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Research Article

Prevalence of Type 2 Diabetes and Its Associated Metabolic Disorders and Anemia among Cambodian population in Takhmao, Cambodia: A Retrospective Study

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Abstract

Background: *Diabetes mellitus (DM) is a chronic metabolic disorder marked by persistent hyperglycemia. Type 2 diabetes mellitus (T2DM) is the most common form, accounting for over 90% of all DM cases. T2DM primarily linked to insulin resistance, and often associated with obesity, physical inactivity, and genetic predisposition. T2DM contributes to a range of metabolic disturbances, including dyslipidemia, renal impairment, electrolyte imbalances, and anemia and can result in serious complications, such as cardiovascular disease, diabetic retinopathy, and peripheral neuropathy.*

Objective: *The study was conducted among the Cambodian population in Takhmao town and aim to 1). Determine the prevalence rate of T2DM between 2021 and 2024; 2). Investigate diabetic metabolic proteins in T2DM patients and correlate their levels with T2DM severity; 3). Assess the prevalence anemia in diabetic populations relative to non-diabetic counterparts.*

Methods and Materials: *The retrospective single-institution study will review laboratory records of individuals who sought diabetic screening at Dialab Takhmao Medical Laboratory (Takhmao, Kandal province, Cambodia) between 2021 and 2024. The study involves collecting laboratory variables such as Fasting Blood Sugar (FBS), Glycosylated Hemoglobin (HbA1c), metabolic tests (e.g., triglycerides, cholesterol, kidney function), electrolytes (Na+, K+, Cl+), and complete blood count (CBC). Study participants are classified into three age groups: under 40, 40-60, and over 60 years.*

Results: *The study found that from 2021 to 2024, the annual prevalence of type 2 diabetes mellitus (T2DM) in Cambodia remained high yet stable, ranging from 29.12% to 34.26%, with 7,798 cases recorded. Women consistently showed slightly higher prevalence than men. Prevalence was lowest among individuals under 40, while men aged 40–60 exhibited unexpectedly higher rates than those over 60. T2DM was associated with significant metabolic abnormalities, including elevated cholesterol, triglycerides, LDL, and VLDL levels, even among younger patients, suggesting early lipid dysregulation. Signs of early kidney involvement were evident with increased urea levels, while creatinine remained unchanged. Electrolyte imbalances were observed, notably reduced sodium and chloride levels, while potassium remained stable. Regression analysis showed positive correlations of triglycerides, urea, and potassium with FBS, and negative correlations of sodium and chloride, indicating deteriorating metabolic parameters with increasing blood glucose levels. These patterns were not influenced by sex. T2DM was not associated with increased anaemia risk. In fact, anaemia prevalence was lower among individuals with T2DM across all age groups and both sexes, compared with non-diabetic counterparts. Anaemia increased with age in both T2DM and non-T2DM individuals, suggesting that age, rather than diabetes, may be the primary contributor.*

Conclusion: *These findings underscore the persistent burden of T2DM in Cambodia and highlight the need for broader national studies to better capture regional and demographic disparities.*

Keywords: Diabetes mellitus (DM), Type 2 diabetes mellitus (T2DM), Anemia, Fasting blood sugar (FBS), Glycosylated hemoglobin (HbA1c)

1. Introduction

Diabetes mellitus (DM) is a metabolic disease characterized by abnormally high blood glucose levels (Figure 1) [1]. DM is one of the leading causes of death and disability worldwide and has emerged as one of the most critical public health concerns globally. According to the world health organization, in 2021, an estimated 537 million adults aged 20-79 had diabetes, accounting for 10.5% of all adults in all age groups [2]. The number of adults with diabetes is projected to increase to 643 million and 783 million in 2030 and 2045 [2]. DM is classified into several categories such as type 1, type 2, maturity-onset diabetes of the young, gestational diabetes, neonatal diabetes [3]. The main subtype of DM, that are more prevalent in people are type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM). The pathogenesis of T1DM and T2DM differs, resulting in distinct etiologies, clinical manifestations, and treatment approaches for each condition. Long-term complications of DM include diabetic retinopathy (eye damage), diabetic nephropathy (kidney damage), diabetic neuropathy (nerve damage), and macrovascular complications such as heart attack, stroke, and peripheral arterial diseases [4,5]. The management of DM involves a combination of lifestyle changes, such as a healthy diet, regular physical activity, and maintaining a normal body weight, along with medications and regular monitoring of blood sugar levels [6,7]. This research will focus on prevalence study of T2DM and the impacts of T2DM on metabolic parameters and the development of anemia within Cambodian population the southern region of Cambodia.

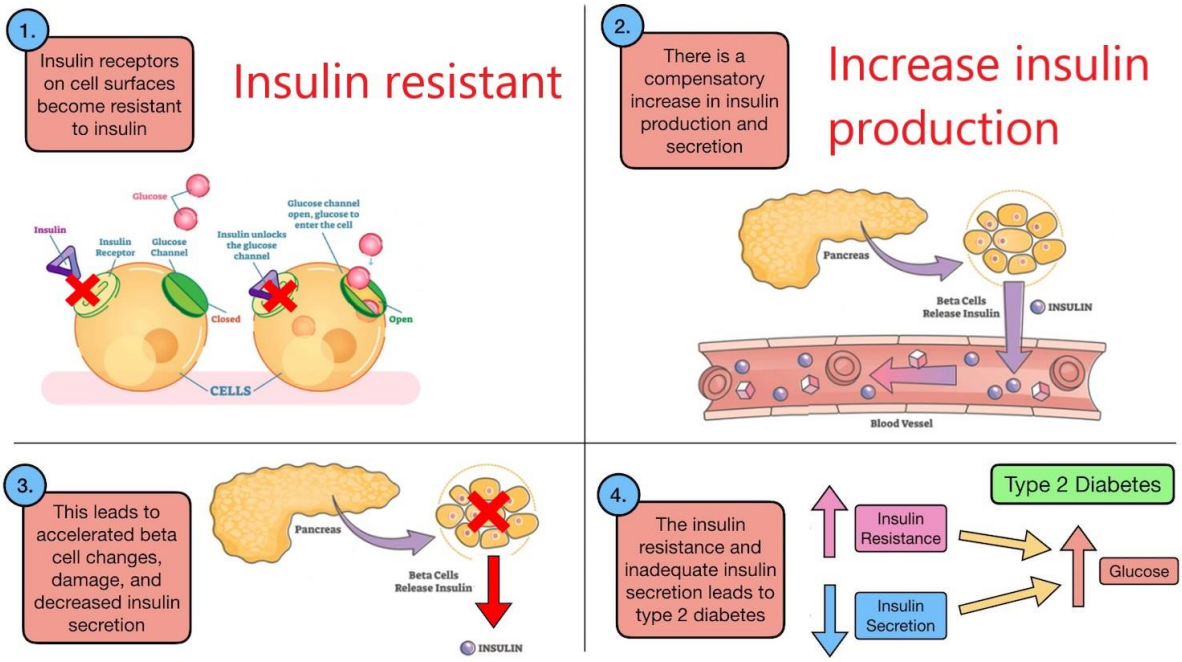

Figure 1: Overview of T2DM

T2DM develops due to a combination of insulin resistance and insufficient insulin production by pancreatic beta cells. This leads to elevated glucose levels in the blood, a condition known as hyperglycemia [8].

1.1. Diabetes in Cambodia

Cambodia is a country located in Southeast Asia, bordered by Thailand, Laos, Vietnam, and the Gulf of Thailand. As of the most recent estimates, Cambodia has a population of approximately 17 million people [9]. The country has experienced significant economic growth over the past two decades. However, it remains one of the lower-middle-income nations in the region. Despite improvements in infrastructure and living standards, healthcare in Cambodia remains underdeveloped, particularly in rural areas. The healthcare system is challenged by a lack of medical personnel, limited access to advanced medical technologies, and insufficient funding, leading to disparities in healthcare access and quality between urban and rural populations.

The healthcare system in Cambodia relies heavily on expense of each individual, and many people in rural areas face barriers to accessing basic healthcare services, including preventive care and chronic disease management. While Cambodia has made progress in combating infectious diseases and improving maternal and child health, non-communicable diseases (NCDs) such as diabetes are emerging as significant public health challenges. The burden of diabetes, particularly T2DM, is rising due to changing lifestyles, urbanization, and dietary shifts. According the published study by the National Institute of Public Health, Cambodia, a country in Southeast Asia, has seen a notable surge in T2DM with 9.6% prevalence rate among adults aged 18 to 69 in 2016, marking a significant increase from 2.9% in 2010 [10]. However, this data is largely under reported [11]. Furthermore, IDF found that 5,540 diabetic patients died in Cambodia in 2013, which may have been attributable to inequal access to diabetic cares largely in under-served population [12].

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A recent study showed that 20% of T2DM patients developed anemia, a disease characterized by a decrease in the normal red blood cells [13]. In Cambodia, anemia remains a significant public health problem [14]. However, it is unknown what proportion of anemia is specifically attributable to diabetes and whether the presence anemia in Cambodian diabetic patients contribute to disease severity remains unexplored. Moreover, although some studies have reported that diabetes change metabolic profiles (i.e., increased triglyceride or cholesterol, impaired kidney function) of the patients [8,15], these have never been investigated in Cambodian T2DM patients. This is significance because prolonged metabolic disorder caused by diabetes can lead several complications such as inflammatory disorders [16], hypertension, stroke and cardiovascular diseases [17-19].

2. Study objective and significance

The study selected Takhmao town, located in southern region of Cambodia to gather additional prevalence rate of and T2DM. Of particular interest, the study, for the first time, will examine the associated complications of diabetes with a particular focus on anemia and metabolic disorders in T2DM patients, who sought diabetic screening at The Dialab Takhmao Medical Laboratory, Takhmao, Cambodia. By collecting additional prevalence rate of diabetes, examining metabolic changes and anemia in Cambodian diabetic patients, the research will inform the Cambodian Ministry of Health to develop targeted treatment guidelines for T2DM tailored to the Cambodian population and guide the development of preventive strategies to mitigate the incidence of diabetes.

3. Materials and methods

This retrospective and single institution study will be based on the laboratory record of people, who sought diabetic screening at a registered Dialab Takhmao Medical Laboratory (Takhmao, Kandal province, Cambodia) between 2021 and 2024. The study was approved by the National Ethics Committee for Health Research, Cambodia. During this 4-year period, this study will review the laboratory record of people receiving diabetic screening (Fasting blood sugar (FBS) and Glycosylated hemoglobin (HbA1c)) and having their metabolic tests (e.g., Triglyceride, cholesterol, low density lipoprotein (LDL), very low-density lipoprotein (VLDL), kidney function (Urea, Creatin), Electrolytes (Na+, K+, CL+) and complete blood count (CBC)) performed. The analysis will include the collection of all these above-mentioned variables and demographics in study participants and divide the populations to three groups: Group 1 (under 40 years old), Group 2 (aged 40-60 years old) and Group 3 (more than 60 years old). T2DM is defined in individuals with FBS ≥126 mg/dL and absence of anti-GAD, anti-IA2. FBS and metabolic protein measurements are made using colometric and enzymatic methods (BA 200 Biosystem, Barcelona, Spain), while HbA1c and autoantibodies are measured using High-performance liquid chromatography method (Lifotronic H100, China) and Chemiluminescent Immunoassays (SNIBE Maglumi 2000, China) respectively. CBC is measured using Electrical Impedance method (Modonic M32, Sweden).

3.1. Statistical analyses

The prevalence rate of diabetes among study participants is calculated by dividing the number of individuals with diabetes by the total study population. Since the study compares the prevalence rate of diabetes between gender and age group and diabetic associated metabolic proteins between diabetes and non-diabetic subjects, chi-square test will be used to compare prevalence and proportion between groups followed by pair-wise comparison using Bonferroni correction. Multivariate linear regression models will also be used to compare the difference of diabetic associated metabolic disorders between gender and age group and to investigate the association of metabolic disorders with diabetes severity using FBS as an outcome. Interaction (effect modification) between genders and diabetic associated metabolic disorders expressed as continuous variables, will be examined to determine whether the impacts of metabolic disorders on diabetes is modified by gender. Since the study has less than 20 predictors variables, all of them will be used in one single model. Predictor variables with $P<0.05$ are retained in the model. Model diagnosis (e.g., normal distribution, constant variance) will be assessed to ensure the proper interpretation of the model. All the analyses will be performed using R environment for statistical computing and p-value less than 0.05 is significant.

4. Results

4.1. The annual prevalence of T2DM is high, but stable from 2021 to 2024

T2DM cases are rising rapidly in Cambodia. However, national prevalence studies have yet to cover all regions, particularly the southern part of the country, making the reported prevalence less representative. A retrospective review of laboratory records from the southern region of Cambodia was conducted for the period 2021–2024. Notably, the number of individuals who underwent diabetic screening each year were as follows: 3441 in 2021 (1179 diabetes, 2262 non-diabetes), 6,058 in 2022 (1,781 diabetes, 4,277 non-diabetes), 76,498 in 2023 (2,424 diabetes, 5,225 non-diabetes), and 8,291 in 2024 (2,414 diabetes, 5,877 non-diabetes) (Figure 2A). The annual prevalence for T2DM was 34.26%, 29.4%, 31.6% and 29.12% respectively in 2021, 2022, 2023, and 2024 (Figure 2B). During the 4-year period from 2021 to 2024, a total of 7798 cases of diabetes were identified in comparison to non-diabetes cases (Figure 2C), accounting for an overall 30.7% prevalence rate for the entire period of 2021 to 2024 (Figure 2D). Overall, these findings highlight a substantial burden of T2DM in the studied region. The observed 30.7% prevalence over the four-year period underscores the need for more comprehensive national studies, particularly in underrepresented areas.

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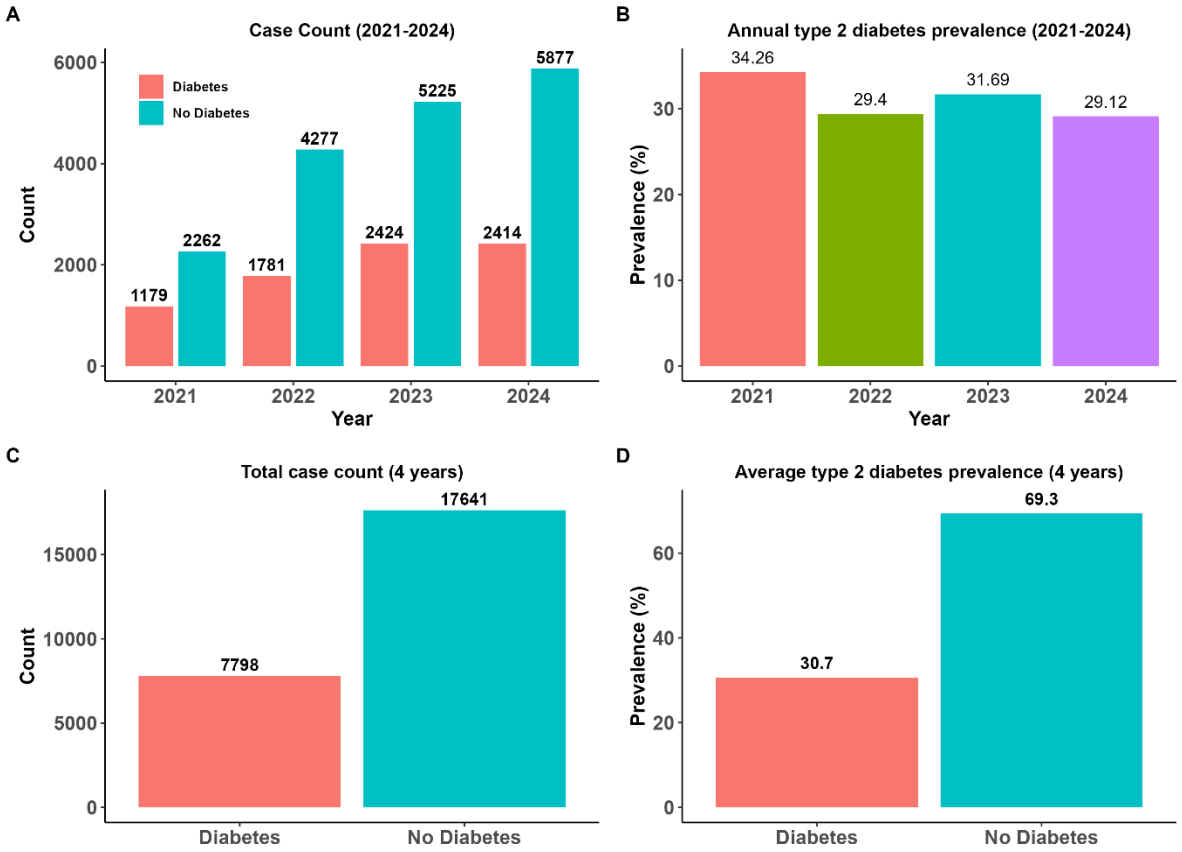

Figure 2: Annual prevalence of T2DM is high, but stable from 2021 to 2024
A. case count of type 2 diabetes in 2021, 2022, 2023, and 2024 as represented by bar graph as diabetic and non-diabetic counts. **B.** Annual prevalence of type 2 diabetes from 2021 to 2024. **C.** Cumulative number of type 2 diabetes cases recorded between 2021 and 2024. **D.** Prevalence of T2DM for the entire four-year period (2021–2024).

4.2. Male and female T2DM prevalence are similar across four-year period

To explore the prevalence of T2DM among men and women across different age groups over a four-year span, the study population was divided by sex (male and female) and categorized into three age groups: under 40, 40-60, and over 60 years. Among women, T2DM prevalence remained consistent over the four years, with rates of 18.45% in 2021, 15.3% in 2022, 16.89% in 2023, and 16.1% in 2024 (Figure 3A). A similar pattern observed for men, where annual prevalence stayed relatively stable, peaking at 15.81% in 2021 and decreasing to 13.01% in 2024 (Figure 3A). Notably, women showed slightly higher T2DM prevalence than men in both 2021 (18.45% vs. 15.81%) and 2024 (16.1% vs. 13.01%).

Next, the prevalence of T2DM was examined across the three age groups for both sexes of combined four years. As expected, individuals under 40 had a lower prevalence, compared to those aged 40-60 and over 60 (Figure 3B). However, an unexpected finding was that men over 60 had a lower prevalence than those aged 40-60 (Figure 3B).

Finally, the annual prevalence of T2DM was assessed within each age group for both men and women. Among women, prevalence was consistently lower in the under-40 group compared to the 40-60 and over-60 groups across all four years (Figure 3C). In 2021, women over 60 showed a slightly higher prevalence than those aged 40-60 (Figure 3C). For men, as expected, the 40-60 age group had a higher prevalence than those under 40 (Figure 3C). Surprisingly, men over 60 exhibited a lower prevalence, similar to the under-40 group and below the 40-60 group (Figure 3C). Overall, over a four-year period, the prevalence of T2DM remained relatively stable for both men and women, with women consistently showing slightly higher rates than men, particularly in 2021 and 2024. Across age groups, T2DM prevalence was lowest in those under 40, while men aged 40-60 unexpectedly exhibited higher rates than those over 60, contrasting with typical trends.

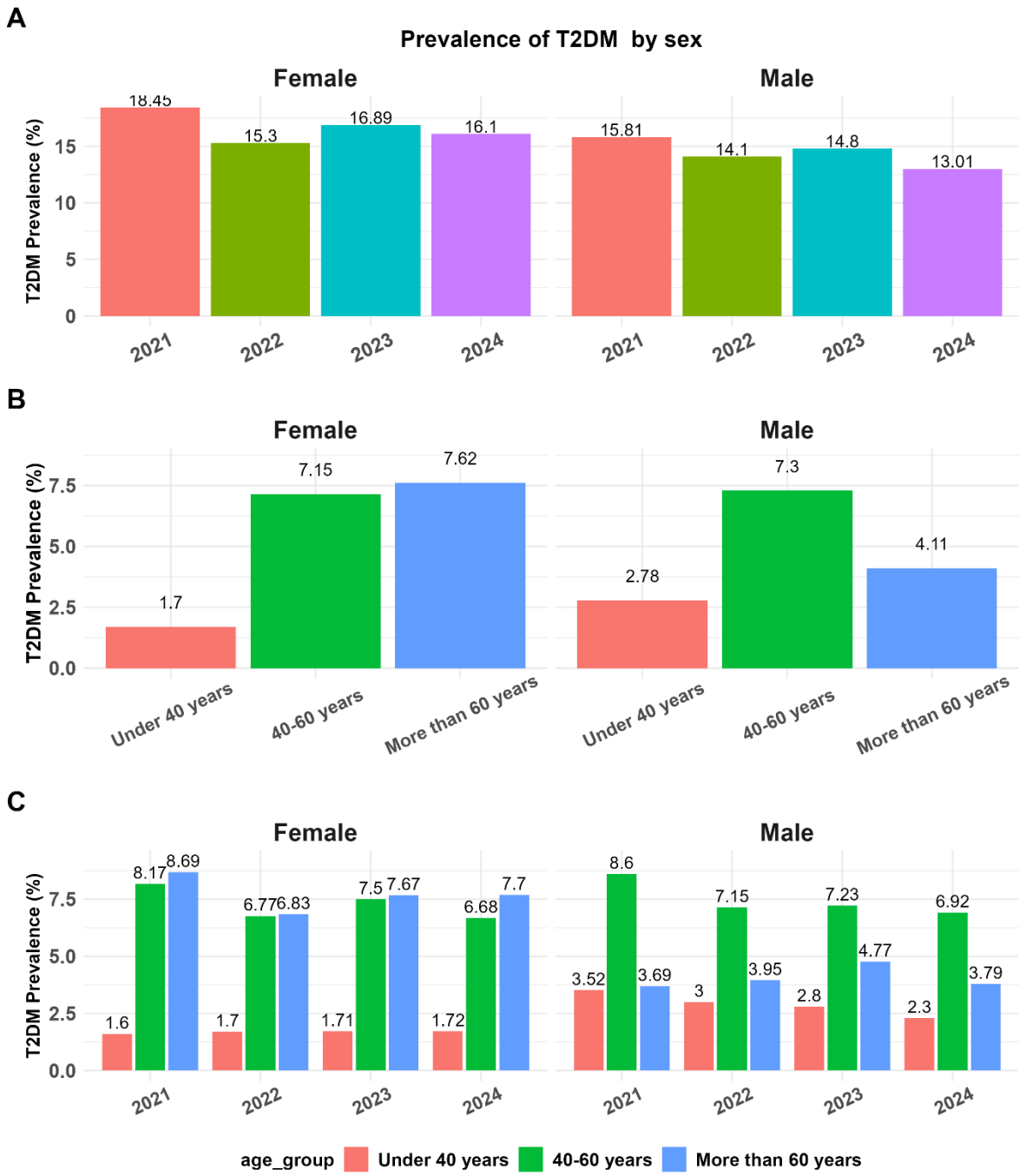

Figure 3: Male and female T2DM prevalence are similar across four-year period
A. Bar graph representing annual prevalence of T2DM by sex. **B.** The overall prevalence of T2DM of three age groups (under 40, 40-60, above 60 in men and women. **C.** The annual prevalence of T2DM of three age groups (under 40, 40-60, above 60 in men and women.

4.3. Altered lipid profile, renal dysfunction, and electrolyte imbalance in T2DM patients

T2DM is known to significantly impact the metabolic profile of affected individuals. However, these alterations have not been investigated in Cambodian T2DM patients. The study hypothesized that T2DM is associated with increased lipid levels, reduced kidney function, and an imbalance in electrolyte levels. To address this, Biochemical markers, including key lipid, renal function parameters, and serum electrolytes, were analyzed in individuals with and without T2DM across different age groups. T2DM patients exhibited elevated total cholesterol and triglyceride levels compared to non-T2DM individuals across all three age groups, suggesting a consistent dyslipidemia pattern in the diabetic population (Figure 4A-B). In addition, low density lipoprotein (LDL), commonly known as 'bad cholesterol', was significantly higher in T2DM individuals aged under 40 and over 60, relative to their non-T2DM counterparts (Figure 4D). Very-low-density lipoprotein (VLDL) levels were also notably increased in younger T2DM individuals under 40 years of age (Figure 4E), indicating early lipid dysregulation. Next, Renal function was examined using urea and creatinine

levels. Urea was significantly elevated in T2DM patients across all age groups, reflecting impaired renal function (Figure 4F). Interestingly, creatinine levels did not differ between T2DM and non-T2DM individuals in any age group (Figure 4G), suggesting that changes in urea may precede detectable alterations in creatinine in early diabetic kidney involvement.

In addition to lipid and renal parameters, serum electrolyte levels were also examined, as previous studies have reported dysregulation in T2DM. Sodium and chloride levels were consistently reduced in T2DM individuals, compared to non-T2DM controls across all age groups (Figure 4H-J), indicating possible electrolyte imbalance associated with diabetes. In contrast, potassium levels remained comparable between T2DM and non-T2DM individuals in all age groups (Figure 4I), suggesting selective alterations in electrolyte regulation. Taken together, these findings highlight the multifaceted impact of T2DM on metabolic health, including dyslipidemia, impaired renal function, and electrolyte imbalance. The consistent elevation of lipid levels, increased urea, and reduced sodium and chloride across age groups underscore the systemic nature of metabolic disturbances in T2DM.

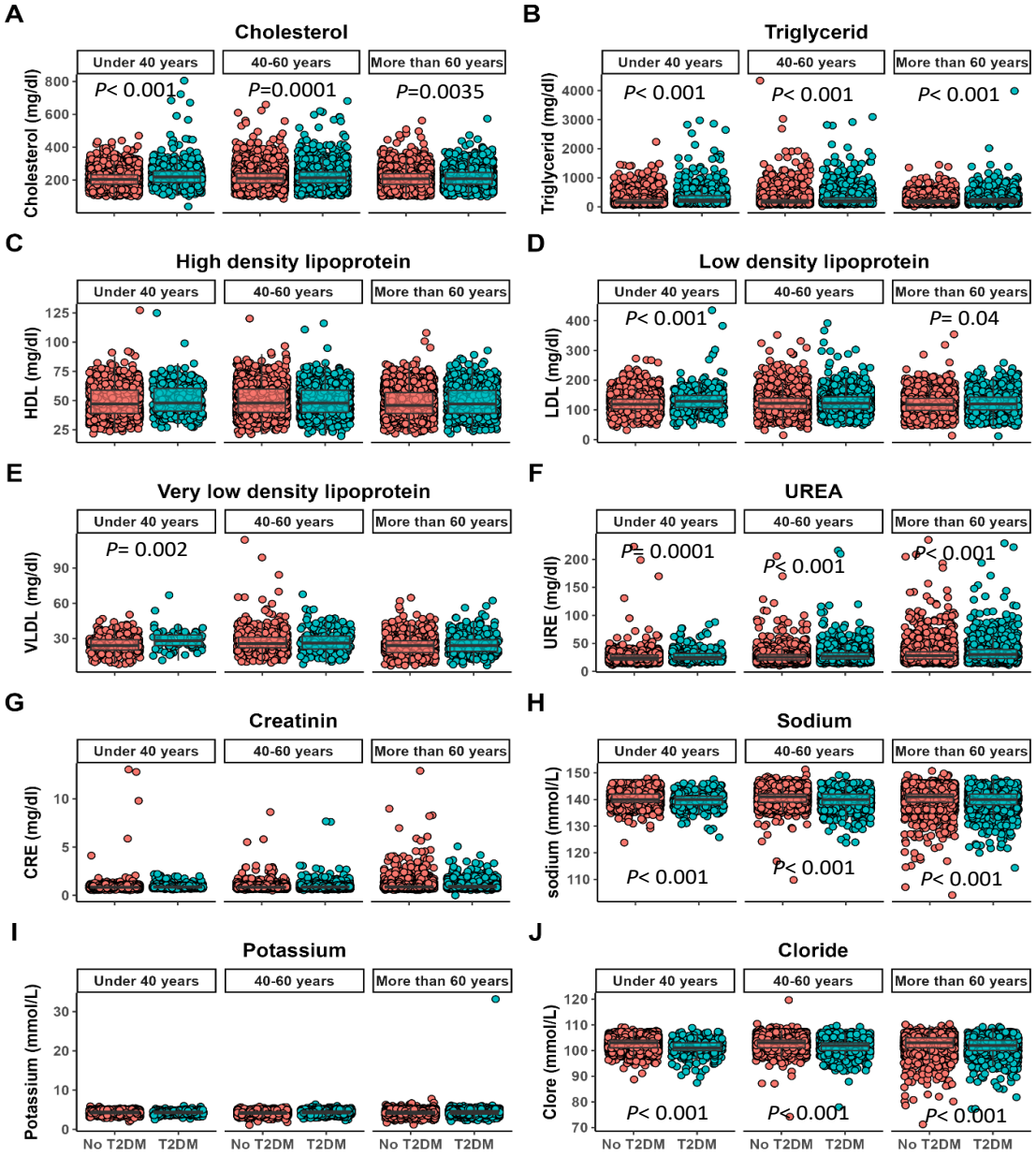

Figure 4: Altered Lipid Profile, Renal Dysfunction, and Electrolyte Imbalance in T2DM
(A–B) Cholesterol and triglyceride levels in T2DM patients compared to non-T2DM individuals across three age groups. (C-E) lipid levels including HDL, LDL and VLDL levels in T2DM, relative to non-T2DM inviduals. (F –G) Renal functions (Urea and Creatinin) between T2MD and non-T2DM. (H-J) electrolyte contents (Sodium, potassium and chloride) levels in the T2DM, compared to non-T2DM individual across all age groups. One-way analysis of variance for multiple group comparison, p value less than 0.05 is significant.

4.4. Severity of T2DM Is associated with elevated triglyceride levels and electrolyte imbalance

To further understand the metabolic alterations associated with T2DM, associations between T2DM severity and key biochemical parameters, including key lipids (triglycerides, total cholesterol, LDL), urea, and electrolytes, were examined after adjustment for other co-variates. To address this, multiple linear regression models were constructed using FBS as the outcome variable, with all measured variables in Figure 3 as predictor variables. The analysis revealed that triglycerides, urea, and potassium were positively associated with FBS, suggesting that higher blood glucose levels may be linked to elevated lipid levels and impaired renal function (Table 1). In contrast, sodium and chloride were negatively associated with FBS, indicating potential electrolyte imbalances in more severe cases of T2DM (Table 1). These associations remained consistent across both sexes and no difference were observed between male and female T2DM, and thus sex was excluded from the final model.

Predictor	Estimate	95 % CI	p-value	Significance
(Intercept)	24.725	(23.08, 26.36)	< 2e-16	***
Triglyceride	0.00189	(0.001, 0.002)	< 2e-16	***
Urea	0.00828	(0.0057, 0.01)	2.79e-10	***
Sodium	-0.06713	(-0.08, -0.053)	< 2e-16	***
Potassium	0.309909	(0.242, 0.375)	< 2e-16	***
Chloride	-0.11417	(-0.129, -0099)	< 2e-16	***
40–60 years	0.64153	(0.55, 0.72)	< 2e-16	***
More than 60 years	0.75817	(0.67, 0.84)	< 2e-16	***
< 40 years old is a reference group in the model				

Table 1: Summary of Final Multiple Linear Regression Model

4.5. T2DM does not contribute to anemia in the Cambodian study population

Limited evidence suggests that T2DM may contribute to anemia [20]. To investigate whether T2DM could lead to anemia in our study population, the prevalence of anemia in the study population was analyzed. Anemia was defined according to the World Health Organization as hemoglobin levels below 120 g/L for non-pregnant women and below 130 g/L for men [21]. Unexpectedly, the prevalence of anemia is lower in individuals with T2DM, compared to non-T2DM, across both males and females, and throughout the combined age groups and the entire study period (2021-2024) (Figure 6A). This trend persists even when the analysis is conducted within the three distinct age groups (Figure 6B). Interestingly, the study found that the prevalence of anemia increased progressively with age among individuals with T2DM (Figure 6B), and a similar trend was also seen in those without T2DM (Figure 6B), suggesting that age may be a contributing factor to anemia regardless of T2DM status. Taken together, our analysis did not suggest the causal relationship between T2DM and increased anemia prevalence. In fact, the prevalence of anemia was unexpectedly lower in T2DM individuals across both genders and all age groups throughout the study period. These findings suggest that diabetes may not be a contributing factor to anemia in this population.

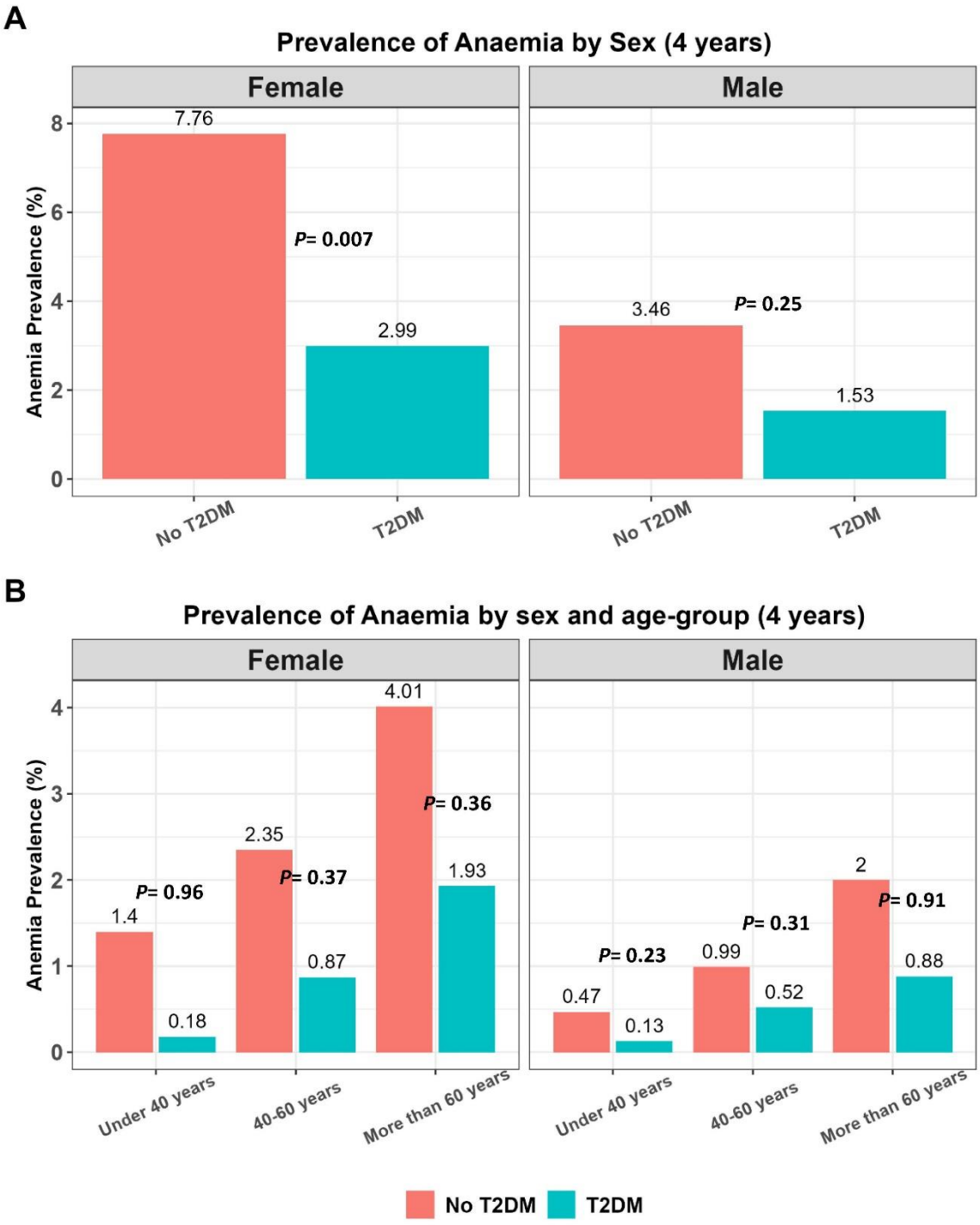

Figure 5: Prevalence of anemia within T2DM is lower than non-T2DM
A. Prevalence of ane m ia within T2DM and non-T2DM in male and female of combined age for four-year period (2021-2024).
B. Prevalence of anemia within T2DM and non-T2DM in by sex and age-group for whole study perioud (2021-2024). Chi-square test for two proporton comparison and p-value less than 0.05 is significant.

5. Discussion

In Cambodia, the prevalence of T2DM has risen significantly, reaching 9.6% among adults aged 18 to 69 in 2016, compared to 2.9% in 2010 [22]. More recent data indicate a further increase, with T2DM affecting 11% of the population in a semi-urban community [23]. However, these studies had limitations, particularly in their coverage, as they focused only on selected populous regions, reducing the generalizability of the findings. Additionally, these studies did not report differences of T2DM between men and women or across various age groups. The current study leverages secondary data from a registered diagnostic laboratory, located in southern Cambodia, where individuals underwent diabetic screening to assess the prevalence of T2DM from 2021 to

2024. Preliminary of the current study findings revealed a high annual T2DM prevalence at an average of 30% when combining both sexes and all age groups. Nationwide prevalence of T2DM has never been conducted due to limited budget and therefore, there is a lack of the precise prevalence of diabetes in Cambodia. However, it is predicted that the prevalence of T2DM is increasing rapidly as more and more adolescent and young adults increasingly consume power drink (high carbohydrate content). Another potential reason for the high prevalence rate could be the selection of a single institution, leading to a bias since individuals seeking diabetic screening are likely part of a high-risk population for T2DM. This increases the likelihood of detecting more T2DM cases. Therefore, the current findings should be validated through studies conducted in randomly selected regions to ensure broader representation. Nevertheless, these results signal a critical need for validation through broader, randomized studies and immediate action from Cambodia's Ministry of Health to address the rising T2DM burden, likely fueled by increasing consumption of high-carbohydrate energy drinks among younger populations.

This study also provides novel insights into the metabolic changes of T2DM in the Cambodian population, showing consistent patterns of dyslipidemia, early renal dysfunction, and electrolyte imbalance across age groups. The observation of elevated total cholesterol, triglycerides, and LDL in T2DM individuals, particularly among those under 40 and over 60 years of age highlights the early induction of lipid abnormalities in T2DM patients. These findings align with global evidence that dyslipidemia is a hallmark of T2DM and a key contributor to cardiovascular risk [24-26]. Notably, the marked increase in very-low-density lipoprotein (VLDL) in younger diabetic individuals suggests that increased lipid parameters may begin early in the disease course, potentially increasing cardiovascular risk if not promptly managed.

Long-term T2DM can cause a decline in renal function, often manifesting through diabetic nephropathy, which includes glomerular damage and reduced renal clearance capacity [27,28]. Despite these associations observed globally, no prior studies have examined renal function markers among T2DM patients in the Cambodian population. In this study, urea levels were observably elevated in individuals with T2DM across all age groups, suggesting early signs of impaired renal function. This finding aligns with global data and supports the notion that hyperglycemia-associated metabolic stress in T2DM can lead to subclinical renal impairment [27,28]. Interestingly, while urea levels were elevated, creatinine levels remained comparable between T2DM and non-T2DM individuals. This discrepancy may reflect the early phase of diabetic kidney disease in which urea elevation precedes detectable changes in creatinine. These results highlight the potential utility of urea as an early indicator of renal involvement in Cambodian T2DM patients.

In terms of electrolyte balance, the consistent reduction in serum sodium and chloride in T2DM individuals across age groups is critical. A study from Khan et al also reported reduction in sodium and chloride in uncontrolled T2DM individual [29]. This pattern may reflect underlying osmotic changes due to hyperglycaemia-induced diuresis or altered renal handling of electrolytes in the diabetic state [30]. The maintenance of potassium levels despite these changes indicates selective dysregulation, which may be influenced by other mechanisms or variations in dietary intake and medication use. Taken together, these results underscore the impacts of T2DM to disrupt multiple physiological pathways. Given the rising prevalence of T2DM in the region and globally, these findings have significant implications for public health planning and suggest that routine assessment of lipid panels, renal markers, and electrolytes should be incorporated into diabetes care protocols in Cambodia. Further longitudinal studies are warranted to determine whether these biochemical alterations predict clinical outcomes such as cardiovascular events, nephropathy, or hospitalization rates.

Contrary to prior reports suggesting a potential link between T2DM and increased risk of anaemia [20], the study findings indicated a lower prevalence of anaemia among individuals with T2DM compared to their non-T2DM counterparts across both sexes and all age groups. While some studies have reported increased incidence of anaemia in diabetic populations [20], the current data suggest that there is no association of T2DM and anaemia in the general Cambodian T2DM population, at least within the timeframe of this study (2021–2024). The absence of a higher anaemia burden in the diabetic cohort may also reflect early-stage or well-managed diabetes in the study population, where renal complications have not yet progressed to levels that would impact red blood cells.

6. Conclusion

In conclusion, this study identified a high prevalence of T2DM in the study population (approximately 30%) which exceeds previously reported figures. It also revealed significant metabolic disturbances, including dyslipidemia, impaired renal function, and electrolyte imbalances. These findings underscore the importance of utilizing multiple renal biomarkers for effective monitoring of diabetic patients, especially in resource-constrained settings like Cambodia. There is an urgent need for intervention by the Cambodian Ministry of Health to address the growing burden of T2DM and to develop treatment strategies that are tailored to the specific needs of the Cambodian population.

Limitation of the study

This study has some limitations as it collected data exclusively from a single diagnostic laboratory located in Takhmao town. Consequently, there might be a bias in the prevalence rate we calculate from the study, as the individuals seeking diabetic screening at Dialab Takhmao Medical Laboratory tend to belong to middle-income families. Additionally, the laboratory records lack comprehensive demographic details beyond gender. Therefore, the current findings, particularly regarding anemia and metabolic disorders, could be influenced by the absence of other demographic information.

Ethics for study

The study was approved by the National Ethics Committee for Health Research (NECHR) in Cambodia and by the Ethics Approval Committee of the School of Human Sciences at London Metropolitan University in the United Kingdom. Additionally, the data utilized in this study have received approval from Dialab Takhmao Medical Laboratory.

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1 APPENDICES

Appendix 1: National Ethic Committee for Health Research Approval, Cambodia

ព្រះរាជាណាចក្រកម្ពុជា
KINGDOM OF CAMBODIA
ជាតិ សាសនា ព្រះមហាក្សត្រ
NATION RELIGION KING

ក្រសួងសុខាតិបាល
MINISTRY OF HEALTH
គណៈកម្មាធិការជាតិក្រមសីលធម៌
សំរាប់ការស្រាវជ្រាវសុខភាពដែលទាក់ទងនឹងមនុស្ស
National Ethics Committee for Health Research

ថ្ងៃចន្ទ ទី៩ ខែធ្នូ ឆ្នាំច សំរឹទ្ធិស័ក ព.ស.២៥៦៨

№ 485.....NECHR

Phnom Penh, December 30, 2024

Mr. Tous Chansamrach

Project: Prevalence of type I and Type II diabetes and their associated metabolic disorders and anemia among Cambodian population: A retrospective study in Takhmao town. Version N°1, dated 01st November 2024

Reference: - Your letter on 09th December 2024
- Summary report of NECHR's secretaries on 23rd December 2024

Dear Mr. Tous Chansamrach,

I am pleased to notify you that your study protocol entitled "Prevalence of type I and Type II diabetes and their associated metabolic disorders and anemia among Cambodian population: A retrospective study in Takhmao town. Version N°1, dated 01st November 2024" has been approved by National Ethic Committee for Health Research (NECHR). This approval is valid for twelve months after the approval date.

NECHR also wish to remind the Principal Investigator that all research activities to be conducted during the COVID-19 pandemic must strictly follow the latest prevention measures set by the MOH and the relevant local authorities.

The Principal Investigator of the project shall submit following document to the committee's secretariat at the National Institute of Public Health at #80 Samdach Penn Nouth Blvd, Sangkat Boeungkok 2, Khan Tuol Kork, Phnom Penh. (Tel: 012 528 789, 012 203 382, Email: nouthsarida@gmail.com, cheatasoft27@gmail.com):

- Annual progress report
- Final scientific report
- Patient/participant feedback (if any)
- Analyzing serious adverse events report (if applicable)

The Principal Investigator should be aware that there might be site monitoring visits at any time from NECHR team during the project implementation and should provide full cooperation to the team.

Regards,

Chairman

Prof. Lem Dara

National Ethics Committee for Health Research (NECHR)

ឡូតិ៍លេខ៨០,វិថីសម្តេច ប៉ែន នុត (២៨៩) សង្កាត់បឹងកក់២ ខណ្ឌ ទួលគោក រាជធានីភ្នំពេញ, ទូរស័ព្ទ (៨៥៥-០១២) ៥២៨ ៧៨៩, (៨៥៥-០៨៦) ៧៦២ ១១៣, (៨៥៥-០១២) ២០៣ ៣៨២
Lot #80, Samdach Penn Nouth Blvd (289), Sangkat Boeungkok2, Khan Tuol Kork, Phnom Penh, Cambodia. Tel: (855-012) 528 789, (855- 086) 762 113, (855-012) 203 382

Appendix 2: School of Human Sciences - Ethics Approval Check List, UK

LONDON METROPOLITAN UNIVERSITY

School of Human Sciences - Ethics Approval Check List

Ethics evaluation must be undertaken for **all** research projects to decide whether the project needs to be reviewed by a panel to ensure it conforms to current legislation. The first step is to decide about human involvement.

Does my project need ethical review?

Yes

If the research involves data from human volunteers, or volunteers are to be given samples of food to eat, or subjected to physical or psychological testing, or body fluids or tissue samples are be collected, then ethical approval through the Research Ethics Review Panel (RERP) should be sought.

Projects based at NHS institutions requiring ethical clearance will normally do so through the IRAS.

Where projects involve the secondary analysis of data, you will need to discuss with your supervisor the source of this data and whether there are issues of confidentiality that need to be considered. Datasets retrieved from the public domain do not normally require ethical approval for their analysis.

No

If your project does not involve recruitment of human volunteers or confidential data, e.g. you are using samples from routine diagnostics, simply provide the basic project information, then answer the question in section 1, sign and date the statement in section 6.

When completed, the form should be sent to the Module Leader Dr Simon Dryden (s.dryden@londonmet.ac.uk) for review.

1

Updated DL 20/9/22

Basic project information

Name: CHANSAMRACH TOUS

Course: BM7P20DL Research Project (60 credits)

Year: 2024-2025

Workplace: DIALAB TAKHMAO Diagnostic Laboratory

Work place Supervisor: Dr. Synat Keam, MSc, PhD

His contact email: synatkeamlab@gmail.com

Title of project: Prevalence of Type I and Type II diabetes and their associated metabolic disorders and anemia among Cambodian population: A retrospective study in Takhmao town

1. Are you recruiting human volunteers for your project?

Delete as necessary: **NO**

If **YES**, continue completing this form from section 2. NHS based projects may require evidence of an IRAS assessment.

If **NO**, go to section 6, complete and return the form to the module leader for confirmation.

Citation: Chansamrach, T., Sharif, A., Synat, K. (2026). Prevalence of Type 2 Diabetes and Its Associated Metabolic Disorders and Anemia among Cambodian population in Takhmao, Cambodia: A Retrospective Study. *Int J Diabetes Complications, 4*(1), 01-22.

2. **Main aim of study:**

3. **Number of research participants:**

4. **Who are the research participants? Provide as much detail as possible.**

Describe how you will recruit your participants:

5. Research Procedures

Please complete the following:

a. When and where will the research be conducted?

b. Will you be using minors (under 18) or the elderly as subjects? Yes/No

If YES then you will need to provide evidence that you have a suitable DBRS check

b. How will you collect the data? E.g. questionnaires, interviews (face-to-face phone, by email etc), physiological measurements (please specify), other (please specify)

c. Are any of these procedures likely to cause any of the following and is this unavoidable?

Anxiety	YES/ NO
Embarrassment	YES/ NO

If you answered 'YES' to any part of this question, please give details and explain how you will seek to minimise the impact of this. Append a separate page to the form if necessary

Citation: Chansamrach, T., Sharif, A., Synat, K. (2026). Prevalence of Type 2 Diabetes and Its Associated Metabolic Disorders and Anemia among Cambodian population in Takhmao, Cambodia: A Retrospective Study. *Int J Diabetes Complications, 4*(1), 01-22.

d. ***Please provide the following information and discuss the details with your lab-based site supervisor. You may be asked to add more detail or change it.***

i. Will you provide a written/oral explanation of the project to the participants *Attach a copy of the participant information sheet with this form*	YES/NO
ii. Will you obtain freely given, explicit and informed consent, preferably in writing, before the research begins? *Attach a copy of the draft consent form*	YES/NO
iii. Will you minimise any risks to your research participants?	YES/NO
iv. Will you explain to the participants that you are a student and undertaking degree studies.	YES/NO
v. Will you explain to the research participants that they may not benefit personally from your study.	YES/NO
vi. If you are using tape or digital recording and other data collection methods, will you explain this to your participants or explain why you are not going to tell them.	YES/NO
vii. Will your research participants be given the opportunity to decline to take part?	YES/NO
viii. Will you offer your research participants the opportunity to withdraw at any stage?	YES/NO
viii. Will you ensure that all data will be treated with absolute confidentiality?	YES/NO
ix. Will you ensure complete anonymity?	YES/NO
x. Have you read the provisions of the Data Protection Act. Indicate how you will comply with it. ?	YES/NO
xi. Will you dispose of personal data when the project has been completed.	YES/NO
xii. If you are working for a commercial client, have you agreed ethical issues with them and also how intellectual property rights have been assigned?	YES/NO

xiii. Will you provide participants with details of the results? Please indicate how you will do this.	YES/NO

If you have answered NO to any question in section d, please provide a written statement of why you have done so.

If you have answered YES to all questions, please continue to complete the remainder of the form in consultation with your work-based laboratory supervisor

6. Statement

Please read the following statement and sign that you have read it.

I, CHANSAMRACH TOUS have assessed the ethics of my research project with my work-based supervisor as indicated above.

If there are NO issues, please **initial** the following numbered items and sign below

I also confirm that:

1. I have discussed my project with the module leader
2. I have read and understood other Codes of Practice that are relevant to this project (ESRC, BBSRC, NHS, MRS, PFSG/IFST etc).
3. I have obtained approval from the laboratory where the project is to be carried out

Signed: .....

Date: August 22, 2024

Signed: .....
(Work-based Supervisor)

Date: August 22, 2024

5

Updated DL 20/9/22

Data Protection Act
There are eight key principles as follows

Data must be

- fairly and lawfully processed;
- processed for limited purposes;
- adequate, relevant and not excessive;
- accurate;
- not kept longer than necessary;
- processed in accordance with people's rights;
- kept secure;
- not transferred abroad without adequate protection.

In addition, people whose data is recorded have the right to view that data ('right of subject access'), make corrections or have it deleted.

For details see:
https://www.gov.uk/data-protection

Updated DL 20/9/22

Appendix 3: BM7P20DL Research Project Enrolment Checklist

BM7P20DL Research Project Enrolment Checklist

This guidance is aimed primarily at projects to be carried out at an NHS institution or facility, but the checklist should be completed by all distance learning project students.

Higher Education Institutions, including LMU, have a legal obligation to review the ethical implications of **all** research projects (undergraduate, masters, PhD etc.) carried out at the university, or in association with it. In order to fulfil this requirement ethical reviews of all BM7P20DL projects are carried out before projects can start.

The majority of projects carried out by distance learning students are work-based, and most involve analysis of patient samples. Often the samples are part of a local bank or collection and will be linked to clinical data but will be anonymous. The NHS has provided new guidance and the Research Student Toolkit for assessing the ethical and research status of projects carried out by students in the NHS workplace, which can be found at:

https://www.hra.nhs.uk/planning-and-improving-research/research-planning/student-research

You should use the Decision Tools in the toolkit and save the decision outcome, which should be submitted in order to enrol. It is not expected that the project will require review by an NHS Research Ethics Committee (REC), but if, for example patients are recruited for the project, a review may be needed through IRAS (Integrated Research Application System). You should seek guidance from your NHS supervisor.

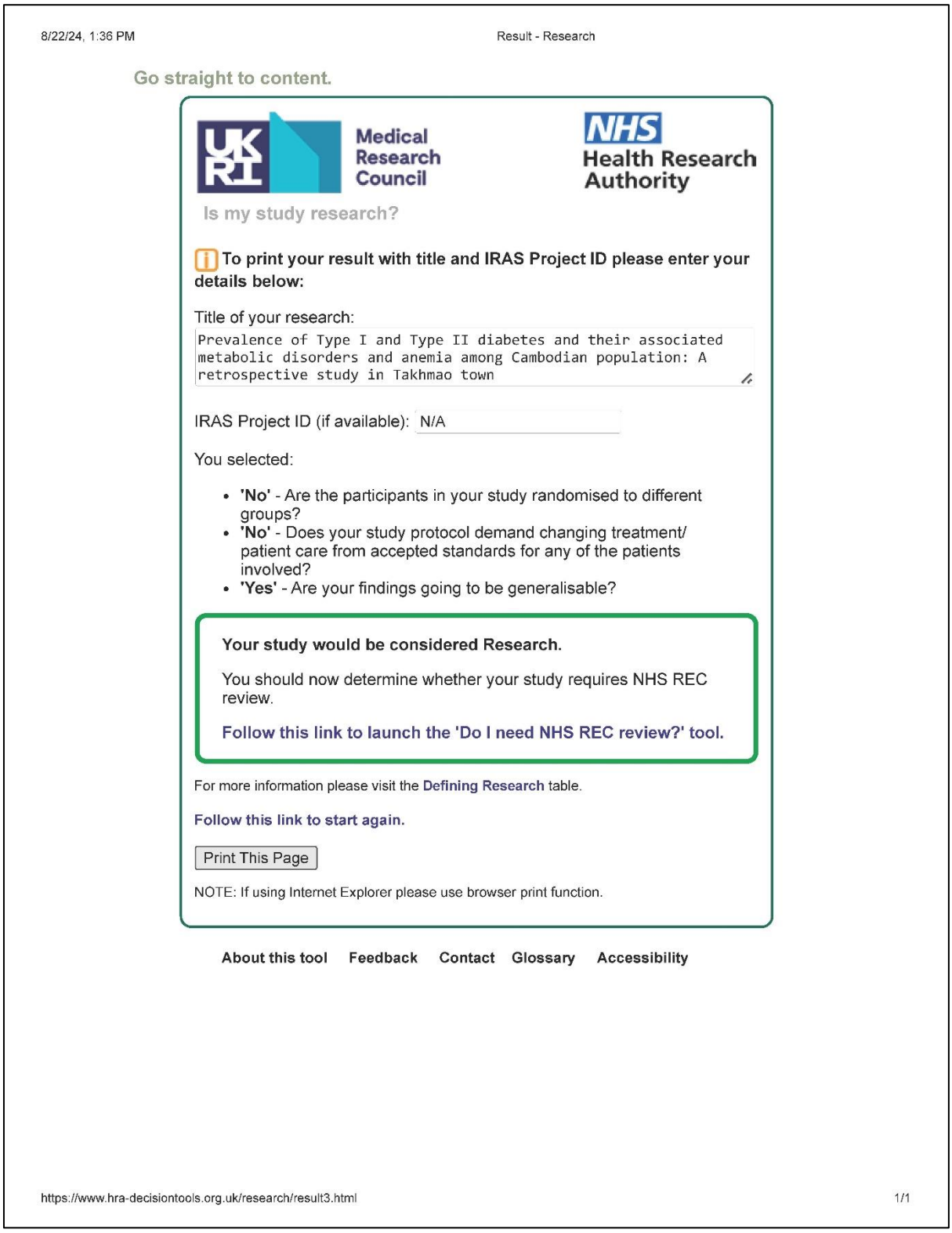
	Yes	No	N/A
Project proposal approved by module leader	☐	☐	☒
NHS Student Research Toolkit (enclose relevant edoc)	☒	☐	☐
Permission from host institution / workplace (by email or edoc)	☒	☐	☐
Completion of LMU Ethics Checklist	☒		
Is pre-existing data being used: (If NO please indicate collection medium e.g., blood/ tissue)	YES		

Name: CHANSAMRACH TOUS Student no.: 22035495

I confirm that **Chansamrach Tous** has used the NHS Student Research Toolkit and that NHS ethical considerations have been satisfied

Workplace Supervisors name: Synat Keam Signature:

Appendix 4: Is my study research?



8/22/24, 1:36 PM Result - Research

Go straight to content.

Medical Research Council

NHS Health Research Authority

Is my study research?

To print your result with title and IRAS Project ID please enter your details below:

Title of your research:

Prevalence of Type I and Type II diabetes and their associated metabolic disorders and anemia among Cambodian population: A retrospective study in Takhmao town

IRAS Project ID (if available): N/A

You selected:

- **'No'** - Are the participants in your study randomised to different groups?
- **'No'** - Does your study protocol demand changing treatment/ patient care from accepted standards for any of the patients involved?
- **'Yes'** - Are your findings going to be generalisable?

Your study would be considered Research.

You should now determine whether your study requires NHS REC review.

Follow this link to launch the 'Do I need NHS REC review?' tool.

For more information please visit the Defining Research table.

Follow this link to start again.

Print This Page

NOTE: If using Internet Explorer please use browser print function.

About this tool Feedback Contact Glossary Accessibility

https://www.hra-decisiontools.org.uk/research/result3.html 1/1

Appendix 5: Do I need NHS REC review?

8/22/24, 1:45 PM Result - England

Go straight to content.

Medical Research Council

NHS Health Research Authority

Do I need NHS REC review?

To print your result with title and IRAS Project ID please enter your details below:

Title of your research:

Prevalence of Type I and Type II diabetes and their associated metabolic disorders and anemia among Cambodian population: A retrospective study in Takhmao town

IRAS Project ID (if available): N/A

Your answers to the following questions indicate that **you do not need NHS REC review for sites in England.**

This tool only considers whether NHS REC review is required, it does not consider whether other approvals are needed. You should check what other approvals are required for your research.

You have answered **'YES'** to: Is your study research?

You answered **'NO'** to all of these questions:

Question Set 1

- Is your study a clinical trial of an investigational medicinal product?
- Is your study one or more of the following: A non-CE marked medical device, or a device which has been modified or is being used outside of its CE mark intended purpose, and the study is conducted by or with the support of the manufacturer or another commercial company (including university spin-out company) to provide data for CE marking purposes?
- Does your study involve exposure to any ionising radiation?
- Does your study involve the processing of disclosable protected information on the Register of the Human Fertilisation and Embryology Authority by researchers, without consent?

Question Set 2

- Will your study involve potential research participants identified in the context of, or in connection with, their past or present use of services (NHS and adult social care), including

https://www.hra-decisiontools.org.uk/ethics/EngresultN1.html 1/3

participants recruited through these services as healthy controls?
- Will your research involve prospective collection of tissue (i.e. any material consisting of or including human cells) from any past or present users of these services (NHS and adult social care)?
- Will your research involve prospective collection of information from any past or present users of these services (NHS and adult social care)?
- Will your research involve the use of previously collected tissue and/or information from which individual past or present users of these services (NHS and adult social care), are likely to be identified by the researchers either directly from that tissue or information, or from its combination with other tissue or information likely to come into their possession?
- Will your research involve potential research participants identified because of their status as relatives or carers of past or present users of these services (NHS and adult social care)?

Question Set 3

- Will your research involve the storage of relevant material from the living or the deceased on premises in England, Wales or Northern Ireland without a storage licence from the Human Tissue Authority (HTA)?
- Will your research involve storage or use of relevant material from the living, collected on or after 1st September 2006, and the research is not within the terms of consent for research from the donors?
- Will your research involve the analysis of human DNA in cellular material (relevant material), collected on or after 1st September 2006, and this analysis is not within the terms of consent for research from the donor? And/or: Will your research involve the analysis of human DNA from materials that do not contain cells (for example: serum or processed bodily fluids such as plasma and semen) and this analysis is not within the terms of consent for research from the donor?

Question Set 4

- Will your research involve at any stage procedures (including use of identifiable tissue samples or personal information) involving adults who lack capacity to consent for themselves, including participants retained in study following the loss of capacity?
- Is your research health-related and involving offenders?
- Does your research involve xenotransplantation?
- Is your research a social care project funded by the Department of Health and Social Care (England)?
- Will the research involve processing confidential information of patients or service users outside of the care team without consent? And/ or: Does your research have Section 251 Support or will you be making an application to the Confidentiality Advisory Committee (CAG) for Section 251 Support?

If your research extends beyond **England** find out if you need NHS REC review by selecting the 'OTHER UK COUNTRIES' button below.

Citation: Chansamrach, T., Sharif, A., Synat, K. (2026). Prevalence of Type 2 Diabetes and Its Associated Metabolic Disorders and Anemia among Cambodian population in Takhmao, Cambodia: A Retrospective Study. *Int J Diabetes Complications, 4*(1), 01-22.

OTHER UK COUNTRIES

If, after visiting all relevant UK countries, this decision tool suggests that you do not require NHS REC review follow this link for final confirmation and further information.

Print This Page

NOTE: If using Internet Explorer please use browser print function.

About this tool Feedback Contact Glossary Algorithm Accessibility

Citation: Chansamrach, T., Sharif, A., Synat, K. (2026). Prevalence of Type 2 Diabetes and Its Associated Metabolic Disorders and Anemia among Cambodian population in Takhmao, Cambodia: A Retrospective Study. *Int J Diabetes Complications, 4*(1), 01-22.