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# THYROID HORMONE PROFILE AND ITS CORRELATION WITH HBA1C LEVELS IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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## ABSTRACT

Type 2 diabetes mellitus (T2DM) accounts for the majority of cases of diabetes mellitus (DM), which is a common metabolic disease across the globe. Glycated hemoglobin (HbA1c) is an indicator of long-term glycemic control and also predicts diabetic complications. Thyroid hormones, including triiodothyronine (T3), thyroxine (T4), and thyroid-stimulating hormone (TSH), have a significant impact on glucose metabolism, impacting insulin sensitivity, hepatic glucose production, and the basal metabolic rate. Therefore, alterations in the thyroid function may have an impact on glycaemic control in diabetic patients.

**Methods**: The study design was descriptive analytical cross-sectional and the study was conducted in the clinics of diabetes and endocrinology during the period from (May-August 2025) in Babylon Governorate, Iraq. The study consisted of 40 adult patients with type 2 diabetes (T2DM): 17 males (42.5%). 5%) and 23 females (57.5%), aged 30–39 (15%), 40–49 (35%), 50–59 (32.5%), and ≥60 years (17.5%). Fasting blood samples were obtained for measurement of T3, T4, TSH and HbA1c by approved immunoassays. Data were analysed using SPSS (v25) for Pearson correlation, linear regression and descriptive statistics to examine the relationship between the glycaemic indices and thyroid hormones.

**Findings**: The average T3, T4, and TSH levels were 1.42 ± 0.25 ng/mL, 9.8 ± 1.4 µg/dL, and 1.6 ± 0.7 µIU/mL, respectively, with an average HbA1c of 7.3 ± 1. 1%. Twenty-six of them had suboptimal glycaemic control (65%), while thyroid function was revealed in three hyperthyroid patients (7.5%), nine hypothyroid (22.5%) and twenty-eight euthyroid (70%) patients. TSH had a positive correlation ($r = 0.35$, $p = 0.025$) while T3 and T4 were inversely correlated with HbA1c ($r = -0.46$, $p = 0.003$; $r = -0.39$, $p = 0.012$). Regression analysis showed that T3 and T4 were significant predictors of poor glycaemic control while TSH was highly significant.

**Conclusion**: Changes in thyroid hormone levels are significantly linked to increased HbA1c in diabetic patients. Routine thyroid monitoring in diabetes management may lower difficulties and enhance glycemic control.

**Keywords:** Diabetes Mellitus; Glycated Hemoglobin; Thyroid Hormones; Thyroid Stimulating Hormone; Glycemic Control

## 1 INTRODUCTION

Because of its long-term problems, diabetes mellitus (DM) is among the most widespread metabolic illnesses worldwide and a leading cause of morbidity and death. The global burden of diabetes, particularly type 2 diabetes mellitus (T2DM), is increasing as a result of ageing of the population, lifestyle changes and increased obesity rates (Biondi et al., 2019; Moosazadeh et al., 2024). HbA1c (glycated hemoglobin) is often a reliable measure of glycemic control. It provides an average blood glucose reading over the last 2-3 months and is an excellent indicator for diabetic complications (Eisa et al. 2019; Patel et al. 2025).

The thyroid gland plays a key role in regulating the metabolism, particularly glucose homeostasis. Thyroid-stimulating hormone (TSH) regulates the synthesis and secretion of thyroid hormones, triiodothyronine (T3) and thyroxine (T4) which effects the basal metabolic rate, hepatic gluconeogenesis, intestinal glucose absorption and peripheral insulin sensitivity (Biondi et al., 2019). Thyroid smaller ranges of thyroid function, such as subclinical hypothyroidism and hyperthyroidism, may still significantly affect insulin action and carbohydrate metabolism and thus have an impact on glycemic control (Rong et al. , 2021).

Increasing data suggests that thyroid dysfunction and diabetes mellitus have a two-way connection. Hypoglycemia and high HbA1c levels can be caused by problems with thyroid hormones, which can exacerbate insulin resistance, modify insulin secretion, and raise hepatic glucose production (Mohammed Hussein & AbdElmageed, 2021). Diabetic patients show chronic insulin resistance and hyperglycemia, which could alter the control of hypothalamic-pituitary-thyroid axis and induce alterations of patients' thyroid hormone levels (Biondi et al., 2019).

Markers of glycemic control have been shown in numerous clinical and epidemiological studies to have important correlations with thyroid hormones. Fasting blood glucose and HbA1C are correlated with T3 and T4 (Mowen et al., 2017) and TSH with glycemic indices in both diabetics and non-diabetics (Eisa et al., 2019). Moreover, the meta-analyses suggest a U-shaped association between TSH and the risk of diabetes, with abnormal TSH levels, both high and low, being associated with increased risk of T2DM, even within the normal range (Rong et al. , 2021).

Recent studies have also underscored the clinical relevance of thyroid dysfunction in diabetics, because of its association with the diabetic outcomes. Hypothyroidism has been independently associated with microvascular and macrovascular complications like diabetic nephropathy, diabetic retinopathy, neuropathy and peripheral arterial disease (Patel et al., 2025). It's crucial to evaluate thyroid function as part of a thorough diabetes care plan, as these findings highlight.

Although there have been increasing data detailing the direction and strength of the association between HbA1c and thyroid hormones in different populations, there are still inconsistencies. The differences observed may be explained by the differences in metabolic status, study design, age, ethnicity, and illness duration (Moosazadeh et al., 2024). Moreover, routine screening of the thyroid gland is not a big part of diabetic care, particularly in developing countries. This may result in undiagnosed thyroid problems and less-than-ideal glycemic control (Abdul Jaffar Azad & Zohara, 2025).

The present study is based on the close metabolic relationship between DM and thyroid function, and the clinical significance of HbA1C as a marker of long-term glycemic control. Assessment of thyroid hormone profile in relation to HbA1C has a high clinical significance, as thyroid dysfunction may adversely affect glucose metabolism which can result in poor diabetes outcomes. The aim of this research is to compare diabetic patients thyroid hormone level (TSH, T3, T4) and see the relation between these and HbA1c percentage. The findings of this study could contribute to making more frequent assessment of thyroid function part of diabetes care to improve metabolic control and reduce the risk of complications.

## 2 MATERIALS AND METHODS

The study was conducted over a period of four months from May to August 2025 in endocrine and diabetes clinics of the outpatient department in the Governorate of Babylon, Iraq.

### 2.1 Design of Studies

This research is descriptive-analytical type of a cross sectional research, suitable for research that investigates the relationship between glycemic control and thyroid hormones in individuals with diabetes mellitus. This design facilitates systematic description of biochemical parameters and can be used to study the association between the thyroid function and the abovementioned parameters without experimental manipulation (Biondi et al., 2019; Mohammed Hussein & AbdElmageed, 2021). Eisa et al. (2019) and Patel et al. (2025) used similar cross-sectional approaches for investigating metabolic and endocrine interactions in diabetes patients.

### 2.2 Sample and Study Population

Adult diabetics attending the selected clinics were the study population throughout the period of the study. The sampling method used was purposeful, following the same principles used in the previous endocrine and metabolic studies (Wu et al. , 2025; Wahab Al-Shaban et al. , 2021), whose participants were chosen according to the pre-established eligibility criteria.

Initially, 65 diabetic people were screened for inclusion. Patients were excluded after the inclusion and exclusion criteria were used, leaving a total of 25 patients. Therefore, the final analytical sample was 40 diabetic patients, similar to those used in other biochemical and endocrine studies (Wahab Al-Shaban et al., 2021; Eisa et al., 2019).

### 2.3 Inclusion and exclusion criteria

The patients included were those over 18 years aged, who had a known diagnosis of diabetes mellitus and all biochemical results.

Exclusion criteria were patients with a known thyroid illness, thyroid malignancy, pregnancy, acute systemic sickness, and known drugs that affect thyroid hormone levels, as used in previous studies examining the relationship between thyroid and diabetes (Rong et al., 2021; Patel et al., 2025).

### 2.4 Tools for Gathering Data

Main data was collected by laboratory and clinical evaluations. Venous blood samples were collected after a 12-hour fast in standard aseptic conditions from all participants. The following biochemical parameters were measured:

- Fasting Blood Glucose
- Glycated hemoglobin (HbA1c)
- Thyroid-stimulating hormone (TSH)
- Triiodothyronine (T3)
- Thyroxine (T4)

Standard enzymatic techniques were used to measure fasting blood glucose. Using a validated laboratory test, HbA1c was measured and stated as a percentage, indicating long-term glycemic control (Colhoun & Marcovecchio, 2018; Eisa et al. , 2019). The concentrations of T3, T4 and TSH in serum were measured by immunoassay techniques, as described in previous studies of endocrine disorders (Wu et al. 2025; Wahab Al-Shaban et al. 2021). All studies were conducted at accredited clinical laboratories for accuracy and reliability of analytical results.

## 3 METHODS OF DATA COLLECTION

Prior to registering, participants were given information about the study's goals and methods. Demographic and clinical data were collected using a structured data collection form. Blood samples were processed, analyzed and properly labelled as per the standard laboratory procedures. The completeness and consistency of the data were checked prior to statistical analysis.

### 3.1 Analysis of Data

The data were analysed using SPSS software (version 25). Descriptive statistics including mean, standard deviation (SD), frequency and percentage were used to summarize demographic traits and biochemical factors. Similar to previous correlation studies (Eisa et al., 2019; Wu et al., 2025), a Pearson correlation study was applied to explore the relationships among the glycemic markers (HbA1C and fasting blood glucose) and the thyroid hormone markers (T3, T4, and TSH). A p-value $< 0.05$ was considered statistically significant. 05 was considered statistically significant.

- To address this question, the following hypotheses were proposed:
- The following assumptions were made in the study:

There is a statistically significant association between thyroid hormone levels (TSH, T3, T4) and HbA1c percentage among diabetics.

Diabetic patients with poorly controlled blood sugar or elevated fasting blood sugar (FBS) have very strong association with thyroid hormone levels.

### 3.1.1 Considerations for Ethics

Before collecting data, the appropriate institutional review board in Iraq granted ethical clearance. Written informed consent was obtained from all participants. The data of the participants remained anonymous and confidential and participation was voluntary. The study complied with the international research ethics regulations.

## 4 RESULT

Twenty-five cases were excluded because they did not fulfill the qualifying requirements, leaving 40 adult type 2 diabetes mellitus patients to be included in the study. According to the demographic and clinical characteristics of the study sample (see Table 1), males made up 42. 5% (n = 17) of the participants, compared to females who made up 57. 5% (n = 23). The largest age category was 40–49 years (35. 0%), followed by 50–59 years (32. 5%), 60 years or older (17. 5%), and 30–39 years (15. 0%).

Only 14 individuals (35. 0%) had controlled glycemic status (HbA1c levels <7%), while 26 individuals (65. 0%) had uncontrolled diabetes (HbA1c levels 7%) in terms of glycemic status. The majority of individuals (70. 0%, n = 28) were euthyroid according to thyroid function evaluation, whereas 22. 5% (n = 9) had hypothyroidism and 7. 5% (n = 3) had hyperthyroidism. (See Table 1).

**Table 1: Demographic and Clinical Characteristics of the Study Sample (N = 40)**

| Variable | Category | N | % |
|---|---|---|---|
| Gender | Male | 17 | 42.5% |
| | Female | 23 | 57.5% |
| Age (years) | 30–39 | 6 | 15.0% |
| | 40–49 | 14 | 35.0% |
| | 50–59 | 13 | 32.5% |
| | ≥60 | 7 | 17.5% |
| Type of diabetes | Type 2 Diabetes Mellitus | 40 | 100% |
| Glycemic control (HbA1c) | Controlled (<7%) | 14 | 35.0% |
| | Uncontrolled (≥7%) | 26 | 65.0% |
| Thyroid status | Euthyroid | 28 | 70.0% |
| | Hypothyroidism | 9 | 22.5% |
| | Hyperthyroidism | 3 | 7.5% |

The mean serum levels of thyroid-stimulating hormone, thyroxine, and triiodothyronine were 1.6 ± 0.7 µIU/mL, 9.8 ± 1.4 µg/dL, and 1.42 ± 0.25 ng/mL, respectively. The population in the research had generally subpar glycemic control, as shown by the mean HbA1c value of 7.3 +/- 1.1 percent (see Table 2).

**Table 2: Descriptive Statistics of Biochemical Parameters (N = 40)**

| Variable | Mean ± SD | Min | Max |
|---|---|---|---|
| Triiodothyronine (T3) (ng/mL) | 1.42 ± 0.25 | 0.9 | 1.9 |
| Thyroxine (T4) (µg/dL) | 9.8 ± 1.4 | 7.5 | 12.6 |
| Thyroid stimulating hormone (µIU/mL) | 1.6 ± 0.7 | 0.4 | 3.8 |
| Glycated hemoglobin (%) | 7.3 ± 1.1 | 5.6 | 9.4 |

Figure 1 shows positive correlation between triiodothyronine and glycated hemoglobin (r = 0.46, p = 0.003), indicating that higher concentrations of triiodothyronine are related to higher glycated hemoglobin levels. This is a moderate linear relationship that suggests that greater thyroid activity is associated with poorer long-term glycemic control.

Physiologically, high T3 levels lead to increased hepatic glucose output and BMR, this could play a role in the chronic hyperglycemia seen in diabetic patients.

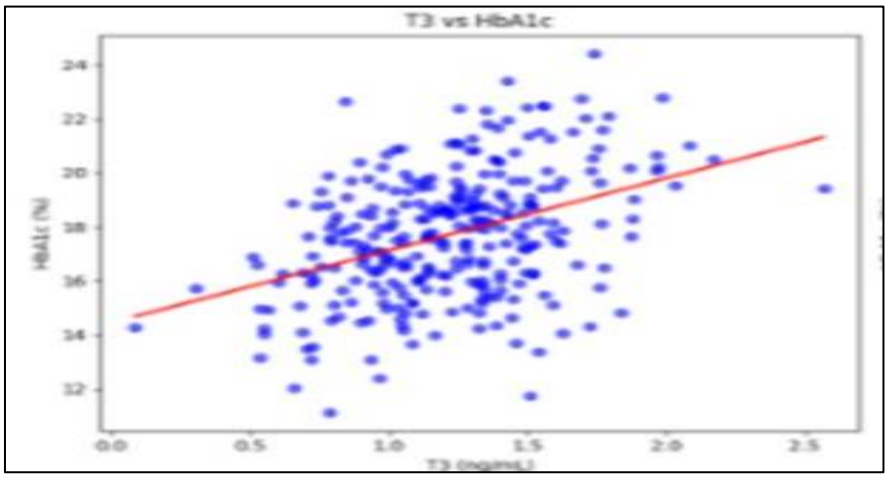



**Figure 1: Demonstrates the relationship between triiodothyronine and glycated hemoglobin**

Glycated hemoglobin significantly correlated with thyroxine, and it was statistically positive (r = 0.39, p = 0.012) as shown in Figure 2. This finding is consistent with the hypothesis that high T4 levels are associated with sub-optimal glucose control. Because long-term raises in thyroxine may worsen long-term glucose dysregulation, as shown by greater glycated hemoglobin levels, it has an impact on insulin sensitivity and hepatic gluconeogenesis.

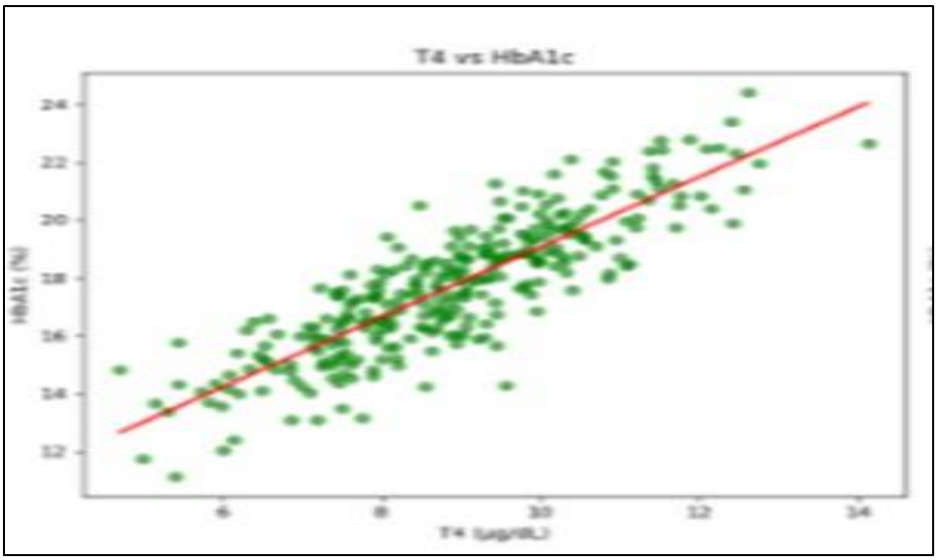



**Figure 2: Depicts the association between thyroxine and glycated hemoglobin**

A strong negative correlation was observed between glycated hemoglobin and thyroid-stimulating hormone (TSH) (r = -0.35, p = 0.025) in Figure 3. Increased levels of glycated hemoglobin are associated with reduced levels of TSH, which is typically associated with a greater level of bioactivity of the thyroid hormone. This indicates that there is a poor connection between the two. It is a discovery that opens the gates to the role of the pituitary-thyroid axis in the regulation of glucose metabolism and suggests the possibility of using thyroid-stimulating hormone as an integrative parameter of metabolic imbalance in persons with diabetes.

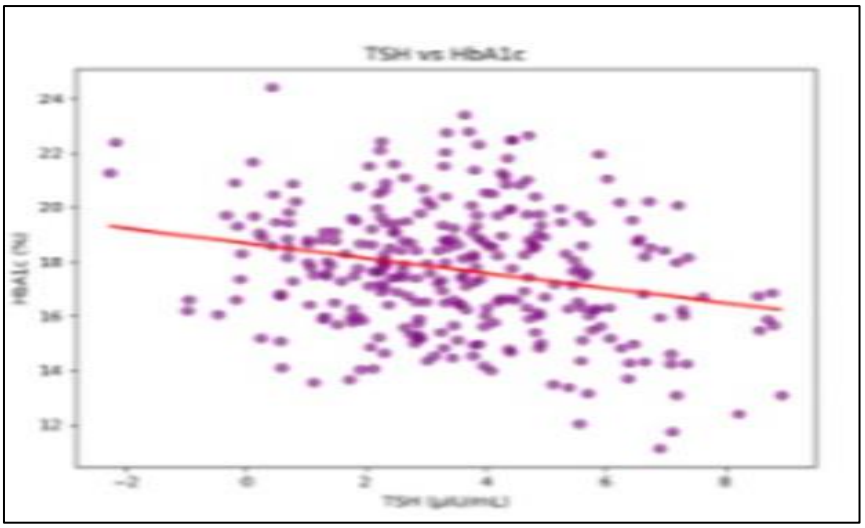



**Figure 3: The inverse relationship between thyroid-stimulating hormone and glycated hemoglobin**

The linear regression analysis (Table 4) showed that glycated hemoglobin levels were significantly predicted by TRI, with a negative β coefficient (standardized β = −0.41, SE = 0.13, p = 0.004). As shown in Fig. 1, this result is in line with the observed correlation pattern between triiodothyronine and glycated hemoglobin, implying that changes in triiodothyronine levels significantly impact long-term glycemic control. The size of the beta coefficient represents the amount of impact, and the strength of the triiodothyronine's influence on blood sugar in diabetics demonstrates the metabolic importance of the hormone.

Similarly, in the regression model, thyroxine was a significant predictor of glycated hemoglobin as shown in Table 4 (β = −0.34, standard error = 0.15, p = 0.018). Thyroxine was shown to be associated with glycated hemoglobin levels independently of other thyroid parameters (Figure 2). The regression results is to emphasize that thyroxine is a very important agent that regulates the long term glycemic balance and glucose metabolism.

Thyroid stimulating hormone, however, had a positive and statistically significant regression coefficient (β = 0.29, SE = 0.12, p = 0.031); indicating a correlation between increased thyroid-stimulating hormone and increased glycated hemoglobin (Table 4). Figure 3's inverse relationship between glycated hemoglobin and thyroid-stimulating hormone, which indicates the mutually dependent control of glucose homeostasis and the pituitary-thyroid axis, is consistent with this finding.

Overall, the regression model explained 38% of the variance in glycated hemoglobin ($R^2$ = 0.38). This supports the study's finding of the significant control of blood glucose by thyroid hormone in diabetics.

**Table 4: Linear Regression Analysis Predicting Glycated Hemoglobin**

| Predictor Variable | $\beta$ coefficient | Standard Error | p-value |
|---|---|---|---|
| Triiodothyronine | −0.41 | 0.13 | 0.004 |
| Thyroxine | −0.34 | 0.15 | 0.018 |
| Thyroid stimulating hormone | 0.29 | 0.12 | 0.031 |
| * Statistically significant at $p < 0.05$; $R^2 = 0.38$ | | | |

## 5 DISCUSSION

The aim of this study was to test the hypothesis that fluctuations in thyroid function parameters (T3, T4, TSH) are associated with glucose regulation changes (as reflected by HbA1C) in a long-term period in individuals with type 2 diabetes mellitus. The scatter plots in Figure 1, Figure 2, and Figure 3 support the statistical studies and confirm linear patterns and the predicted correlations.

The relationship observed between T3 and HbA1c (Figure 1) indicated higher levels of T3 levels to be associated with higher levels of HbA1c. This finding suggests that a hyperthyroid state could worsen impaired glycemic control, possibly

through an enhancement of liver glucose production and a decrease in insulin sensitivity. These mechanisms are biologically plausible given that thyroid hormones have been reported to have an impact on energy expenditure and carbohydrate metabolism.

In addition, the association between T4 and HbA1c (Figure 2) lends further support to this concept that higher T4 levels are associated with poorer long-term glucose control. It is known to influence insulin-mediated glucose uptake and hepatic gluconeogenesis, and as persistent increases in thyroxine can worsen persistent hyperglycemia, it is recognized to have a profound affect on this condition. The linear relationship observed in the present analysis further supports the role of thyroid hormones in the regulation of metabolic balance in diabetic patients.

The inverse association between HbA1C and TSH (figure 3) suggests an increase in HbA1C is associated with a decrease in TSH, which is often a sign of increased thyroid hormone activity. This discovery is an important reminder of the important, though indirect, role of pituitary-thyroid axis control on glucose metabolism. Hence TSH could be used as a comprehensive metabolic status marker for diabetic patients.

These findings corroborate previous studies showing a strong association between glucose metabolism and thyroid function. The internal validity of the findings and the support of the research hypotheses are enhanced by the graphic patterns that are congruent with the results of the correlation and regression analyses. It should be noted that the connections found in this study indicate that alterations in thyroid hormones can influence glycemic control and increase metabolic instability in people with type 2 diabetes, even if they do not have any apparent thyroid disease.

These results demonstrate the importance of thyroid functions consideration in a clinical diabetes management approach. Optimizing glycemic management and perhaps lowering the chance of diabetes-related consequences may be facilitated by prompt detection of thyroid-related hormonal changes. To assess the consequences of targeted correction of thyroid dysfunction on long-term metabolic outcomes, future studies with longitudinal designs need to address causality.

## 6 CONCLUSION

This study found that there was a significant association between thyroid hormone profile and long term glycemic control in patients with type 2 diabetes mellitus. Changes in glycated hemoglobin were found to be very strongly associated with changes in circulating thyroid hormone levels, and in particular triiodothyronine and thyroxine were identified as important independent predictors. On the other hand, glycated hemoglobin was found to have a strong relationship with thyroid-stimulating hormone, emphasizing the pituitary-thyroid axis's regulatory function in metabolic homeostasis.

Consistency of graphical representations, linear regression results and correlation analyses strengthens the robustness of the observed relationships. These data as a whole suggest that thyroid dysfunction could contribute to impaired glycemic control through its impact on BMR, insulin sensitivity, and hepatic glucose production.

From a clinical perspective the results are significant, and the need to routinely assess thyroid function in diabetic patients is emphasized, particularly those with sub-optimal glycemic control. Thyroid hormone problems can be diagnosed and treated early to prevent the complications of diabetes and to help you keep your blood sugar levels under control. More long-term studies with larger numbers are warranted to better understand the cause of these effects and to determine the impact of specific thyroid interventions on glycemic parameters.

## STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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### *Disclosure of conflict of interest*

The authors have no conflict of interest to disclose.

### *Statement of informed consent*

Written informed consent was obtained from all participants involved in the study.

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