risk of glaucoma/OHT development compared with patients who received a single steroid injection (2 injections: p<0.001, HR 1.15, 95% CI 1.06 to 1.23; 3 injections: p <0.001, HR 1.42,

Table 1 Development of glaucoma/ocular hypertension following periocular and/or intravitreal steroid injections according to patient demographics, indications for steroid injections, and type and location of steroid injections

	Any glaucoma outcome	Diagnosis of glaucoma/OHT	IOP-lowering drops	Glaucoma surgery and/or laser	No glaucoma	Total
Full cohort	5141 (26.8%)	3932 (20.5%)	3345 (17.5%)	435 (2.27%)	14015 (73.2%)	19156
Age						
18–40 years	346 (22.4%)	257 (16.7%)	249 (16.1%)	47 (3.05%)	1196 (77.6%)	1542
41–64 years	2831 (28.1%)	2087 (20.7%)	1928 (19.2%)	248 (2.47%)	7228 (71.9%)	10059
≥65 years	1964 (26.0%)	1588 (21.0%)	1168 (15.5%)	140 (1.85%)	5591 (74.0%)	7555
Sex						
Male	2599 (28.4%)	1981 (21.6%)	1740 (19.0%)	241 (2.63%)	6554 (71.6%)	9153
Female	2542 (25.4%)	1951 (19.5%)	1605 (16.0%)	194 (1.94%)	7461 (74.6%)	10003
Indication for injection						
Scleritis	72 (28.5%)	61 (24.1%)	45 (17.8%)	8 (3.16%)	181 (71.5%)	253
Anterior uveitis	886 (31.8%)	669 (24.0%)	579 (20.8%)	96 (3.45%)	1898 (68.2%)	2784
Intermediate, posterior and panuveitis	819 (34.1%)	606 (25.3%)	565 (23.5%)	78 (3.25%)	1581 (65.9%)	2400
Diabetic retinopathy	1367 (29.3%)	1039 (22.2%)	967 (20.7%)	146 (3.12%)	3306 (70.7%)	4673
Cystoid macular oedema	662 (26.3%)	515 (20.4%)	411 (16.3%)	34 (1.35%)	1859 (73.7%)	2521
Retinal vein occlusion	963 (34.9%)	731 (26.5%)	658 (23.8%)	108 (3.91%)	1796 (65.1%)	2759
Macular degeneration	648 (25.7%)	524 (20.8%)	359 (14.2%)	36 (1.43%)	1875 (74.3%)	2523
None specified	800 (17.6%)	603 (13.3%)	462 (10.2%)	45 (0.99%)	3733 (82.4%)	4533
Injection type and location						
Triamcinolone subconjunctival injection	264 (14.8%)	219 (12.3%)	115 (6.46%)	19 (1.07%)	1516 (85.2%)	1780
Triamcinolone retrobulbar injection	1779 (26.2%)	1409 (20.8%)	1130 (16.7%)	153 (2.26%)	5002 (73.8%)	6781
Triamcinolone intravitreal injection	2649 (29.5%)	1977 (22.0%)	1780 (19.8%)	244 (2.72%)	6336 (70.5%)	8985
Dexamethasone intravitreal implant (Ozurdex)	1449 (36.0%)	1097 (27.3%)	1069 (26.6%)	142 (3.53%)	2573 (64.0%)	4022
Fluocinolone acetonide intravitreal implant (Iluvien)	97 (44.9%)	75 (34.7%)	80 (37.0%)	18 (8.33%)	119 (55.1%)	216
Fluocinolone acetonide intravitreal implant (Retisert)	24 (64.9%)	19 (51.4%)	21 (56.8%)	13 (35.1%)	13 (35.1%)	37

IOP, intraocular pressure; OHT, ocular hypertension.

95% CI 1.29 to 1.56; ≥4 injections: p<0.001, HR 1.54, 95% CI 1.42 to 1.67; figure 3). There was a significant increase in overall glaucoma/OHT risk after 3 steroid injections compared with 2 injections; however, the risk of glaucoma/OHT did not significantly increase with ≥4 injections compared with 3 injections.

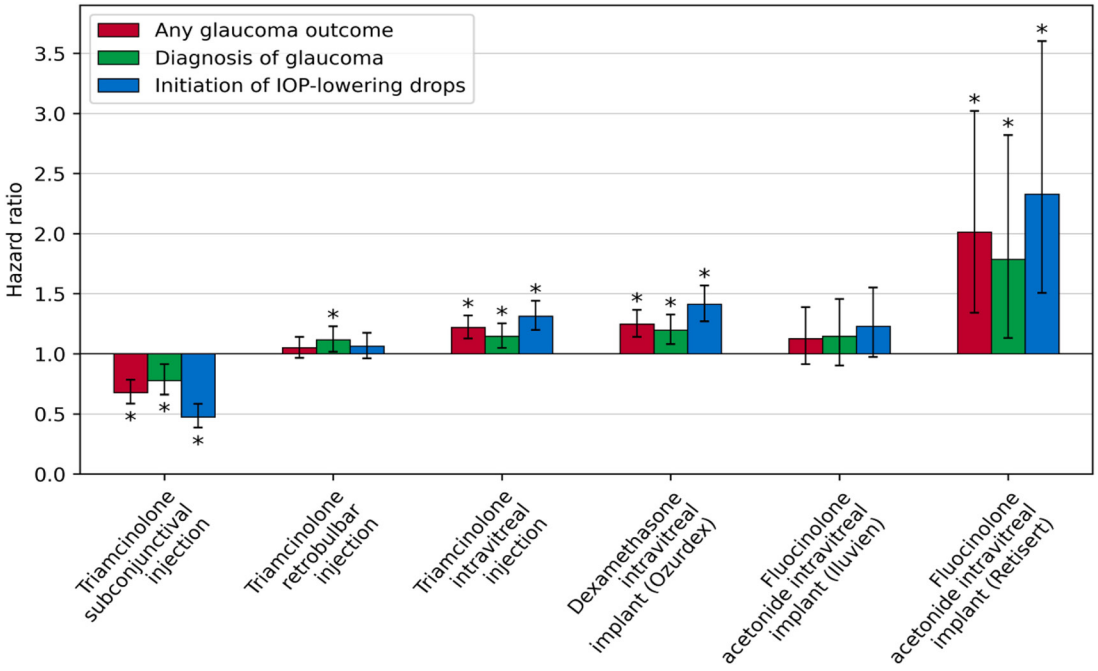

Figure 2 Risk of postinjection glaucoma/OHT development (represented by HRs with 95% CIs) according to the steroid type and route of administration. The effect of each steroid group on glaucoma/OHT risk was determined relative to all patients not part of the specified group. *p<0.05. IOP, intraocular pressure; OHT, ocular hypertension.

DISCUSSION

In this study, we used a large, nationwide insurance claims database to assess rates of new glaucoma and OHT development following periocular and intravitreal steroid injections over a multiyear period in patients with no prior history of glaucoma or OHT. We showed that patients receiving ocular steroid injections are at considerable risk of developing glaucoma/OHT, particularly in the setting of sustained-release intravitreal steroid implants and/or multiple steroid injections over time.

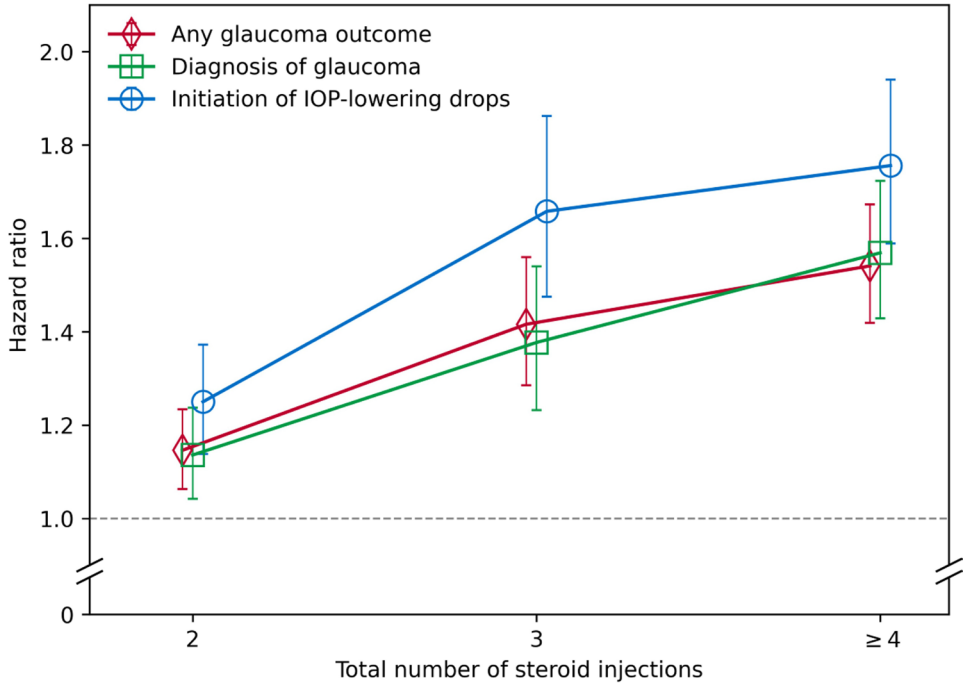

Figure 3 Risk of postinjection glaucoma/OHT development (represented by HRs with 95% CIs) according to the total number of steroid injections received over time. The effect of injection number on glaucoma/OHT risk was determined relative to a single steroid injection. All p values are <0.05. IOP, intraocular pressure; OHT, ocular hypertension.

Although the association of steroids and OHT/glaucoma is well known, our utilisation of a large-scale, nationwide database with an extended follow-up period allowed us to investigate clinical questions—such as how the total number of steroid injections over time influences the risk of OHT/glaucoma development, and how different types and routes of steroid injections impact OHT/glaucoma risk within a single population—that smaller clinic-based or hospital-based studies have not addressed. These findings help to provide practical insights into the potential risks, clinical course and follow-up needs of patients receiving periocular and intravitreal steroid injections.

Compared with other types of ocular steroid injections in our study, intravitreal steroid injections and sustained-release intravitreal steroid implants were associated with the highest risk of glaucoma/OHT development. Multiple previous studies have demonstrated an association between the intravitreal injection procedure and spikes in IOP, including for non-steroidal medications such as anti-vascular endothelial growth factor (VEGF) agents.[13–15] This IOP elevation is thought to be due, at least in part, to an acute volume effect of injecting fluid into a relatively confined space within the eye.[13] Another study of anti-VEGF injections suggested that trauma from the injection procedure led to trabecular meshwork damage, resulting in less efficient aqueous outflow and elevated IOP.[16] In the context of anti-VEGF injections, however, the prevalence of IOP elevation with associated glaucomatous damage is relatively low (<5%).[17] Our study and others have demonstrated a higher rate of documented glaucoma/OHT after even a single steroid injection, suggesting that additional factors may be involved in the development of IOP elevation following steroid administration.[4 18]

In addition to mechanical changes associated with the intravitreal injection procedure, the pharmacodynamics and concentration of steroids within the eye may also contribute to the substantial rate of glaucoma/OHT that we observed following intravitreal steroid administration. Weijtens *et al* demonstrated that the intravitreal route of medication delivery enabled a maximum concentration of intraocular corticosteroids compared with subconjunctival or retrobulbar injections.[19 20] Additionally, these high intravitreal steroid concentrations have been shown to persist within the human eye for multiple months to years, even after a single intravitreal injection.[21] Sustained-release intravitreal steroid implants have also been associated with OHT and glaucoma.[22] The prolonged action of steroids within the vitreous is especially notable for sustained-release implants such as Iluvien and Retisert, which deliver fluocinolone acetonide intraocularly for up to 36 months.[23] While the exact mechanism of steroid-induced glaucoma is not yet fully elucidated, corticosteroids are hypothesised to interact with various enzymes and cytoskeletal components within the trabecular meshwork to cause increased aqueous outflow resistance and therefore elevated IOP.[2 3] Studies have demonstrated that corticosteroids can lead to microstructure alterations within the trabecular meshwork through the upregulation of myocilin and through binding to glucocorticoid receptor beta.[24 25] Others have postulated that physical obstruction of the trabecular meshwork by glucocorticoid crystals contributes to reduced aqueous outflow.[26] Our data support that the intravitreal route of steroid delivery facilitates more direct and prolonged interaction between corticosteroids and trabecular meshwork, ultimately leading to higher rates of increased aqueous outflow resistance and sustained IOP elevation compared with subconjunctival or retrobulbar routes.

The risk of postinjection glaucoma/OHT was also significantly higher for patients receiving multiple steroid injections over time. Other studies have similarly shown increased rates of IOP elevation and glaucoma following repeated steroid administration, suggestive of a cumulative or dose-dependent effect of steroids on glaucoma development.[4 6] Our findings contrast with a smaller retrospective study by Jonas *et al*, which demonstrated no increased risk of IOP elevation after repeated triamcinolone acetonide intravitreal injections.[27] Of note, we analysed the total number of any type of ocular steroid injections (including both intravitreal and periocular routes). Comparing the number of individual injection types was not possible given that many of the patients receiving multiple steroid injections were given different types of injections over time. Interestingly, we found that the largest increase in glaucoma/OHT risk occurred after a total of three steroid injections. In addition to reflecting a potential cumulative effect of repeated steroid injections on glaucoma/OHT development, this finding may also represent a temporal delay that can occur between steroid administration and subsequent IOP elevation. For instance, multiple studies have shown that glaucoma can take weeks and even months to develop after initial steroid exposure.[18 28] These results highlight the importance of maintaining long-term vigilance in IOP monitoring even in the absence of initial IOP elevation.

We also found that the rate of glaucoma/OHT development and, in particular, the need for IOP-lowering drops did not significantly increase with four or more steroid injections compared with three injections. A multicentre retrospective study even found that patients receiving four or more injections had a marginally lower risk of IOP elevation compared with patients receiving fewer injections.[29] While these findings may seem contrary to a dose-dependent relationship between steroids and glaucoma, they are perhaps also reflective of provider decision-making and the patients' known risk factors, such as family history of glaucoma, corneal hysteresis, myopia and/or thinner corneas.[10 30 31] Clinicians tend to avoid repeated steroid injections in patients with previous known steroid-induced IOP elevation, or consider IOP lowering intervention prior to repeat injections.[29] A further prospective investigation of how serial steroid injections modulate the risk of glaucoma/OHT

would be useful in order to facilitate informed decision-making with patients who require repeated intraocular or periocular steroid treatments.

Our study underscores the potential for using large-scale healthcare claims data to investigate patterns in steroid-related glaucoma development. However, certain limitations are inherent to our claims-based study. For example, because insurance claims data do not include IOP measurements, detailed ocular examination findings or glaucoma family history, we relied on diagnostic coding and treatment initiation to determine glaucoma/OHT outcomes and comorbidities within our cohort. While prior studies have demonstrated strong agreement between administrative claims data and corresponding patient records in ophthalmology,[32 33] the accuracy of this coding is dependent on providers with a wide range of clinical backgrounds who therefore may differ in their approach to the diagnosis and treatment of ocular diseases.[34] Additionally, the ICD-9 coding system lacks laterality information, which limited our analyses to a patient—rather than eye—level. Consequently, the development of postinjection glaucoma/OHT in a patient could potentially be confounded by diagnoses or treatments in their contralateral eye, as well as systemic diagnoses or medications. Despite this limitation, the patient-level rates of new OHT/glaucoma in our study may be useful for both clinicians and patients to better understand the overall risks associated with ocular steroid injections, and they align with general trends of steroid-related OHT/glaucoma development that have been identified in prior hospital-based and clinic-based studies.[4 6–8] Due to the claims-based nature of the database and lack of ocular examination findings, we were unable to ascertain the degree of uveitis control or the presence of neovascularisation in each patient; this could potentially confound our findings, as neovascularisation of the angle can cause IOP elevation and active ocular inflammation can either raise or lower IOP (although we excluded patients with documented neovascular or uveitic glaucoma and also controlled for conditions such as diabetic retinopathy and uveitis in our multivariate analyses to reduce the risk of confounding).[35] The database could also not differentiate between types and doses of triamcinolone (such as Kenalog and Triescence) or between variations in technique of sub-Tenon injections (anterior vs posterior sub-Tenon approach), which could also influence the extent of postinjection IOP elevation.[4 7] Finally, our study was based on retrospective analyses of compiled deidentified data and was, therefore, purely observational in nature. Future prospective studies could incorporate longitudinal postinjection IOP measurements and examination findings (including the duration of steroid-related IOP elevation and treatments) in order to address these limitations. Evaluation of large, multicentre databases that contain both clinical and genetic data would be useful to further understand the risk factors for this condition, as recent evidence suggests a likely genetic influence on steroid-induced OHT and glaucoma development.[36]

In summary, this study demonstrates that patients receiving periocular and/or intravitreal steroid injections are at considerable risk of developing new glaucoma/OHT, with a substantial proportion of patients requiring topical, laser or even surgical intervention to lower IOP. Whereas many prior studies have used smaller, select populations to assess OHT/glaucoma risk, our study assessed a massive population of patients throughout the USA in order to determine the rate of OHT/glaucoma development after ocular steroid injections.[4–7] Based on our findings, we suggest that patients receiving ocular steroid injections be closely monitored for glaucoma and OHT development, particularly in the setting of intravitreal and/or repeated steroid administration. There are currently no well-defined, broadly accepted guidelines regarding the specific frequency and duration of glaucoma screening in patients receiving intravitreal or periocular steroid injections. Future work to better characterise and risk-stratify these patients would be useful both to provide practical, individualised patient counselling and to help guide clinicians as they treat and monitor their patients over time.

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Contributors All authors have contributed significantly to the manuscript, reviewed and agreed to the manuscript content. The following outlines specific author involvement: conception and design of research (AP, KCL, DG, DSG, JH, BMW and BCS), acquisition of data (AP, JH and BS), analysis and interpretation of data (AP, JH and BCS), writing and review of manuscript (AP, KCL, DG, DSG, JH, BMW and BCS), and guarantor (BCS).

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study was exempt from institutional review board approval given that the data were completely deidentified.

Provenance and peer review Not commissioned; externally peer reviewed.

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Supplemental Table 1. List of diagnosis, medication, and procedure codes used to determine patient clinical characteristics from the SOURCE data repository. (CPT = Current Procedural Terminology; HCPCS = Healthcare Common Procedure Coding System; ICD9 = International Classification of Diseases, 9th revision; ICD10 = International Classification of Diseases, 10th revision; IOP = intraocular pressure; MIGS = minimally invasive glaucoma surgery; NDC = National Drug Codes; OHT = ocular hypertension)

Category (Code type)	Variable	Code numbers
Glaucoma or OHT diagnosis (ICD9, ICD10)	Steroid response glaucoma	ICD9: 365.03, 365.31, 365.32 ICD10: H40.04x
	Ocular hypertension	ICD9: 365.04 ICD10: H40.05x
	Open-angle glaucoma	ICD9: 365.00, 365.01, 365.05, 365.10, 365.11, 365.12, 365.15 ICD10: H40.01x, H40.02x, H40.11x, H40.12x, H40.15x
Risk factors for glaucoma or OHT (ICD9, ICD10; CPT)	Type 1 diabetes mellitus	ICD9: 250.01 ICD10: E10.9
	Connective tissue disease	ICD9: 710.x, 714.x ICD10: L94.x, M05.x, M06.x, M30.x, M31.x, M32.x, M33.x, M34.x, M35.x, M36.x
	High myopia	ICD9: 360.21 ICD10: H44.2x
	History of penetrating keratoplasty	CPT: 65730, 65750, 65755
Indications for ocular steroid injections (ICD9, ICD10)	Scleritis	ICD9: 379.0x ICD10: H15.0x
	Anterior uveitis	ICD9: 364.x, 054.44, 053.22 ICD10: H20.x, A18.54, B00.51, B02.32
	Intermediate and posterior uveitis	ICD9: 363.x ICD10: H30.x, H43.89
	Panuveitis	ICD9: 360.12 ICD10: H44.x
	Diabetic retinopathy (type 1 diabetes)	ICD10: E10.3x

	Diabetic retinopathy (type 2 diabetes)	ICD10: E11.3x
	Unspecified diabetic retinopathy	ICD9: 362.07 ICD10: E13.3x
	Cystoid macular edema	ICD9: 362.53 ICD10: H59.03x, H35.35x
	Central retinal vein occlusion	ICD9: 362.35 ICD10: H34.81x
	Branch retinal vein occlusion	ICD9: 362.36 ICD10: H34.83x
	Age-related macular degeneration	ICD9: 362.50, 362.51, 362.52 ICD10: H35.31x, H35.32x
IOP-lowering drops (NDC)	Alpha agonists	0023-9177-05, 0023-9177-10, 0023-9177-15, 0023-9321-03, 0023-9321-05, 0023-9321-10, 0023-9321-15, 0065-0660-10, 0299-5980-00, 0299-5980-02, 0299-5980-30, 0299-5980-35, 0299-5980-45, 14445-400-05, 14445-400-10, 14445-400-15, 17478-715-10, 17478-715-11, 17478-715-12, 17478-716-10, 17478-716-11, 24208-411-05, 24208-411-10, 24208-411-15, 50090-1046-0, 50090-1800-0, 50090-4224-0, 61314-143-05, 61314-143-10, 61314-143-15, 61314-144-05, 61314-144-10, 61314-144-15, 61314-665-05, 61314-665-10, 70069-231-01, 70069-232-01, 70069-233-01, 0023-9211-03, 0023-9211-05, 0023-9211-10, 0023-9211-15, 0065-4147-25, 0065-4147-27, 0078-0904-38, 0078-0904-98

Beta blockers	0023-9211-03, 0023-9211-05, 0023-9211-10, 0023-9211-15, 0065-0246-10, 0065-0246-15, 0187-1496-05, 0187-1496-99, 0187-1498-25, 0378-0055-01, 0378-0221-01, 0378-0715-01, 10702-013-01, 10702-014-01, 13811-618-10, 13811-620-10, 17478-189-24, 17478-288-10, 17478-288-11, 17478-288-12, 17478-288-25, 17478-289-10, 17478-289-11, 17478-289-12, 17478-289-25, 17478-365-05, 17478-366-05, 17478-366-10, 17478-366-15, 17478-705-10, 17478-705-11, 17478-705-12, 17478-705-25, 24208-004-01, 24208-004-02, 24208-004-03, 24208-812-05, 24208-813-05, 24208-813-10, 24208-814-25, 24208-816-05, 24208-818-25, 24208-819-05, 24658-700-01, 24658-701-01, 42806-038-01, 42806-038-10 ,42806-039-01, 42806-039-10, 45865-121-01, 50090-0558-0, 50090-3441-0, 50090-5091-0, 50383-021-05, 50383-021-10, 50383-021-15, 60429-753-01, 60429-754-01, 60505-1005-1, 60505-1005-4, 60758-801-05, 60758-801-10, 60758-802-05, 60758-802-10, 61314-224-05, 61314-224-25, 61314-225-05, 61314-225-25, 61314-226-05, 61314-226-10, 61314-226-15, 61314-227-05, 61314-227-10, 61314-227-15, 61314-245-01, 61314-245-02, 61314-245-03, 62332-545-05, 62332-546-05, 63629-7167-1, 63629-7167-2, 63629-7167-3, 63629-7167-4, 64980-513-01, 64980-513-05, 64980-513-15, 64980-514-01, 64980-514-05, 64980-514-15, 67877-229-11, 67877-229-15, 67877-229-55, 68682-045-25, 68682-045-50, 68682-812-05, 68682-813-05, 68682-813-10, 70518-2353-0, 76478-001-05, 76478-001-10, 76478-001-15, 76478-002-05, 76478-002-10, 76478-002-12, 76478-002-15, 76519-1163-0, 0527-1763-73, 17478-514-11, 17478-604-15, 17478-604-30, 17478-604-90, 17478-605-10, 24208-486-05, 24208-486-10, 42571-147-26, 50090-1247-0, 50383-233-05, 50383-233-10, 50383-261-61, 50383-261-91, 60429-115-10, 61314-030-01, 61314-030-02, 65862-947-18, 65862-947-60, 69315-305-05, 69315-305-10, 70069-051-12

Carbonic anhydrase inhibitors	0006-3519-36, 0065-0275-10, 0065-0275-15, 0065-0275-25, 0998-0203-15, 0998-0204-15, 0998-0206-15, 17478-223-12, 17478-224-12, 17478-226-12, 24208-485-10, 42571-141-26, 50090-1246-0, 50090-5280-0, 50383-232-05, 50383-232-10, 60219-1745-8, 60219-1746-8, 60219-1747-8, 60429-114-10, 61314-019-10, 61314-203-15, 61314-204-15, 61314-206-15, 62332-519-10, 69238-1745-8, 69238-1746-8, 69238-1747-8, 69315-304-05, 69315-304-10, 70069-181-01, 70069-191-01, 70069-201-01, 0527-1763-73, 17478-514-11, 17478-604-15, 17478-604-30, 17478-604-90, 17478-605-10, 24208-486-05, 24208-486-10, 42571-147-26, 50090-1247-0, 50383-233-05, 50383-233-10, 50383-261-61, 50383-261-91, 60429-115-10, 61314-030-01, 61314-030-02, 65862-947-18, 65862-947-60, 69315-305-05, 69315-305-10, 70069-051-12, 0065-4147-25, 0065-4147-27, 0078-0904-38, 0078-0904-98
Prostaglandin analogues	0013-8303-04, 0023-3205-02, 0023-3205-03, 0023-3205-05, 0023-3205-08, 0065-0260-02, 0065-0260-05, 0065-0260-25, 0078-0946-25, 0078-0946-40, 0078-0946-98, 0378-9651-32, 0378-9651-50, 0781-6185-56, 0781-6185-75, 0781-6206-75, 0781-6206-93, 13985-610-02, 17478-609-10, 17478-609-30, 17478-609-90, 17478-625-12, 24208-463-25, 47335-317-90, 47335-317-92, 47335-317-94, 47335-317-98, 50383-908-02, 50383-908-05, 50383-908-07, 50383-912-03, 50383-912-05, 59762-0333-2, 60505-0583-1, 60505-0583-4, 60505-0583-5, 60505-0593-1, 60505-0593-4, 61314-547-01, 61314-547-03, 61919-112-25, 62332-507-05, 62332-507-25, 62332-510-05, 62332-510-25, 62332-511-03, 62332-511-05, 64980-516-25, 65862-872-25, 68071-4612-2, 68071-4650-2, 68071-4893-2, 68083-295-01, 68083-296-01, 68180-429-01, 68180-429-02, 68180-429-03, 70069-401-01, 70069-402-01, 70069-403-01, 70069-421-01, 70069-421-03, 71205-154-25, 72266-139-01, 72266-140-01, 24208-504-01, 24208-504-02, 24208-504-05, 24208-504-06, 70727-529-25, 70727-529-99
Nitric oxide donators	24208-504-01, 24208-504-02, 24208-504-05, 24208-504-06
Rho kinase inhibitors	70727-497-25, 70727-497-99, 70727-529-25, 70727-529-99

Glaucoma surgeries and laser procedures (CPT)	Incisional glaucoma shunt surgery	1261, 1264, 1265, 1267, C1783, L8612, 66160, 66170, 66172, 66179, 66180, 66184, 66185
	MIGS drainage devices	0191T, 0253T, 0376T, 0449T, 0450T, 0474T, 66183, 66989, 66991
	Other MIGS without drainage devices	65820, 65850, 66174, 66175
	Laser glaucoma procedures	65855, 66710, 66711
Type of steroid injection (HCPCS)	Triamcinolone	J3300, J3301
	Dexamethasone	J7312
	Fluocinolone	J7311, J7313
Location of steroid injection (CPT)	Subconjunctival	68200
	Retrobulbar (including sub-Tenons)	67515, 67500
	Intravitreal	67027, 67028