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ORIGINAL RESEARCH

Validation of Diagnostic Codes to Identify Glaucoma in Taiwan's Claims Data: A Multi-Institutional Study

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Background: Healthcare databases play a crucial role in improving our understanding of glaucoma epidemiology, which is the leading cause of irreversible blindness globally. However, the accuracy of diagnostic codes used in these databases to detect glaucoma is still uncertain.

Aim: To assess the accuracy of ICD-9-CM and ICD-10-CM codes in identifying patients with glaucoma, including two distinct subtypes, primary open-angle glaucoma (POAG) and primary angle-closure glaucoma (PACG).

Methods: We analyzed electronic medical records data from a 2% random sample of patients who newly underwent visual field examination in Taiwan's largest multi-institutional healthcare system from 2011 to 2020. The diagnosis of glaucoma was confirmed by two ophthalmologists, based on the glaucoma diagnostic criteria. The positive predictive value (PPV), negative predictive value (NPV), sensitivity and specificity for ICD-9-CM codes 365.1X and 365.2X, and ICD-10-CM codes H4010X, H4011X, H4012X, H4020X, H4021X, H4022X, H4023X and H4024X for glaucoma were calculated.

Results: We randomly selected 821 patients (mean age: 56.9 years old; female: 50.5%) from the original cohort of 41,050 newly receiving visual field examination in the study. Among 464 cases with an ICD-9-CM glaucoma code, the sensitivity, specificity, PPV and NPV for glaucoma were 86.5, 96.5, 91.9, and 90.9%, respectively. Among 357 cases with an ICD-10-CM glaucoma code, the sensitivity, specificity, PPV and NPV for glaucoma were 87.0, 92.8, 92.2 and 87.9%, respectively. The accuracy of diagnostic codes to identify POAG and PACG remained consistent.

Conclusion: The diagnostic codes were highly reliable for identifying cases of glaucoma in Taiwan's routine healthcare practice. These results provide confidence when using ICD-9-CM and ICD-10-CM codes to define glaucoma cases in healthcare database research in Taiwan.

Keywords: primary open angle glaucoma, primary angle closure glaucoma, ICD-9-CM codes, ICD-10-CM codes, validation, database research, chang gung research database

Introduction

Glaucoma is the leading cause of irreversible blindness worldwide,[1] and the estimated number of people affected by glaucoma will reach nearly 112 million by the year 2040, having increased from 76 million in 2020.[2–4] Since the epidemiological features of glaucoma are incompletely understood, and treatment strategies are constantly being improved,[5–10] it is important to assess clinical features, risk factors and treatment effectiveness of glaucoma in the population under real-world conditions.

Many observational studies using secondary data sources [eg, electronic medical records (EMRs), healthcare data, health insurance claims data or administrative data] have been published to address the clinical questions related to glaucoma, and their findings may improve disease understanding and promote further decisions in clinical practice. For example, based on California Medicare data, Yao et al found that myopia was associated with greater risk of POAG.[11] Shao et al, using Taiwan's EMR data, indicated that use of sodium glucose co-transporter 2 inhibitors was associated

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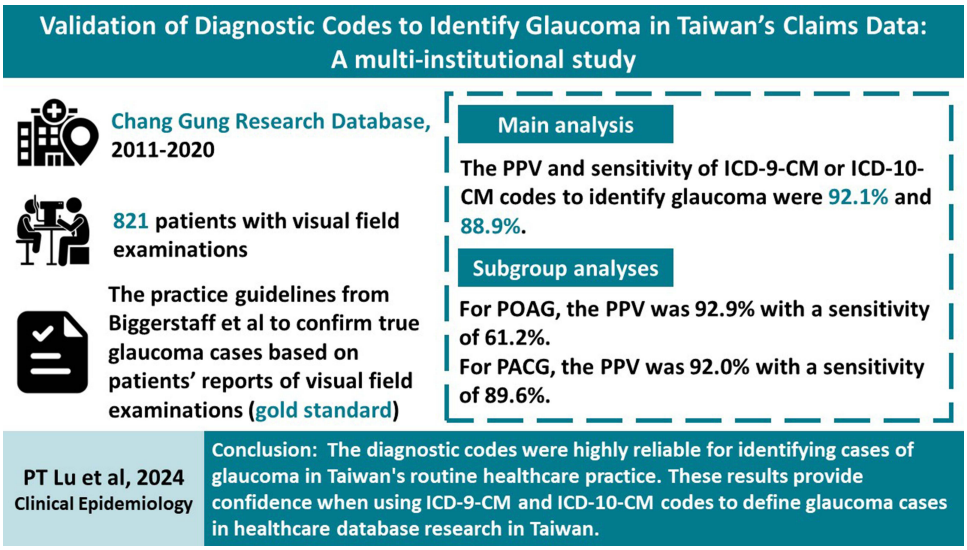
Graphical Abstract



with a lower risk of incident glaucoma.[12] Since most secondary database studies identify glaucoma by using the relevant disease diagnostic codes, the impact of misclassification bias may threaten the study validity if the coding accuracy is unclear in these secondary databases.[13]

So far, only three validation studies conducted in the USA and UK have assessed the accuracy of glaucoma diagnostic codes in secondary databases.[14–16] However, there is still a need for more extensive evaluations of coding validity for glaucoma. For instance, none of the prior studies examined the accuracy of diagnostic codes specifically related to primary angle-closure glaucoma (PACG), a significant subtype of glaucoma prevalent in Asia.[17,18] Moreover, previous validation investigations solely concentrated on the precision of ICD-9-CM codes for glaucoma,[14–16] leaving the coding accuracy of ICD-10-CM glaucoma codes uncertain. To fill these research gaps, we acquired EMRs from a randomly selected group of patients who had undergone visual field examinations – considered the gold standard for diagnosing glaucoma – within Taiwan's largest healthcare system. We proceeded to evaluate the accuracy of ICD-9-CM and ICD-10-CM codes in identifying patients with glaucoma, as well as two specific subtypes of glaucoma (primary angle-closure glaucoma, PACG and primary open-angle glaucoma, POAG).

Materials and Methods

Study Settings

This study analyzed data from the Chang Gung Research Database (CGRD) which collects the EMRs from nine hospitals affiliated with the Chang Gung Medical Foundation (CGMF), the largest multi-institutional healthcare system in Taiwan.[19] These CGMF hospitals, including Taipei, Keelung, Tucheng, Linkou, Taoyuan, Yunlin, Chiayi, Kaohsiung, and Fengshan branches, cover more than 10% of the total healthcare volume in Taiwan.[19] As an important data source, the CGRD has provided much real-world evidence for clinical practitioners or policy makers.[20–24] The study was approved by the Institutional Review Board of CGMF (IRB No: 202200878B0) and was conducted in accordance with the principles outlined in the Declaration of Helsinki. Due to its retrospective design, the requirement for informed consent was waived, ensuring patient privacy and confidentiality were upheld throughout the study.

Study Cohort

This study used the claims data reported to the National Health Insurance Administration, retrieved from the CGRD. Since visual field examinations are commonly used in clinical practice to assess suspected cases of glaucoma and exclude other diseases in the field of neuro-ophthalmology,[25] we initially identified all patients who underwent visual field examination between 2011 and 2020 from the CGRD as the original study cohort. If patients received multiple visual field examinations during the study period, we only included the first result for each patient. From the original study cohort, a 2% patient sample was selected using simple random sampling, ensuring that all patients had an equal chance of being selected and no patients were selected more than once, to review their EMRs in order to assess the validity of ICD-9-CM or ICD-10-CM glaucoma codes in the claims data.

Ascertainment of Glaucoma

Two ophthalmologists (PTL and THT) independently reviewed the EMRs of the random sample taken from the original cohort,[26,27] whereby any discrepancies between the reviewers were resolved through comprehensive discussion with a senior glaucoma specialist (LHC). We followed the practice guidelines from Biggerstaff et al to confirm true glaucoma cases based on patients' reports of visual field examinations (gold standard),[14] and the primary diagnostic criteria for glaucoma, including at least one of the following: 1) Cup to disc ratio of ≥ 0.6 in at least one eye. 2) Cup to disc ratio difference of ≥ 0.2 between the right and left eyes. 3) Humphrey visual field (HVF) results indicating patterns consistent with glaucomatous defects or 4) History of previous glaucoma surgery, specifically involving trabeculectomy or tube shunt implantation. Due to the clear diagnostic criteria for glaucoma, the rate of agreement on glaucoma case ascertainment between the two reviewers was 96% in this validation study. To further verify the glaucoma subtypes, we also examined gonioscopy records to determine if the angle was open or closed. For patients without gonioscopy records, the angle findings were determined through slit lamp bio-microscopy using the Van Herick method.[28] Patients were classified as having POAG if gonioscopy or slit lamp bio-microscopy indicated an open angle. Conversely, patients were categorized as having PACG if an angle closure was observed.

Statistical Analysis

We evaluated the positive predictive value (PPV), negative predictive value (NPV), sensitivity and specificity with 95% confidence intervals (CI) of ICD-9-CM codes of 365.1X (open-angle glaucoma), 365.2X (angle-closure glaucoma) and ICD-10-CM codes of H4010X (unspecified open-angle glaucoma), H4011X (primary open-angle glaucoma), H4012X (low-tension glaucoma), H4020X (unspecified primary angle-closure glaucoma), H4021X (acute angle-closure glaucoma), H4022X (chronic angle-closure glaucoma), H4023X (intermittent angle-closure glaucoma), H4024X (residual stage of angle-closure glaucoma) to identify glaucoma in the CGRD.[29] We also reported the coding accuracy for POAG (ICD-9-CM code: 365.1X; ICD-10-CM codes: H4010X, H4011X and H4012X), PACG (ICD-9-CM code: 365.2X; ICD-10-CM codes: H4020X, H4021X, H4022X, H4023X and H4024X) and unspecified glaucoma (ICD-9-CM code: 365.9; ICD-10-CM code: H409). Specifically, the unspecified glaucoma codes lacked the diagnostic specificity needed to identify false negative cases, making it only possible to calculate the PPV. Finally, we reported the number and frequency to summarize the reasons for false-positive glaucoma cases identified by the ICD-9-CM and ICD-10-CM codes. Data analyses were performed using SPSS version 23 (SPSS Inc., Chicago IL).

Results

We identified a total of 41,050 patients who underwent visual field examinations in the study, of which a random sample of 821 patients (2% of the total) was included for the detailed review of their EMRs (Figure 1). The average age of this random sample was 56.9 years, with 415 (50.5%) being female. A total of 390 patients out of the random sample (390/821=47.5%) were assigned ICD-9-CM or ICD-9-CM glaucoma codes. We found 359 of these (359/390=92.1%) were confirmed as true-positive glaucoma cases, and 31 (31/390=7.9%) were judged as false-positive cases identified by ICD-9-CM or ICD-10-CM glaucoma codes. A total of 431 patients out of the random sample (431/821=52.5%) were not assigned ICD-9-CM or ICD-10-CM glaucoma codes. We found 386 of these (386/431=89.6%) were judged as true-negative glaucoma cases, but 45 (45/431=10.4%) were confirmed as false-negative cases identified by ICD-9-CM or ICD-10-CM glaucoma codes. Overall,

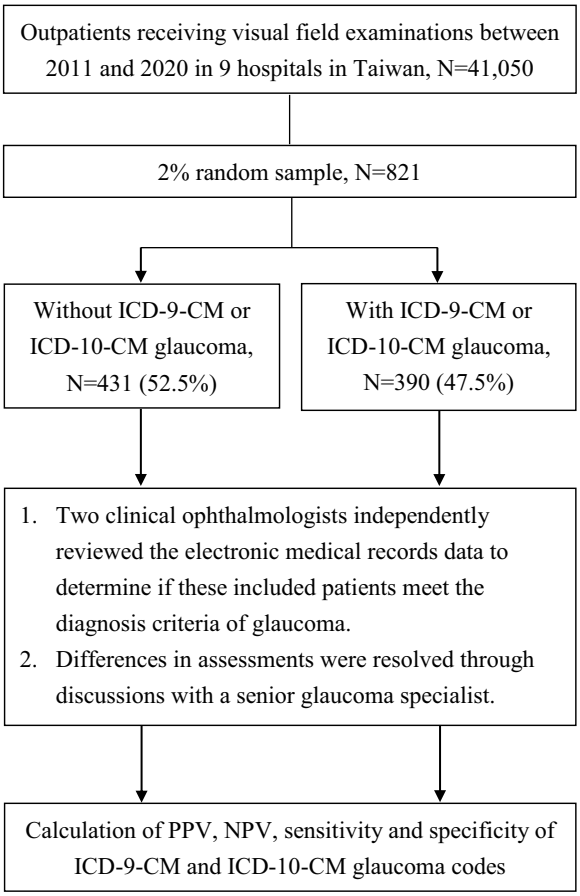


Figure 1 Process of validation study.

the PPV, NPV, sensitivity and specificity of ICD-9-CM or ICD-10-CM codes to identify glaucoma was 92.1%, 90.0%, 88.9% and 92.6%, respectively.

The coding validity for each ICD-9-CM and ICD-10-CM glaucoma code is separately summarized in Table 1. The ICD-9-CM glaucoma codes demonstrated a sensitivity of 86.5%, specificity of 96.5%, PPV of 91.9%, and NPV of 90.9%, and the ICD-10-CM glaucoma codes showed a sensitivity of 87.0%, specificity of 92.8%, PPV of 92.22%, and NPV of 87.9%. The ICD-9-CM POAG codes showed a sensitivity of 64.4%, specificity of 96.5%, PPV of 91.9%, and NPV of 90.9%, and ICD-10-CM POAG codes showed a sensitivity of 57.4%, specificity of 97.4%, PPV of 92.5%, and NPV of 80.1%. In addition, the PPVs of the ICD-9-CM (91.1%) and ICD-10-CM (90.5%) low-tension glaucoma codes were similar to those of the overall coding validity for POAG. The ICD-9-CM PACG glaucoma codes revealed a sensitivity of 96.3%, specificity of 99.0%, PPV of 92.9%, and NPV of 99.5%, and ICD-10-CM PACG codes revealed a sensitivity of 73.9%, specificity of 99.4%, PPV of 89.5%, and NPV of 98.2%. The ICD-9-CM and ICD-10-CM unspecified glaucoma codes each showed PPVs of 82.1% and 81.0%, respectively.

In total, we identified 31 cases (31/390=7.9%) falsely coded by ICD-9-CM or ICD-10-CM glaucoma codes. We found that 58.1% of these cases were tentatively diagnosed with glaucoma but later changed to normal visual field interpretation, 25.8% of these cases were judged to be borderline glaucomatous but with insignificant visual field progression during follow-up, and 16.1% of these cases were finally judged as other diseases, such as retinitis pigmentosa, optic neuritis, age-related macular degeneration and pituitary tumor (Table 2).

Table 1 Accuracy of ICD-9-CM and ICD-10-CM Codes to Identify Glaucoma

	TP, n	FP, n	FN, n	PPV, % (95% CI)	NPV, % (95% CI)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
All glaucoma subtypes	359	31	45	92.1 (88.9–94.5)	90.0 (86.7–92.7)	88.9 (85.4–91.8)	92.6 (90.0–94.9)
ICD-9-CM codes (365.1X, 365.2X, 365.9)	205	18	22	91.9 (87.5–95.2)	90.9 (86.5–94.2)	86.5 (81.5–90.6)	96.5(93.2–98.5)
ICD-10-CM codes (H4010X, H4011X, H4012X, H4020X, H4021X, H4022X, H4023X, H4024X)	154	13	23	92.2 (87.1–95.8)	87.9 (82.4–92.2)	87.0 (81.1–91.6)	92.8 (88.0–96.1)
Primary open-angle glaucoma	170	13	108	92.9 (88.2–96.2)	83.1 (80.0–85.9)	61.2 (55.2–66.9)	97.6 (95.9–98.7)
ICD-9-CM codes (365.1X)	96	7	53	93.2 (86.5–97.2)	85.3 (81.2–88.8)	64.4 (56.2–72.1)	97.8 (95.5–99.2)
ICD-10-CM codes (H4010X, H4011X, H4012X)	74	6	55	92.5 (84.4–97.2)	80.1 (75.0–84.7)	57.4 (48.4–66.0)	97.4 (94.4–99.0)
Primary angle-closure glaucoma	69	6	8	92.0 (83.4–97.0)	98.9 (98.0–99.5)	89.6 (80.6–95.4)	99.2 (98.3–99.7)
ICD-9-CM codes (365.2X)	52	4	2	92.9 (82.7–98.0)	99.5 (98.2–99.9)	96.3 (87.3–99.6)	99.0 (97.5–99.7)
ICD-10-CM codes (H4020X, H4021X, H4022X, H4023X, H4024X)	17	2	6	89.5 (75.7–98.7)	98.2 (96.2–99.4)	73.9 (51.6–89.8)	99.4 (97.9–99.9)
Unspecified glaucoma*	120	27	N/A	81.6 (74.4–87.5)	N/A	N/A	N/A
ICD-9-CM code (365.9)	69	15	N/A	82.1 (72.3–89.7)	N/A	N/A	N/A
ICD-10-CM code (H409)	51	12	N/A	81.0 (69.1–89.8)	N/A	N/A	N/A

Notes: *We only calculated the PPVs of ICD-9-CM and ICD-10-CM unspecified glaucoma codes, because no false negative cases could be detected with these codes.
Abbreviations: TP, True positive; FP, false positive; FN, false negative; ICD-9-CM code, International Classification of Diseases Code; 9th Revision; Clinical Modification; ICD-10-CM, International Classification of Diseases; 10th Revision; Clinical Modification; PPV, positive predictive value; NPV, negative predictive value; CI, confidence interval; N/A, not applicable.

Table 2 Reasons for False-Positive Glaucoma Cases

Reasons	n (%)
All glaucoma subtypes (n=31)	
Tentative diagnosis to rule out glaucoma but final interpretation was normal visual field	18 (58.1)
Borderline glaucomatous finding without significant visual field progression during serial follow-ups	8 (25.8)
Misclassification	
Retinitis pigmentosa	2 (6.5)
Optic neuritis	1 (3.2)
Age-related macular degeneration	1 (3.2)
Pituitary tumor	1 (3.2)
Primary open angle glaucoma (n=13)	
Tentative diagnosis to rule out glaucoma but final interpretation was normal visual field	1 (7.7)
Misclassification	
Primary angle closure glaucoma	8 (61.5)
Secondary glaucoma	4 (30.8)
Primary angle closure glaucoma (n=6)	
Tentative diagnosis to rule out glaucoma but final interpretation was normal visual field	2 (33.3)
Misclassification	
Secondary glaucoma	3 (50.0)
Age-related macular degeneration	1 (16.7)
Unspecified glaucoma (n=27)	
Tentative diagnosis to rule out glaucoma but final interpretation was normal visual field	15 (55.6)
Borderline glaucomatous finding without significant visual field progression during serial follow-ups	8 (29.6)
Misclassification	
Retinitis pigmentosa	2 (7.4)
Optic neuritis	1 (3.7)
Pituitary tumor	1 (3.7)

Notes: *Concurrent coding for both primary open-angle glaucoma and unspecified glaucoma was carried out in 15 false-positive glaucoma cases.

Discussion

This multi-institutional cross-sectional study was the first to report the validity of ICD-9-CM and ICD-10-CM codes to identify glaucoma cases in Taiwan, and our results indicated a PPV of 92.1% and a sensitivity of 88.9% for all types of ICD-9-CM and ICD-10-CM glaucoma codes. Specifically, for POAG, the PPV was 92.9% with a sensitivity of 61.2%. For PACG, the PPV was 92.0% with a sensitivity of 89.6%. More importantly, the validities of ICD-9-CM and ICD-10-CM glaucoma codes were consistent. Based on these findings, we could conclude that the accuracy of ICD-9-CM and ICD-10-CM glaucoma codes used in routine care data in Taiwan are acceptable and reliable for identifying glaucoma cases.

The patient characteristics of the sample in this present study show that 50.5% were female with a mean age of 56.9 years. Our results are compatible with the epidemiology of glaucoma in previous studies in Asia, reinforcing the data representativeness of potential glaucoma cases recorded in the CGRD.[30,31] The PPVs for ICD-9-CM and ICD-10-CM glaucoma codes (92%) in our study were higher than those reported in two validation studies from the US (65%) and UK (84%), but similar to another report from the UK (89%),[14–16] and two possible reasons may explain the difference in reported PPVs of glaucoma diagnostic codes. First, different coding practices in different healthcare systems should be noted. For example, Biggerstaff KS et al validation study in the US found that 71% of glaucoma diagnostic codes were coded by ophthalmology residents, 18% by an optometrist, 3% by an attending ophthalmologist, and 0.5% by an ophthalmology fellow in the study eye center.[14] However, in this present study, the glaucoma diagnostic codes were all coded by attending ophthalmologists. Given the varying coding practices within different healthcare systems, our findings reinforce the importance of individual validation study of glaucoma diagnostic codes in different healthcare databases.[27] Second, different validation algorithms among studies should also be noted. For example, Kang et al validation study in the UK used a patient self-reporting questionnaire to confirm the glaucoma diagnostic codes, which may have underestimated the true glaucoma cases. However, in this present study, the glaucoma diagnostic codes were confirmed by two independent ophthalmologists based on practice guidelines from Biggerstaff et al[14] and our findings suggested more reliable and more accurate validity of ICD-9-CM and ICD-10-CM glaucoma codes.

We observed generally similar validity for ICD-9-CM and ICD-10-CM codes to identify the glaucoma subtypes, but lower sensitivity of these diagnosis codes for POAG, compared to those for PACG. We found clinical ophthalmologists often use ICD-9-CM code 365.9 or ICD-10-CM codes 365.9 or H40.9 (unspecified glaucoma) for POAG diagnoses in Taiwan. The explanation for this coding practice may be that it is due to the time constraints and high workload demands placed on ophthalmologists in the outpatient clinics in hospitals. However, we did not find this issue in cases of PACG. This could be attributed to the clinical characteristics of narrow-angle conditions, which are relatively discernible and distinct, prompting clinical ophthalmologists to select the diagnostic code specifically for PACG rather than for a more general "unspecified glaucoma" diagnostic code. Under the National Health Insurance program, patients in Taiwan have full and unrestricted access to all medical care facilities.[32] For example, the number of outpatient visits per year is over 9 million in CGMF hospitals, and doctors frequently see over 50 outpatients in a morning, spending only 5 min or less for each consultation.[32] Our findings suggested proper training and awareness among ophthalmologists and healthcare providers about the significance of accurate coding for POAG should be reinforced to avoid misclassification of such cases in Taiwan's healthcare database.

Our findings could serve as an essential reference for future investigators who are interested in analyzing Taiwan's secondary healthcare database for glaucoma research. The high PPVs of ICD-9-CM and ICD-10-CM glaucoma codes ensure their accuracy to identify true glaucoma cases. In addition, the high NPVs of ICD-9-CM and ICD-10-CM glaucoma codes indicate a low probability of missing true glaucoma cases if patients were not assigned the diagnosis codes for glaucoma.

This study has several notable strengths. First, it was the first study to validate ICD-10-CM glaucoma codes, and our results indicated that the validity of ICD-10-CM glaucoma codes is similar to that of ICD-9-CM glaucoma codes in Taiwan. Also, similar PPVs for low-tension glaucoma diagnosis codes reaffirmed our result robustness. Second, it was also the first study to validate the ICD-10-CM PACG codes, a significant subtype of glaucoma that is prevalent in Asian countries.[17,18] Third, our study analyzed Taiwan's largest multi-institutional EMR database, and our findings may be more generalizable to routine practice in Taiwan. However, it is also essential to acknowledge some limitations in our study. First, we reviewed the EMRs to assess validity of glaucoma codes in the claims data from only 821 patients (2%),

who were selected by simple random sampling from the original cohort. However, this group was actually larger than in the two previous, similar validation studies.[14,16] Second, we observed that 33.4% of confirmed glaucoma cases were coded by ICD-9-CM or ICD-10-CM unspecified glaucoma codes. This, in fact, may potentially reduce the sensitivity of ICD-9-CM or ICD-10-CM POAG codes. Third, this represents the largest multi-institutional validation study of glaucoma diagnostic codes in Taiwan. The CGMF hospitals account for over 10% of the total healthcare volume in Taiwan, but they do not include local clinics. Consequently, it remains uncertain whether our study results can be extrapolated to the general population served by clinics in Taiwan. Therefore, additional validation studies conducted at local clinics are necessary to corroborate our findings.

Conclusion

This study established optimal validity for the ICD-9-CM and ICD-10-CM glaucoma codes in Taiwan's routine care data. The consistency observed in the validity of ICD-9-CM and ICD-10-CM codes indicated their accuracy for identifying glaucoma within routine care data. Our findings provide a valuable foundation for future research utilizing healthcare databases, which could contribute to enhancing the comprehension and management of glaucoma.

Author Contributions

All authors made a significant contribution to the reported work, whether in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas. All authors took part in drafting, revising or critically reviewing the article; they all gave approval for the final version to be published and all have agreed on the journal to which the article is to be submitted. Furthermore, all authors agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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