*Original Article*

# *Medications Adherence among Type 2 Diabetic Patients Attending Primary Healthcare Centers in Cairo*

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**Abstract**

**Background:** Medication adherence in chronic diseases such as diabetes is an important part in successful therapeutic outcome. Poor adherence to medications limits benefits of treatment, increase incidence of adverse events and higher mortality and morbidity.

**Objectives:** To gauge prevalence of non-adherence to diabetes medications among individuals with type 2 diabetes visiting primary healthcare centers. Additionally, to identify factors contributing to this non-adherence. Furthermore, to evaluate agreement between two measurement tools: Measure Treatment Adherence questionnaire and Adherence to Refills and Medications Scale questionnaire, both utilized for assessing treatment adherence in diabetes patients.

**Methods:** A Cross sectional study performed on 131 patients with type 2 diabetes. Each patient answered a structured interview questionnaire about socio-demographic and medical characteristics and possible factors affecting medication adherence. In assessing adherence levels, two self-reported questionnaires were utilized.

**Results:**

Medication adherence among diabetic patients attending primary health center was 65.6%. Many factors were found to affect medication adherence including regular monitoring of blood glucose level (76.7%), regular follow-up visit (75.9%), presence of family support (20.6), and sufficient monthly income (84.2%). A statistically significant strong negative correlation was found between the two questionnaires' scores ($r=-0.8644$, p-value $< 0.001$).

**Conclusion:**

Participants in the study demonstrated high level of adherence to diabetes medications. Several factors were identified as influencing medication adherence, including regular monitoring of blood glucose levels, consistent follow-up visits, and presence of family support. Both Measure Treatment Adherence and Adherence to Refills and Medications Scale questionnaires are effective tools for measuring adherence among patients attending primary healthcare centers.

**Keywords:** Medication adherence, Type2 Diabetes Mellitus, Primary healthcare center; Measure Treatment Adherence; Adherence to Refills and Medications Scale questionnaires

## Introduction

Diabetes has emerged as a significant global health challenge in the 21st century, ranking among the top 10 causes of death worldwide. It accounts for 10.7% of all-cause mortality in the 20-79 age group across the globe. In Egypt, the prevalence of diabetes was notably high at 16.2% in 2016 [1]. Individuals with poorly managed diabetes face an elevated risk of developing chronic micro- and macro-vascular complications that can damage vital organs, including the heart, kidneys, brain, and eyes. This not only affects healthcare costs but also diminishes overall quality of life [2]. Optimal glucose control hinges on the effective adherence to prescribed medications, dietary guidelines, and lifestyle changes, ultimately reducing the risk of long-term complications [3]. In the context of chronic diseases like diabetes, adherence to medication plays a pivotal role in achieving successful therapeutic outcomes [4]. The World Health Organization defines medication adherence as the degree to which an individual's actions align with the recommendations provided by healthcare providers [5]. In contrast, poor medication adherence constitutes a significant public health issue. It not only hinders the effectiveness of treatments but also increases the likelihood of adverse events, raising both financial and human costs, including higher mortality and morbidity among patients [6]. The barriers to medication adherence encompass a multitude of factors, including complex medication regimens, dosing frequency, behavioral considerations, and the potential side effects of treatment [7]. Various methods are employed to gauge adherence to medications. Among these, indirect approaches, such as patient self-reports and interviews, stand out as the simplest and most commonly used techniques for assessing adherence [8]. In some cases, the attainment of treatment goals, particularly when treatment is linked to quantifiable outcomes like achieving normal blood glucose levels, provides a measure of medication adherence. Regional cross-sectional studies were conducted in Arabic regions like Egypt and Saudi Arabia. In these studies, The study revealed a concerning low overall adherence rate of 38.9% among the participants, with specific demographics and behaviors strongly linked to non-adherence. Factors such as gender, educational background, urban residence, irregular follow-up, neglecting drug prescriptions, skipping exercise routines, and non-compliance with insulin and oral metformin regimens were significantly associated with lower adherence rates [9.] Existing research on diabetes often focuses on assessing medication adherence and its impact on metabolic control, yet there is a notable gap in the analysis of the factors influencing medication adherence itself [3]. Considering the widespread issue of non-adherence to medication and the scarcity of comprehensive studies on this critical health concern, it becomes crucial to investigate the specific factors influencing medication adherence in diabetic patients attending primary healthcare centers. Understanding these factors is vital for developing effective interventions and strategies to improve adherence rates and overall health outcomes in this population.

## Subjects and methods

### Study design and settings

This was a cross-sectional study handled in the primary healthcare center (PHC) of Saray El Quobba which is in Cairo Governorate, Egypt. Data was gathered over a period of five months.

### Sample size calculation

The proportion of diabetic patients' non-adherent to treatment is used to calculate

the sample size and is proposed to be 50% to have the maximum sample size[10]. A sample size of 104 results in a two-sided confidence interval with a width of 0.2, at a 95% confidence level, when the sample proportion is 0.5. For comparison between the two groups (Adherent and Non-adherent groups) we assume a moderate effect size of 0.5 and this would increase the sample size to 130 cases equally divided between the two groups with level of significance of 0.05 and power of 0.80 using a two-sided z test [11]. During the study timing 131 patients were interviewed.

**Patient selection**

In the study, a total of 131 patients diagnosed with type 2 diabetes mellitus (T2DM) at least 3 months before the enrollment were included. However, patients with type 1 diabetes mellitus (T1DM), a known history of psychiatric illness or cognitive impairment, communication issues such as aphasia, and severe hearing or visual impairment were excluded from the study. A systematic random sample with random selection of the days for recruitment of cases was done using the Fishbowl method (Tuesdays). The first participant selected was the third patient, after that every other patient was included in the study.

**Data collection**

Each patient answered a structured interview questionnaire about socio-demographic and medical characteristics of the patients. Also, Arabic version [12]of Mini–Mental State Examination (MMSE) was used to screen for cognitive function among participants [13] , and possible factors affecting medication adherence such as monitoring of blood glucose, drug regimen, side effects of treatment and duration of illness were screened for. Measuring the level of adherence was conducted using two self-reported questionnaires:

1) **Measure Treatment Adherence (MTA)**: developed by ***Delgado and Lima, 2001*** [14], MTA is a modified version of the Morisky-Green Test, comprising seven questions. Responses range from "always" to "never," with scores ranging from 1 to 4 points. Higher scores indicate a higher level of medication adherence. Patients who scored more than 75% of the highest points were categorized as having good adherence, those scoring less than 50% were classified as non-adherent, and patients scoring between 50% and 75% were categorized as having poor/partial adherence.

2) The second questionnaire was the **Adherence to Refills and Medication Scale (ARMS):** this scale, validated for assessing adherence in chronic disease populations, includes a 4-item refill adherence subscale and comprises a total of 12 questions. Responses are recorded on a 4-point scale, from 1 (none of the time) to 4 (all the time). The scores from these responses are summed to create an overall adherence score ranging from 12 to 48. Higher scores indicate lower medication adherence [15].

**Data analysis**

The collected data were subjected to rigorous analysis using the Statistical Package for Social Sciences (SPSS) version 20. Quantitative data were presented in terms of mean, standard deviation (SD), and range values, offering a comprehensive view of the numerical aspects of the study. On the other hand, qualitative data were represented as frequencies (n) and percentages (%), aiding in the visualization of categorical information.

To delve deeper into the qualitative variables, Chi-square tests as well as Fisher's Exact tests were conducted, providing valuable insights into the relationships and associations within the data. These tests were instrumental in uncovering patterns and correlations among the categorical variables.

For the quantitative variables, the normality of the data distribution was assessed using the Shapiro-Wilk test, ensuring the robustness of subsequent analyses. Variables conforming to a normal distribution were described using mean and standard deviation (mean±SD), providing a clear overview of the central tendency and dispersion of the data.
In the realm of statistical significance, a threshold of p-value < 0.05 was established, guiding the interpretation of results. Any finding with a p-value below this threshold was considered significant, indicating meaningful relationships and outcomes in the dataset. This stringent criterion ensured that the analyses were focused on robust and meaningful results, enhancing the reliability of the study's conclusions.

## Results

A total of 131 patients were included in the study with 82 being females (62.6%) and 49 being males (37.4%) patients were included in the study. Their mean age was 58.4 ± 9.4 years and most of the participants (more than 80%)were ≥ 50 years old. Only 62 (47.3%) received high education and most were married (71.8%). A total of 81 (61.8%) were unemployed and 50 (5.4%) had a job. All participants were free from dementia with MMSE score ranging between 24-30 (**Table 1**). It was found that patients who had intermediate education had higher adherence than both illiterate and patients with higher education levels (p-value 0-009) using the ARMS score means. Males were more adherent than females, however no statistically significant association between them was found. There was no statistically significant association between the other socio-economic variables and the level of adherence measured by MTA score (**Table 1**).

**Table 1: Relation between socio-demographic variables and both ARMS score and MTA score.**

| N =131 | | ARMS score | | | | MTA score | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | S.D. | F test | P-value | Partial-Poor adherence | | Good adherence | | Chi-square | p-value |
| | | | | | | No | % | No | % | | |
| Age group | <40 | 21.0 | 5.4 | 0.159 | 0.923 | 8 | 36.4 | 14 | 63.6 | 2.489 | 0.477 |
| | 50- | 21.7 | 5.4 | | | 17 | 40.5 | 25 | 59.5 | | |
| | 60- | 21.5 | 4.9 | | | 17 | 33.3 | 34 | 66.7 | | |
| | 70+ | 20.8 | 5.9 | | | 3 | 18.8 | 13 | 81.3 | | |
| Social | Married | 21.2 | 5.2 | 0.37 | 0.544 | 30 | 31.9 | 64 | 68.1 | 0.879 | 0.346 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| status | Others | 21.8 | 5.4 | | | 15 | 40.5 | 22 | 59.5 | | |
| Sex | Male | 20.9 | 5.4 | 0.681 | 0.411 | 12 | 24.5 | 37 | 75.5 | 3.376 | 0.066 |
| | Female | 21.7 | 5.1 | | | 33 | 40.2 | 49 | 59.8 | | |
| Education | Illiterate | 19.8 | 6.4 | 3.524 | **0.009** | 8 | 26.7 | 22 | 73.3 | 6.887 | 0.142 |
| | Read and write | 22.3 | 5.5 | | | 7 | 53.8 | 6 | 46.2 | | |
| | Primary to secondary | 22.0 | 4.9 | | | 8 | 30.8 | 18 | 69.2 | | |
| | Intermediate institute | 23.3 | 4.5 | | | 17 | 44.7 | 21 | 55.3 | | |
| | University and postgraduate | 19.1 | 3.7 | | | 5 | 20.8 | 19 | 79.2 | | |
| Occupation | Not-working-Housewife | 21.4 | 5.3 | 0.047 | 0.829 | 30 | 37.0 | 51 | 63.0 | 0.679 | 0.41 |
| | Working | 21.2 | 5.2 | | | 15 | 30.0 | 35 | 70.0 | | |
| Family size | 1-2 | 21.8 | 5.8 | 0.434 | 0.784 | 7 | 33,3 | 14 | 66.7 | 3.653 | 0.455 |
| | 3 | 21.0 | 5.9 | | | 5 | 23.8 | 16 | 76.2 | | |
| | 4 | 20.4 | 4.5 | | | 8 | 26.7 | 16 | 73.3 | | |
| | 5+ | 21.8 | 4.8 | | | 25 | 42.4 | 34 | 57.6 | | |

*S.D.: Standard Deviation, ARMS: Adherence to Refills and Medication Scale, MTA: Measure Treatment Adherence*

The majority, (58.8%), of participants, were on diabetic treatment for 1–5 years. Among all participants, (96.9%- 68.7%- 66.4%) had good doctor patient relationship, regular monitoring of blood glucose level and regular follow-up visit respectively. Most of respondents, (87.8%) were on both oral hypoglycemic agents and insulin. No side effects to diabetic medication had been reported by (87.8%) of participants. Among all respondents, (39.7%, 34.4%, 26%) obtain their drugs from insurance, out of pocket and PHC centers respectively (**Table 2**).

**Table (2): Distribution of different variables among the patients**

| | | No | % |
|---|---|---|---|
| Good doctor patient relationship | No | 4 | 3.1 |
| | Yes | 127 | 96.9 |
| Monitoring blood glucose level | No | 41 | 31.3 |
| | Yes | 90 | 68.7 |
| Regular follow up visit | No | 44 | 33.6 |
| | Yes | 87 | 66.4 |
| Drug taken for diabetes | Oral hypoglycemic | 115 | 87.8 |
| | Insulin with or without oral hypoglycemic | 16 | 12.2 |
| Frequency of taking diabetic medications/day | 1 | 33 | 25.2 |
| | 2 | 69 | 52.7 |
| | 3+ | 29 | 22.1 |
| Number of drugs taken/day | 1-2 | 48 | 36.6 |
| | 3 | 43 | 32.8 |
| | 4 | 26 | 19.8 |
| | 5+ | 14 | 10.7 |
| Co morbidities like HTN, IHD | No | 41 | 31.3 |
| | Yes | 90 | 68.7 |
| Side effects of diabetic drugs | No | 115 | 87.8 |
| | Yes | 16 | 12.2 |
| Way to get diabetic drugs | Out of pocket | 45 | 34.4 |
| | PHC | 34 | 26.0 |
| | Insurance | 52 | 39.7 |
| Duration Illness<br>Mean ±Sd 6.9 ± 6.3 years Range 1-30 years | 1-2 years | 38 | 29.0 |
| | 3-5 years | 39 | 29.8 |
| | >5 years | 54 | 41.2 |
| Drug regimen | Complex | 9 | 6.9 |
| | Simple | 122 | 93.1 |
| Access to care | Complex | 15 | 11.5 |
| | Simple | 116 | 88.5 |
| Family support | No | 50 | 38.2 |
| | Yes | 81 | 61.8 |
| Family income | <1000 LE | 11 | 8.4 |
| | 1000- 1999LE | 38 | 29.0 |
| | 2000-3000 LE | 36 | 27.5 |
| | > 3000 LE | 46 | 35.1 |

Among the study sample, 65.6% had good medication adherence, whereas (33.6%) had a fair adherence, and 1(0.8%) had poor adherence as measured by MTA. The poor and partial adherence were grouped due to the small number (**Figure 1**).

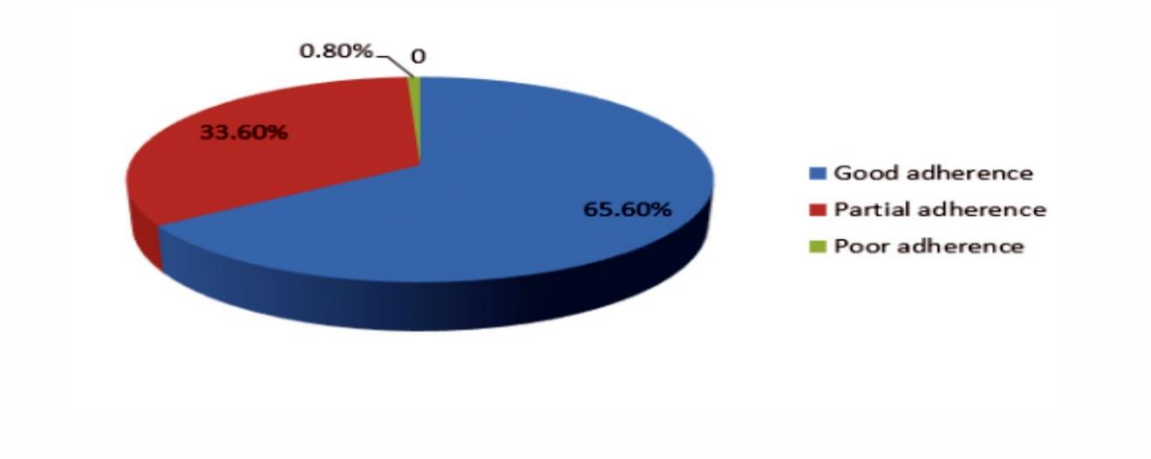


**Figure 1** Medication adherence level among participants using ATM score

ARMS mean score was 20.0 ± 5.24, a range from 12 to 36 and a median of 20. There was no clearly documented cutoff point between the satisfactory and unsatisfactory adherence and accordingly the score is analyzed as a continuous variable with lower score indicating better adherence.

Monitoring blood glucose and maintaining regular follow-up visits were associated with good adherence (p-value <0.001). Family income was statistically significantly associated with level of adherence p-value (0.039) and with family income between1000-1999 LE had the highest proportion of good adherence (84.2%) (**Table 1& 3**).

**Table 3: Relation between factors affecting medication adherence and both MTA and ARMS scores.**

| | | MTA score | | | | | | ARMS score | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Partial-Poor adherence | | Good adherence | | Chi-square | p-value | Mean | S.D. | F test | P-value |
| | | No | % | No | % | | | | | | |
| Good doctor patient relationship | No | 2 | 50.0 | 2 | 50.0 | * | 0.607 | 25.5 | 6.0 | 2.603 | 0.109 |
| | Yes | 43 | 33.9 | 84 | 66.1 | | | 21.2 | 5.2 | | |
| Monitoring blood glucose level | No | 24 | 58.5 | 17 | 41.5 | 15.479 | **<0.001** | 24.5 | 5.4 | 25.618 | **<0.001** |
| | Yes | 21 | 23.3 | 69 | 76.7 | | | 19.9 | 4.5 | | |
| Regular follow up visit | No | 24 | 54.5 | 20 | 45.5 | 11.984 | **<0.001** | 24.1 | 5.1 | 20.25 | **<0.001** |
| | Yes | 21 | 24.1 | 66 | 75.9 | | | 20.0 | 4.8 | | |
| Drug taken for diabetes | Oral hypoglycemic | 41 | 35.7 | 74 | 64.3 | 0.707 | 0.401 | 21.4 | 5.4 | 0.089 | 0.766 |
| | Insulin with or without oral hypoglycemic | 4 | 25.0 | 12 | 75.0 | | | 21.0 | 3.7 | | |
| Frequency of taking diabetic medications/day | 1 | 8 | 24.2 | 25 | 75.8 | 2.239 | 0.329 | 20.4 | 4.9 | 1.086 | 0.341 |
| | 2 | 25 | 36.2 | 44 | 63.8 | | | 21.4 | 5.2 | | |
| | 3+ | 12 | 41.4 | 17 | 58.6 | | | 22.3 | 5.6 | | |
| Number of drugs taken/day | 1-2 | 14 | 29.2 | 34 | 70.8 | 2.396 | 0.494 | 20.3 | 5.3 | 1.241 | 0.298 |
| | 3 | 16 | 37.2 | 27 | 62.8 | | | 21.7 | 4.6 | | |
| | 4 | 8 | 30.8 | 18 | 69.2 | | | 21.7 | 5.5 | | |
| | 5+ | 7 | 50.0 | 7 | 50.0 | | | 23.1 | 6.1 | | |
| Co morbidities like HTN, IHD | No | 17 | 41.5 | 24 | 58.5 | 1.339 | 0.247 | 21.2 | 4.9 | 0.063 | 0.802 |
| | Yes | 28 | 31.1 | 62 | 68.9 | | | 21.4 | 5.4 | | |
| Side effects of diabetic drugs | No | 42 | 36.5 | 73 | 63.5 | 1.967 | 0.161 | 21.7 | 5.4 | 3.024 | 0.084 |
| | Yes | 3 | 18.8 | 13 | 81.3 | | | 19.3 | 3.5 | | |
| Way to get diabetic drugs | Out of pocket | 14 | 31.1 | 31 | 68.9 | 0.439 | 0.803 | 21.1 | 5.0 | 0.088 | 0.916 |
| | PHC | 13 | 38.2 | 21 | 61.8 | | | 21.4 | 5.5 | | |
| | Insurance | 18 | 34.6 | 34 | 65.4 | | | 21.6 | 5.4 | | |
| Duration Illness | 1-2 years | 17 | 44.7 | 21 | 55.3 | 2.668 | 0.263 | 21.3 | 5.4 | 0.052 | 0.949 |
| | 3-5 years | 11 | 28.2 | 28 | 71.8 | | | 21.6 | 5.5 | | |
| | > 5 years | 17 | 31.5 | 37 | 68.5 | | | 21.2 | 5.1 | | |
| Drug regimen | Complex | 2 | 22.2 | 7 | 77.8 | * | 0.718 | 21.0 | 3.8 | 0.047 | 0.829 |
| | Simple | 43 | 35.2 | 79 | 64.8 | | | 21.4 | 5.3 | | |
| Access to care | Hard | 3 | 20.0 | 12 | 80.0 | 1.547 | 0.214 | 20.1 | 4.3 | 0.939 | 0.334 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Easy | 42 | 36.2 | 74 | 63.8 | | | 21.5 | 5.3 | | |
| Family support | No | 19 | 38.0 | 31 | 62.0 | 0.477 | 0.490 | 22.6 | 5.2 | 4.769 | **0.031** |
| | Yes | 26 | 32.1 | 55 | 67.9 | | | 20.6 | 5.1 | | |
| Family income | <1000 LE | 4 | 36.4 | 7 | 63.6 | 8.379 | **0.039** | 20.4 | 7.2 | 3.785 | **0.012** |
| | 1000- 1999LE | 6 | 15.8 | 32 | 84.2 | | | 19.3 | 4.7 | | |
| | 2000-3000 LE | 15 | 41.7 | 21 | 58.3 | | | 22.9 | 4.8 | | |
| | > 3000 LE | 20 | 43.5 | 26 | 56.5 | | | 22.1 | 5.0 | | |

**Fisher exact test was used.*

*S.D.: Standard Deviation, HTN: Hypertension, IHD: Ischemic Heart Disease, PHC: Primary Health Care, ARMS: Adherence to Refills and Medication Scale, MTA: Measure Treatment Adherence*

The agreement between MTA and ARMS questionnaires was evaluated, there was a statistically significant strong negative correlation between them (r=-0.8644, p-value <0.0001) (Figure2). The cutoff point of the ARMS score was estimated to be 22 with sensitivity = 88.4% and specificity = 93.3% (**Table 4**).

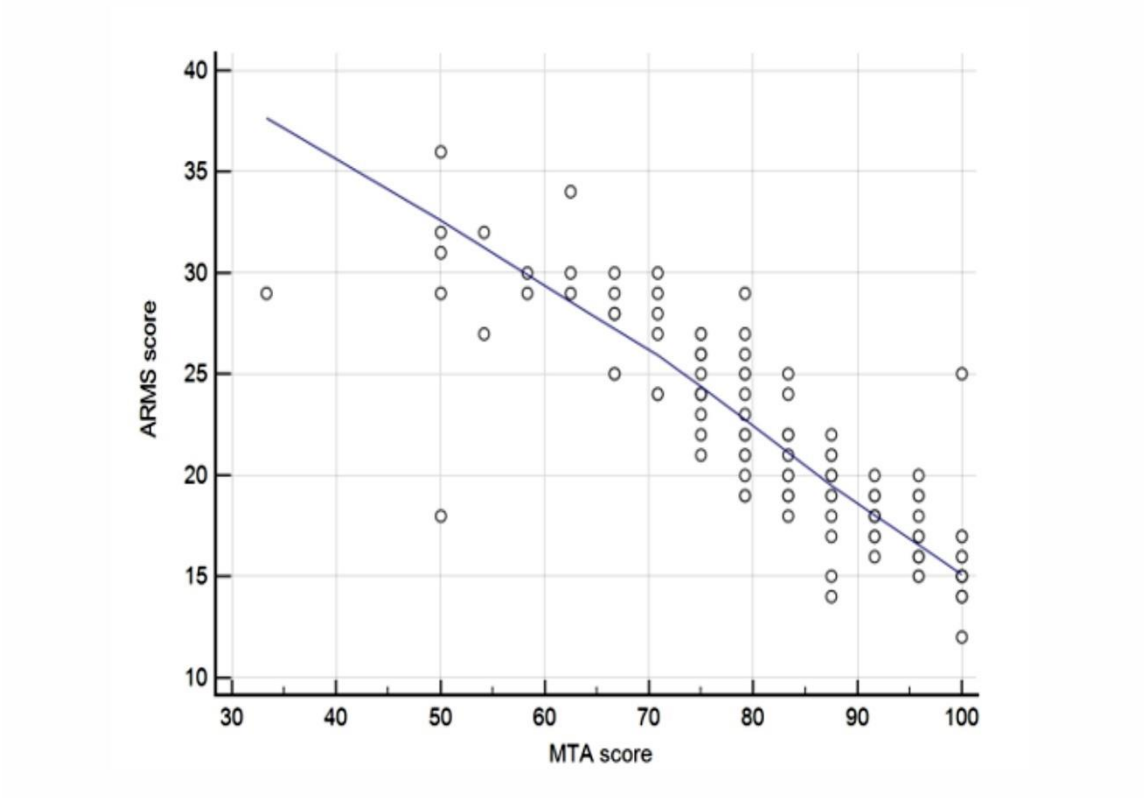


**Figure 2** Scatter plot of MTA score and ARMS score

**Table 4: Youden index for ARMS score**

| | |
|---|---|
| Youden index J | 81.71 |
| Associated criterion | ≤22 |
| Sensitivity | 88.37 |
| Specificity | 93.33 |

## Discussion

The global adherence rates for diabetes medication range widely, from 36% to 93% across different regions **[16]**. In the context of this study, the findings revealed a notably positive trend. Specifically, a significant majority of patients diagnosed with Type 2 Diabetes Mellitus (T2DM) and attending the primary healthcare center of Saray El Quobba exhibited high medication adherence, amounting to an impressive 65.6%. Similar findings were seen in a study in an Ethiopian general hospital on 275 T2DM patients where 70.5% of the respondents were adherent to their medications [17]. On the other hand, low rates of adherence were reported in Malaysian general hospital on 165 T2DM patients (29.1%) [18]. The rate of adherence from this study compared to others could be attributed to several factors like the reported good doctor patient relationship 96.9%, regular monitoring of blood glucose level 68.7%, regular follow-up visits 66.4% and the fact that most of the participants obtain their medication either from PHC itself or from insurance hospital as demonstrated by the study results.

A comprehensive meta-analysis on adherence outcomes has revealed intriguing insights into assessment methodologies. Specifically, the analysis indicated that employing multiple subjective measures, such as self-report questionnaires, in evaluating medication adherence might enhance sensitivity. However, this heightened sensitivity does not necessarily translate to increased accuracy compared to utilizing a single objective measure [19]. In the current study, agreement between MTA and ARMS questionnaires was found with higher sensitivity and higher accuracy. The comparison between mean scores of the adherence questionnaire scales as adherent and non-adherent populations can determine the cutoff value [20]. In comparison between MTA and ARMS scores, the proposed cut-off point of ARMS was 22 with sensitivity = 88.4% and specificity = 93.3%. In the current study, there was no statistically significant correlation between socioeconomic variables and the adherence level assessed using the Measure Treatment Adherence (MTA) questionnaire. This finding aligns with a study conducted in Brazil involving 423 patients with Type 2 Diabetes Mellitus (T2DM) [20]. Conversely, the educational level exhibited a significant association with adherence level when assessed using the Adherence to Refills and Medication Scale (ARMS). This correlation mirrors a similar discovery from a cross-sectional study conducted in Korea involving 160 patients [21]. Furthermore, regular

monitoring of blood glucose levels, consistent follow-up visits, and monthly income demonstrated statistically significant relationships with adherence level when measured using the MTA questionnaire. These factors exhibited similar statistical significance in a study conducted in Egypt involving 372 patients with T2DM. These findings underscore the importance of these factors in influencing medication adherence among patients with diabetes and highlight their relevance across different cultural and demographic contexts [22].

In line with a study conducted on 376 diabetic patients attending a tertiary care diabetic clinic in Botswana [23], The current study revealed that patients across various age groups exhibited similar levels of medication adherence. An earlier study conducted on 395 T2DM patients from University Diabetic Center in Saudi Arabia established that medication adherence boosted with age [24], which may be explained by differences in sample sizes, inclusion and exclusion criteria, the mean age of the sample studied, measurement tools and population characteristics.

Gender was not found to be a significant variable on medication adherence in the current study. Findings regarding gender differences in medication adherence are variable. A study conducted in the clinics of traditional medicine in Iran on 320 patients [25] and another study in a national hospital in Kenya on 190 T2DM patients [26] showed that gender does not affect medication adherence. On the other hand, an Indian study conducted in a tertiary care hospital on 150 T2DM patients reported that men had higher adherence than women [27]. Our results might be attributed to socio-demographic and cultural factors among the participants.

Regarding education, the relation between medication adherence and educational level took U-shaped curve with the illiterate and the University and Post-graduates had the highest medication adherence. The association between educational level and medication adherence is complex and multifaceted. In the context of the current study, patients with higher educational levels displayed better adherence to their diabetes treatment regimen. This trend aligns with findings from a study conducted in a Canadian pharmacy involving 56 patients with type 2 diabetes. The results suggest that individuals with higher educational backgrounds tend to possess more health-related knowledge, which can positively influence their adherence to prescribed treatments [28]. However, it is essential to note that this pattern is not universally applicable. A contrasting study conducted in Nepal, involving 343 patients with type 2 diabetes, found that individuals with lower education levels exhibited higher treatment adherence. This unexpected result was attributed to the higher trust these individuals placed in medical recommendations, potentially compensating for their limited health-related knowledge [29].

Family income was statistically associated with level of adherence. Family income between 1000-1999 LE had the highest proportion of good medication adherence compared to the other income strata. The relatively low adherence in the relatively high-income group might be attributed to the fact the 47% paid out of pocket for their medications. The occurrence of non-compliance with medication among individuals with type 2 diabetes mellitus (T2DM) was found to be similar to that observed in a cross-sectional investigation encompassing three public health clinics in Malaysia, which involved 500 patients [30]. Conversely, a separate analysis involving 285 diabetic patients in a general hospital in Ethiopia demonstrated a correlation between low income and heightened levels of non-adherence to medication [16]. Furthermore, a recent study conducted in Sri Lanka involving 200 T2DM patients

concluded that income was not a determining factor in medication adherence [31].

The findings of the present investigation demonstrated that there existed no notable correlation between the adherence to medication and either the marital status or the quantity of offspring. This discovery aligned with a study that was performed at a tertiary medical institution in Saudi Arabia, encompassing 5457 patients diagnosed with Type 2 Diabetes Mellitus [32]. Conversely, certain studies identified a significant connection between medication adherence and the number of children, in which a lower number of offspring was linked to a higher adherence to medication [33]. This phenomenon may be attributed to the fact that individuals with larger families experience heightened concerns and preoccupations, which may detrimentally influence their adherence to prescribed medications.

In the current study, no statistically significant correlation was found between medication adherence and comorbid conditions. This finding aligns with an earlier study conducted in Malaysian public health clinics, which similarly reported that comorbidities such as dyslipidemia, hypertension, or diabetes-related complications did not significantly affect medication adherence among adults with type 2 diabetes attending public health clinics [30]. However, it's important to note that other studies have presented contrasting results. Several research studies have reported that comorbidities are associated with low adherence to medications [26, 34]. These studies have pointed out that comorbid conditions often lead to multiple medical visits and the prescription of multiple medications. The burden of managing multiple health conditions and the complexities of adhering to various medications can be overwhelming for patients.

Multiple studies have consistently demonstrated that patients on complex drug regimens tend to exhibit lower adherence rates compared to those on simpler treatment plans [16,17,23,35]. Also, the occurrence of side effects associated with medications poses another significant barrier to adherence. Patients who experience adverse reactions to their medications may be hesitant to continue their treatment, leading to intentional non-adherence. One of them was a pilot qualitative study conducted in diabetic healthcare center in Iran on 12 T2DM patients [36]. Another one conducted in Ethiopia on 384 T2DM patients [16]. However, the current study didn't find significant correlation between medication adherence and neither treatment complexity nor side effects of treatment as most of the participants perceived simple medication regimen and none of them reported side effects to medications.

Easy access to care has been consistently linked to better adherence to medications in numerous studies. Patients who can readily access healthcare facilities, receive timely appointments, and obtain their prescribed medications are more likely to adhere to their treatment plans [16]. However, in the current study, no significant correlation was found between medication adherence and access to care among the participants. Most of the participants reported having easy access to care, indicating that geographic proximity to healthcare facilities might not have been a significant challenge for this particular group.

In the current study, there was no significant correlation between medication adherence and duration of illness. This is similar to some studies which found no significant association [23, 24, 37]. On the other hand, an earlier study revealed that medication adherence was better in newly diagnosed diabetics[26, 38]. Other studies showed that medication adherence increased the longer the duration of disease

was. One was a study conducted in two regional hospitals in Cameron on 195 T2DM patients[39], and the other study was conducted in university hospital in Ethiopia on 1497 T2DM patients[40]. One potential rationale is that individuals in the initial stages of illness may lack awareness of the potential for significant complications. However, once these complications arise and the individual begins to experience the hardships associated with the disease, their perspective towards the illness and the corresponding treatments may shift, resulting in a heightened commitment to medication adherence and adherence to healthcare professionals' guidance. The difference between studies might also be attributed to socio-demographic characteristics, measurement tools and settings.

Regular monitoring of blood glucose and follow-up visits in the current study were associated with higher proportion of good adherence**.** As Patients going to follow-up appointments are usually aware they would be asked about blood glucose monitoring and their adherence to medications, hence they would be more adherent to their medications[30 ,41].

In the current study, family support was associated with better adherence. Poor social support was associated with nonadherence to medications in a recent study conducted in a Nigeria outpatient clinic of tertiary hospital [42]. Patients that receive social support from other people feel cared for, and their emotional well-being will be increased. They would therefore take a positive attitude toward their chronic diseases.

**Study limitations**

The study only included diabetics in a single primary care center (Saray El Quobba) as it was the area of catchment for the data collector where we obtained the approval to gather information, which may limit the generalizability of the findings to other institutions.

**Conclusion**

The adherence rate of patients who attended the primary healthcare center of Saray El Quobba was recorded at 65.6% using the MTA measurement method. The correlation analysis revealed a statistically significant strong negative relationship between the MTA and ARMS questionnaires (r= -0.8644, p-value <0.0001). The threshold for the ARMS score was determined to be 22, with a sensitivity of 88.4% and a specificity of 93.3%. Various factors were discovered to be associated with favorable medication adherence, including regular monitoring of blood glucose levels, frequent follow-up visits, the presence of family support, monthly income, and educational level. The agreement between MTA and ARMS was confirmed (r= -0.8644, p<0.0001).

**Ethical considerations**

Approval of ethical committee of Faculty of Medicine, Ain Shams University was obtained (FWA 000017585). Administrative approval from PHC of Saray El Quobba was obtained.

Informed consent was obtained from all participants after explaining the objectives of the study**.**

**Consent for publication**

Not applicable

**Availability of data and materials**

The data supporting the results of this study are available from the corresponding author upon reasonable request.

**Acknowledgement**

The authors would like to thank the physicians and nurses at the primary healthcare center of Saray El Quobba for their cooperation.

**Funding**

No financial support and sponsorship were offered to this research.

**Competing interests**

The authors declare that they have no competing interests.

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