

## Original Article

**Associated Factors with Hyperglycemia in Diabetic Patients Admitted to Emergency Department**Hamed Aminiahidashti<sup>1</sup> Touraj Assadi<sup>2</sup> Seyed Hossein Montazer<sup>3</sup> Adele Bahar<sup>4</sup>  
Mahdis Nozari<sup>5</sup> **Seyed Mohammad Hosseinejad**\*<sup>6</sup>

1. Associate professor, Faculty of Medicine, Mazandaran University of Medical Sciences, Sari, Iran
2. Assistant professor, Diabetes Research Center, Faculty of Medicine, Mazandaran University of Medical Sciences, Sari, Iran
3. Assistant professor, Orthopedic Research Center, Faculty of Medicine, Mazandaran University of Medical Sciences, Sari, Iran
4. Associate professor, Diabetes Research Center, Faculty of Medicine, Mazandaran University of Medical Sciences, Sari, Iran
5. Medicine student, Faculty of Medicine, Mazandaran University of Medical Sciences, Sari, Iran
6. Associate professor, Diabetes Research Center, Faculty of Medicine, Mazandaran University of Medical Sciences, Sari, Iran

\*Correspondence to: Seyed Mohammad Hosseinejad  
[drhoseinejad@yahoo.com](mailto:drhoseinejad@yahoo.com)

(Received: 28 May. 2020; Revised: 5 Aug. 2020; Accepted: 1 Oct. 2020)

**Abstract**

**Background and Purpose:** Given the increasing prevalence of diabetes and its associated healthcare costs, this study aimed to identify the factors contributing to the increase in blood glucose followed by inadequate control in diabetic patients registered in the Imam Hospital in Sari.

**Materials and Methods:** This cross-sectional descriptive study was performed on diabetic patients admitted to the emergency department suffering from increase in blood glucose (more than 200 mg/dL). Demographic, clinical, and social information were entered into the checklist, and the factors associated with the rise in blood glucose was investigated.

**Results:** In this study, 301 diabetic patients with increase in blood glucose levels were included. Mean age was 65±10.6 years, 50.8% (153) were between 70-61 years, and lethargy with 37.9% (114 patients) had the highest cause of complaints in patients, meanwhile 38.9% (117) of the patients had 4 visits a year by specialist. In addition, 53.8% (162) had "while at work" physical activity status, and only 6.6% (20) of the patients had sportive-recreational activity. 42.2% (127) of the studied cases were also not in any type of abuse situation (clean), and 32.9% (99) of them experienced drug abuse. Among the referring patients, 51.5% were suffering hyperglycemia with infection, and 22.6% were documented to be with reduced or discontinued medication.

**Discussion:** Based on the results, a general description associated factors with hyperglycemia patients can be used for prevention and treatment of these patients and prevention of future complications.

**Keyword:** Hyperglycemia; Diabetic patients; Emergency Department

**Citation:** Aminiahidashti H, Assadi T, Montazer SH, Bahar A, Nozari M, **Hosseinejad SM\***. Associated factors with hyperglycemia in diabetic patients admitted to Emergency Department. Iran J Health Sci. 2020; 8(4): 10-19.

## 1. Introduction

Diabetes mellitus is a chronic disease in which treatment is done in a way to limit the potential serious long-term and short-term side effects. The World Health Organization (WHO) has declared it a latent epidemic in light of the growing trend of diabetes worldwide (1). The global prevalence of diabetes in 2012 was about 371 million, and was estimated to reach 552 million by 2030 (2). This increase is in line with the aging population, lifestyle changes associated with economic development, and an increase in obesity (3). Population-based estimates indicate that approximately 14% of US adults have diabetes, especially type2 diabetes, and by 2012, approximately 25% of the population with diabetes had not been diagnosed prior to being admitted to the Emergency Department(ED) with an acute condition or elevated blood sugar levels (4). Given the increasing prevalence of diabetes in the general population, it is the most common chronic disease among emergency patients (5). A continuous rise in blood sugar will cause acute toxicity, not only due to insulin resistance but also due to incomplete insulin release through the pancreatic beta cells. Over time, this increase will have detrimental effects on the vascular system. Among the major emergencies of acute hyperglycemia are diabetic ketoacidosis (DKA) and hyperosmolar hyperglycemic syndrome (HHS) with similar clinical manifestations occurring in one third of the cases simultaneously (6). The incidence of diabetic ketoacidosis usually occurs very quickly, sometimes in less than 24 hours, whereas the occurrence of HHS in most patients takes days and weeks. Although acute hyperglycemia is present in both,

DKA is more associated with ketones and HHS more with hyperosmolarity and dehydration (6). Some studies have emphasized the psychological factors and patients' rejection of treatment for ketoacidosis. Fear of weight gain and sugar loss, diabetes-related stress, or eating disorders caused by mental disorders can lead to insulin blockage in individuals (7). Diabetic ketoacidosis and hyperglycemic hyperosmolar state represent two levels of hyperglycemic spectrum that cause difficult clinical and managerial challenges, especially for emergency physicians. Due to the increase in inactivity and obesity, its prevalence is expected to increase even more rapidly. Since the progression of side-effects and high cost of treatment in these patients are mainly due to inadequate blood glucose control (8), achieving proper glycemic control has delayed the onset and progression of complications of the disease. Complications of diabetes include cardiovascular complications, nephropathy, neuropathy, retinopathy, and cataract leading to disability, incapacity, high cost of treatment, and death (9). Proper glycemic control through personal patient management, careful monitoring of blood sugar, dietary restrictions, foot care, and eye and cardiac examinations can reduce the incidence and progression of diabetes complications (10). These diseases, in addition to high mortality, have high health and financial costs for the community. In the US, for example, the average cost of managing diabetic ketoacidosis is \$17500 per patient, and the overall estimated annual cost of hospital treatment for patients with hypoglycemic emergency in the US is over \$2 billion (11). Since the majority of emergency patients is

comprised of diabetic patients who have been under treatment, their admissions and hospitalizations impose high costs on the health system. By designing this study and identifying the factors contributing to poor blood sugar control in patients, we sought to facilitate prevention and treatment for these patients.

## 2. Materials and Method

The present study was a cross-sectional descriptive-analytical study that was conducted in Sari in 2017. The study population consisted of patients admitted to the emergency room of Imam Khomeini University Hospital who had type 2 diabetes with elevated blood sugar (blood glucose greater than 200 mg/dL). Patients who did not have diabetes but were admitted to the emergency room during this time due to hyperglycemia were excluded. A total of 301 patients with type 2 diabetes and elevated blood sugar were then selected and enrolled in the current study. Data were collected by questionnaires completed by medical students. The questionnaire consisted of three parts: the first part was demographic information; age, gender, education level (illiterate, without college education, college education), economic status (excellent, good, average, and poor), employment status (employed, unemployed, retired, housewife) and the place of residence (urban, rural). The second part of the patient's clinical information included the type of treatment received (oral monotherapy, combination oral, insulin therapy), the type of drugs used (Metformin, Sulfonylurea, Thiazolidine, Insulin), family history of diabetes, previous disease history (hypertension, hyperlipidemia, cardiovascular disease), patient's main complaint (nausea and vomiting), probably causes of

hyperglycemia (infection, discontinuation or decrease of insulin consumption, discontinuation or reduction of oral drug use), and poor management and consumption of corticosteroids (chemotherapy drug). The third section of social information included the examination of smoking habits, drugs and alcohol use, and physical activity (during working hours, commuting, recreational-sports activities). Hyperglycemia and diabetes diagnoses was assessed by standard criteria for disease definition and measurement was done using the Blood Glucose Detection Kit (Pars Azmoon-Iran) and Blood Glucose Monitoring Machine (BT300 Autoanalyzer-Italy). Sampling method was based on availability and was done by checking the compliance of the ED admission procedure with the inclusion criteria, obtaining written consent and assuring anonymity. Parallel method was used to determine the scientific reliability of the tools; two separate forms were completed by 10 easily selected type 2 diabetes patients. The scientific validity of the appliance was assessed through content validity. For this purpose, after translation, the appliance was provided to 5 faculty members of Mazandaran University of Medical Sciences and approved by the Research Committee after final observations. Finally, the data were analyzed by SPSS Software version 22 using descriptive statistics. This study has been approved by the Ethics Committee of Mazandaran University of Medical Sciences, Sari, Iran (IR.MAZUMS.IMAMHOSPITAL.REC.1397.1166).

### 3. Results

The sample size of the present study was 301, from which 51.2% (154 patients) were male and 56.8% (171) were illiterate. The mean age of the subjects was  $65 \pm 10.6$  years, 50.8% (153) were between 70-61 years, 61.8% (186) of them were married,

and only 10% (30) were single. 38.9% (117) of the cases were housewives, and 21.9% (66) were unemployed. Meanwhile, 67 % (202) of the sample were rural residents, and 39.2 % (118) were with poor economic status, which accounted for most of the emergency cases admitted to ED (Table 1).

**Table 1.** Demographic information of patients according to the studied variables

Variables	Hyperglycemic (301 patients)
<b>Gender: Cases (%)</b>	
Men	154 (51.2%)
Women	147 (48.8%)
<b>Age Group (year): Cases (%)</b>	
< 50	20 (6.6%)
51-60	50 (16.6 %)
61-70	153 (50.8 %)
>70	78 (25.9 %)
<b>Marital Status: Cases (%)</b>	
Single	30 (10%)
Married	186 (61.8%)
Widowed	85 (28.2%)
<b>Education Status: Cases (%)</b>	
Illiterate	171 (56.8%)
Without college education	120 (39.9 %)
College education	10 (3.3%)
<b>Job status: Cases (%)</b>	
Employed	80 (26.6%)
Unemployed	66 (21.9%)
Retired	38 (12.6%)
Housewife	117 (38.9%)
<b>Economic status: Cases (%)</b>	
Poor	118 (39.2%)
Average	113 (37.5%)
Well-off	70 (23.3%)
<b>Residence Status: Cases (%)</b>	
Urban	99 (32.9%)
Rural	202 (67.1%)

According to the clinical data collected, 51.5% (155) of the cases were hyperglycemic-infected patients, 22.6% (668) were hyperglycemic with reduction or discontinuation of oral medication or insulin, 6.3% (19) used corticosteroid or chemotherapy medication, 10% (30) had a poor control, and 9.6% (29) were hyperglycemic with other conditions. Weakness and lethargy with 37.9% (114 patients) had the highest cause of complaints in patients with high blood sugar, followed by dyspnea with 13% (39

patients) causing adverse conditions. 57.5% (173) of the clients also had no family history of diabetes, and 32.9% (99) had a previous history of hypertension, hyperlipidemia, and cardiovascular disease. In addition, 38.9% (117) patients had 4 visits a year by specialist and 3.3% (10) were visited once a year. Among the patients, 34.9% (105) used combination medication (metformin, sulfonylurea, and insulin) and 22.9% (69) used only metformin medication (Table 2).

**Table 2.** Clinical information of patients according to the studied variables

Variables	Hyperglycemic (301 patients)
<b>Hyperglycemia occurrence: Cases (%)</b>	
Infection	155 (51.5%)
Reduction/discontinuation of oral medication or Insulin	68 (22.6%)
Corticosteroid use and chemotherapy medication	19 (6.3%)
Poor control	30 (10%)
Other causes	29 (9.6%)
<b>Main complaint: Cases (%)</b>	
Weakness and lethargy	114 (37.9%)
High blood sugar	39 (13%)
Dyspnea	39 (13%)
Diarrhea	20 (6.6%)
Diabetic foot ulcer	20 (6.6%)
Other	89 (29.6%)
<b>Specialist visits: Cases (%)</b>	
Once a year	10 (3.3%)
Twice a year	36 (12%)
3 visits a year	98 (32.6%)
4 visits a year	117 (38.9%)
+4 visits a year	40 (13.2%)
<b>Underlying disease: Causes (%)</b>	
Yes	226 (75.1%)
No	75 (24.9%)
<b>Family history of diabetes: Cases (%)</b>	
Yes	128 (42.5%)
No	173 (57.5%)
<b>Prescribed medication: Cases (%)</b>	
Metformin	69 (22.9%)
Sulfonylurea	28 (9.3)
Insulin	40 (13.3%)
Combination medication	105 (34.9%)
Other oral medications and injections	59 (19.6%)

In addition, 53.8% (162) of the patients had "while at work" physical activity status, and only 6.6% (20) of them had sportive-recreational activity. It was also found that

42.2% (127) of hyperglycemic cases were not in any type of abuse situation (clean), and 32.9% (99) of them experienced drug abuse (Table 3).

**Table 3.** Social information of patients according to the studied variables

Variables	Hyperglycemic (301 patients)
<b>Substance abuse: Cases (%)</b>	
Cigarette Smoker	59 (19.6%)
Drug abuse	99 (32.9%)
Alcohol	16 (5.3%)
Clean	127 (42.2%)
<b>Physical Activity: Cases (%)</b>	
While at work	162 (53.8%)
Commute	119 (39.5%)
Sportive-Recreational	20 (6.6%)

Among the referring patients, 51.5% experienced hyperglycemia with infection, and 22.6% reduced or discontinued medication. Among hyperglycemic-infected cases, 54.8% were in the age group of 61-70 years, 6.5% were involved in physical activities, 61.3% of them were illiterate, and only 19.4% were in a good economic status. Besides, in Hyperglycemic-Reduction/Discontinuation

medication cases, 70.6% were in the age group of 61-70 years, none of them were involved in physical activities, 41.2% of them were illiterate, and only 29.4% were in a good economic status. In hyperglycemic patients with infection, 58.1% had a history of underlying disease, and in those with reduction/discontinuation of medication, 85.3% experienced it (Table4).

**Table 4.** Associated factors with hyperglycemia in diabetic patients

Variables	Related Causes with hyperglycemia % (n)		
	Infection	Reducing/Discontinuation medication	Other causes
<b>Age Group</b>			
< 50	12.9% (20)	0	0
51-60	12.9% (20)	14.7% (10)	25.6% (20)
61-70	54.8% (85)	70.6% (48)	25.6% (20)
>70	19.4% (30)	14.7% (10)	48.7% (38)
<b>Marital Status</b>			
Single	6.5% (10)	0	25.6% (20)
Married	63.9% (99)	55.9% (38)	62.8% (49)
Widowed	29.9% (46)	44.1% (30)	11.5% (9)
<b>Physical Activity</b>			
While at work	48.4% (75)	57.4% (39)	61.5% (48)
Commute	45.2% (70)	42.6% (29)	25.6% (20)
Sportive-Recreational	6.5% (10)	0	12.8% (10)
<b>Education Status</b>			
Illiterate	61.3% (95)	41.2% (28)	61.5% (48)
Without college education	32.3% (50)	58.8% (40)	38.5% (30)
College education	6.5% (10)	0	0
<b>Underlying disease</b>			
Yes	58.1% (40)	85.3% (39)	100% (78)
No	41.9% (115)	14.7% (29)	0
<b>Economic Status</b>			
Poor	25.8% (40)	29.4% (20)	74.4% (58)
Average	54.8% (85)	41.2% (28)	0
Well-Off	19.4% (30)	29.4% (20)	25.6% (20)

#### 4. Discussion

In this study, 301 diabetic patients with increase in blood glucose levels were included. Mean age was  $65 \pm 10.6$  years, 50.8% (153) were between 70-61 years, and lethargy with 37.9% (114 patients) had the highest cause of complaints in patients, 38.9% (117) patients had 4 visits a year by specialist. In addition, 53.8% (162) had "while at work" physical activity status and only 6.6% (20) patients had sportive-recreational activity. It was also found that 42.2% (127) were not in any type of abuse situation (clean). Among the referring patients, 51.5% experienced hyperglycemia with infection and 22.6% reduced or discontinued medication. Among hyperglycemic-infected cases, 54.8% were in the age group of 61-70 years, 6.5% were involved in physical activities, 61.3% of them were illiterate, and only 19.4% had a good economic status.

In the present study, 32.9% of patients with multiple underlying diseases were admitted to the ED. These findings were consistent with the results of a study conducted by Yan et al. (2017), examining two preventive factors associated with frequent admissions to the ED for hyperglycemia over a 30-day period; blood pressure and heart rate were considered as significant factors, such that patients with normal blood pressure (SBP 90-150 mmHg) were less likely to be unnecessarily admitted to the ED within 30 days due to hyperglycemia, compared to those with low or high blood pressure. In addition, people whose heart rate was less than 110 bpm were less likely to return to the ED because of hyperglycemia (12). In the present study, the mean age of the subjects was  $65 \pm 10.6$  years, and 50.8% (153) of them were between 70-61 years. Yun Jae et al. (2015) studied the clinical features of Elderly

diabetic patients in emergency hyperglycemia. Overall, 16 patients with mean age of 78.9 were enrolled. The results of their study indicated that elderly patients with diabetes were prone to experiencing hyperglycemic emergencies (13). In their study, % (118) of those with poor economic status accounted for most of the emergency cases admitted to ED. The findings of a study conducted by Shani (14) suggested that there was a significant relationship between economic status and glycemic control, which in turn reduced the risk of hyperglycemia. Research findings by Mojtabai (15) also showed that many people with poor financial status consciously refused to buy or take the recommended dosage. On the other hand, unfortunate financial status was found to indirectly impair blood glucose control and create the potential for exposure to hyperglycemia by causing stress and anxiety in the individual (16). In Yan's study (12), the unpredictable result was that patients with family physicians were at higher risk for unplanned recurring trips to the ED due to hyperglycemia, although these results were not statistically significant (lower point of 95% CI was 1.01). This is quite possibly the result of patients' poor glycemic control, and more severe diabetic complications may be more proactive in having regular follow-up sessions with a physician, while those with milder disease or better control may not need to be listed on the family physician list. Studies of other chronic diseases, such as congestive heart failure or chronic obstructive pulmonary disease, have shown that access to follow-up sessions within 30 days was associated with a reduced risk of admission to the ED and hospital readmission (16, 17). Diabetes is one of the most common non-communicable chronic

diseases in the developed world and in developing countries, which is increasing worldwide due to people's lifestyle and eating habits (18). Diabetes patients account for more than 20% of ED visits, while the costs of such admissions, most of which are due to non-hyperglycemic emergencies, have increased by 2011 (19). However, after a five-year period (2006-2011), significant changes were seen in the subgroup of patients admitted to the ED with hyperglycemic emergency, including a significant increase in women (29%) and adults between 65-74 years of age (17%) (20). Elevated glucose levels in blood affect the normal cell cycle at three levels of gene (DNA), transcription (RNA), and translation (protein) (21). Hyperglycemia directly or indirectly causes damage to DNA, facilitates ROS formation and mutation accumulation, and creates irregularities in tumor oncogenes and repressors by various mechanisms (22). DNA damage also modifies the expression of tumor suppressors and oncogenes, and by P53 phosphorylation, prevents its protective role against DNA damage. Hyperglycemia-induced mutations increase the mortality of people with DNA damage who are susceptible to cancer (23). Since the treatment of acute complications of diabetes is multifaceted, the role of the emergency personnel in patient care is vital, and through waiting for these emergencies to be resolved, the desired results are achieved. Experience has shown that admission to the ED due to hyperglycemia is frequently associated with poor management of outpatient diabetes. Recently, more emphasis has been placed on the use of programs aimed at preventing re-admission after an emergency visit. In addition, referral to the ED may be an opportunity to identify high-risk patients in

need of long-term control. Concentrated treatments for these patients are probably more cost effective than other methods. In an effort to improve access to outpatient diabetes care, ED staff were allowed to enter the diabetic clinic. In the following year, significant reduction in hospitalization, emergency admissions, HbA1C, and healthcare costs were observed (24). A Diabetes Self-Management Education (DSME) for emergency patients with random blood glucose levels (<200 mg/dl) showed significant improvement in glycemic control and adherence to treatment after 4 weeks (25). Close follow-up by a diabetes pharmacist or nurse following ED discharge may be another effective strategy to prevent readmission and improve long-term blood sugar control (26). However, this information is more observational and inadequate for implementing these strategies in a large scale.

## 5. Conclusion

The results of this study may help the emergency physicians for follow-up visits, making the process of decision-making easier for them based on the current status of patients with hyperglycemia. While the examined factors associated with hyperglycemia in this study need to be validated, these factors can introduce variables that are important to an emergency physician. In general, frequent admissions to the ED because of hyperglycemia indicate an inadequate outcome for diabetic patients and a negative impact on the helpfulness of the healthcare system.

## Conflicts of Interest

The authors have no financial conflicts of interest.



## References

1. Shafiee G, Bandarian F, Ghodsi M, Nasli-Esfahani E, Larijani B. Iran Diabetes Research Roadmap (IDRR) Study; Trends of Publications in Management of Diabetes in Iran. *Iranian Journal of Public Health*. 2017;46(Supple1):3-9.
2. Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes research and clinical practice*. 2010;87(1):4-14. PMID: 19896746
3. Narayan KV, Boyle JP, Geiss LS, Saaddine JB, Thompson TJ. Impact of recent increase in incidence on future diabetes burden: US, 2005–2050. *Diabetes care*. 2006;29(9):2114-6. PMID: 16936162
4. Menke A, Casagrande S, Geiss L, Cowie CC. Prevalence of and trends in diabetes among adults in the United States, 1988–2012. *Jama*. 2015;314(10):1021-9. PMID: 26345782
5. Kea B, Fu R, Lowe RA, Sun BC. Interpreting the National Hospital Ambulatory Medical Care Survey: United States Emergency Department Opioid Prescribing, 2006–2010. *Acad Emerg Med*. 2016;23(2):159-65. PMID: 26802501
6. Sabzghabaei A, Mirbaha S, Shojaee M. Acute Metabolic Complications of Diabetes in Emergency Department. *Iranian Journal of Emergency Medicine*. 2017;4(2):83-90. [magiran.com/p1672809](http://magiran.com/p1672809)
7. Wolfsdorf JJ, Allgrove J, Craig ME, Edge J, Glaser N, Jain V, et al. Diabetic ketoacidosis and hyperglycemic hyperosmolar state. *Pediatric diabetes*. 2014; 15(S20):154-79. [doi.org/10.1111/pedi.12165](https://doi.org/10.1111/pedi.12165)
8. Rhee MK, Slocum W, Ziemer DC, Culler SD, Cook CB, El-Kebbi IM, et al. Patient adherence improves glycemic control. *The Diabetes Educator*. 2005;31(2):240-50. PMID: 15797853
9. Ahmadi A, Hasanzadeh J, Rahimi M, Lashgari L. Factors affecting the quality of life in patients with type 2 diabetes Chahar Mahal Bakhtiari. *Journal of North Khorasan University of Medical Science*. 2011;3(1):7-13.
10. Guariguata L, Whiting DR, Hambleton I, Beagley J, Linnenkamp U, Shaw JE. Global estimates of diabetes prevalence for 2013 and projections for 2035. *Diabetes research and clinical practice*. 2014;103(2):137-49. PMID: 24630390
11. Umpierrez G, Korytkowski M. Diabetic emergencies- ketoacidosis, hyperglycaemic hyperosmolar state and hypoglycaemia. *Nature Reviews Endocrinology*. 2016;12(4):222.
12. Yan JW, Gushulak KM, Columbus MP, van Aarsen K, Hamelin AL, Wells GA, et al. Risk factors for recurrent emergency department visits for hyperglycemia in patients with diabetes mellitus. *International Journal of Emergency Medicine*. 2017;10(1):23-31. PMID: 28702883
13. Shin YJ, Kim DI, Lee DW, Jeon BK, Ji JG, Lim JA, et al. Clinical and biochemical characteristics of elderly patients with hyperglycemic emergency state at a single institution. *Annals of Geriatric Medicine and Research*. 2017;20(4):185-9.
14. Shani M, Taylor TR, Vinker S, Lustman A, Erez R, Elhayany A, et al. Characteristics of diabetics with poor glycemic control who achieve good control. *The Journal of the American Board of Family Medicine*. 2008;21(6):490-6. PMID: 18988715
15. Mojtabai R, Olfson M. Medication costs, adherence, and health outcomes among Medicare beneficiaries. *Health Affairs*. 2005;22(4):220-9.
16. Hernandez AF, Greiner MA, Fonarow GC, Hammill BG, Heidenreich PA, Yancy CW, et al. Relationship between early physician follow-up and 30-day readmission among Medicare beneficiaries hospitalized for heart failure. *Jama*. 2010;303(17):1716-22. PMID: 20442387
17. Sharma G, Kuo Y-F, Freeman JL, Zhang DD, Goodwin JS. Outpatient follow-up visit and 30-day emergency department visit and readmission in patients hospitalized for chronic obstructive pulmonary disease. *Archives of internal medicine*. 2010;170(18):1664-70. PMID: 20937926
18. Saikumar S, Giridhar A, Mahesh G, Elias A, Bhat S. Awareness about eye diseases among diabetic patients: a survey in South India. *Community Eye Health*. 2007;20(61):16.23. PMID: 17515978
19. Ozieh MN, Bishu KG, Dismuke CE, Egede LE. Trends in health care expenditure in US adults with diabetes: 2002–2011. *Diabetes care*. 2015;38(10):1844-51. PMID: 17515978

20. Wang J, Geiss LS, Williams DE, Gregg EW. Trends in emergency department visit rates for hypoglycemia and hyperglycemic crisis among adults with diabetes, United States, 2006-2011. *PLoS One*. 2015;10(8):e0134917.
21. Basu AK. DNA damage, mutagenesis and cancer. *International journal of molecular sciences*. 2018;19(4):970.
22. Singh VP, Bali A, Singh N, Jaggi AS. Advanced glycation end products and diabetic complications. *The Korean Journal of Physiology & Pharmacology*. 2014;18(1):1-14. PMID: 24634591
23. Li L, Wu C-S, Hou G-M, Dong M-Z, Wang Z-B, Hou Y, et al. Type 2 diabetes increases oocyte mtDNA mutations which are eliminated in the offspring by bottleneck effect. *Reproductive Biology and Endocrinology*. 2018;16(1):110-115. doi.org/10.1186/s12958-810-0423-1
24. Palermo NE, Modzelewski KL, Farwell AP, Fosbroke J, Shankar KN, Alexanian SM, et al. Open access to diabetes center from the emergency department reduces hospitalizations in the subsequent year. *Endocrine Practice*. 2016;22(10):1161-9. doi:10.4158/E161254.OR
25. Magee MF, Nassar CM, Mete M, White K, Youssef GA, Dubin JS. The synergy to enable glycemic control following emergency department discharge program for adults with type 2 diabetes: step-diabetes. *Endocrine Practice*. 2015;21(11):1227-39. PMID: 26214111
26. Chung N, Rascati K, Lopez D, Jokerst J, Garza A. Impact of a clinical pharmacy program on changes in hemoglobin A1c, diabetes-related hospitalizations, and diabetes-related emergency department visits for patients with diabetes in an underserved population. *Journal of Managed Care Pharmacy*. 2014;20(9):914-9. PMID: 25166290