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Analysis of the Relationship between Duration of Diabetes Mellitus and HbA1c Levels in Type 2 DM Patients at Primary Health Center in Kupang City

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ABSTRACT:
Background: Type 2 diabetes mellitus (T2DM) is a growing global health challenge characterised by chronic hyperglycaemia and progressive metabolic dysfunction. Glycated haemoglobin (HbA1c) serves as the gold standard for assessing long-term glycaemic control and is closely linked to the risk of diabetes-related complications. Disease duration has been hypothesised to influence glycaemic outcomes; however, findings from previous studies remain inconsistent, warranting further investigation.
Objective: This study aimed to examine the association between disease duration and glycaemic control, as measured by HbA1c levels, in patients with type 2 diabetes mellitus.
Methods: An analytical observational study with cross-sectional design was conducted on 71 type 2 diabetes mellitus patients at three primary health centres in Kupang City from July to August 2025. Disease duration data were obtained through interviews and medical records, categorised as less than one year, one to five years, and more than five years. HbA1c levels were measured using high performance liquid chromatography method. Data analysis used Spearman's correlation test with significance level of α=0.05.
Results: Mean HbA1c levels demonstrated an ascending trend across duration categories: 8.25±3.15% for less than one year, 9.06±2.14% for one to five years, and 9.92±2.76% for more than five years. Spearman correlation analysis revealed a statistically significant positive relationship between disease duration and HbA1c levels (r=0.247; p=0.038).
Conclusion: A significant positive correlation exists between type 2 diabetes mellitus duration and HbA1c levels, although with weak correlation strength. This finding emphasises the importance of regular glycaemic monitoring and comprehensive multifactorial management approaches, as glycaemic control is influenced not only by disease duration but also by modifiable factors including medication adherence, lifestyle modifications, and psychosocial support.

KEYWORDS: Diabetes mellitus, HbA1c, Duration, Primary Care, Indonesia.

INTRODUCTION

Diabetes mellitus (DM) constitutes a chronic metabolic disorder characterised by persistent hyperglycaemia resulting from impaired insulin secretion, insulin action, or both.[1] The global burden of diabetes continues to rise, with more than 537 million adults affected worldwide in 2025 and projections reaching 783 million by 2045. Indonesia is among the countries with the highest prevalence, reporting approximately 19.4 million cases in 2021, with a continued upward trend.[2] In East Nusa Tenggara Province, diabetes remain a significant public helath concern, particularly in Kupang City, where a substantial proportion of patiens have limited access to continuous and comprehensive diabetes care.[3,4]

Glycated haemoglobin (HbA1c) represents the gold standard biomarker for evaluating long-term glycaemic control in diabetes management, reflecting average blood glucose concentrations over the preceding two to three months.[5] The American Diabetes Association recommends HbA1c for both diagnostic parameter and monitoring of diabetes due to its high reliability minimal biological variability, and independence from fasting status.[6] Optimal glycaeminc control, as indicated by HbA1c levels, is essential to prevent chronic complications and reduce diabetes related morbidity and mortality.[5]

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Disease duration has been proposed as factor influencing glycaemic control. However, evidence remains inconclusive. Several studies have reported a positive association between longer diabetes duration and higher HbA1c levels, attributed to progressive beta-cell dysfunction and declining treatment adherence.[7,8,9] This inconsistencies highlight the need for further investigation, particularly in primary healthcare settings.

Most previous studies relied predominantly on secondary data from medical record, which are susceptible to incomplete documentation and may not reflect patient's current glycaemic status or self-management practices. Moreover, no published studies have specifically examined the relationship between type 2 diabetes mellitus duration and HbA1c levels in Kupang City, an area characterized by distinct geographical challenges, cultural diversity, and variability in healthcare accessibility. This study therefore presents novelty by utilizing primary data collection through direct patient interviews and contemporaneous HbA1c measurement, providing a more accurate and context specific assessment at the primary healthcare level.

This cross-sectional analytic observational study employed primary data obtained form patients with type 2 diabetes mellitus attending three primary helath centres in Kupang City. Disease duration was determined through interviews and medical record verification, while HbA1c levels were measured using high-performance liquid chromatography. The study aimed to analyse the relationship between disease duration and HbA1c levels, with the hypothesis tha longer diabetes duration is associated with poorer glycaemic control.

METHODS

This analytical observational study employed a cross-sectional design conducted at three primary health centres in Kupang City (Puskesmas Oepoi, Puskesmas Sikumana, and Puskesmas Bakunase) during July to August 2025. The study population comprised all patients diagnosed with type 2 diabetes mellitus at primary health centres in Kupang City. Sample size calculation utilised the Lemeshow formula for known populations with 95% confidence level and 5% margin of error, yielding a minimum sample requirement of 69 participants. A total of 71 patients were recruited through consecutive sampling technique. Inclusion criteria encompassed patients diagnosed with type 2 diabetes mellitus, aged 18-59 years, and willing to participate by providing written informed consent. Exclusion criteria comprised patients with medical conditions potentially affecting HbA1c levels (anaemia, haemoglobinopathies, blood transfusion history within 2-3 months, renal dysfunction), pregnant or lactating women, and patients unable to cooperate or experiencing communication difficulties. The study received ethical approval from the Health Research Ethics Committee of the Faculty of Medicine and Veterinary Medicine, Nusa Cendana University (approval number 55/UN15.21/KEPK-FKKH/2025).

Following institutional approval and participant recruitment, trained personnel conducted home visits to provide comprehensive study information and obtain written informed consent. Participants were subsequently scheduled for data collection and blood sampling at their respective primary health centres. Disease duration data were obtained through structured interviews and verified against medical records, categorised into three groups: less than one year, one to five years, and more than five years. Additional demographic and clinical data collected included age, gender, occupation, fasting blood glucose, medication adherence assessed through self-report questionnaire regarding missed doses in the past month, body mass index calculated from measured weight and height, and physical activity level using adapted International Physical Activity Questionnaire assessing frequency and duration of light, moderate, and vigorous activities. Venous blood samples (3 mL) were collected from the median cubital vein by trained laboratory personnel and stored in Ethylene Diamine Tetra-Acetic Acid (EDTA) vacuum tubes. HbA1c measurement was performed at Prodia Laboratory using the High Performance Liquid Chromatography (HPLC) method with BIO-RAD D10 instrument, standardised according to the National Glycohaemoglobin Standardization Program (NGSP).

Data analysis utilised statistical software with significance level set at 0.05. Univariate analysis described frequency distributions and measures of central tendency for study variables. Data normality was assessed using the Kolmogorov-Smirnov test, which revealed that disease duration data showed non-normal distribution whilst HbA1c data demonstrated normal distribution. Consequently, bivariate analysis employed Spearman's rank correlation test to examine the relationship between disease duration and HbA1c levels. Correlation strength interpretation followed established criteria: 0.00-0.19 (very weak), 0.20-0.39 (weak), 0.40-0.59 (moderate), 0.60-0.79 (strong), and 0.80-1.00 (very strong).

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RESULTS

A total of 71 patients with type 2 diabetes mellitus participated in this study across three primary health centres in Kupang City. The demographic and clinical characteristics of participants revealed several notable patterns. The study population was predominantly female, representing nearly three-quarters of participants, with the majority falling within the older adult age range. Most participants were housewives, reflecting the gender distribution observed. Clinical assessment demonstrated that the vast majority of participants had poor glycaemic control, as evidenced by fasting blood glucose levels in the diabetic range and HbA1c values exceeding the recommended target. A concerning finding was the high proportion of participants reporting irregular medication adherence, which may contribute to suboptimal disease management. Additionally, most participants were classified as overweight according to body mass index measurements, a known risk factor for insulin resistance and poor glycaemic outcomes. These baseline characteristics are detailed in Table 1.

Table 1 presents the comprehensive characteristics of 71 study participants. The majority were female (74.6%) with the largest age group being 55-59 years (33.3%). Occupationally, most participants were housewives (53.6%). Medication adherence assessment revealed that 59.2% of participants did not regularly consume antidiabetic medications. The majority of participants had body mass index ≥23.0 kg/m² (78.3%) and engaged in moderate physical activity (66.2%).

Table 1. Characteristics of Respondents

Characteristics	*Frequency*	*Precentage (%)*
Gender		
Male	18	25.4
Female	53	74.6
Age (Years)		
30-34 years old	1	1.4
35-39 years old	2	2.8
40-44 years old	5	7.0
45-49 years old	17	23.9
50-54 years old	21	29.6
55-59 years old	25	35.2
Occuptaion		
Housewife	38	53.5
Goverment employee	10	14.1
Professional employee	4	5.6
Self-employee	12	16.9
Farmer	2	2.9
Retired	5	7.0
Medication Adherence		
Regular	29	40.8
Irregular	42	59.2
Body Mass Index		
Normal (18.5-22.9 kg/m2)	15	21.1
Overweight (≥23.0 kg/m2)	56	76.9
Physical Activity		
Light	9	12.7
Moderate	47	66.2
Vigorous	15	21.1
HbA1c Control Target		
Achieved (<7%)	19	26.8
Not achieved (≥7%)	52	73.2

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Duration of Disease		
1< year	14	19.7
1-5 years	38	53.3
>5 years	19	26.8

Table 2 illustrates mean HbA1c levels across disease duration categories, demonstrating an ascending trend. Participants with duration less than one year exhibited mean HbA1c of 8.25±3.15%, those with 1-5 years showed 9.06±2.14%, and participants with more than 5 years demonstrated 9.92±2.76%.

Table 2. Distribution of HbA1c Levels by Disease Duration

Duration of Diabetes Melitus	*n*	*Mean±SD (%)*	*Median (%)*	*Min-Max (%)*
<1 year	14	8.25±3.15	7.1	4.80-13.30
1-5 years	38	9.06±2.14	9.4	4.50-13.90
>5 years	19	9.92±2.76	10.2	4.90-13.80

Spearman's rank correlation test revealed a statistically significant positive relationship between disease duration and HbA1c levels (correlation coefficient r=0.247; p=0.038), as presented in Table 3. The correlation coefficient of 0.247 indicates a weak positive correlation, suggesting that longer disease duration is associated with higher HbA1c levels.

Table 3. Relationship Between Duration of Type 2 DM and HbA1c Levels

Variable	*Correlation Coefficient (r)*	*p-value*	*Interpretation*
Disease Duration – HbA1c	0.247	0.038*	Positive, weak, significant

*Significant at α=0.05

DISCUSSION

This investigation identified a statistically significant positive correlation between type 2 diabetes mellitus duration and glycated haemoglobin levels among patients attending primary health centres in Kupang City. Whilst the correlation strength is categorised as weak, the finding demonstrates that disease duration maintains a meaningful relationship with long-term glycaemic control.[10] The statistical significance of this association confirms that the observed relationship is not attributable to chance, thereby supporting the research hypothesis that longer disease duration is associated with elevated HbA1c levels.

These findings align with previous investigations examining the relationship between diabetes duration and glycaemic outcomes. Nurgajayanti et al. (2024) reported a correlation between diabetes duration and HbA1c levels in their Indonesian cohort, demonstrating that prolonged disease duration correlates with deteriorating glycaemic control.[8] The researchers attributed this finding to progressive pancreatic beta-cell dysfunction, a well-established pathophysiological feature of type 2 diabetes mellitus progression, as well as decreased treatment adherence over time, potentially due to diabetes-related distress and treatment fatigue.[11,12] Similarly, Gupta (2019) observed elevated mean HbA1c values in patients with duration exceeding 10 years compared to those with less than 5 years, a pattern consistent with the ascending HbA1c trend across duration categories observed in the present study. The progressive increase in mean HbA1c from newly diagnosed patients to those with long-standing disease corroborates these previous observations and provides additional evidence supporting the hypothesis that diabetes duration influences glycaemic control trajectories.[13]

Despite this consistency in directional findings, the magnitude of correlation observed in this study was notably weaker than that reported by Nurgajayanti et al. (2024). This discrepancy may reflect differences in study populations, healthcare settings, or the influence of unmeasured confounding variables that vary across contexts. The weaker correlation observed in Kupang City's primary health centres suggests that local factors including healthcare quality, patient education programmes, medication availability, and socioeconomic conditions may modify the relationship between disease duration and glycaemic control.[4] This finding underscores the importance of conducting research in diverse settings to understand how contextual factors influence diabetes outcomes.

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In contrast to the present findings, Sinha et al. (2019) found no direct significant correlation between disease duration and HbA1c levels in cross-sectional analysis of Indian patients, despite disease duration emerging as an independent predictor in multivariate regression. This apparent paradox suggests that the relationship between duration and glycaemic control is complex and potentially mediated by multiple confounding factors. The authors proposed that variables such as medication adherence, socioeconomic status, and lifestyle factors might exert stronger influences on HbA1c than disease duration per se, thereby masking the duration effect in simple bivariate analysis.[9] The present study's identification of a significant albeit weak correlation represents an intermediate position between the strong correlations reported by some researchers and the absent correlation found by others, potentially reflecting the particular characteristics of the Kupang primary healthcare setting.

The physiological mechanisms underlying the observed correlation between disease duration and HbA1c can be explained through multiple interconnected pathways. Firstly, type 2 diabetes mellitus is characterised by progressive pancreatic beta-cell dysfunction, whereby insulin secretory capacity gradually declines over time despite treatment interventions.[1] The UK Prospective Diabetes Study definitively demonstrated this phenomenon, showing that beta-cell function declined at approximately four to five percent per year regardless of treatment modality. This progressive dysfunction necessitates treatment intensification over time to maintain glycaemic control, and delays in appropriate treatment escalation can result in prolonged periods of suboptimal control. The biological inevitability of beta-cell decline provides a physiological basis for the observed correlation between longer disease duration and elevated HbA1c levels.[11]

Secondly, insulin resistance tends to worsen over time in many patients with type 2 diabetes mellitus, particularly in the context of weight gain, ageing, and declining physical activity. The combination of progressive beta-cell dysfunction and worsening insulin resistance creates a dual defect that becomes increasingly difficult to manage with standard oral medications alone, often requiring insulin therapy in later disease stages.[1] This pathophysiological progression provides an additional biological mechanism linking disease duration to glycaemic deterioration.

Thirdly, accumulation of microvascular and macrovascular complications in patients with longer disease duration may paradoxically worsen glycaemic control through various mechanisms.[14] Diabetic nephropathy alters medication pharmacokinetics and necessitates dose adjustments that may temporarily destabilise glycaemic control. Diabetic neuropathy can limit physical activity capacity and thereby reduce energy expenditure and worsen insulin sensitivity.[15] Cardiovascular disease may necessitate medications that adversely affect glucose metabolism. Thus, duration-related complications can create a vicious cycle whereby poor control leads to complications, which in turn further impair control.

The weak correlation strength observed in this study, indicating that disease duration explains only a modest proportion of HbA1c variation, underscores the multifactorial nature of glycaemic control in diabetes mellitus. This finding is consistent with contemporary understanding of diabetes as a complex chronic disease influenced by multiple biological, behavioural, psychological, and social determinants operating simultaneously and interactively.[6] The substantial proportion of HbA1c variance not explained by disease duration alone highlights the critical importance of other factors documented to influence glycaemic control.

Among these factors, medication adherence emerged as particularly salient in the present study, with more than half of participants reporting irregular medication consumption. This finding has substantial implications for glycaemic control, as multiple studies have established that medication adherence exerts strong influences on HbA1c levels.[16,17] García-Pérez et al. (2013) reported that medication adherence demonstrated stronger correlation with HbA1c than disease duration, whilst Kirkman et al. (2015) found that medication non-adherence contributed to nearly half of failures to achieve glycaemic targets. The observation that adherence correlation with HbA1c substantially exceeds the duration correlation observed in this study helps explain why duration exhibits only weak correlation despite statistical significance. This finding suggests that the duration-HbA1c relationship may be partially mediated by declining adherence over time, as longer-duration patients experience treatment fatigue and diminishing motivation.

Lifestyle factors including dietary patterns and physical activity represent additional modifiable determinants of glycaemic control that may obscure the duration effect. The present study documented that the majority of participants were classified as overweight according to Asia-Pacific criteria, a finding with important implications as obesity is strongly associated with insulin resistance and poor glycaemic outcomes.[18] Weight management through dietary modification and increased physical activity represents a cornerstone of diabetes management, yet achieving and maintaining weight loss proves challenging for most patients.[1]

Regarding physical activity, the majority of participants in this study engaged in moderate intensity activities. Colberg et al. (2016) demonstrated that structured physical activity can reduce HbA1c by clinically meaningful amounts, an effect consistent

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regardless of disease duration, suggesting that lifestyle interventions remain effective even in long-standing diabetes.[15] The fact that lifestyle factors exert effects independent of disease duration helps explain why duration alone shows weak correlation with HbA1c.

Psychosocial aspects including diabetes distress and depression represent additional factors that can worsen over disease duration and negatively impact glycaemic control. Fisher et al. (2012) identified relationships between diabetes distress and both elevated HbA1c values and poorer adherence to diabetes self-management behaviours.[12] The continuous demands of diabetes self-management can become increasingly burdensome over years and decades, leading to emotional exhaustion and decreased motivation. Gonzalez et al. (2008) demonstrated that depression significantly correlates with diabetes medication non-adherence, with strongest effects observed for missed medical appointments and composite self-care measures.[19] These psychosocial mechanisms provide plausible explanations for why longer disease duration correlates with poorer glycaemic control, operating through their effects on self-management behaviours and treatment adherence.

The finding that even patients with relatively short disease duration demonstrated mean HbA1c above recommended targets suggests challenges in achieving optimal glycaemic control from the early stages of disease management at primary healthcare level. This observation highlights opportunities for more intensive intervention immediately following diagnosis, when patients may be most receptive to behaviour change and before complications develop. Diabetes self-management education and support programmes, when delivered systematically following diagnosis, have demonstrated effectiveness in improving glycaemic control.[20] However, availability and utilisation of such programmes at primary health centres in Indonesia remain suboptimal, representing an important target for health system strengthening.[1]

These findings carry important clinical implications that extend beyond the specific context of Kupang City. Although disease duration demonstrates significant correlation with HbA1c, the weak relationship strength emphasises that diabetes management cannot focus on a single factor. A comprehensive multifactorial approach encompassing medication adherence optimisation, diabetes self-management education, lifestyle modification, and psychosocial support is essential for achieving optimal glycaemic control.[6] This integrated approach should address individual patient factors through education and behavioural support, healthcare provider factors through training and decision support systems, and health system factors through improved care coordination and medication access.

The significant correlation between disease duration and HbA1c, despite its modest magnitude, supports the practice of more intensive monitoring for patients with longer disease duration who face elevated risk of poor control and complications.[7] Healthcare providers should recognise that longer-duration patients may require not only treatment intensification due to progressive beta-cell dysfunction, but also enhanced psychosocial support to address treatment fatigue and maintain motivation for self-management.[11,12] Proactive identification of longer-duration patients experiencing declining control enables timely intervention before severe hyperglycaemia or complications develop.

This finding also underscores the importance of early intervention and primary diabetes prevention. Li et al. (2008) demonstrated that lifestyle changes could delay diabetes onset, with protective benefits persisting for decades.[21] Given that longer disease duration correlates with worse outcomes, preventing or delaying diabetes onset through population-level and high-risk individual interventions represents a crucial public health strategy. Similarly, screening programmes to enable early diagnosis before extensive beta-cell loss has occurred may improve long-term prognosis.[6] Early establishment of good glycaemic control may alter disease trajectories and prevent or delay the progressive deterioration observed with increasing disease duration.

At primary healthcare level, these findings highlight the importance of routine HbA1c monitoring, particularly in patients with longer disease duration. The American Diabetes Association Standards of Care in Diabetes (2023) recommends HbA1c testing at least twice annually in patients with stable control, and more frequently in those with therapy changes or failing to achieve glycaemic targets.[6] Implementation of these recommendations at primary health centres would enable early identification of glycaemic deterioration and prompt treatment adjustments. However, HbA1c testing availability at primary health centres remains limited in many Indonesian settings, necessitating collaboration with referral laboratories to facilitate optimal monitoring.[4] Investment in point-of-care HbA1c testing equipment at high-volume primary health centres could improve access to this critical monitoring tool.

The implications of these findings for the advancement of diabetes care science are multifaceted. The study contributes to the evidence base regarding diabetes natural history in primary healthcare settings of developing countries, a context underrepresented in international diabetes research.[2] The finding that disease duration correlates with glycaemic control even after

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accounting for its modest effect size validates the inclusion of disease duration as a relevant variable in diabetes research and clinical assessment. However, the weak correlation strength challenges simplistic models that view duration as a primary determinant of outcomes, instead supporting complex systems perspectives that recognise multiple interacting influences on diabetes control.[6]

The contextual variation in correlation strength across different studies and settings suggests that universal generalisations about the duration-HbA1c relationship may be inappropriate. Instead, the relationship appears to be modified by local healthcare quality, patient characteristics, and sociocultural factors. This finding has implications for the external validity and generalisability of diabetes research, suggesting the need for multi-site studies across diverse contexts to understand how relationships vary and what factors moderate observed associations. Such research could inform development of context-appropriate interventions tailored to local circumstances rather than assuming universal applicability of findings from high-income countries.[3,4]

The study also contributes methodologically by demonstrating the value of primary data collection with standardised contemporary measurements rather than reliance on medical records. The use of HPLC-measured HbA1c using methods standardised to international reference standards ensures comparability with global diabetes research, facilitating integration of findings into the international evidence base.[5] The triangulation of disease duration assessment through both patient report and medical record verification enhances measurement validity. These methodological strengths can inform future diabetes research in similar resource-constrained settings.

This study possesses several limitations that warrant consideration when interpreting findings. Firstly, the cross-sectional design precludes establishment of causal relationships between disease duration and HbA1c levels.[10] Whilst the observed association is consistent with hypothesised causal pathways, alternative explanations cannot be definitively excluded. Longitudinal studies tracking HbA1c changes within individuals over time would provide stronger evidence regarding the causal effect of duration on glycaemic control. The cross-sectional design also cannot distinguish between effects of disease duration per se versus cohort effects, whereby individuals diagnosed in different calendar periods may have experienced different standards of care that influence current glycaemic control independent of duration.

Secondly, several potentially important confounding variables were not measured in this study, including educational level, household income, diabetes self-efficacy, diabetes distress, and specific medications being used. Unmeasured confounding may bias the observed association between duration and HbA1c in either direction depending on the relationships between confounders and both exposure and outcome. For example, if longer-duration patients tend to have lower socioeconomic status due to diabetes-related work disability, and lower socioeconomic status independently predicts poor control, the observed correlation might overestimate the true causal effect of duration. Conversely, if longer-duration patients have accumulated more diabetes knowledge and experience that partially compensates for physiological deterioration, the observed correlation might underestimate the biological effect of duration.

Thirdly, medication adherence was assessed through self-report, which is susceptible to recall bias and social desirability bias whereby participants overreport adherence to present themselves favourably. More objective adherence measures such as pharmacy refill data or electronic monitoring would provide more accurate assessment, though these methods were not feasible in this study setting. The self-reported adherence data should therefore be interpreted cautiously, recognising that actual adherence may be lower than reported. This measurement error in the adherence variable, if non-differential with respect to disease duration, would tend to attenuate rather than create the weak correlation between duration and HbA1c.

Fourthly, the study population distribution was uneven across age groups, with predominance of participants aged fifty to fifty-nine years, potentially limiting generalisability to younger adults with diabetes. However, this age distribution reflects the epidemiology of type 2 diabetes mellitus, which predominantly affects middle-aged and older adults.[2,3] The exclusion of patients aged sixty years and above was implemented to minimise confounding from age-related changes in erythrocyte turnover that could affect HbA1c interpretation, but this exclusion also limits generalisability to elderly populations who represent a substantial and growing proportion of diabetes patients.[22]

Fifthly, the study was conducted at three primary health centres in one city, which, whilst providing adequate sample size and representation of diverse neighbourhoods, may limit generalisability to other geographic regions of Indonesia with different healthcare infrastructure, patient populations, or cultural contexts. Urban primary health centres in provincial capitals like Kupang may differ systematically from rural facilities or those in larger metropolitan areas in terms of staffing, equipment, medication

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availability, and patient case-mix. Multi-centre studies across diverse settings would enhance external validity and enable examination of how contextual factors modify the duration-HbA1c relationship.

Finally, the categorisation of disease duration into three groups, whilst facilitating analysis and clinical interpretation, results in loss of information compared to treating duration as a continuous variable. The specific cut-points selected for categorisation were based on clinical considerations and previous research, but alternative categorisations might yield different results. Sensitivity analyses using alternative duration categorisations or treating duration as continuous would strengthen confidence in findings. Additionally, recall bias in patient-reported disease duration, despite verification against medical records, may introduce measurement error that could attenuate observed associations.

Despite these limitations, the study possesses important strengths including prospective primary data collection with standardised protocols, contemporary HbA1c measurement using internationally standardised methods, verification of disease duration through multiple sources, adequate statistical power based on formal sample size calculation, and focus on primary healthcare settings where the majority of diabetes management occurs in Indonesia. These strengths enhance confidence in the validity of findings and their relevance to real-world diabetes care. Future research should address current limitations through longitudinal designs, more comprehensive measurement of potential confounders and mediators, objective adherence assessment methods, and multi-site studies across diverse Indonesian contexts to enhance generalisability and mechanistic understanding of relationships between disease duration and glycaemic outcomes.

CONCLUSION

This study demonstrates that a positive relationship exists between disease duration and glycaemic control among patients with type 2 diabetes mellitus attending primary health centres in Kupang City. Longer disease duration is associated with higher HbA1c levels, indicating a gradual decline in glycaemic control over time. However, the relationship observed is relatively weak, suggesting that disease duration alone does not fully determine long-term glycaemic outcomes. These findings confirm that while the length of time living with diabetes contributes to glycaemic control, other factors such as individual behaviour, treatment compliance, and self-management capacity play a more substantial role in influencing HbA1c levels among patients at the primary healthcare level.

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