



Ocular Complications in Type 2 Diabetes Mellitus Patients with Chronic Kidney Disease: A Retrospective Cohort Study based on the Indonesian National Health Insurance Data

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Abstract

The global prevalence of type 2 diabetes mellitus (T2DM) is projected to rise dramatically. Southeast Asia regions will predictably face a 73% increase by 2050, exacerbating risks of microvascular complications like chronic kidney disease (CKD) and ocular disorders. This study aims to investigate the association between ocular comorbidity in type 2 diabetes mellitus (T2DM) patients with a chronic kidney disease (CKD) according to the Indonesian National Health Insurance data. This retrospective cohort study analyzed 7,581 T2DM patients (11.4% with CKD) from Indonesian National Health Insurance (NHI) database year 2016–2023. Odds ratios (OR) and hazard ratios (HR) for ocular diagnoses (ICD-10 codes) were calculated using contingency tables and cox regression after propensity score matching (PSM) for age and sex. Other retinal disorders (OR: 2.96, 95% CI: 2.22–3.96), vitreous body disorders (OR: 2.92, 95% CI: 2.09–4.08), and other cataracts (OR: 1.70, 95% CI: 1.35–2.13) had significantly higher odds of CKD occurrence in T2DM patients. Conversely, refractive errors showed a lower OR (0.79, 95% CI: 0.64–0.99). Adjusted HRs confirmed elevated risks of CKD in T2DM patients with other retinal disorders (HR: 2.03) and vitreous body disorders (HR: 1.72). T2DM patients with retinal disorders, vitreous body disorders, globe abnormalities, cataracts, and glaucoma showed markedly higher risks of developing CKD, underscoring the need for integrated screening and management.

INTRODUCTION

The Diabetes Atlas 2025 predicts that the global prevalence of diabetes mellitus will rise by 45%, from 588.7 million in 2024 to 852.5 million by 2050. Notably, Southeast Asia is expected to have the most increase in diabetes mellitus, with a 73% rise underscoring a significant regional concern (IDF, 2025). The rising burden of type 2 diabetes mellitus (T2DM) is linked to various microvascular and macrovascular complications,

which significantly contribute to morbidity, mortality, and healthcare costs (Alnaim et al., 2023; Erdogan et al., 2024; Kim et al., 2019; Laotaveerungrueng et al., 2018; Li et al., 2023; Vijayakumar et al., 2018; Yan et al., 2023).

Diabetic kidney disease (DKD) is a major complication, affecting 30-50% of diabetic patients (Thomas et al., 2015) and serving as the primary cause of end-stage kidney disease (ESKD) worldwide (Harris et al., 2021; Snow et

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al., 2022; Sukkar et al., 2020; Yang et al., 2022). Moreover, diabetes mellitus, particularly T2DM, also heightens the risk of various ocular disorders, including diabetic retinopathy (DR), cataracts, glaucoma, and diabetic macular edema (DME), which remain the leading causes of preventable blindness worldwide (Estevez et al., 2024; Jonny et al., 2023; Yan et al., 2023; Zhang et al., 2020). The prevalence of vision loss due to diabetic retinopathy varies across populations and is influenced by comorbidities, notably chronic kidney disease (CKD) (Estevez et al., 2024; He et al., 2024; Lupidi et al., 2025). A recent study found that patients with diabetes receiving renal hemodialysis demonstrated a high prevalence of diabetic retinopathy and associated with vision loss in the vulnerable population. These findings highlight the increased risk associated with diabetic complications along with CKD, particularly among populations receiving intensive renal therapy (Estevez et al., 2024; He et al., 2024; Lupidi et al., 2025). It is particularly crucial to detect and treat eye problems early, especially in people with microvascular diseases such as CKD (Sayin, 2015a).

Despite the growing body of evidence globally, data on the relationship between CKD and a ocular microvascular disease specific to Southeast Asian populations, including Indonesia, remain limited. Indonesia faces an alarming rise in diabetes prevalence, coupled with an increasing burden of CKD (Hidayat et al., 2022; IDF, 2025; Soewondo et al., 2013). The study aims to evaluate the burden of ocular complications as risks of CKD, encompassing other retinal illnesses, vitreous body disorders, globe disorders, cataracts, glaucoma, and refractive and accommodative disorders, in high-risk population like T2DM patients. This study's results are important to develop an efficient screening and management plan for cutting down on vision loss among T2DM patients.

METHOD

Study Design

This study employed a retrospective cohort design to evaluate the association between ocular comorbidity and the occurrence of chronic kidney disease (CKD) events in T2DM patients. We identified a cohort of adult T2DM patients (aged ≥ 18 years) from de-identified claims. Within this cohort, patients were stratified by the presence of an eye complication and then followed to assess CKD occurrence. The index date was defined as the first T2DM claim, with follow-up until the occurrence of CKD, death, loss to follow-up,

or study end. Ocular diseases included retinal disorders (H35), vitreous body disorders (H43), globe disorders (H44), cataracts (H26), glaucoma (H40), and refraction/accommodation disorders (H52), identified via ICD-10 codes. This design also assessed both prevalence and incidence of ocular comorbidity diseases, adjusting for confounders to estimate CKD occurrence.

Data Source

This study utilized data from Prolanis Program, a part of the Indonesia's National Health Insurance (NHI) program, spanning from 2016 to 2023. The data set included adult patients diagnosed with T2DM, identified using the ICD-10 code E11. To be included in the study, patients must have at least one record of an outpatient or inpatient visit. CKD was identified using ICD-10 codes of N18. Approximately 90% of CKD cases were classified as advanced-stage CKD (N18.5–N18.6), while the remaining 10% were recorded as unspecified CKD.

Data Analysis

Descriptive statistics were employed to compare baseline characteristics between CKD patients ($n = 864$) and those without CKD ($n = 6,717$). These statistics provided an overview of different demographics and clinical presentations between the two groups. Logistic regression analyses were conducted to calculate odds ratios for various ocular diagnoses. This analysis aimed to assess the likelihood of different ocular complications occurring in CKD patients compared to those without CKD, as detailed in Table 2.

To adjust potential confounding variables, the researchers employed propensity score matching (PSM) (Zhao et al., 2021). This method balanced age and sex between CKD and non-CKD groups using the nearest neighbor matching variables with a caliper of 0.01, ensuring a more accurate comparison of outcomes. Age and sex were selected as matching variables because they were consistently and completely available in the claim database. Besides, they are recognized as important determinants of both CKD and ocular complications among T2DM patients. Post-matching, cox proportional hazards models were used to estimate hazard ratios of CKD occurrence. These models assessed time-to-occurrence data and evaluated CKD occurrence. All statistical analyses were performed using R software, version 4.2.2, ensuring rigorous and reproducible results.

Ethical Approval

The study was approved by the Health Research Ethics Committee, Faculty of Public Health, Diponegoro University, with a certificate number 372/EA/KEPK-FKM/2024. As this study involved the analysis of the secondary data, the requirement for informed consent was waived by the ethics committee.

RESULTS AND DISCUSSION

The comparison between T2DM patients and T2DM patients with CKD revealed notable differences in clinical and demographic characteristics. The CKD group comprised 864 patients (11.4%), while the non-CKD group included 6,717 patients (88.6%). The mean age was slight-

ly higher in the non-CKD group (54.3 ± 9.0 years) compared to the CKD group (53.1 ± 9.1 years), and the difference was statistically significant ($p = < 0.001$), indicating that patients with CKD tended to be younger. The distribution of sex was comparable across groups. No significant difference was observed between males (45.7–45.9%) and females (54.1–54.3%), with p-values exceeding 0.960.

Regarding clinical history and visit patterns, significant differences were observed in the number of healthcare visits. CKD patients showed a higher mean visit (180.6; min 2, median 133.5, max 993) than non-CKD patients (79.3; min 2, median 54, max 1107). The difference in clinical history and visit patterns was highly sig-

Table 1. Baseline characteristics of T2DM patients according to CKD status

Characteristics	Total	CKD	Non-CKD	p-value
Patients, n (%)	7581	864 (11.4)	6717 (88.6)	-
Age, years (mean $\pm$ SD)	54.2 ± 9.0	53.1 ± 9.1	54.3 ± 9.0	<0.001
Male, n (%)	3,477 (45.9)	395 (45.7)	3,082 (45.9)	0.960
Female, n (%)	4,104 (54.1)	469 (54.3)	3,635 (54.1)	
Visit numbers, mean (min, med, max)	90.8 (2; 61; 1107)	180.6 (2; 133.5; 993)	79.3 (2; 54; 1107)	< 0.001
Overweight/Obesity, n (%)	2,035 (26.8)	211 (24.4)	1,824 (27.2)	0.150
Hypertension, n (%)	736 (9.7)	97 (11.2)	639 (9.5)	0.100
Cardiovascular disease, n (%)	377 (5.0)	27 (3.1)	350 (5.2)	0.050
Heart failure, n (%)	18 (0.2)	4 (0.5)	14 (0.2)	0.090

Abbreviations: CKD = chronic kidney disease; SD = standard deviation; T2DM = type 2 diabetes mellitus. Continuous variables are presented as mean $\pm$ SD or mean (minimum, median, maximum). Categorical variables are presented as n (%). P-values were calculated using the Mann–Whitney U test for continuous variables and the chi-square test for categorical variables.

Table 2. The risk of ocular disorder on chronic kidney diseases

Code	Type of diagnosis	Diagnosis Status	CKD	Non-CKD	P-value	Odds Ratio (95% CI)	Risk Ratio (95% CI)
H35	Other retinal disorders	Yes	62	279	<0.001	2.96	2.32
		No	510	6,799		(2.22-3.96)	(1.84–2.92)
H43	Disorders of vitreous body	Yes	45	201	<0.001	2.92	2.17
		No	527	6,877		(2.09-4.08)	(1.84–2.92)
H44	Disorders of globe	Yes	11	49	0.002	2.81	2.22
		No	561	7,029		(1.45-5.44)	(1.24–3.98)
H26	Other cataract	Yes	101	794	<0.001	1.70	1.38
		No	471	6,284		(1.35-2.13)	(1.13–1.68)
H40	Glaucoma	Yes	25	203	0.044	1.55	1.38
		No	547	6,875		(1.01-2.37)	(0.94–2.03)
H52	Disorders of refraction and accommodation	Yes	102	1,521	0.040	0.79	0.85
		No	470	5,557		(0.64-0.99)	(0.70–1.02)

Table 3. Survival analysis of CKD according to ocular complications among T2DM patients

Exposure	Median Follow-Up (Exp/Unexp)	Person-Years (Exp/Unexp)	Incidence Rate (Exp/Unexp)	Pre-Match PH (p-val)	Pre-Match HR	Post-Match PH (p-val)	Post-Match HR (95% CI)
Refraction Accommodation	8.45/7.58	20568.35/37087.67	8.95/10.46	0.042	0.87 (0.73-1.04)	0.235	0.82 (0.67-1.00)
Other Retinal Disorders	8.25/7.90	4022.03/53633.99	21.13/9.08	0.032	2.25 (1.79-2.83)	0.026	2.03 (1.40-2.94)
Disorders Vitreous Body	8.33/7.90	2187.43/55468.59	21.94/9.45	0.003	2.17 (1.61-2.92)	0.004	1.72 (1.06-2.80)
Other Cataract	8.53/7.73	11444.95/46211.07	12.49/9.28	0.454	1.55 (1.28-1.89)	0.309	1.33 (1.03-1.71)
Glaucoma	8.85/7.87	3090.67/54565.35	12.30/9.79	0.859	1.28 (0.92-1.77)	0.534	1.18 (0.73-1.91)

nificant ($p < 0.001$).

The prevalence of overweight or obesity was about 24.4% in CKD patients and 27.2% in non-CKD patients, with a p-value of 0.150. Hypertension was slightly more common among CKD patients (11.2%) than non-CKD patients (9.5%), but this difference was not statistically significant ($p = 0.100$). Similarly, heart failure was more frequent in CKD patients (0.5%) than non-CKD patients (0.2%), but the difference was not statistically significant ($p = 0.090$). However, cardiovascular disease showed a rather significantly higher prevalence in the non-CKD group (5.2%) compared to the CKD group (3.1%), with a p-value of 0.05. The data suggest that younger age increased healthcare utilization, and a higher burden of cardiovascular comorbidities was associated with CKD in the T2DM population.

Patients with various ocular conditions exhibited a markedly higher likelihood of developing CKD. Specifically, the odds of CKD occurrence were nearly three times higher in patients with other retinal disorders (OR = 2.96; 95% CI: 2.22–3.96; $p < 0.001$), and similarly, the vitreous body disorders showed a significant association, being approximately three times more likely to be affected by CKD (OR = 2.92; 95% CI: 2.09–4.08; $p < 0.001$). Disorders of the globe were also strongly associated with CKD, with an odds ratio of 2.81 (95% CI: 1.45–5.44; $p = 0.002$).

Furthermore, other cataracts and glaucoma were significantly linked to a higher prevalence of CKD (OR = 1.70; 95% CI: 1.35–2.13; $p < 0.001$) and (OR = 1.55; 95% CI: 1.01–2.37; $p = 0.044$). Conversely, disorders of refraction and accommodation were less common in patients with CKD, with an odds ratio of 0.79 (95% CI: 0.64–0.99; $p = 0.040$), indicating a statistically significant inverse association. These findings suggest that several major ocular pathologies, es-

pecially retinal and globe-related anomalies, were strongly associated with CKD in T2DM patients. Therefore, this high-risk group need targeted ophthalmic screening.

Survival analysis of five ophthalmic exposure categories revealed heterogeneous associations with the outcome across subgroups. Among the specific disorder categories, other retinal disorders and disorders of the vitreous body (H43) demonstrated the strongest associations, with post-matching hazard ratios of 2.03 (95% CI 1.40–2.94) and 1.72 (95% CI 1.06–2.80), respectively, although both violated the proportional hazards assumption, warranting cautious interpretation of these single-summary HRs. Other cataract cases (H26) showed a modest but statistically significant elevation in hazard (post-matching HR 1.33, 95% CI 1.03–1.71) with the proportional hazard assumption, representing the most methodologically reliable finding among the elevated-risk subgroups. Glaucoma (H40) showed no significant association with the outcomes (post-matching HR 1.18, 95% CI 0.73–1.91), likely limited by statistical power given the smaller number of exposed person-years. Refraction and accommodation disorders (H52) exhibited a borderline protective effect (post-match HR 0.82, 95% CI 0.67–1.00), possibly reflecting a healthy-user bias among patients with regular ophthalmic follow-up. Consistent attenuation of hazard ratios after propensity score matching across all exposures indicates that pre-matching estimates were subject to positive confounding, in which the matching process was effectively addressed.

Our study highlights critical associations between CKD and various ocular pathologies in T2DM patients. The demographic analysis revealed that CKD patients tend to be slightly younger than non-CKD counterparts. This result is consistent with previous research indicating earlier

microvascular damage in younger diabetic patients with renal impairment (Wang et al., 2023). Notably, sex distribution was remarkably similar between groups, with no significant difference between males and females ($p = 0.96$), consistent with prior studies suggesting that sex may not be a major determinant of CKD progression or ocular complications in this population (Kaewput et al., 2019).

The number of healthcare visits among CKD patients was markedly higher with an average of 180.6 visits compared to 79.3 among non-CKD patients ($p < 0.0001$). This increased healthcare utilization likely reflects the complexity and severity of CKD and its associated comorbidities, which necessitate more frequent monitoring and management. The more frequent visit underlines the importance of frequent screening and potentials for integrated care approaches (Kresnowati et al., 2025), especially in the early detection of ocular complications. Frequent visits may also facilitate earlier diagnosis and treatment, potentially mitigating the progression of retinal and other ocular disorders in patients with CKD (Cushley et al., 2022; Kresnowati et al., 2025; Ting et al., 2016).

The research data demonstrate that retinal disorders (OR = 2.96), vitreous body disorders (OR = 2.92), globe abnormalities (OR = 2.81), and cataracts (OR = 1.70) were associated with substantially higher odds of developing CKD. These findings support previous evidence that microvascular damage related to CKD and diabetic retinopathy occurs concurrently (Kaewput et al., 2019; Sayin, 2015b). These results indicate a shared risk mechanism between CKD and eye disease, with both conditions sharing similar risk factors and pathogenetic mechanisms. Diabetic retinopathy shares several risk factors with CKD, such as age, diabetes mellitus, hypertension, obesity, and hyperlipidemia (Cheung & Wong, 2007; Klein MD Barbara E.K. E.K; Moss MA Scott E; De Mets. Dr, 1984; Klein MD Ronald; Klein MD, 1984; T. Y. Wong et al., 2004; Yau et al., 2012). Similarly, cataracts and CKD share risk factors such as age, smoking, diabetes mellitus, and obesity (Seddon et al., 2006; Weintraub WC; Rosner B; Colditz GA; Seddon JM; Hankinson SE, 2002). The pathogenic mechanisms shared between CKD and diabetic retinopathy include atherosclerosis, endothelial dysfunction, oxidative stress, inflammation, dysfunction of the renin-angiotensin system, and the klotho gene. In patients with CKD and cataracts, atherosclerosis, oxidative stress, and the klotho gene are also present (C. W. Wong et al., 2014).

The elevated odds ratios for retinal and vitreous disorders highlight the critical need for regular ophthalmic screening, especially in CKD patients, who are at higher risk of progressing to sight-threatening conditions such as proliferative diabetic retinopathy and diabetic macular edema (Ou et al., 2024; Wang et al., 2023). Conversely, the inverse association with disorders of refraction and accommodation (OR = 0.79) may reflect a behavioral bias in DM patients with comorbid refractive and accommodation disorders who seek medical checkups more regularly. In Indonesia, access to eye care services under the National Health Insurance scheme has been expanded to increase the utilization of comprehensive eye examinations and reduce financial barriers to obtaining ophthalmic care (Simanjuntak et al., 2018). Consequently, these patients may have more frequent interactions with healthcare providers, thereby creating more opportunities in preventing diabetes and detecting diabetes-related complications early (Sasongko et al., 2021; T. Y. Wong et al., 2018). Given the high hazard ratios observed for these ocular conditions, implementing routine early screening protocols is imperative for high-risk populations such as T2DM patients to prevent irreversible visual impairment (Elsayed et al., 2023). According to Cooper, early screening and treatment can often stop or reverse the progression of diabetes-related retinal disease (DRD) and protect vision. Routine eye examinations provide a thorough medical history, which is the most important aspect of any medical examination, and this applies to ocular evaluations in people with diabetes (Cooper, 2022).

In summary, the current research presents a significant finding that ocular microvascular complications are strong predictors of CKD. Future prospective studies should explore how these variables interact over time to inform tailored preventive strategies. A multidisciplinary approach involving endocrinologists, nephrologists, and ophthalmologists is crucial in reducing the burden of visual loss in patients with diabetes and CKD complications.

The innovative approaches such as “telere-tinal imaging and mobile eye screening” may be the cost-effective and feasible measures, applied in various healthcare settings across countries such as Australia, the United States, the United Kingdom, and India. These approaches may facilitate early detection and timely intervention of diabetic retinopathy, especially in remote and resource-limited areas (Ting et al., 2016).

This study has several limitations. First, its retrospective claims-based design limits the avail-

lability of detailed clinical information. Laboratory parameters such as HbA1c and CKD staging were not included in the analysis, and diabetes duration could not be assessed. Diabetes identification in primary care (E11 coding) was primarily based on fasting plasma glucose in this study. Meanwhile, HbA1c was more commonly used in referral care settings to assess glycemic control and disease severity; however, HbA1c-based stratification was beyond the scope of this study. Second, reliance on administrative coding may introduce potential coding and surveillance bias. Finally, residual confounding from unmeasured clinical and behavioral factors cannot be excluded from the analysis.

Education initiatives targeting patients and healthcare providers about the importance of regular ocular examinations are also crucial. Early detection and management, combined with improved access to specialized eye care, have the potential to significantly decrease the prevalence of preventable blindness in high-risk populations, such as patients with CKD. Future research should evaluate the long-term impact and cost-effectiveness of these screening modalities in the Indonesian healthcare context.

CONCLUSION

This study reveals a significant association between various ocular complications and CKD among T2DM patients in Indonesia. T2DM patients with retinal disorders, vitreous body disorders, globe abnormalities, cataracts, and glaucoma showed markedly higher risks of developing CKD, thus highlighting the shared microvascular damage pathways between the kidneys and eyes. These findings underscore the importance of early detection and regular ophthalmic screening in diabetic patients to prevent irreversible vision loss and CKD occurrence.

Integrating multidisciplinary care and innovative approaches such as teleretinal imaging, mobile eye screening, and targeted education can improve early diagnosis and treatment, especially in resource-limited settings. As the prevalence of diabetes and CKD continues to rise, implementing cost-effective, accessible screening strategies and coordinated care among endocrinologists, nephrologists, and ophthalmologists will be crucial to the reduction of preventable blindness in high-risk populations.

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DECLARATION OF GENERATIVE AI

This manuscript received limited assistance from an AI-based language tool (Quillbot and ChatGPT) for language refinement and grammar checking. The authors critically reviewed and finalized all content and accept full responsibility for the published work. No AI tools were used in data analysis or the interpretation of findings.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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