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Factors affecting glycemic control among Egyptian people with diabetes attending primary health care facilities in Mansoura District

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Abstract

Background: Diabetes is a rapidly growing health problem worldwide. In 2019, the International Diabetes Federation (IDF) estimates that Egypt is the 9th country worldwide with about 8,850,400 cases and a prevalence of 15.2% in adults. By 2045, Egypt is expected to be the 7th country worldwide. Several factors affecting glycemic control are related to patients, physicians, and the infrastructure of primary health care facilities (PHCFs). The effect of health care infrastructure and resources is not well studied. This cross-sectional study aims to explore factors affecting glycemic control among subjects with diabetes visiting PHCFs in the Mansoura District. A questionnaire was done to assess these factors among subjects with diabetes, primary care physicians (PCPs), and PHCFs infrastructure and resources. Three hundred and two subjects with diabetes attending PHCFs in the Mansoura District underwent a detailed clinical history. Also, HbA1c was obtained.

Results: Factors in patients that affect diabetic control include patient's education and occupation and their smoking status. Practicing physical exercise is important for diabetes control. Physicians can affect diabetes control by their rural residence, older age, participation in diabetes training, early graduation year, longer durations since started dealing with subjects with diabetes, and following guidelines. Resources of infrastructure have a role in diabetes control. Metformin and investigation availability has a positive association with diabetes control.

Conclusion: Patients, physicians, and resources of infrastructure have a role in diabetes control.

Keywords: Diabetes, Primary health care facilities (PHCFs), Primary care physicians (PCPs), Health care infrastructure and resources

Background

Diabetes is a huge and rapidly growing health problem worldwide. In 2019, IDF estimated 463 million have diabetes that expected to be 578 million by 2030, and 700 million by 2045. Two-thirds of people with diabetes live in urban areas and three out of four are of working age [1].

Type 2 diabetes characterized by peripheral insulin resistance and pancreatic β cell failure, leading to major comorbidity and mortality as a result of micro and macrovascular complications [2]. Globally, type 2 diabetes represents 90-95% of overall diabetic cases and still increasing [3].

Egypt is one of the 21 countries of the IDF MENA region. About 55 million people in the MENA region are diabetic and expected to be 108 million by 2045. In 2019, IDF estimated that Egypt is the 9th country worldwide with about 8,850,400 cases and a prevalence of

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15.2% in adults. By 2045, Egypt expected to be the 7th country worldwide [1].

For all subjects with diabetes, the main therapeutic goal is maintaining good glycemic control to prevent micro and macrovascular complications. However, the majority of them failed to achieve good glycemic control and the reasons for this poor glycemic control are multifactorial and complex [4].

The effectiveness of diabetes management is mainly based on patient compliance with medications and recommendations; thus, patient education is essential for proper diabetes management. The patient needs to understand the importance of a healthy diet, exercise practicing, smoking and alcohol cessation, medication adherence, foot hygiene, suitable footwear, periodic evaluation of glycemic control, and occurrence and progression of any complication [5].

Ahmad et al. reported that the four variables affecting the outcome of glycemic control were patient age, diabetes duration, drug utilization pattern, and adherence. As a short diabetes duration, monotherapy and good drug adherence impact the achievement of good glycemic control [6].

People with diabetes require access to continuous, systematic, and organized care by skilled medical personnel. Outcomes could undergo improvement at the primary care level with basic interventions including medications, education, counseling, and continuous follow-up. Such organized care must include a periodic evaluation of glycemic control and complications, agreed and updated care plan, and access to person-centered care delivered by a multidisciplinary team [5].

Diabetes care is an important component in PHC within the society. Community care of diabetes depends mainly on health knowledge, education, and communication which are extremely efficient and cost-effective. Using health education like a PHC tool shown to reduce risk, prevent or delay the onset of major diabetic complications [7].

Primary care physicians (PCPs) are at the forefront of diabetes care as most people attend PHCFs firstly, especially in low-income countries where these services are ill equipped to address the rising demand and have a shortage of specialists. Thus, PCPs should be well qualified to give optimal diabetes care to prevent complications and improve the quality of life of affected subjects [8].

The greatest challenge is that diabetes management necessitates many processes and decisions involving physicians and patients. Despite the technical advances in diabetes management, diabetes care is still, the most complex chronic illness to be treated at the PHC level [9].

To our knowledge, there is little research done on the control of diabetes and factors affecting it at PHCFs in our locality. And most studies done did not include the effect of health care infrastructure and resources on glycemic control. So, we are directing our research to study this.

Patients and methods

Patients

This cross-sectional study includes 302 subjects with diabetes visiting 24 PHCFs in Mansoura District during the period from March 2019 to March 2020 after the approval of the Mansoura Faculty of Medicine Institutional Research Board (MFM-IRB). Agreement to participate in the study by informed written consent was approved by the local ethical committee at the Mansoura Faculty of Medicine. Any participant who refused to contribute to the study was excluded.

Methods

In Mansoura District, there are 54 PHCFs, but in our study, we visited 24 facilities, 6 urban and 18 rural chosen by simple random sample. In each facility, we filled 3 questionnaires, one for infrastructure, one for physicians responsible for subjects with diabetes in the facility, and one for subjects with diabetes visiting the facility for any reason either to follow up diabetes or any other cause.

- Health care infrastructure questionnaire includes information about available drugs, are they available all the time or not, available investigations, are they available all the time or not, time of result of investigation either on the same day or another day, is their referral system or not, is there available health education (HE) material or not and if the facility uses special registration forms for diabetics or not.
- Physician questionnaire includes information about age, residence, gender, graduation year, duration since dealing with diabetic patients, specialization, participate in training for diabetes mellitus or not, follow guidelines usually, sometimes or never, do health education usually, sometimes, or never, do complete or incomplete system examination, and do foot examination or not.
- Patient questionnaire includes information about personal history as age, gender, occupation, residence, education, social status, and special habit. Present history as duration of diabetes, recent treatment, medication adherence, associated diseases, exercise, diet, follow-up, foot care, cause of visit, symptoms of high or low blood glucose or infection in the last 2 weeks, and family support. History of hospitalization in the last 12 months and family history of diabetes.

All participants were subjected to anthropometric measurements (weight, height, and BMI), and complete clinical examination with specific reference to any micro or macrovascular complications.

Sampling

A 5-ml venous blood sample was collected from each subject on K2EDTA tubes via proper venipuncture technique under complete aseptic condition. Samples were sent to the lab of the faculty of medicine to be examined for glycosylated hemoglobin (HbA1c) that was measured by the ion-exchange chromatography method (Biosystem Co., Spain).

Statistical analysis

Collected data was coded, computed, and statistically analyzed using SPSS version 16. The data presented in tables and figures. Qualitative variables were presented as frequency and percentage while continuous quantitative variables were presented as mean ± SD. For comparison of qualitative data, chi-square (χ^2) was used, which is replaced by Monte Carlo exact probability if the value of any expected cell was less than 5. Binary regression was used to detect the prediction of factors affecting glycemic control. The difference was considered significant at a p value ≤ 0.05.

Results

**Un-tabulated data

Demographic data of subjects

The age of most of our participants was 40-60 years old (67.9%); with medians of age were 52 years. Most of them were females (78.8%), from rural areas (71.9%), married (72.8%), with basic or no education (47.4%), and housewives (46.4%). Most of our participants never smoked (85.8%). Among smoker subjects (66.7%) were cigarette smokers. Physical exercise was not practiced in most of the subjects (62.3%).

Most of the participants had a positive family history of diabetes (84.1%), and 183 participants (72%) were of first-degree relatives. Most of the subjects visiting primary health centers because these facilities were near places for measuring blood sugar (55%).

Only 15.6% of studied subjects were hospitalized in the last year, 76.6% of them were hospitalized one time. Most of the subjects (47.5%) were hospitalized because of operations and 41.1% due to diabetes complications.

Duration of diabetes and type of treatment

About one-third of the participants (30.8%) having diabetes for less than 5 years. The percentage of subjects taking oral hypoglycemic agents (60%) was higher than the percentage of subjects taking metformin (55%) or insulin (35.8%), and 103 subjects (34.1%) were taking oral hypoglycemic and metformin together.

In our study, 108 subjects were taking insulin, 62 subjects were taking insulin only, 36 subjects were taking insulin and metformin, 6 subjects were taking insulin with oral hypoglycemic drugs and metformin, and 4 subjects only were taking insulin with oral hypoglycemic drugs. Most of the subjects were taking mixed insulin 70/30 (97.2%). Only 4 subjects were taking glargine insulin at night. Most of the subjects were taking insulin before breakfast and dinner (63.9%). Most of the subjects were injecting insulin in the arm and thigh (26.9%).

Most of the subjects had no follow-up schedule and visited doctors only on demand. Medium medication adherence was found in 51.3% of subjects, high adherence in 30.5% and low adherence in only 18.2%.

Infrastructure characteristics of the studied PHCFs

Three-quarters of visited PHCFs were in rural areas (75%). All of them did not have insulin but had oral hypoglycemic drugs. Nineteen facilities only had metformin (79.2%). In most of the facilities (62.5%), medications were available all the time. Most of the facilities had fasting blood glucose (FBG) and random blood glucose (RBG) investigations (95.8%), while most of them had no lipids or complete blood count (CBC) investigations (83.3-79.2% respectively), and all of them had hemoglobin (HB) investigations. In most of the facilities, investigations available all the time (83.3%), and in all of them, the results of the investigations were taken on the same day. In most of the facilities, there was no referral (66.7%), no available health education materials (95.8%), and there were special registration forms for diabetes (66.7%).

Physicians' characteristics of the PHCFs

More than one-half of the physicians were from rural areas (55.9%), were females (82.4%), and aged from 30-40 years old (47.1%). More than half (55.9%) were general practitioners, while 26.5% had fellowship and 17.6% had a master's degree. In total, 52.9% participated in training of diabetic care. Nearly one-half of the physicians (44.1%) have been dealing with subjects having diabetes for less than 5 years. Fifty percent of physicians usually follow guidelines while 47.1% of them sometimes follow guidelines, and only one physician does not follow guidelines. Most of them usually do health education, foot examination but incomplete systematic examination.

**Tabulated data

Relationship between controlled blood glucose and some factors of the studied subjects

Table 1 shows that the percentage of glycemic control was higher among younger age subjects (< 40 years),

Table 1 Relationship between controlled blood glucose and some factors of the studied subjects

Factors	Total	Controlled HbA1c ≤ 7		Uncontrolled HbA1c > 7		*P*	OR (95% CI)	Regression AOR (95% CI)
		No.	%	No.	%			
Age (years)								
< 40	28	13	46.4	15	53.6		*r*	
40–	204	71	34.8	133	65.2	0.230	1.62 (0.73-3.60)	
60+	70	22	31.4	48	68.6	0.162	1.89 (0.77-4.62)	
Gender								
Males	61	25	41.0	36	59.0		*r*	
Females	241	81	33.6	160	66.4	0.281	2.80 (1.39-5.60)	
Residence								
Rural	217	77	35.5	140	64.5		*r*	
Urban	85	29	34.1	56	65.9	0.823	3.51 (2.07-5.95)	
Education								
High	40	24	60.0	16	40.0		*r*	
Secondary	119	38	31.9	81	68.1	0.002	3.20 (1.52-6.71)	0.27 (0.13-0.57)
Basic or less	143	44	30.8	99	69.2	<0.001	1.03 (0.52-2.04)	0.24 (0.11-0.51)
Social status								
Unmarried	82	31	37.8	51	62.2		*r*	
Married	220	75	34.1	145	65.9	0.548	1.18 (0.69-1.99)	
Smoking								
Never smoke	259	90	34.7	169	65.3		*r*	2.25 (0.94-5.48)
Ex-smokers	22	12	54.5	10	45.5	0.064	0.44 (0.18-1.07)	
Current smokers	21	4	19.0	17	81.0	0.143	2.26 (0.74-6.93)	
Practicing physical ex.								
Sports	5	4	80.0	1	20.0		*r*	
Walking	109	43	39.4	66	60.6	0.072	6.14 (0.66-56.8)	
No	188	59	31.4	129	68.6	0.022	8.75 (0.96-79.7)	3.66 (1.21-8.46)
Family history								
Negative	48	20	41.7	28	58.3		*r*	
Positive	254	86	37.8	168	62.2	0.298	1.40 (0.74-2.62)	
Associated diseases								
No	99	40	40.4	59	59.6		*r*	
Yes	203	66	32.5	137	67.5	0.177	1.41 (0.86-2.31)	
Hospitalization in last y.								
No	255	90	35.3	165	64.7		*r*	
Yes	47	16	34.0	31	66.0	0.889	1.07 (0.55-2.04)	
Family support								
Yes	148	56	7.8	92	62.2		*r*	
No	154	50	32.5	104	67.5	0.328	1.27 (0.78-2.03)	
Duration since starting ttt								
≥ 10 year	121	45	37.2	76	62.8		*r*	
< 10 year	181	61	33.7	120	66.3	0.534	0.47 (0.29-0.76)	
Treatment								
OHG	194	75	38.7	119	61.3		*r*	
Insulin	62	20	32.2	42	67.8	0.364	1.32 (0.72-2.13)	

Table 1 Relationship between controlled blood glucose and some factors of the studied subjects *(Continued)*

Factors	Total	Controlled HbA1c ≤ 7		Uncontrolled HbA1c > 7		*P*	OR (95% CI)	Regression AOR (95% CI)
		No.	%	No.	%			
OHG + insulin	46	11	23.9	35	76.1	0.061	2.01 (0.96-4.19)	
Medication adherence								
High	92	38	41.3	54	58.7		*r*	
Medium	155	52	33.5	103	66.5	0.221	1.39 (0.82-2.37)	
Low	55	16	29.1	39	70.9	0.137	1.72 (0.84-3.51)	
BMI								
Average	15	8	53.3	7	46.7		*r*	
Overweight	74	20	26.7	54	73.3	0.050	3.09 (0.99-9.62)	
Obese	213	78	36.7	135	63.4	0.196	1.98 (0.69-5.66)	

males, from rural areas, highly educated, and not married. Also, the percentage of glycemic control was higher among never smoked and ex-smoker subjects in comparison to currently smoker subjects. Also, it was higher among subjects practicing physical exercises, with negative family history of diabetes, had no associated chronic diseases, not hospitalized in last year, had family support, started treatment at an older age (≥ 40 years), received oral hypoglycemic drugs, having high medication adherence and with average BMI. The level of significance ($P = \leq 0.05$) was present with three factors: education, practicing physical exercises, and BMI. Lower level of education, current smoking, and non-practicing physical exercises were the most factors predicting uncontrolled glycemic level, as adjusted odd's ratio (AOR) at 95.0% CI for them were 3.20. 1.03, 2.25, and 3.66 respectively.

Distribution of the studied subjects according blood glucose control and its relation to PHCFs infrastructure factors

As shown in Table 2, the percentage of glycemic control was higher among subjects who received care at PHCFs in rural areas, where metformin was available, metformin was available all the time, available investigation for FBG, RBG, lipids, CBC, HB, and other investigations. Also, it is higher where, these investigations were available all the time, a referral system was used, available HE materials, and using special registration form for diabetic patients. The significance level ($P = \leq 0.05$) was present with three factors: available of metformin, available lipids, and other investigations. Availability of other investigations was the factor predicting controlled glycemic level, as adjusted odd's ratio (AOR) at 95.0% CI was 0.465 (0.283-0.764).

Distribution of the studied subjects according blood glucose control and its relation to PCPs factors

As shown in Table 3, the percentage of glycemic control was higher among subjects received care by physician characterized by living in rural areas, males, older age (≥ 40 years), graduated early, had a master degree, participated in diabetes training, started dealing with diabetic patients since ≥ 5 years, follow guidelines, doing HE, doing complete systematic examination, and doing foot examination. The significance level ($P = \leq 0.05$) was present in the following physicians' related factors: residence in rural areas, older age, early graduation, participated in diabetes training, dealing with diabetic patients for a longer period, and following guidelines. Older age of physician (≥ 40 years) and following guidelines in giving care to diabetic patients were the most factors predicting uncontrolled glycemic level, as adjusted odd's ratio (AOR) at 95.0% CI for both were 1.64 (1.00-2.70) and 2.66 (1.64-4.33) respectively.

Discussion

In Egypt, there is no yearly routine checkup policy or screening program for chronic noncommunicable illnesses [10]. People with diabetes usually visit governmental health care centers to get medications for free or for a little cost, but not for periodic examination [11].

In our current study, 24 PHCFs were evaluated, 6 urban (25%), and 18 rural (75%) for their infrastructure characteristics and their impact on the glycemic control of subjects attending these facilities.

We reported that oral hypoglycemic agents were found in all facilities (100%), while insulin was not found in all of them (100%). Metformin was not found in 5 facilities (20.8%); also, medications were not found all-time at 9 facilities (37.5%). FBG and RBG tests were found in all PHCFs except one (4.2%). Lipid investigations were found in 4 facilities (16.7%), also CBC tests were found only in 5 facilities (20.8%). The investigations were found all the time at 20 facilities (83.3%), and the results were obtained on the same day in all 24 facilities (100%). Only 8 facilities (33.3%) make referrals for complicated cases. The health education material was found in just one facility (4.2%), and the usage of special registration forms was found in 16 facilities (66.7%).

Table 2 Distribution of the studied subjects according blood glucose control and its relation to PHCFs infrastructure factors

Factors	Total	Controlled HbA1c ≤ 7		Uncontrolled HbA1c > 7		*P*	OR (95% CI)	Regression AOR (95% CI)
		No.	%	No.	%			
Residence								
Rural	216	78	36.1	138	63.9		*r*	
Urban	86	28	32.5	58	67.5	0.559	0.85 (0.51-1.45)	
Metformin availability								
Yes	267	99	37.1	168	62.9		*r*	
No	35	7	20.0	28	80.0	0.047	2.36 (1.00-5.60)	
Metformin available all time								
Yes	192	72	37.5	120	62.5		*r*	
No	110	34	30.9	76	69.1	0.248	1.34 (0.81-2.21)	
Available FBG/RBG								
Yes	288	102	35.7	186	64.3		*r*	
No	14	4	28.8	10	71.2	0.602	1.37 (0.42-4.48)	
Available lipids								
Yes	97	45	46.4	52	53.6		*r*	
No	205	61	29.8	144	70.2	0.005	2.04 (1.24-3.36)	
Available CBC								
Yes	88	35	39.8	53	61.2		*r*	
No	214	71	33.2	143	66.8	0.275	1.33 (0.80-2.22)	
Available HB								
Yes	302	106	100.	196	100.			
No	0	0	0.0	0	0.0			
Available other investigation								
Yes	100	47	47.0	53	53.0		*r*	
No	202	59	29.2	143	70.8	0.002	2.15 (1.31-3.53)	0.47 (0.28-0.76)
Available investigation all the time								
Yes	260	94	36.2	166	63.8		*r*	
No	42	12	28.6	30	72.4	0.339	1.41 (0.69-2.90)	
Time of investigation results								
Same day	302	106	100.	196	100.			
Other day	0	0	0.0	0	0.0			
Referral								
Yes	125	45	36.0	80	64.0		*r*	
No	177	61	34.5	116	65.5	0.783	1.07 (0.66-1.73)	
Available HE materials								
Yes	39	18	46.2	21	53.3		*r*	
No	263	88	33.5	175	66.5	0.121	1.70 (0.86-3.36)	
Use special registration form								
Yes	214	77	36.0	137	64.0		*r*	
No	88	29	33.0	59	67.0	0.617	1.14 (0.68-1.73)	

In our study, we found the percentage of glycemic control was higher among subjects who received care at PHCFs in rural areas, where metformin was available, metformin was available all the time, available investigation for FBG, RBG, lipids, CBC, HB, and other investigations. Also, it is higher where, these investigations were available all the time, a referral system was used, available health education materials, and using

Table 3 Distribution of the studied subjects according blood glucose control and its relation to PCPs factors

Physician's factors	Total	Controlled HbA1c ≤ 7		Uncontrolled HbA1c > 7		*P*	OR (95% CI)	Regression AOR (95% CI)
		No.	%	No.	%			
Physician's residence								
Rural	100	46	46.0	54	54.0		*r*	
Urban	202	60	29.7	142	70.3	0.005	2.02 (1.23-3.31)	
Physician's gender								
Males	54	20	37.0	34	63.0		*r*	
Females	248	86	34.7	162	65.3	0.742	1.11 (0.60-2.04)	
Physician's age								
≥ 40	131	57	43.5	74	56.5		*r*	
< 40	171	49	28.7	122	71.3	0.007	1.92 (1.19-3.10)	1.64 (1.00-2.70)
Physician's graduate								
≤ 2000	198	82	41.4	116	58.6		*r*	
> 2000	104	24	23.1	80	76.9	0.002	2.36 (1.38-4.03)	
Specialty								
Master	85	37	43.5	48	56.5		*r*	
Fellowship	57	21	36.8	36	63.4	0.426	1.32 (0.66-2.63)	
GP	160	48	30.0	112	70.0	0.034	1.79 (1.04-3.11)	
Participate in DM training								
Yes	149	63	42.3	86	57.7		*r*	
No	153	43	28.1	110	71.9	0.009	1.86 (1.16-3.03)	
Duration since dealing with DM patients								
≥ 5 years	186	75	40.3	111	59.7		*r*	
< 5 years	116	31	26.7	85	73.4	0.016	1.85 (1.12-3.07)	
Follow guidelines								
Usually	141	66	46.8	75	53.2		*r*	
Sometimes	161	40	24.8	121	75.2	< 0.001	2.66 (1.63-4.33)	2.66 (1.64-4.33)
Doing HE								
Usually	250	89	35.6	161	64.4		*r*	
Sometimes	52	17	32.7	35	67.3	0.689	1.14 (0.60-2.15)	
Do systemic examination								
Complete	140	54	38.6	86	61.4		r	
Incomplete	162	52	32.1	110	67.9	0.240	1.33 (0.83-2.13)	
Doing foot exam								
Done	249	93	37.3	156	62.7		*r*	
Not done	53	13	24.5	40	75.5	0.076	1.83 (0.93-3.61)	

special registration form for diabetic patients. The significance level ($P = \leq 0.05$) was present with three factors: available of metformin, available lipids, and other investigations. Availability of other investigations was the factor predicting controlled glycemic level, as adjusted odd's ratio (AOR) at 95.0% CI was 0.465 (0.283-0.764).

A study done by Assunção et al. to recognize factors associated with poor glycemic control in subjects with diabetes seen at 32 primary health care centers in southern Brazil that included 372 subjects. They described the infrastructures in their study and stated that 37 subjects followed the diabetes patient care program. Subjects who had followed the available schedules in the PHC were 48.7%. Capillary glycemia measuring bands were available for 16.1% of the subjects. Also, they stated that subjects on oral hypoglycemic agents ($n = 246$) 63.0% and insulin ($n = 40$) 57.5% attended visits where such

drugs were regularly available. Special records for subjects with diabetes were available for 21% of them. Educational material was available for 35.5% of subjects [9].

In our current study, 34 physicians gave the care for subjects with diabetes in the 24 PHCFs, 6 males (17.6%) and 28 females (82.4%). Most of them were from rural areas (55.9%); most of them were aged from 30 to 40 years (47.1%). Also, most of them were general practitioners (55.9%). Physicians usually followed the guidelines were 50% and 47.1% sometimes followed the guidelines. A lot of them (85.3%) do health education to the subjects, and 85.3% do foot examination while examining the subjects. Most of the physicians (44.1%) dealing with subjects having diabetes for less than 5 years.

As matched by a study done by Assunção et al. reported that subjects with diabetes were seen by 58 physicians, and 52% of the subjects were treated by non-specialists or general practitioners. Approximately 80% of the subjects were examined by physicians who worked at health centers for more than a year. Most of the physicians were females (65%) [9].

A study done by Ciccone et al. aimed at a project named Leonardo Project. This project showed the feasibility of incorporating care managers (specially trained nurses) into the health care system to support general practitioners and specialists in the treatment of subjects with diabetes. In this project, care managers worked directly with patients, helping them to change lifestyles, monitoring their conditions, offering the required information, improve self-care skills, and achieve better compliance with care recommendations. This model resulted in a tangible improvement in the clinical parameters of the enrolled subjects thus achieved better control of their disease. In such a setting, the combined efforts and networking of all the involved subjects create a strong collaborative health team, and this what must occur in all the primary health care centers [12].

The chief drive for diabetes care is not only the availability and adequacy of the health care workforce but the level of knowledge and skills needed for caring for the subjects. This because not all health care workers know about diabetes care, rather it necessitates special trainings and mentoring by experienced health providers [13].

In our study, we found the percentage of glycemic control was higher among subjects received care by physician characterized by living in rural areas, males, older age (≥ 40 years), graduated early, had a master's degree, participated in diabetes training, started dealing with diabetic patients since ≥ 5 years, follow guidelines, doing HE, doing complete systematic examination, and doing foot examination. The significance level ($P = \leq 0.05$) was present in the following physicians' related factors: residence in rural areas, older age, early graduation, participated in diabetes training, dealing with diabetic patients for a longer period, and following guidelines. Older age of physician (≥ 40 years) and following guidelines in giving care to diabetic patients were the most factors predicting uncontrolled glycemic level, as adjusted odd's ratio (AOR) at 95.0% CI for both were 1.64 (1.00-2.70) and 2.66 (1.64-4.33) respectively.

In our current study, we evaluate 302 subjects with diabetes from different areas in the Mansoura District, 20.2% were men, 78.8% were women, 28.1% were from urban areas, 71.9% were from rural areas, and about 67.9% of them aged from 40 to 60 years. Of the studied group, 47.4% had basic and less educational status, 39.4% had secondary educational status, and 46.4% of the studied subjects were housewives.

A study done by El-Khawaga and Abdel-Wahab in Dakahlia included 750 subjects with diabetes; women represented 56.1%. Most of the subjects (94.8%) aged ≥ 30 years, 31.1% were housewives, and 66.3% of them were from rural areas. The educational status of the included subjects was less than secondary in 31.9% and illiteracy in 31.3% [14]. Also, a study done by Abdo and Mohamed included 122 subjects with diabetes, stated that 63.11% were females, 58.2% were illiterate, 66.3% were from rural areas with average age ranged from 41 to 70 years, and the middle social class was 68.03% [15].

So, when comparing our subjects to other studies, the majority of subjects were females with low- to mid-socioeconomic states and mostly from rural areas with average age of more than 40 years.

In our current study, the age, the gender, residency, and the social status of the included subjects had no effect on controlling the HbA1c ($P > 0.05$), but the education level and the occupations of the included subjects had roles in diabetic control (controlling the HbA1c) ($P \leq 0.05$).

In our current study, the majority of subjects were non-smokers (85.8%), while 7.3% were ex-smokers and 7% were smokers. Most of the smokers (60%) had smoked about 10-20 cigarettes per day as the cigarettes were used mainly for smoking; shisha smokers were less than cigarette smokers. Smoking had shown a negative effect on diabetic control.

Similarly, a study done by Kassahun et al. included 309 subjects with type 2 diabetes, 22 were smokers (7%) most of them (4%) know the effect of smoking on diabetes [16]. Also, Khan and Hamdy, in their study, reported that approximately 39.7% of Egyptian adult men smoke cigarettes. In subjects with diabetes, smoking is directly linked to increased incidence of micro and macrovascular complications [17].

In our current study, 62.3% of the included subjects did not practice any exercises, and 36.1% just did walking exercises. Our current work found a statistically

significant positive association between physical activity and the control of diabetes. In the same line, Al-Shehri reported that practice exercise of about 30 min for 3 days a week or more affected the control of diabetes [18].

In our current study, 60.4% of the subjects take oral hypoglycemic agents, 35.8% take insulin, and 55% were treated with metformin. Most of the subjects (34.1%) were treated mainly by oral hypoglycemic agents and metformin. These variations did not show an effect in controlling HBA1c in the included subjects.

On the other hand, a study done by Ahmad et al. included 557 subjects with diabetes, stated that about 60.3% of them take a combination of oral antidiabetics, followed by monotherapy (24.4%), and a combination of oral antidiabetic drugs and insulin (15.3%), he reported that the optimal glycemic control was achieved by subjects on monotherapy, followed by subjects receiving a combination of oral antidiabetics and then subjects on a combination of insulin and oral antidiabetics [6]. This perhaps could be due to the increasing difficulty in taking more than one drug and then the injections, thus, also probably affecting adherence. However, in another study done by Van Gaal and De Leeuw showed that more than 80% of subjects did not consistently maintain HbA1c control 2 years after initial monotherapy with metformin or sulphonylureas [19].

In our current study, 51.3% of the included subjects had medium medication adherence, 30.5% had high adherence, and 18.2% had low adherence. Most of the subjects (47%) do follow up on demand, and 30.5% of them do follow up monthly. The adherence to the drugs in this study did not show significant effect on controlling HbA1c ($P > 0.05$).

In contrast, a study done by Souza et al. reported that 87.2% of subjects (78 subjects) were considered to be adherent to the medication and show a significant-good control of diabetes [20].

In our current study, 15 subjects had average weight, 74 subjects were overweight, and 213 subjects were obese. So, most of our included subjects had weight more than the average. The body mass index (BMI) in this study show a significant effect on the control of HbA1c ($p = \leq 0.05$).

Such results agreed with Husseinet al.'s study that found a statistically significant negative relationship between BMI and physical and psychological health [21]. Also, agreed with the results of the study done by Papadopoulos et al. that reported a correlation between BMI and diabetes control [22]. In contrast, a study done by Kazemi-Galougahi et al. revealed no significant association between BMI and diabetes control [23].

In our current study, we found the percentage of glycemic control was higher among never smoked and ex-smoker subjects in comparison to currently smoker subjects. Also, it was higher among subjects practicing physical exercises, with negative family history of diabetes, had no associated chronic diseases, not hospitalized in last year, had family support, started treatment at an older age (≥ 40 years), received oral hypoglycemic drugs, having high medication adherence, and with average BMI. The level of significance ($P = \leq 0.05$) was present with two factors: practicing physical exercises and BMI. Current smoking and nonpracticing physical exercises were the most factors predicting uncontrolled glycemic level, as adjusted odd's ratio (AOR) at 95.0% CI for both were 2.25 (0.94-5.48) and 3.66 (1.21-8.46) respectively.

So, our current study shows an association between diabetes control and health care infrastructure, physician characteristics as well as subject's characteristics.

In contrast, a study done by Assunção et al. showed that there was no correlation between poor glycemic control and health facility infrastructure or physician characteristics. It was found to be linked, instead, to subject's characteristics (time span since diagnosis, BMI, and utilization of medical therapy) [9].

Conclusion

We concluded that there are several factors affecting glycemic control in subjects with diabetes. These factors are related to subjects as well as to service providers represented in PCPs or family physicians and PHCFs. Education and occupations of the subjects affect glycemic control positively, while smoking affects glycemic control negatively. Availability of metformin, lipids investigations, and other investigations are important factors for glycemic control. Physicians from rural areas, older physicians, physicians who participate in training for diabetes, physicians with longer duration in dealing with subjects having diabetes, and physicians following guidelines affect glycemic control positively. So, PHCFs and family physicians or PCPs have an important role in diabetic control of subjects with diabetes.

Abbreviations

IDF: International Diabetes Federation; PHCFs: Primary health care facilities; PCPs: Primary care physicians; PHC: Primary health care; HE: Health education; BMI: Body mass index; FBG: Fasting blood glucose; RBG: Random blood glucose; CBC: Complete blood count; HbA1c: Glycosylated hemoglobin; AOR: Adjusted odd's ratio; SD: Standard deviation

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None

Authors' contributions

MA made substantial contributions in the analysis, and interpretation of the data. AA made substantial contributions to the design of the work, supervising the work, and doing the statistical analysis of the data. MG is the corresponding author, has a major role in collecting the data, writing the manuscript, and revising the work. All authors have read and approved the final manuscript.

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Availability of data and materials
The data used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study protocol was approved by the Ethics Review Board of Faculty of Medicine, Mansoura University, and informed written consent was obtained from all participants according to the Declaration of Helsinki. The committee's reference number is MD/17.08.92.

Consent for publication
Not applicable

Competing interests
The authors declare that they have no competing interests.

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