REVIEW

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Association of type 2 diabetes mellitus and hypertension with chronic kidney disease in patients at a primary health center in Bali, Indonesia: a cross-sectional study

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ABSTRACT

Chronic kidney disease (CKD) is a major global health problem, with type 2 diabetes mellitus (T2DM) and hypertension recognized as key risk factors. However, evidence from primary healthcare settings in Indonesia remains limited. This study aims to evaluate the association of T2DM and hypertension with CKD. This analytic observational study used a cross-sectional design and was conducted at Banjar 2 Primary Health Center, Bali, Indonesia. Secondary data were obtained from medical records covering the period from January to December 2023. The variables analyzed included T2DM, hypertension, and CKD. Data were analyzed using univariate analysis and multivariate logistic regression. Model evaluation included the Omnibus test, Hosmer–Lemeshow test, and Nagelkerke R Square. A total of 199 patients were included, with a higher proportion of females, and most participants aged 56–65 years (35%). T2DM and hypertension were commonly observed, while CKD was less frequent. Multivariate analysis showed that T2DM and hypertension were not significantly associated with CKD ($p = 0.424$). Despite this, both T2DM and hypertension showed a positive association with CKD. There was no statistically significant association between T2DM, hypertension, and CKD in this study. These findings emphasize the need for further research incorporating additional risk factors and more robust study designs to better understand the determinants of CKD in primary healthcare settings.

Keywords: chronic kidney disease, diabetes mellitus, hypertension, primary healthcare.
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INTRODUCTION

Chronic kidney disease (CKD) is a progressive and irreversible condition characterized by a gradual decline in kidney function, affecting more than 10% of the global population, with over 800 million individuals impacted worldwide.[1,2] CKD has become a major contributor to global mortality, ranking among the leading causes of death and projected to rise to the fifth position by 2040.[3] In Indonesia, CKD remains a significant public health concern, with a reported prevalence of approximately 0.38%, and a large proportion of patients requiring long-term renal replacement therapy such as hemodialysis.[4] Furthermore, data from the Indonesian Renal Registry indicate that hypertension (42%) and diabetic nephropathy (22%) are the primary underlying causes of CKD among patients undergoing dialysis. The increasing number of CKD patients has also led to a substantial rise in healthcare expenditure, making CKD one of the highest-cost diseases in the national health system.

Hypertension and type 2 diabetes mellitus (T2DM) are widely recognized as the most important modifiable risk factors contributing to the development and progression of CKD.5 Globally, the prevalence of hypertension is estimated at approximately 31.1%, while in Indonesia it increased significantly from 25.8% in 2013 to 34.1% in 2018.4 In Bali, the prevalence of hypertension among adults has reached 9.57%, reflecting a growing burden at the regional level.[4]

Similarly, T2DM continues to rise worldwide, affecting approximately 463 million adults and contributing to an estimated 4.2 million deaths annually.[6] The number of individuals with diabetes is projected to increase substantially in the coming decades, further exacerbating the burden of chronic complications such as CKD.[6]

From a pathophysiological perspective, chronic hyperglycemia in T2DM leads to diabetic nephropathy through mechanisms including glomerular hyperfiltration, oxidative stress, and structural damage to the renal microvasculature.[7] Meanwhile, hypertension contributes to kidney damage by increasing intraglomerular pressure, resulting in progressive nephrosclerosis and loss of nephron function.[8] These mechanisms highlight the strong biological plausibility linking both conditions to CKD development.

At the primary healthcare level, hypertension and T2DM are among the most frequently encountered chronic

diseases. Preliminary data from Banjar 2 Primary Health Center indicate that both conditions consistently rank among the top diagnoses in outpatient visits, suggesting a potentially high risk of CKD in this population. However, evidence examining the association between T2DM, hypertension, and CKD in this specific setting remains limited.

Most previous studies investigating CKD risk factors have been conducted in hospital-based or tertiary care settings, which may not fully represent the characteristics of patients in primary healthcare facilities. Therefore, understanding this relationship in a primary care context is essential for early detection, prevention strategies, and resource allocation. Based on these considerations, this study aims to determine the association between type 2 diabetes mellitus, hypertension, and chronic kidney disease among patients at Banjar 2 Primary Health Center.

METHODS

Study Design and Setting

This study employed an analytic observational design with a cross-sectional approach to assess the association between type 2 diabetes mellitus (T2DM), hypertension, and chronic kidney disease (CKD). The study was conducted at Banjar 2 Primary Health Center, Bali, Indonesia, using secondary data obtained from medical records covering the period from January 1 to December 31, 2023. Data extraction was performed retrospectively from patient records that met the study criteria. Given that the study utilized facility-based data, there is a possibility of selection bias, as the included population may not fully represent the broader community, particularly individuals who do not seek care at primary health facilities. The study protocol has received ethical clearance from the Universitas Pendidikan Ganesha Research Ethics Committee under number 062/UN48.24.11/LT/2024.

Study Population

The study population consisted of all patients registered at Banjar 2 Primary Health Center during the study period. A total of 199 patients were included using a total sampling technique. Inclusion criteria were patients with complete medical records and documented diagnoses relevant to the study variables. Patients with incomplete or missing key data were excluded from the analysis. No formal sample size calculation was performed, which may affect the statistical power of the study.

Data Sources and Measurement

Data were obtained from secondary sources in the form of medical records. Diagnoses of T2DM, hypertension, and CKD were based on clinical assessments documented by healthcare professionals. The outcome variable was CKD, categorized as present or absent based on physician diagnosis. The exposure variables included T2DM and hypertension, both categorized as yes or no according to recorded diagnoses. Age and sex were included as covariates.

Operationally, CKD was defined as a documented diagnosis of chronic kidney disease in the medical record. T2DM was defined as a recorded diagnosis of type 2 diabetes mellitus, while hypertension was defined as a documented diagnosis of elevated blood pressure requiring clinical management. The reliance on medical records introduces potential information bias due to incomplete or inaccurate documentation. Additionally, important confounding variables such as obesity, smoking status, and duration of disease were not available, which may lead to residual confounding.

Statistical Analysis

Data were analyzed using SPSS software version 25.0. All variables were treated as categorical variables. Age was categorized into predefined groups for descriptive purposes. Univariate analysis was performed to describe the distribution of variables using frequencies and percentages. Multivariate analysis was conducted using logistic regression to assess the association between T2DM, hypertension, and CKD.

Model evaluation included the Omnibus test of model coefficients to assess overall model significance, the Hosmer–Lemeshow test to evaluate goodness-of-fit, and Nagelkerke R Square to determine the explanatory power of the model. The Wald test was used to assess the significance of individual predictors. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Participants

A total of 199 patient records from Banjar 2 Primary Health Center in 2023 were reviewed and included in the final analysis. Records with incomplete information on key study variables were excluded prior to data processing to ensure data quality and consistency. After applying the inclusion and exclusion criteria, all remaining records were eligible and analyzed, with no missing data reported among the included participants. This ensured that the dataset used for analysis was complete and suitable for subsequent statistical evaluation.

Descriptive Characteristics

The distribution of participants based on demographic characteristics is presented in **Table 1**. The prevalence of T2DM, hypertension, and CKD within the study population is also summarized in Tables 1. The majority of patients were found in the older age groups, indicating a higher burden of chronic conditions among aging populations. In terms of sex distribution, female patients constituted a larger proportion compared to males.

Further stratification of the data (**Table 2**) demonstrated that type 2 diabetes mellitus (T2DM), hypertension, and chronic kidney disease (CKD) were more commonly observed among older individuals.[9] This pattern suggests a potential age-related increase in the prevalence of chronic non-communicable diseases, which is consistent with general epidemiological trends observed in primary healthcare settings. [9]

Overall, these findings indicate that chronic diseases, particularly hypertension and T2DM, represent a substantial burden in this primary healthcare setting. The coexistence of these conditions within the same population highlights the importance of integrated management strategies at the primary care level.[10]

Association between T2DM, Hypertension, and CKD

In the individual analysis, neither T2DM (p = 0.219; OR = 2.75; 95% CI = 0.552-

Table 1. Demographic characteristics

Variables	Frequency (n)	Percentage (%)
Age Group		
Early adulthood (26–35 years)	13	7
Late adulthood (36–45 years)	10	5
Early elderly (46–55 years)	54	27
Late elderly (56–65 years)	70	35
Older adults (>65 years)	52	26
Sex		
Male	122	61
Female	77	39
History of T2DM		
Yes	109	55
No	90	45
History of Hypertension		
Yes	59	30
No	140	70
History of CKD		
Yes	12	6
No	187	94

CKD, chronic kidney disease; T2DM, type 2 diabetes mellitus.

Table 2. Age and sex group across medical histories

Variables	Frequency, n (%)		
	T2DM	Hypertension	CKD
Age Group			
Early Adulthood (26–35 years)	0 (0)	1 (2)	0 (0)
Late Adulthood (36–45 years)	2 (2)	2 (3)	0 (0)
Early Elderly (46–55 years)	29 (27)	14 (24)	3 (25)
Late Elderly (56–65 years)	47 (43)	20 (34)	4 (33)
Older Elderly (> 65 years)	31 (28)	22 (37)	5 (42)
Sex			
Male	60 (55)	33 (56)	8 (67)
Female	49 (45)	26 (44)	4 (33)

13.459) nor hypertension (p = 0.32; OR = 2.26; 95% CI = 0.453-11.322) demonstrated a statistically significant association with CKD, as indicated by the Wald test results (p > 0.05 for both variables). Although the calculated Odds Ratios (OR) suggested a positive direction of association, these findings did not reach statistical significance.

Multivariate analysis using logistic regression was conducted to evaluate the association between T2DM, hypertension, and CKD. The overall regression model was not statistically significant based on the Omnibus test (p = 0.424), indicating that the independent variables, when considered simultaneously, did not significantly predict the occurrence of CKD.

The explanatory power of the model was low, with a Nagelkerke R Square value of 0.023, indicating that only 2.3% of the variability in CKD occurrence could be explained by the variables included in the model. Despite this, the Hosmer–Lemeshow test showed a p-value of 0.240, suggesting that the model had an acceptable goodness-of-fit and was not inconsistent with the observed data.

DISCUSSION

This study found that type 2 diabetes mellitus (T2DM) and hypertension were positively associated with chronic kidney disease (CKD), although the associations were not statistically significant, with a very low explanatory power observed in the regression model (Nagelkerke R^2 = 0.023). These findings indicate that the variables included in this study explained only a small proportion of CKD variability, suggesting the presence of other important contributing factors. The absence of a statistically significant association contrasts with a substantial body of evidence identifying T2DM and hypertension as major risk factors for CKD development and progression.[1,3] Previous studies have consistently demonstrated that T2DM contributes to CKD primarily through diabetic nephropathy, while hypertension induces progressive renal damage via increased intraglomerular pressure and vascular injury.[5,8]

Several explanations may account for these findings. One possible reason is the limited number of variables included in the analysis, as important confounding factors such as duration of diabetes, glycemic control, obesity, smoking status, and medication use were not available in the dataset. These variables are known to significantly influence CKD risk and may have masked the true association in this study.[6] Additionally, the use of secondary data from medical records introduces the possibility of information bias, including incomplete or inaccurate documentation, which may have affected the classification of both exposure and outcome variables. Early-stage CKD may also have been underdiagnosed in this setting, leading to potential underestimation of the true prevalence and weakening the observed associations.[2]

The primary healthcare setting of this study may further explain the results. Compared to hospital-based studies, which often involve patients with more advanced disease, primary care populations typically include individuals at earlier stages of illness or with milder clinical presentations. This difference in disease spectrum may reduce the apparent strength of association between risk factors and CKD. Despite the lack of statistical

significance, the direction of association observed in this study remains consistent with established biological mechanisms. Chronic hyperglycemia in T2DM leads to glomerular hyperfiltration, oxidative stress, and structural damage to the renal microvasculature, ultimately resulting in diabetic nephropathy.[7] Similarly, hypertension contributes to CKD through sustained elevation of intraglomerular pressure, leading to nephrosclerosis and progressive nephron loss.[4] These mechanisms support the continued clinical relevance of both conditions as important contributors to CKD development.

The findings of this study differ from several previous studies that reported significant associations between T2DM, hypertension, and CKD, particularly in hospital-based or large cohort populations.[1,3] However, some studies conducted in primary care or community-based settings have reported weaker or non-significant associations, especially when key confounding variables were not included in the analysis.[6] These discrepancies highlight the influence of study design, population characteristics, and variable selection on research outcomes.

Several limitations should be considered when interpreting these findings. The cross-sectional design does not allow for causal inference, as exposure and outcome were assessed simultaneously. The use of secondary data may introduce information bias, and the absence of several important confounders limits the ability to fully explain CKD risk. Furthermore, the very low Nagelkerke R^2 value indicates that the model has limited explanatory capacity, suggesting that other unmeasured factors play a more substantial role in CKD development.

The generalizability of these findings is limited to populations similar to those attending primary healthcare facilities such as Banjar 2 Primary Health Center. Caution should be exercised when applying these results to hospital-based populations or regions with different epidemiological profiles. Nevertheless, the findings emphasize that, despite the lack of statistical significance, T2DM and hypertension remain clinically important conditions that require early detection and proper management to prevent CKD progression. Future studies with larger sample sizes, more comprehensive variables, and longitudinal designs are needed to better elucidate the causal relationships between these risk factors and CKD.

CONCLUSION

This study found that type 2 diabetes mellitus and hypertension were not significantly associated with the occurrence of chronic kidney disease among patients at Banjar 2 Primary Health Center. Although both conditions demonstrated a positive direction of association, the findings suggest that other unmeasured factors may play a more substantial role in the development of chronic kidney disease in this population. These results highlight the importance of comprehensive risk assessment and early detection strategies at the primary healthcare level. Future studies are recommended to include a broader range of clinical and lifestyle variables, as well as to employ study designs that can better establish causal relationships.

CONFLICT OF INTEREST

All authors declared that there is no conflict of interest regarding this article.

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ETHICS APPROVAL

The study protocol has received ethical clearance from the Universitas Pendidikan Ganesha Research Ethics Committee under number 062/UN48.24.11/LT/2024.

AUTHOR'S CONTRIBUTION

All authors contributed equally in the writing process of this article.

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