

Knowledge, Attitudes and Practice Among Primary Care Physicians in Sudan Regarding Prediabetes: A Cross-Sectional Survey

Abstract

Background: Prediabetes is an important stage before diabetes that can be treated with intensive lifestyle changes. The aim of this study was to assess knowledge, attitudes, and practice of primary care physician in Sudan about prediabetes. **Methods:** A cross-sectional questionnaire-based study was conducted among primary care physicians working at two family and primary health care centers in Khartoum. Data were analyzed using descriptive statistics and expressed as percentages. **Results:** Out of 200 primary care physicians, 189 completed the questionnaire. 60.8% of the participants had satisfactory knowledge about prediabetes and positive attitude towards prediabetes and their practice was relatively good. Knowledge score was significantly correlated with age ($P = 0.000$), duration of experience (P value = 0.000), the number of working hours per day (P value = 0.001), and the number patients seen per day (P value = 0.001). Logistic regression analysis showed that attending courses relevant to prediabetes revealed statistically significant result in knowledge, and attending such courses were likely to be associated with gaining sufficient knowledge than those who didn't by 2 times (P value 0.033, OR 2, CI. 1.063-4.079). **Conclusions:** Primary care physicians in Sudan have satisfactory knowledge, attitude, and practice about prediabetes. As they are in the front line in dealing with community, primary care physicians' efforts can help in slowing down the epidemic of diabetes in Sudan.

Keywords: Attitude, knowledge, practice, prediabetes, Sudan

Introduction

Prediabetes is defined as an intermediate state of hyperglycemia with glucose levels above the normal state but below the diagnostic levels of diabetes.^[1] The latest estimates from the International Diabetes Federation (IDF) Diabetes Atlas published in 2019 indicate that the global prevalence of diabetes is 9.3% with an estimated 463 million people with diabetes across the world^[2] while the global prevalence of prediabetes is 7.5% i.e., 374 million people with prediabetes. Sudan has a very high prevalence of diabetes for instance the prevalence of diabetes in the eastern part of Sudan was estimated to be 20.8%.^[3] The number of people with prediabetes in Sudan is expected to increase from 8.2% in 2017 to 9.4% in 2045 as part of the estimation of prediabetes in the Middle East (these figures applies to all countries in the region).^[2]

Diabetes is a major cause of different comorbidities like stroke, ischemic heart

disease, and chronic kidney disease and high risk of mortality.^[1-3] The American Diabetes Association (ADA) has a cut-off value for impaired glucose tolerance (IGT) of 140-200 mg/dL and a cut-off value for impaired fasting glycaemia (IFG) of 100-125 mg/dL. In addition, HbA1c-based criterion for diagnosis of prediabetes is 5.7% to 6.4%.^[4] Despite different metabolic abnormalities that characterize IFG and IGT, both confer increased risk for future T2DM. Prospective epidemiologic studies have reported an approximate 5% annual conversion rate to T2DM for both isolated IFG and isolated IGT. Because of the increased risk for T2DM associated with IFG and IGT, they have been referred to as prediabetes.^[5] Clusters of features of the metabolic syndrome (high blood pressure, high triglyceride, low high-density lipoprotein and abdominal obesity) have also been associated with an increase in incidence of diabetes.^[6]

In order to reduce the progression from prediabetes to diabetes, maintenance of a healthy weight through exercise

Amel Mohamed Saleh,
Ahmed Omer Almobarak¹,
Safaa Badi²,
Samar B. Siddiq³,
Hanan Tahir,
Mohamed Suliman⁴,
Mohamed H. Ahmed⁵

Public and Tropical Health Program, Dean of Graduate College, University of Medical Sciences and Technology, Khartoum, Sudan, ¹Department of Pathology, Faculty of Medicine, University of Medical Sciences and Technology, Khartoum, Sudan, ²Department of Clinical Pharmacy, Faculty of Pharmacy, Omdurman Islamic University, Khartoum, Sudan, ³Department of Research and Training, Alsharg Ahlia University, Kassala, Sudan, ⁴Imperial College London Diabetes Centre, AL Ain, United Arab Emirates, ⁵Department of Medicine and HIV Metabolic Clinic, Milton Keynes University Hospital NHS Foundation Trust, Eaglestone, Milton Keynes, Buckinghamshire, UK

Address for correspondence:
Dr. Mohamed H. Ahmed,
Department of Medicine and HIV Metabolic Clinic, Milton Keynes University Hospital NHS Foundation Trust, Eaglestone, Milton Keynes, Buckinghamshire, UK.
E-mail: elziber@yahoo.com; Mohamed.Hassan-Ahmed@mkuh.nhs.uk

Access this article online

Website:
www.ijpvmjournal.net/www.ijpvm.ir

DOI:
10.4103/ijpvm.IJPVM_164_20

Quick Response Code:



How to cite this article: Saleh AM, Almobarak AO, Badi S, Saddiq SB, Tahir H, Suliman M, *et al*. Knowledge, attitudes and practice among primary care physicians in Sudan regarding prediabetes: A cross-sectional survey. *Int J Prev Med* 2021;12:80.

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

and healthy eating should be advised. Exercising for at least 150 minutes a week and losing about 7% of body weight has been shown in the Diabetes Prevention Program (DPP) to prevent or delay progression to type 2 diabetes. Metformin has also been shown to be effective in the treatment of prediabetes especially in patients less than 60 years of age and in women with a history of gestational diabetes. Many patients are keen and motivated to reverse prediabetes.^[4] Primary care physicians can play an important role in increasing patient awareness about pre-diabetes and guiding them to use behavioral weight loss programs.^[7] Primary care physicians in some developed countries were also reported to overlook the issue of prediabetes. For instance, in USA only slightly more than half of physicians surveyed reported following national guidelines for diabetes prevention and physicians perceive significant barriers to diabetes prevention.^[8] Mainous *et al.* reported that physicians who have a positive attitude towards prediabetes, were more likely to follow national guidelines for screening and recommend metformin to their patients for prediabetes.^[9] Creating awareness about diabetes risk and complications among stakeholders may be the key to promoting healthy behavior.^[10,11] Several studies showed that intensive life style changes and metformin can be used in prediabetes.^[10,12,13] As the burden of diabetes and prediabetes in Sudan is increasing rapidly, investment in the treatment of prediabetes can be one part in the management of diabetes epidemic in this poorly resourced country. Hence, this study aimed to assess knowledge, attitudes, and practice of primary care physicians in Sudan toward prediabetes management.

Methods

Study setting

This was a descriptive, cross-sectional, health facility-based study. The study was conducted in Primary Health Care Centres at Khartoum and Karary localities in Khartoum State. Each center is served by an average of 5–10 doctors. The working days of each doctor are between 3 and 5 days a week with 5-7 working hours per day. The doctors in these centers provided their medical care services for 30–60 patients per day. The study was conducted during the period from May to December 2019. The study population were primary care physicians who were employed at primary care health centers at specified localities during the study period.

Inclusion criteria

All primary care doctors in the study area who agreed to participate in the study were included.

Sampling size

The total number of primary care doctors in the targeted 2 health care centers was 200, with 133 doctors in the

Khartoum center and 67 in the Karary center. The sampling method used was the total coverage. Totally, 189 doctors completed the questionnaire and this represents response rate of 94.5%.

Data collection

Data were collected through a pretested, self-administered, online questionnaire. The questionnaire consisted of five sections: demographic characteristics of the participants, knowledge section, attitude, practice, and the perceived barriers section.

Knowledge assessment

A correct answer was given 1 mark while no mark was given for each question that was wrongly answered or left blank. The total score ranged from 0 to 8 and the median score was found to be 4. Therefore, participants were divided into two categories, those who scored 4 (the median score of knowledge) or more were called as having sufficient knowledge and those who scored less than 4 were called as having insufficient knowledge.

Ethical consideration

Ethical clearance was obtained from SUMASRI Institutional Review Board (SIRB). Research purpose and objectives were explained to participants in clear simple words. Verbal consent was obtained from participants.

Data analysis

The collected data was analyzed by using Statistical Package for Social Science (SPSS) version 25 and excel version 16. The results obtained were presented in the form of descriptive statistics (tables and figures, means, median, and standard deviations) as well as inferential statistics (Chi-square test for cross tabulation at 0.05 margins of error (P value) and 95% confidence intervals.

Results

Demographic characteristics of the participants

There was a high response to the questionnaire as 189 primary care doctors out of 200 (94.5%) answered. Female doctors represented 79%. The median age of the participants was 34 years. The median duration of clinical experience was 7 years while the median working hours for each doctor per day was 7 hours. The average number of patients which the participants see per day was 40 (± 15). The median number of patients with pre-diabetes per shift or working day was 2 patients. Fifty-two percent of the participants were family medicine MSc holders, 12% were general practitioners while only 1.6% had a family medicine MD. Forty-two percent of the participants worked abroad and nearly two thirds of them attended relevant courses about dealing with prediabetes either inside or outside the country [Table 1].

Participants' knowledge toward prediabetes

Table 2 showed that 82.5% and 56.5% recognized the fasting glucose and HbA1c cutoff indicative of prediabetes, respectively. Totally, 82% of them recognized that Family history of type 2 diabetes is a risk factor for prediabetes. Near to third the participants recognized that age 40–70 and overweight or obese is one of the USPSTF recommendations in screening adults for abnormal glucose. Overall, 60.8% of doctors had sufficient knowledge about prediabetes.

Table 1: Demographic characteristics of the participants (n=189)

Demographics	Responses	%
Gender	Males	21
	Females	79
Qualifications	Family medicine MD	1.6
	Family medicine MSc	51.9
	Family medicine registrar	33.9
	General Practitioner	12.7
worked abroad for a while	Yes	42
	No	58
Attended relevant courses dealing with prediabetes	Yes	63.5
	No	36.5

Attitude of the participants

Table 3 shows that 61% of the participants agreed that the national guidelines and recommendations for diabetes prevention focused on screening for prediabetes are useful in their practice. Near to half the participants agreed that diabetes prevention should be a focus for all patients, regardless of blood glucose levels. Only 13% of them agreed that diagnosing a patient with prediabetes can represent risks overtreatment while 45% agreed that current evidence supports the effectiveness of treating prediabetes.

Management of prediabetes

Table 4 shows that about 23% of the participants agreed that most health professionals do not consider screening for prediabetes to be a high priority in diabetes prevention while 28% of them reported that they give general lifestyle advice targeted toward reducing cardiovascular disease instead of advice specific to diabetes patients with abnormal blood glucose. More than one third the participants recommend metformin to most patients with prediabetes. More than half the participants follow the United States Preventive Services Task Force (USPSTF) current guideline.

Perceived barriers to diabetes prevention

Table 5 shows that medication compliance was a barrier to diabetes prevention for 51% of the participants, while

Table 2: The distribution of study participants by knowledge towards prediabetes (n=189)

Knowledge questions	Correct response	n	%
1. Correct identification of prediabetes laboratory criteria	2-h oral glucose tolerance test	15	7.9
	fasting glucose	89	47.1
	HbA1c*	81	42.9
	Non-fasting glucose	4	2.1
2. What is fasting glucose cutoff indicative of prediabetes?	≤125mg/dl*	156	82.5
	Others	33	17.5
3. What is HbA1c cutoff indicative of prediabetes?	≤6.4%*	107	56.6
	Others	82	43.4
4-What proportion of their starting weight it is recommended that prediabetics lose?	≥5% *	143	75.7
	Others	46	24.3
5. Recommended physical exercise per week	150 mins*	98	51.9
	Others	91	48.1
6. How often do patients return for follow-up clinic visit?	Annually*	10	5.3
	Others	179	94.7
7. Which of the following is a risk factor for prediabetes	Age over 40	17	9.0
	BMI of 20	4	2.1
	Family history of type 2 diabetes* mellitus	155	82.0
	No answer	13	6.9
8. (USPSTF1) recommends screening adults for abnormal glucose if they are:	Age 40 to 70 and overweight or obese*	59	31.2
	No answer	23	12.2
	Over the age of 45 and have at least one additional risk factor for abnormal glucose	66	34.9
	Overweight and obese at any age	41	21.7

*Stands for the correct response. ¹United States Preventive Services Task Force (USPSTF) current guideline

Table 3: The distribution of study participants by their attitude towards prediabetes (n=189)

Variable	Responses	n	%
1. The national guidelines and recommendations for diabetes prevention focused on screening for prediabetes are useful in my practice	Agree	115	60.8
	Disagree	4	2.1
	Neutral	41	21.7
	Strongly agree	25	13.2
	Strongly disagree	4	2.1
2. Diabetes prevention should be focused on individuals with lab values indicating abnormal blood glucose consistent with prediabetes	Agree	104	55
	Disagree	29	15.3
	Neutral	38	20.1
	Strongly agree	9	4.8
	Strongly disagree	5	2.6
3. Diabetes prevention should be a focus for all patients, regardless of blood glucose levels	Agree	88	46.6
	Disagree	31	16.4
	Neutral	43	22.8
	Strongly agree	24	12.7
	Strongly disagree	3	1.6
4. Diagnosing a patient as being prediabetic is an effective way to increase patient awareness of their need for treatment.	Agree	86	45.5
	Disagree	7	3.7
	Neutral	28	14.8
	Strongly agree	66	34.9
	Strongly disagree	2	1.1
5. Diagnosing prediabetes is misleading to patients regarding them having a disease.	Agree	26	13.8
	Disagree	103	54.5
	Neutral	36	19.0
	Strongly agree	4	2.1
	Strongly disagree	20	10.6
6. Diagnosing a patient with prediabetes risks overtreatment.	Agree	25	13.2
	Disagree	109	57.7
	Neutral	34	18.0
	Strongly disagree	21	11.1
	Agree	107	56.6
7. Current evidence supports the utility of screening for prediabetes.	Disagree	8	4.2
	Neutral	54	28.6
	Strongly agree	18	9.5
	Strongly disagree	2	1.1
	8. Current evidence supports the effectiveness of treating prediabetes.	Agree	85
Disagree		4	2.1
Neutral		80	42.3
Strongly agree		19	10.1
Strongly disagree		1	0.5

patient acceptance of prediabetes diagnosis was a barrier for more than third the participants. Knowledge of treatment options for prediabetes was a barrier for 18% of the participants. Lack of sustaining patient motivation and lack of time for patient follow-up were the barriers for 15% and 25%, respectively.

T Test

When an independent T test was done to compare between means, we found that the mean score among males (5 ± 1.9) was more than that among females (4 ± 1.7) (p value 0.002). Moreover, the mean score of those who attended relevant courses about dealing with prediabetes (4.7 ± 1.7) was more than those who didn't (3.5 ± 1.5) (P value = 0.000).

Chi-square test

When Chi-square test was performed to determine the associations between knowledge and categorical data, we found that: Knowledge had statistically significant association with attendance of courses related to prediabetes (P values 0.001). while it had statistically insignificant association with qualifications and the participants' marital status and working abroad for a while (P values = 0.153, 0.441, 0.059), respectively.

Pearson correlation test

When Pearson correlation test was done to determine the correlation between variables, we found that the score of knowledge was correlated with age ($p = 0.000$), duration of experience (P value = 0.000), the number of working hours per day (P value = 0.001), and the number patients seen per day (P value = 0.001)

Logistic regression: showed that attending courses relevant to prediabetes revealed statistically significant result, those who attended courses were more likely to have sufficient knowledge than those who didn't by 2 times (P value 0.033, OR 2, CI. 1.063-4.079). Moreover, males were more likely to have a sufficient knowledge by 1.6 times than females (OR = 1.6, CI, 0.646-3.726, P value 0.326) [Table 6].

Discussion

Health authorities in Sudan should focus in treatment of prediabetes as one step to decrease the epidemic of diabetes in Sudan. The prevalence of diabetes in the north of Sudan can range between 19 and 22%,^[14,15] while the prevalence in Eastern of Sudan was 20.8%.^[3] This likely due to high prevalence of obesity in Sudan, in association with decreased physical activity and excess sugar and carbohydrate intake.^[16-18] In this study, we have shown that primary care and family physician have excellent knowledge, good attitude and practice about prediabetes. Identification and screening for prediabetes is not only enough unless it was combined with health education and encouragement of individuals to engage in intensive lifestyles. This important for low resource country like Sudan, where diabetes was associated with high prevalence of complications. For instance, the prevalence of diabetes complications like retinopathy, nephropathy, ischaemic heart disease, heart failure, stroke, and diabetic foot were found to, respectively.^[16,18-22] The high level of diabetes complications can be attributed to high prevalence of uncontrolled glycaemia.^[23,24] Prediabetes is also a condition

Table 4: The distribution of study participants by their management practice towards prediabetes (n=189)

Variable	Responses	n	%
1. Most doctors do not consider screening for prediabetes to be a high priority in diabetes prevention.	agree	43	22.8
	disagree	66	34.9
	neutral	29	15.3
	strongly agree	9	4.8
	strongly disagree	42	22.2
2. I give general lifestyle advice targeted toward reducing cardiovascular disease instead of advice specific to diabetes to patients with abnormal blood glucose.	agree	52	27.5
	disagree	61	32.3
	neutral	37	19.6
	strongly agree	28	14.8
	strongly disagree	11	5.8
3. Most patients cannot successfully comply with lifestyle changes needed for diabetes prevention.	agree	121	64.0
	disagree	6	3.2
	neutral	41	21.7
	strongly agree	17	9.0
	strongly disagree	4	2.1
4. I recommend metformin to most patients with prediabetes.	Agree	73	38.7
	Disagree	32	16.9
	Neutral	42	22.2
	Strongly agree	41	21.7
	Strongly disagree	1	0.5
5. Primary lifestyle change stressed	Changing diet	13	6.9
	Increasing the time of physical activity	12	6.3
	Stress all 3 equally	144	76.2
	Weight loss	20	10.6
6. Primary method of identifying someone at risk of developing diabetes	Asking about family history	33	17.5
	Assessing Body Mass Index (BMI)	30	15.9
	Other	11	5.8
	Testing blood glucose concentrations	115	60.8
7. Do you offer counseling of diet control as preventive measure?	No	4	2.1
	Yes	185	97.9
8. Do you discuss exercise as preventive measure?	No	4	2.1
	Yes	185	97.9
9. Do you follow national guideline or screening recommendation?	No	32	16.9
	Yes	157	83.1
10-Primary guideline followed	American Diabetes Association (ADA)	41	21.7
	Don't know	21	11.1
	Other/combination of guidelines	20	10.6
	United States Preventive Services Task Force (USPSTF) current guidelines	107	56.6

that associated with an increase in different comorbidities like hypertension, fatty liver polycystic ovary syndrome, hyperlipidemia, metabolic syndrome, an increase risk of cardiovascular disease, decrease in chromium and an increase in oral lesions. Importantly, diabetes was significantly associated with high hospital mortality with COVID-19, but prediabetes was not statistically associated with high hospital mortality^[25-29]

Our study also showed that increasing educational courses about diabetes and increasing clinical experience have

positive impact in increasing knowledge about prediabetes for primary care physicians. Therefore, Health authorities in Sudan need to invest in course related to diabetes education for health professionals.

Assaad Khalil *et al.* identified barriers that can hinder measures to manage prediabetes in North Africa and Middle East. Among them were lack of knowledge of the public about diabetes and obesity. They also identified that small budget for diabetes prevention resulted in decreasing intervention for prediabetes program and intensive life

Table 5: The distribution of perceived barriers towards diabetes prevention to the study participants (n=189)

Variables	Responses	n	%
1. Medication compliance	A barrier	96	50.8
	Extreme barrier	19	10.1
	Neutral	27	14.3
	Not a barrier	4	2.1
	Somewhat of a barrier	43	22.8
2. Patient acceptance of prediabetes diagnosis	A barrier	71	37.6
	Extreme barrier	33	17.5
	Neutral	28	14.8
	Not a barrier	14	7.4
3. Insurance coverage of education for patient	A barrier	43	22.8
	Extreme barrier	79	41.8
	Neutral	26	13.8
	Not a barrier	34	18.0
	Somewhat of a barrier	23	12.2
4. Patient ability to modify lifestyle	A barrier	27	14.3
	Extreme barrier	91	48.1
	Neutral	19	10.1
	Not a barrier	5	2.6
	Somewhat of a barrier	47	24.9
5. Time needed to educate patient on diet and lifestyle change	A barrier	45	23.8
	Extreme barrier	13	6.9
	Neutral	27	14.3
	Not a barrier	25	13.2
6. Insurance coverage for glucometers for patients	A barrier	79	41.8
	Extreme barrier	52	27.5
	Neutral	30	15.9
	Not a barrier	7	3.7
7. Economic resources of patients	Somewhat of a barrier	29	15.3
	A barrier	65	34.4
	Extreme barrier	57	30.2
	Neutral	30	15.9
8. Sustaining patient motivation	Not a barrier	3	1.6
	Somewhat of a barrier	34	18.0
	A barrier	28	14.8
	Extreme barrier	14	7.4
	Neutral	9	4.8
9. Time for patient follow-up	Not a barrier	69	36.5
	Somewhat of a barrier	8	4.2
	A barrier	61	32.3
	Extreme barrier	47	24.9
	Neutral	6	3.2
9. Time for patient follow-up	Not a barrier	41	21.7
	Neutral	21	11.1
	Not a barrier	21	11.1
	Somewhat of a barrier	74	39.2

Contd...

Table 5: Contd...

Variables	Responses	n	%
10. Knowledge of treatment options for prediabetes	A barrier	34	18.0
	Extreme barrier	6	3.2
	Neutral	49	25.9
	Not a barrier	58	30.7
	Somewhat of a barrier	42	22.2

Table 6: Logistic regression analysis

Variables	P	OR	95% CI OR	
			Lower	Upper
Age	0.159	1.070	0.974	1.175
Gender	0.326	1.551	0.646	3.726
Duration of experience	0.296	1.061	0.949	1.186
Working hrs. per day	0.121	0.882	0.753	1.034
Patients seen per day	0.537	1.007	0.985	1.030
Attending relevant courses dealing with prediabetes	0.033	2.082	1.063	4.079

style changes.^[30] In this study we identified several barriers for prediabetes prevention like individual's acceptance of prediabetes, ability to implement life style changes, lack of motivations, knowledge about diabetes and lack of time for follow up for doctors for those with prediabetes. The attitude of the physician towards treatment of prediabetes is key factor in management of prediabetes. Therefore, local authorities in Sudan should provide opportunities for follow up for individuals with prediabetes. Importantly, Mainous *et al.* reported that Physicians who have a positive attitude towards prediabetes, were more likely to follow national guidelines for management of prediabetes.^[9] This also important in order to empower and increase self-awareness of individuals with prediabetes, doctors and stakeholders about diabetes risk and complications in order to promote healthy behavior.^[10,11]

This study is not without limitations. For instance, the cross-sectional designs of the study may not allow for the temporal relationship. Furthermore, the study was conducted in the capital Khartoum. Therefore, it is not possible to generalize the conclusion of this study to the whole of Sudan. Despite these limitations, the study showed that primary care physicians have good knowledge, attitude, and practice about prediabetes management.

Conclusions

Primary care and family physicians in Sudan have good knowledge, attitude, and practice about prediabetes. As they are in the front line in dealing with community, primary care, and family physicians' efforts can help in decreasing the epidemic of diabetes in Sudan.

Declaration of patient consent

The authors certify that they have obtained all appropriate participants consent forms. In the form the participant(s)

has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The participants understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Received: 02 Apr 20 **Accepted:** 21 Jan 21

Published: 05 Jul 21

References

- Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, *et al.* Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res Clin Pract* 2019;157:107843. doi: 10.1016/j.diabres.2019.107843.
- Hostalek U. Global epidemiology of prediabetes-present and future perspectives. *Clin Diabetes Endocrinol* 2019;5:5.
- Omar SM, Musa IR, ElSouli A, Adam I. Prevalence, risk factors, and glycaemic control of type 2 diabetes mellitus in eastern Sudan: A community-based study. *Ther Adv Endocrinol Metab* 2019;10:2042018819860071. doi: 10.1177/2042018819860071.
- Bansal N. Prediabetes diagnosis and treatment: A review. *World J Diabetes* 2015;6:296-303.
- Ferrannini E, Gastaldelli A, Iozzo P. Pathophysiology of prediabetes. *Med Clin North Am* 2011;95:327-39.
- Prediabetes-Symptoms and causes-Mayo Clinic [Internet]. [cited 2019 Nov 19]. Available from: <https://www.mayoclinic.org/diseases-conditions/prediabetes/symptoms-causes/syc-20355278>.
- Why Screen for and Treat Prediabetes | NIDDK [Internet]. [cited 2019 Dec 13]. Available from: <https://www.niddk.nih.gov/health-information/communication-programs/ndep/health-professionals/game-plan-preventing-type-2-diabetes/prediabetes-screening-how-why/why-screen-for-prediabetes>.
- Tseng E, Greer RC, Rourke PO, Yeh H, McGuire MM, Clark JM, *et al.* Survey of primary care providers' knowledge of screening for, diagnosing and managing prediabetes. *J Gen Intern Med* 2017;32:1172-8.
- Mainous AG, Tanner RJ, Scuderi CB, Porter M, Carek PJ. Prediabetes screening and treatment in diabetes prevention: The impact of physician attitudes. *J Am Board Fam Med* 2016;29:663-71.
- Okosun IS, Lyn R. Prediabetes awareness, healthcare provider's advice, and lifestyle changes in American adults. *Int J Diabetes Mellit* 2015;3:11-8.
- Lee M, Saver JL, Hong KS, Song S, Chang KH, Ovbiagele B. Effect of pre-diabetes on future risk of stroke: Meta-analysis. *BMJ* 2012;344:e3564.
- Mainous AG, Tanner RJ, Baker R. Prediabetes diagnosis and treatment in primary care. *J Am Board Fam Med* 2016;29:283-5.
- Tseng E, Greer RC, O'Rourke P, Yeh HC, McGuire MM, Clark JM, *et al.* Survey of primary care providers' knowledge of screening for, diagnosing and managing prediabetes. *J Gen Intern Med* 2017;32:1172-8.
- Eltom MA, Babiker Mohamed AH, Elrayah-Eliadarous H, Yassin K, Noor SK, Elmadhoun WM, *et al.* Increasing prevalence of type 2 diabetes mellitus and impact of ethnicity in north Sudan. *Diabetes Res Clin Pract* 2018;136:93-9.
- Elmadhoun WM, Noor SK, Ibrahim AA, Bushara SO, Ahmed MH. Prevalence of diabetes mellitus and its risk factors in urban communities of north Sudan: Population-based study. *J Diabetes* 2016;8:839-84.
- Khalil S, Almobarak AO, Awadalla H, Elmadhoun WM, Noor SK, Sulaiman AA, *et al.* Low levels of physical activity in Sudanese individuals with some features of metabolic syndrome: Population based study. *Diabetes Metab Syndr* 2017;11(Suppl 2):S551-4.
- Ahmed MH, Ali YA, Awadalla H, Elmadhoun WM, Noor SK, Almobarak AO. Prevalence and trends of obesity among adult Sudanese individuals: Population based study. *Diabetes Metab Syndr* 2017;11(Suppl 2):S963-7.
- Awadalla H, Elmak NE, El-Sayed EF, Almobarak AO, Elmadhoun WM, Osman M, *et al.* Hypertension in Sudanese individuals and associated risk factors: The critical intersection between salt and sugar intake. *Cardiovasc Diagn Ther* 2018;8:432-8.
- Awadalla H, Noor SK, Elmadhoun WM, Almobarak AO, Elmak NE, Abdelaziz SI, *et al.* Diabetes complications in Sudanese individuals with type 2 diabetes: Overlooked problems in sub-Saharan Africa? *Diabetes Metab Syndr* 2017;11(Suppl 2):S1047-51.
- Almobarak AO, Badi S, Elmadhoun WM, Tahir H, Ahmed MH. The prevalence and risk factors of stroke among Sudanese individuals with diabetes: Cross-sectional survey. *Brain Circ* 2020;6:26-30.
- Ahmed MH, Awadalla H, Elmadhoun WM, Osman M, Noor SK, Almobarak AO. Prevalence and risk factors for acute coronary syndrome among Sudanese individuals with diabetes: A population-based study. *Cardiol Res* 2017;8:184-9.
- Almobarak AO, Awadalla H, Osman M, Ahmed MH. Prevalence of diabetic foot ulceration and associated risk factors: An old and still major public health problem in Khartoum, Sudan? *Ann Transl Med* 2017;5:340. doi: 10.21037/atm.2017.07.01.
- Almobarak AO, Noor SK, Elmadhoun WM, Bushara SO, Salim RS, Forawi SA, *et al.* Metabolic control targets in Sudanese adults with type 1 diabetes: A population-based study. *J Family Med Prim Care* 2017;6:374-9.
- Noor SK, Elmadhoun WM, Bushara SO, Almobarak AO, Salim RS, Forawi SA, *et al.* Glycaemic control in Sudanese individuals with type 2 diabetes: Population based study. *Diabetes Metab Syndr* 2017;11(Suppl 1):S147-51.
- Anari AG, Hazar N, Sadrabad MJ, Kharazmi S, Kheirollahi K, Mohiti A, *et al.* Comparing the frequency of some oral lesions in prediabetic and healthy individuals: Is there any difference? *Int J Prev Med* 2019;10:177. doi: 10.4103/ijpvm.IJPVM_520_17.
- Banihani SA, Jaradat SA, Khader YS. Serum chromium level is increased in Jordanian smokers, decreased in Jordanians with prediabetes and type 2 diabetes, but not altered in Jordanians with hypertension, with obesity, or with family history of diabetes. *Int J Prev Med* 2019;10:145. doi: 10.4103/ijpvm.IJPVM_137_18.
- Hadi Alijanvand M, Aminorroaya A, Kazemi I, Amini M, Aminorroaya Yamini S, Mansourian M. Prevalence and predictors of prediabetes and its coexistence with high blood pressure in first-degree relatives of patients with type 2 diabetes: A 9-year cohort study. *J Res Med Sci* 2020;25:31. doi: 10.4103/jrms.JRMS_472_18.
- Sourij H, Aziz F, Bräuer A, Ciardi C, Clodi M, Fasching P, *et al.* Covid-19 fatality prediction in people with diabetes and prediabetes using a simple score at hospital admission. *Diabetes Obes Metab* 2020. doi: 10.1111/dom.14256.

29. Alateeq MA, Aljohani M, Kinani SS, Aljabr IA, Alduayji AA, Aloud A, *et al.* The prediabetes outcome at National Guard Primary Health Care Centers in Riyadh, Saudi Arabia: Retrospective chart review. *Cureus* 2020;12:e10227.
30. Assaad Khalil SH, Abdelaziz SI, Al Shammery A, Al Zahrani A, Amir A, Elkafrawy N, *et al.* Prediabetes management in the Middle East, Africa and Russia: Current status and call for action. *Diab Vasc Dis Res* 2019;16:213-26.