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Original Research

THE BURDEN OF PREMATURE VISION LOSS: WORKING-AGE VULNERABILITY TO PROLIFERATIVE DIABETIC RETINOPATHY IN INDONESIA

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ABSTRACT

Introduction : Diabetic retinopathy (DR) poses a critical threat to the productive workforce in developing nations. While disease duration and hyperglycemia are established risk factors, the vulnerability of working-age patients relative to the elderly remains to be fully characterized in resource-limited settings. This study aimed to identify independent predictors of Proliferative Diabetic Retinopathy (PDR), specifically evaluating differences across current age strata (working-age vs. elderly)

Methods: A retrospective analytical study was conducted on 118 patients with confirmed DR (NPDR=41; PDR=77) at a tertiary referral eye center in Indonesia. Age was stratified into 20–39, 40–59, and ≥60 years. Multivariate logistic regression was performed to determine independent predictors, adjusting for gender, diabetes duration, glycemic control, and hypertension.

Results: No patients were observed in the 20–39 age stratum ($n=0$). Among the analyzed cohort ($N=118$), 65.3% presented with PDR. Multivariate analysis revealed that current age ≥60 years was significantly associated with reduced odds of PDR (aOR 0.280; 95% CI 0.098–0.803; $p=0.017$), indicating an approximately 3.6-fold higher risk in working-age adults (40–59 years). Diabetes duration ≥10 years (aOR 3.805; $p=0.006$) and HbA1c ≥7.2% (aOR 3.856; $p=0.006$) were confirmed as strong independent predictors.

Conclusion: Working-age patients exhibit higher vulnerability to severe PDR independent of diabetes duration and glycemic control. Rather than introducing new screening timelines, these findings underscore the urgent need for stricter adherence to existing national guidelines recommending immediate retinal examination upon diabetes diagnosis.

Keywords: Diabetic Retinopathy; Diabetes Mellitus; Risk Assessment; Severity of Illness Index; Blindness.

Introduction

Diabetic retinopathy (DR) is a major public health problem and a leading cause of preventable blindness among working-age adults. This burden falls disproportionately on developing nations, where healthcare infrastructure is often limited.[1,2] The prevalence of Type 2 Diabetes Mellitus (T2DM) is rising rapidly and is projected to reach 578 million individuals globally by 2030, with substantial economic consequences from lost workforce productivity and rising healthcare costs.[3] In Southeast Asia, and particularly in Indonesia, clinical data show an alarmingly high prevalence of Proliferative Diabetic Retinopathy (PDR) at initial presentation, driven by delayed diagnosis, suboptimal metabolic control, and limited public awareness of ocular complications.[4–6]

While chronic hyperglycemia and long-standing diabetes are established drivers of retinal microvascular damage, risk profiles may vary across age cohorts.[7,8] A clear distinction must be maintained between working-age status, which reflects current chronological age (40–59 years), and young-onset T2DM, which is defined strictly by age at diabetes diagnosis. Literature on young-onset T2DM describes accelerated microvascular disease driven by heightened oxidative stress and Vascular Endothelial Growth Factor (VEGF) upregulation.[8] Conversely, cross-sectional evaluations based on current age provide valuable epidemiological data on the immediate disease burden observed within active workforce populations.[1]

The national clinical practice guidelines in Indonesia recommend routine dilated fundus examinations at or shortly following T2DM diagnosis.[9] Despite these guidelines, patient adherence to screening remains low, and data characterizing age-specific vulnerability to PDR in local tertiary settings remain sparse.[10] Because age at diabetes diagnosis was not recorded in archived institutional records, this study evaluated whether current working-age status (40–59 years) independently predicts PDR severity relative to elderly status (≥60 years) among patients managed at a tertiary referral eye center in Indonesia.

Methods

Research Design and Setting

This retrospective analytical study was conducted at a tertiary referral eye center in Bandung, Indonesia. Data were obtained from medical records of patients managed between January 1, 2024, and December 31, 2024. The subsequent data extraction and analysis were performed between May and June 2025.

Population and Sampling

The study population included all patients diagnosed with diabetic retinopathy during the study period. A total of 118 eyes were selected using a non-probability purposive sampling technique, calculated to achieve 80% statistical power. Inclusion criteria required a confirmed diagnosis of either Non-Proliferative Diabetic Retinopathy (NPDR) or PDR with complete medical records comprising demographic details, HbA1c levels, and disease duration. Patients with co-existing retinal pathologies, such as retinal vein occlusion or age-related macular degeneration, and those with incomplete records were excluded.

Data Collection

Data were collected using a standardized extraction form to capture variables from electronic medical records. The dependent variable was diabetic retinopathy severity, dichotomized into NPDR and PDR based on fundus examination findings. Independent variables included age (stratified into 20-39, 40-59, and ≥60 years), gender, diabetes duration (<10 and ≥10 years), glycemic control based on HbA1c levels, and history of hypertension. Additionally, metabolic and lifestyle factors, specifically high cholesterol and smoking status, were recorded. Only records with explicitly documented laboratory values and clinical diagnoses were utilized.

Procedure and Analysis

Eligible records were identified using ICD-10 codes specific to diabetic retinopathy, and data were extracted by trained personnel. A double-entry method was applied to a random subset of records to ensure accuracy, and all patient identifiers were anonymized. Statistical analysis was performed using SPSS version 26.0. Univariate analysis provided descriptive statistics for baseline characteristics, while bivariate analysis utilized the Chi-Square test to evaluate unadjusted associations, with significance set at $p<0.05$. Significant variables were subsequently entered into a multivariate binary logistic regression model to determine independent predictors of PDR and calculate Adjusted Odds Ratios (aOR) with 95% Confidence Intervals.

Ethical Clearance

This study adhered to the Declaration of Helsinki and received ethical clearance from the Health Research Ethics Committee of Universitas Pasundan (Protocol No. 2501010002). The requirement for written informed consent was waived due to the retrospective nature of the study, although strict protocols were implemented to maintain patient confidentiality and data security.

Result

Sample Characteristics (Univariate Analysis)

The demographic and clinical characteristics of the 118 eyes included in the study are summarized in Table 1. The cohort exhibited a marked predominance of advanced disease severity at the time of presentation. Data indicated that 65.3% (n=77) of patients were diagnosed with Proliferative Diabetic Retinopathy (PDR), while 34.7% (n=41) presented with Non-Proliferative Diabetic Retinopathy (NPDR). This high prevalence of advanced disease is consistent with referral patterns observed in other developing nations, where late presentation is common. The age distribution showed that the majority of patients (54.2%) belonged to the working-age demographic (40–59 years), with a slight male predominance (52.5%), aligning with global trends in DR prevalence. Clinical evaluation revealed suboptimal metabolic control across the cohort; 50.8% of patients presented with HbA1c levels ≥7.2%, and 60.2% had a documented diabetes duration of ≥10 years. Comorbidities were frequently observed, with 76.3% of patients having a history of hypertension.

Risk Factor Comparison (Bivariate Analysis)

Bivariate analysis (Table 2) was performed to assess the unadjusted associations between risk factors and DR severity. Statistical analysis demonstrated a significant inverse relationship between age and disease severity; patients aged ≥60 years were significantly less likely to present with PDR compared to the working-age reference group (OR 0.199; 95% CI 0.087–0.454; $p<0.001$). This finding contrasts with traditional cumulative models but supports the existence of aggressive phenotypes in younger cohorts.

Female gender was associated with higher odds of PDR in this cohort (OR 2.724; $p=0.002$). As anticipated, established metabolic indicators showed strong correlations with severity: diabetes duration ≥10 years (OR 3.906; $p=0.001$) and HbA1c ≥7.2% (OR 4.000; $p=0.001$) were significantly associated with PDR. Hypertension also demonstrated a significant association (OR 2.840; $p=0.017$). Conversely, neither high cholesterol ($p=0.427$) nor smoking status ($p=0.644$) reached statistical significance in this analysis.

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Table 1. Demographic and Clinical Characteristics of Study Population

Variables	Category	Frequency (n=118)	Percentage (%)
Age Group	**20–39 years**	0	0
	Working-Age (40–59 years)	64	54.2
	Elderly (≥60 years)	54	45.8
Gender	Male	62	52.5
	Female	56	47.5
Diabetes Duration	< 10 years	47	39.8
	≥ 10 years	71	60.2
Glycemic Control (HbA1c)	Good/Moderate (< 7.2%)	58	49.2
	Poor (≥ 7.2%)	60	50.8
Hypertension	Yes	90	76.3
	No	28	23.7
Cholesterol	High	69	58.5
	Normal	49	41.5
Smoking Status	Smoker	61	51.7
	Non-Smoker	57	48.3
DR Severity (Outcome)	NPDR	41	34.7
	PDR	77	65.3

Table 2. Bivariate Analysis of Risk Factors Associated with PDR

Variables	NPDR (n=41)	PDR (n=77)	Total (n=118)	OR (95% CI)	p-value
Age Group					
Working-Age (40-59)	12 (18.8%)	52 (81.2%)	64	*Reference*	**<0.001**
Elderly (≥60)	29 (53.7%)	25 (46.3%)	54	0.199 (0.087 – 0.454)	
Gender					
Female	13	43	56	2.724 (1.228 – 6.043)	**0.002**
Male	28	34	62	*Reference*	
Diabetes Duration					
≥ 10 years	16	55	71	3.906 (1.757 – 8.684)	**0.001**
< 10 years	25	22	47	*Reference*	
Glycemic Control					
Poor (HbA1c ≥ 7.2%)	12	48	60	4.000 (1.770 – 9.041)	**0.001**
Good/Mod (< 7.2%)	29	29	58	*Reference*	
Hypertension					
Yes	26	64	90	2.840 (1.188 – 6.789)	**0.017**
No	15	13	28	*Reference*	
Cholesterol					
High	26	43	69	1.371 (0.629 – 2.986)	0.427
Normal	15	34	49	*Reference*	
Smoking					
Yes	20	41	61	0.836 (0.392 – 1.786)	0.644
No	21	36	57	*Reference*	

Independent Predictors of PDR (Multivariate Analysis)

To isolate independent predictors and control for confounding variables, a multivariate logistic regression model was constructed (Table 3). The analysis revealed that age remained a robust independent predictor of disease severity. Patients in the elderly group (≥60 years) maintained a significantly reduced risk of PDR (aOR 0.280; 95% CI 0.098–0.803; p=0.017) after adjustment. This implies that working-age patients (40–59 years) face an approximately 3.6-fold higher risk of PDR compared to the elderly, independent of other factors. Diabetes duration and glycemic control were confirmed as powerful independent drivers of progression; duration ≥10 years (aOR 3.805; p=0.006) and HbA1c ≥7.2% (aOR 3.856; p=0.006) exhibited similar predictive strength. Gender (p=0.057) and hypertension (p=0.186), both significant in the bivariate analysis, lost statistical significance in the multivariate model. This suggests their effects were mediated by the dominant influence of glycemic control and disease duration.

Discussion

Age-Specific Vulnerability and PDR Risk

This study identified a significant association between current age and PDR severity among patients managed at a tertiary referral eye center. Patients in the working-age group (40–59 years) demonstrated markedly higher odds of presenting with PDR compared with elderly patients (≥60 years; aOR 0.280, 95% CI 0.098–0.803, $p=0.017$), independent of diabetes duration and HbA1c levels. This finding diverges from traditional cumulative risk models, which postulate a linear increase in microvascular complications with advancing age.[7,10] Because age at T2DM diagnosis was unavailable in our retrospective dataset, these results describe disparities between current age strata rather than age-at-diagnosis cohorts. Nevertheless, physiological literature on early-onset metabolic dysregulation provides plausible context.[11,12]

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Chronic exposure to elevated glucose in younger physiology can trigger rapid Protein Kinase C pathway activation, reactive oxygen species accumulation, and marked VEGF expression, accelerating retinal neovascularization.[12,13] The lower prevalence of PDR observed in elderly patients (≥60 years) may also reflect survival bias and the healthy worker effect.[14,15] Diabetic individuals who develop severe early-onset microvascular or cardiovascular complications face higher mortality rates, leaving a survivor cohort of elderly individuals with biologically less aggressive disease.[14,16] Regardless of the underlying biological mechanism, the high prevalence of PDR among 40–59-year-old patients represents a substantial clinical and economic burden, as visual impairment directly compromises workforce productivity in developing economies.[1,3]

The Dominance of Glycemic Control Over Hypertension

In our multivariate model, diabetes duration ≥10 years (aOR 3.805, 95% CI 1.464–9.889, p=0.006) and HbA1c ≥7.2% (aOR 3.856, 95% CI 1.470–10.111, p=0.006) were confirmed as dominant independent predictors of PDR. Conversely, hypertension was significantly associated with PDR in unadjusted analysis (OR 2.840, p=0.017) but lost statistical significance after adjusting for metabolic variables (p=0.186). This suggests that in cohorts with severe metabolic dysregulation (50.8% with HbA1c ≥7.2%), chronic glycemic exposure is the primary driver of microvascular proliferation.[17] Sustained hyperglycemia induces long-lasting cellular alterations, a phenomenon termed "metabolic memory," that maintain vascular damage even when systemic blood pressure is pharmacologically controlled.[17,18] While blood pressure management remains essential for overall vascular health, glycemic control remains the most important therapeutic target to prevent progression to PDR in long-standing diabetes.[19,20]

Re-framing Screening Recommendations

The high risk of PDR observed in working-age adults highlights the need to strengthen clinical screening implementation in Indonesia. Rather than proposing new screening intervals, these findings reinforce the necessity of enforcing strict adherence to existing national guidelines which mandate baseline dilated fundus examination at or immediately following T2DM diagnosis.[9] In clinical practice, working-age individuals frequently delay eye care due to occupational commitments, absence of early visual symptoms, or low awareness of diabetic eye disease.[5,10] Because working-age patients in our study exhibited an approximately 3.6-fold higher risk of severe disease compared to the elderly, clinical strategies must focus on improving primary care referral pathways and raising awareness among active workers to ensure timely baseline evaluations as outlined in current guidelines.[21,22]

Table 3. Multivariate Logistic Regression Analysis for Independent Predictors of PDR

Predictor Variable	Comparison	Adjusted Odds Ratio (aOR)	95% CI	p-value
Age Group	Elderly (≥60) vs. Working-Age	**0.28**	0.098 – 0.803	**0.017**
Diabetes Duration	≥10 years vs. <10 years	**3.805**	1.464 – 9.889	**0.006**
Glycemic Control	HbA1c ≥ 7.2% vs. < 7.2%	**3.856**	1.470 – 10.111	**0.006**
Gender	Female vs. Male	2.508	0.970 – 6.486	0.057
Hypertension	Yes vs. No	2.059	0.707 – 5.996	0.186

Conclusion

This study indicates that working-age patients (40–59 years) attending a tertiary referral eye center in Indonesia carry a significantly higher risk of Proliferative Diabetic Retinopathy than elderly patients, independent of glycemic control and disease duration. The priority is not new screening criteria but stronger compliance with existing Indonesian national clinical guidelines, ensuring prompt baseline retinal examinations upon T2DM diagnosis to prevent premature vision loss in the active workforce.

Conflict of Interest

The authors affirm no conflict of interest in this study

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None

Disclosure statement

The researcher emphasized that there were no personal interests that could influence the research results.There is no relationship with any institution that could lead to data misuse, affecting the integrity and objectivity of the research

Author contribution statement

All authors contributed to the concept, design, definition of intellectual content, literature research, clinical studies, data analysis, manuscript preparation, and editing, and agree to be accountable for all aspects of the work.

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