Original article

Association of medication storage with diabetes control: A cross-sectional study from Saudi Arabia

Ali F. Altebainawi [a,b,c], Mubarak N. Alrashidi [d], Moaath K. Aljbreen [d], Muhammad Majid Aziz [e], Abdullah A. Alhifany [f], Mohamad Aljofan [g], Thamir M. Alshammari [b,h],

[a] Clinical Pharmacy Department, Pharmaceutical Care Services, King Khalid Hospital, Ministry of Health, Hail, Saudi Arabia
[b] Medication Safety Research Chair, King Saud University, Riyadh, Saudi Arabia
[c] Department of Pharmacovigilance, AJA Pharmaceutical Industries Co. Ltd., Hail, Saudi Arabia
[d] College of Pharmacy, University of Hail, Hail, Saudi Arabia
[e] School of Pharmacy, Xian Jiaotong University, Xian, China
[f] Department of Clinical Pharmacy, College of Pharmacy, Umm Al-Qura University, Makkah, Saudi Arabia
[g] Department of Biomedical Sciences, Nazarbayev University School of Medicine, Astana 010000, Kazakhstan
[h] Saudi Food and Drug Authority, Riyadh, Saudi Arabia

ARTICLE INFO

ABSTRACT

Background: In addition to diet restriction and physical activity, diabetes mellitus is managed by the chronic use of medications that require appropriate storage conditions to maintain their stability and effectiveness. However, there is a lack of information regarding patients' knowledge of medication storage and practices in Saudi Arabia. Therefore, the objective of this study was to determine the diabetics' knowledge about medication storage requirements and to evaluate the impact of antidiabetic medications storage on the blood glucose levels.
Methods: This study was a cross-sectional in the form of an interviewer-guided interview using a close-ended questions. The study was conducted among patients diagnosed with diabetes at diabetic clinics of public hospitals and other diabetic specialized clinics in Hail region of Saudi Arabia, over a period of four months between January to April 2019.
Results: A total of 501 completed questionnaires were returned. Of the respondents, 51.5% were males and 48.5% were females. Of the total participants 52.7% never achieved normal blood glucose range, which was associated with health literacy and medication storage knowledge. Almost half of the participants stored the medication correctly and others have poor knowledge and practice of medication storage, of whom 7.8% always store their medicines in their cars.
Conclusion: Almost half of the participants lack the knowledge of appropriate storage conditions of diabetes medications, which was shown to have a significant association with blood glucose levels.

1. Introduction

According to the International Diabetes Federation (IDF), more than 425 million people are currently living with diabetes mellitus (DM) worldwide, and the number is increasing especially in developing countries including Saudi which has one of the world's highest prevalence of DM (Aguiree Florencia et al., 2015; Aguiree et al., 2013). As of 2017, there were 3,852,000 cases of DM reported in Saudi, with a prevalence of 18.5% among adults (Wu et al., 2016). In 2018, the percentage of population (15 years and above) diagnosed with DM was 20% in Hail, which is located in the Northern part of the country, as the second highest region among the kingdom regions (Aljofan et al., 2019).

The direct goal of optimal medication therapy for DM is to achieve and maintain blood glucose to a normal level. To attain this goal, the guidelines for the management of DM have recommended the use of both medications (in the form of oral and parenteral) and lifestyle modifications to achieve an optimal glycaemic control

(Institute, 2014). Specifically, the American Diabetes Association (ADA) has recommended the glycosylated haemoglobin (HbA1c) level of less than 0.7 to provide a measure of the glycaemic control in diabetic patients (Association, 2006). However, achieving normal blood glucose depends on using quality and effective medicines as well as adherence to medication regimens by the patients. Storage of medicines is one of the fundamental factors that affect the quality, effectiveness, and stability of medications (Dennis et al., 2019). Keeping medications stored properly helps to ensure the safety, purity, potency and overall effectiveness of medicines. Improper storage at home or while traveling may cause accidental poisoning and can subject medications to unfavourable conditions such as high temperature, light, and humidity. Thus, medication handling and storage (particularly, those sensitive to high temperature) by patients are becoming an issue of concern (Dennis et al., 2019).

Antidiabetic medications are known to be used by the patients for a long period of time or lifetime in some cases, thus they are likely to be mishandled during this period, including inappropriate storage, and particularly insulin, which requires a special storage requirement based on its thermo-sensitive property. Similarly, the coating of other oral antidiabetic drugs can also be sensitive to temperature too. Hence, these medications need to be stored in a fridge where the storage temperature is low.

Previous studies have shown that the storage of antidiabetic medication was significantly associated with non-adherence and instability of insulin leading to sub-glycaemic control (Angamo et al., 2013; Park et al., 2010; Tewahido and Berhane, 2017). Moreover, adhering to good storage conditions of antidiabetic medications depends on the level of knowledge and awareness of medication storage by the DM patients. Previous studies have identified poor knowledge of DM with regards to disease management and the storage of antidiabetic medications among patients with DM (Almutairi, 2015; Gurmu and Teni, 2014). Therefore, assessing patients' knowledge of the required condition of medication storage would fill a critical gap of knowledge in the effort of reducing the burden of diabetes in the Kingdom of Saudi. Therefore, the study aimed to (i) assess the knowledge of diabetic patients toward practicing optimal storage of their medicines, and (ii) to evaluate the impact of antidiabetic medications storage on the blood glucose level.

2. Methods

2.1. Study design and settings

The study was designed as a cross-sectional questionnaire-based that was conducted in Hail region northern of Saudi Arabia, between Jan until April of 2019. Patients were recruited from different diabetic clinics located at the major governmental hospitals in Hail region including, diabetes clinics at Hail General Hospital, King Khalid Hospital and King Salman Specialist Hospital. Patients consented to participate after they were given full details of the study and its intended aims. They were asked whether they take any diabetic medications and in what form (tablets or injectable), but were not asked about the name of the medication.

2.2. Inclusion and exclusion criteria

Inclusion criteria: Adults men and women who are 18 years old and above taking DM medications for more than a year were included. Exclusion criteria: people that are less than 18 years old, or those who refused to consent were excluded.

2.3. Questionnaire

The questionnaire was designed in English and then translated forward to Arabic and backward to English and verified by three linguistic experts to ensure translation accuracy. The questionnaire is composed of 18 items and the participants' responses recorded on a four-points practice scale from never to always. The items were validated by seven health care practitioners, clinicians and researchers and analyzed by an item-objective congruence (IOC) score method)−1 = not representative, 0 = somewhat representative, 1 = clearly representative(, an average score of IOC > 0.5 were considered good for content validity. Afterward a pilot testing technique was conducted to validate its reliability and the coefficient value of Cronbach's alpha was calculated. On the basis of results, the questionnaire was partially modified.

2.4. Data storage

Data collected were kept in a secure setting, available only to the principal investigator. In addition, all collected forms will be archived and disposed of by the principal investigator, after the completion of the study.

2.5. Statistical analyses

A descriptive statistic for socio-demographic and basic features of the data was applied. Statistical Package for Social Sciences (SPSS v.23) was used. Onaway ANOVA was used to determine the differences between blood glucose level and knowledge of storage. A scale of 4 points was used to determine the exact level of practices. A score of 1 indicated "never, 2 denoted "rarely", 3 indicated "some time", 4 represented "always". A p-Value of less than 0.05 considered significantly different.

3. Results

3.1. Demographic data

There was 501 patients recruited in the study. There was an equal distribution between male and female ratio (51.5%:48.5%), with a quarter of the patients fall within the 18–25 year olds and 20% are older than 63 years of age. More than 70% of the participated individuals have public education or above. Table 1 describes the demographic characteristics of the recruited patients including age group, gender, education level and nationality.

3.2. The difference in patient characteristics and storage place

Each of the participants' characteristics were statistically tested against medication storage places. Pearson Chi-Square indicted that there are significant differences between Age groups $\chi2 = 15. 1$, $P < 0.005 > 0.001$, education $\chi2 = 18.3$, $P < 0.005 > 0.001$, gender $\chi2 = 18.8$, $P < 0.005 > 0.001$, and storage place. However, the difference between nationality $\chi2 = 6.8$, $P < 0.005 < 0.441$ and storage place was not significant (Table 2).

3.3. Comparison of glycaemic control and knowledge of medication storage

Data were computed with Factorial analysis of variance Onaway ANOVA to determine the differences between blood glucose level and knowledge of storage (Table 3). Excluding all other variables, the results indicated that patients with knowledge of medication storage condition have a better glycaemic control than those who

Table 1
Demographic characteristics of participating Patients.

Characteristics	N = 501
Age groups	
18–25 Years	125 (25%)
26–40 Years	91 (18.2%)
41–63 Years	185 (36.4%)
>63 Years	100 (20.0%)
Total	501 (100.0%)
Nationality	
Saudi	482 (96.2%)
Non-Saudi	19 (3.8%)
Total	501 (100.0%)
Gender	
Male	258 (51.5%)
Female	243 (48.5%)
Total	501 (100.0%)
Education	
Non-Educated	134 (26.8%)
Public-Education	203 (40.5%)
Undergraduate	163 (32.5%)
Postgraduate	1 (0.2%)
Total	501 (100.0%)
Dosage forms	
Injections	178 (35.5%)
Tablets	262 (52.2%)
Both	61 (12.2%)
Total	501 (100.0%)
Storage Place	
Fridge	249 (49.7%)
Car	22 (4.4%)
Room	230 (45.9%)
Total	501 (100.0%)

do not (p < 0.05) F (21,479) = 1.163, (P = 0.028). The relationship between the mean of blood glucose level and the knowledge of medication storage condition is shown in (Fig. 1).

3.4. The relationship between blood glucose level and medication storage

There appears to be a direct and proportional relationship between medication storage and blood glucose level (Fig. 2). The Pearson correlation analysis show a significant relationship between blood glucose level and inappropriate storage of medication (r = −0.45), (p = 0.03) at (α = 0.05), which was further confirmed by NOVA test (Table 4).

3.5. Medication management practice

In order to understand patient's behavior towards medication management, participants were asked whether or not they read and understand patient information leaflet (PIL) and medication expiry date. The results showed that 33.1% claimed to never check the PIL, 3.4% rarely check them, 35.1% reported to sometimes check them and 28.3% said they always check the PIL (Fig. 3). However, 64.1% of the participants always check the expiry date of medicines, 17.7% reported to sometimes check the dates, 1.8% rarely, and 16.4% never check the expiry date (Fig. 3).

4. Discussion

Over half of the diabetic patients in this study were taking antidiabetic medications in tablets forms, followed by injections. The pattern was significantly higher among the age group 41–63 years of age, males, and those with formal education. This trend is consistent with the anti-diabetic drug utilization pattern in Saudi Arabia (Misbahuddin et al., 2018). Almost half of the participants showed appropriate storage which is similar to a study in Oman, where 55% of patients at primary health care centres stored their medications in the fridge (Abdo-Rabbo et al., 2009). A significant number of participants inappropriately store their medications in their cars. Those participants are likely to be 63 years of age or older and males. Inappropriate storage of medicines predisposes them to high temperature, which is the case in Saudi, will affect the drug's pharmacological effects. Thus, improved awareness is needed on the need for proper storage of DM medication especially heat sensitive medicines such as insulin, which may be deemed ineffective after prolonged heat exposure. DM patients might be using degraded insulin with less potency due to the inappropriate storage leading to poor blood glucose control (Angamo et al., 2013; Gillani et al., 2018). This could be a contributor to the increasing rate of poor blood glucose control in Saudi Arabia (Aljofan et al., 2019).

Table 2
The difference between patient's characteristics and storage place.

Variables	Fridge	Car	Room	Total	χ2	p	Difference
Age groups					15.1	0.001	
19–25 Years	118	4	3	125			
26–40 Years	26	3	62	91			Yes
41–63 Years	83	7	95	185			
>63 Years	22	8	70	100			
Total	249	22	230	501			
Nationality							
Saudi	241	13	228	482	6.8	0.441	
Non-Saudi	8	9	2	19			No
Total	249	22	230	501			
Gender							
Male	104	14	140	258	18.8	0.001	Yes
Female	145	8	90	243			
Total	249	22	230	501			
Education							
Non-Educated	64	2	68	134	13.8	0.001	
Public-Education	101	12	90	203			Yes
Undergraduate	84	8	71	163			
Postgraduate	0	0	1	1			
Total	249	22	230	501			

Table 3
Comparisons between blood glucose level and knowledge of medication storage.

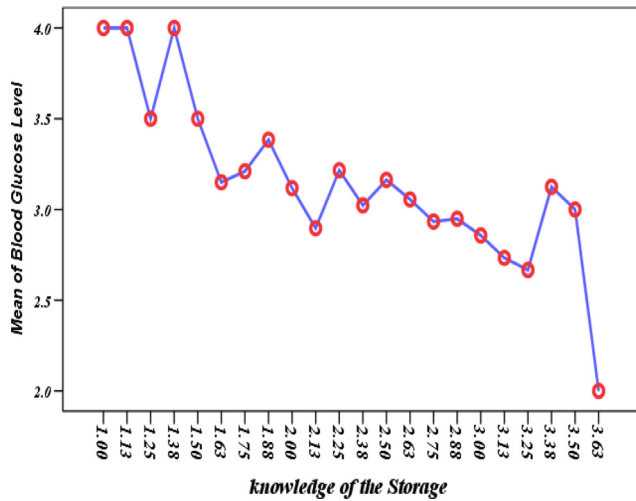| Differences	Sum of Squares	DF	Mean Square	F	p-value
Between Groups	26.49	21	1.261	1.163	0.028
Within Groups	519.67	479	1.085		
Total	546.16	500			

Fig. 1. Comparison of glycemic control and knowledge of medication storage. The graph shows the differences between blood glucose level with knowledge of medication storage.

Participants in the present study have good knowledge of the importance of checking the expiry date of medications, storing medication in their original package, reading patient information leaflets and seeking pharmacist's consultation about medication
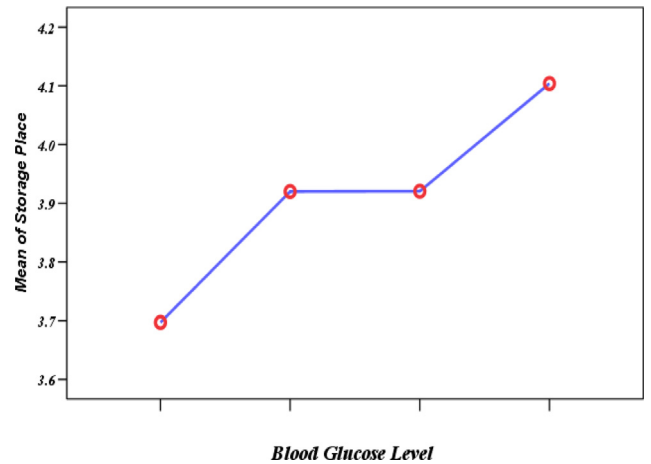

Fig. 2. The relationship between blood glucose level and medication storage. The graph shows the relationship between blood glucose level and inappropriate storage.

Table 4
The Comparison between blood glucose level and storage place.

	Value	Storage place
Blood glucose level	Correlation	−0.45
	p-value	0.03
	N	501

usage and storage. However, 64% always check the expiry dates of their medications before use, which is similar to earlier estimates from other regions of the country, which claimed that 63% of patients interviewed claimed to always checked the expiry date of their medication before use (Abou-Auda, 2003). Similarly, a study conducted by Sandip et al that reported that half patients
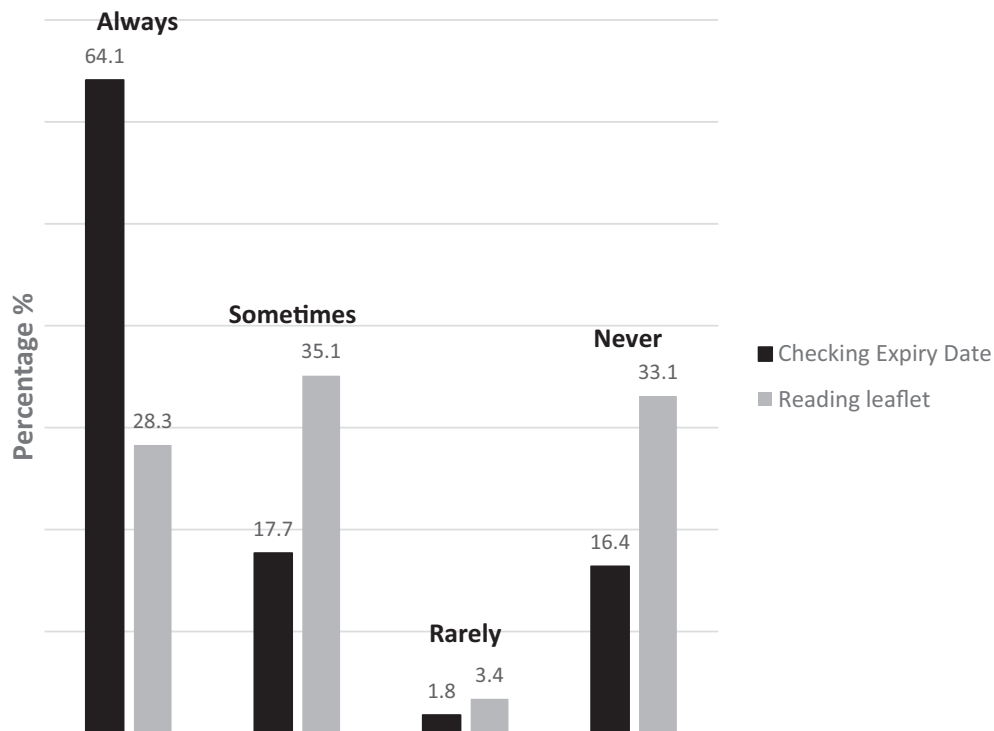

Fig. 3. Medication management practice. The graph shows the percentage of participants who check the medication expiry date and those who read the patient information leaflet (PIL).

in India do not have knowledge of expiry date of medicines (Sandip and Jogdand, 2013). However, the high knowledge of the importance of medication expiry date maybe due to the education level of the participants in this study, which is close to 70% of the participants to have formal education (Table 1). People with a higher level of education have higher health literacy and will be more likely to check expiry dates of medication, read PIL, keep the drug in its original package and engage in decision making with their pharmacist.

However, DM patient surveyed in the current study showed poor knowledge of the consequences of inappropriate storage of medications. This finding aligns with a study conducted in Australia, in which 50% of diabetic patients were reported to have poor knowledge of how to store their antidiabetic medicines (Dunning and Manias, 2005). This may also be an age related issue, more than 20% of the participants were older than 63 years of age, which is supported by previous reports that associated poor health literacy with old age (Baker et al., 2000).

In this study, over 50% of diabetic patients have self-reported never achieving a normal level of blood glucose control. This is in agreement with previous studies from different regions of Saudi including; Riyadh (Azab, 2001; Al-Rasheedi, 2014); Tabuk (Alzaheb and Altemani, 2018), Al Hasa (Khan et al., 2012) and Jazan (Badedi et al., 2016). In a retrospective study conducted by Azab et al., in primary health care centres across the capital city Riyadh, reported that 49% of the diabetic patients had poor diabetic control (Azab, 2001). Also, a similar study by Badedi et al., which reported from primary care centres across several Saudi cities, claimed that 74.9% of diabetic patients had poor blood glycaemic control

(Alzaheb and Altemani, 2018; Badedi et al., 2016). While this may be due to several reported factors commonly medication and dietary nonadherence (Badedi et al., 2016), and inadequate physical activity (Alzaheb and Altemani, 2018), the current study is the first to report an association between DM medication storage and blood glucose control in Saudi Arabia.

5. Conclusion

Approximately half of the participated patients showed low level of knowledge about the appropriate medication storage conditions, which was shown to have a significant association with achieving optimal blood glucose levels. However, an important factor such as appropriate medication storage should have been more known and practiced among all medication taking individuals. Therefore, there is an urgent need to improve health literacy among medication taking patients in the Hail region, Saudi Arabia.

Ethics approval

The questionnaire was voluntary, and the completion and return of the questionnaire were taken as consent to participate.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Data collection form

1) **Gender**: Male, Female

2) **Age** -------------

3) **Nationality**:

Saudi

Non-Saudi

4) **Education**:

Non-educated

Less than high school

High school

Bachelor

Master

PhD

5) **What types of diabetes medications do you take?**

Tablets

Injection

6) **Where do you usually store your medications?**

Kitchen

Refrigerator

Ordinal house rooms

Toilet

Car

Others (plz specify....)

7) **Do you keep medications in the car for a long time?**

Always

Sometimes

Rarely

Never

8) **Do you have sufficient information about how to store your medications?**

Yes

No

9) **Do you check the expiration dates of the medications?**

Always

Sometimes

Rarely

Never

10) **Do you keep the medications in the original package?**

Always

Sometimes

Rarely

Never

11) **Do you put your medication in a place where it is exposed to sunlight?**

Always

Sometimes

Rarely

Never

12) **Do you ask your pharmacist about the best way to store medications?**

Always

Sometime

Rarely

Never

13) **Does the pharmacist inform you how to store the medications and the importance of storing them properly?**

Always

Sometimes

Rarely

Never

14) **Do you think that the proper medication storage is important to the effectiveness of medication?**

Yes

No

15) **Do you know what may happen to medications if they were stored inappropriately?**

Yes

No

16) **Do you keep the opening date of medications after the first use?**

Always

Sometimes

Rarely

Never

17) **Do you read the leaflet that comes with the medications?**

Always

Sometimes

Rarely

Never

18) **Is your blood glucose level in the normal range?**

Always

Sometime

Rarely

Never

References

Abdo-Rabbo, A., Al-Ansari, M., Gunn, B.C., Suleiman, B.J., 2009. The use of medicines in oman: public knowledge, attitudes and practices. Sultan Qaboos Univ. Med. J. 9 (2), 124–131. Epub 2009/08/01. PubMed PMID: 21509288; PubMed Central PMCID: PMCPMC3074770.

Abou-Auda, H.S., 2003. An economic assessment of the extent of medication use and wastage among families in Saudi Arabia and Arabian Gulf countries. Clin. Therap. 25 (4), 1276–1292. Epub 2003/06/18 PubMed PMID: 12809973.

Aguiree, F., Brown, A., Cho, N.H., Dahlquist, G., Dodd, S., Dunning, T., et al., 2013. IDF diabetes atlas.

Aguiree Florencia, B.A., Ho, Cho Nam, Gisela, Dahlquist, Sheree, Dodd, Trisha, Dunning, Michael, Hirst, Christopher, Hwang, Dianna, Magliano, Chris, Patterson, Courtney, Scott, Jonathon, Shaw, Gyula, Soltesz, Juliet, Usher-Smith, David, . IDF Diabetes Atlas. International Diabetes Federation, Basel, Switzerland.

Aljofan, M., Altebainawi, A., Alrashidi, M.N., 2019. Public knowledge, attitude and practice toward diabetes mellitus in Hail region, Saudi Arabia. Int J Gen Med. 12, 255–262. https://doi.org/10.2147/IJGM.S214441. PubMed PMID: 31410048.

Almutairi, K.M., 2015. Quality of Diabetes Management In Saudi Arabia: A Review Of Existing Barriers. Arch. Iran. Med. 18 (12), 816–821. doi: 0151812/aim.005. PubMed PMID: 26621013.

Al-Rasheedi, Ahmad Ali S., 2014. The role of educational level in glycemic control among patients with type II diabetes mellitus. IJHS 8 (2), 177–187 http://Platform.almanhal.com/CrossRef/Preview/?ID=2-52659. https://doi.org/10.12816/0006084.

Alzaheb, R.A., Altemani, A.H., 2018. The prevalence and determinants of poor glycemic control among adults with type 2 diabetes mellitus in Saudi Arabia.

Diab. Metabol. Syndr. Obesity Targ. Therapy 11, 15–21. https://doi.org/10.2147/dmso.S156214. Epub 2018/02/13. PubMed PMID: 29430192; PubMed Central PMCID: PMCPMC5797462.

Angamo, M.T., Melese, B.H., Ayen, W.Y., 2013. Determinants of glycemic control among insulin treated diabetic patients in Southwest Ethiopia: hospital based cross sectional study. PloS one 8 (4), e61759.

Association, A.D., 2006. Standards of medical care in diabetes-2006. Diab. Care 29 (1), S4.

Azab, A.S., 2001. Glycemic control among diabetic patients. Saudi Med. J. 22 (5), 407–409. Epub 2001/05/29 PubMed PMID: 11376381.

Badedi, Mohammed, Solan, Yahiya, Darraj, Hussain, Sabai, Abdullah, Mahfouz, Mohamed, Alamodi, Saleh, Alsabaani, Abdullah, 2016. Factors associated with long-term control of Type 2 diabetes mellitus. J. Diab. Res. 2016, 1–8 https://www.hindawi.com/journals/jdr/2016/2109542/. https://doi.org/10.1155/2016/2109542.

Baker, D.W., Sudano, J., Gazmararian, J.A., Patterson, M., 2000. The association between age and health literacy among elderly persons. J. Gerontol.: Series B 55 (6), S368–S374. https://doi.org/10.1093/geronb/55.6.S368.

Dennis, Raghib, Christian, Robin, Palokas, Michelle, 2019. Effectiveness of financial incentives for long-acting injectable antipsychotic adherence in patients with psychotic and bipolar disorders: a systematic review protocol. JBI Datab. Syst. Rev. Implement. Rep. 17 (1), 43–48. https://doi.org/10.11124/JBISRIR-2017-003926. Epub 2019/01/11. PubMed PMID: 30629042.

Dunning, T., Manias, E., 2005. Medication knowledge and self-management by people with type 2 diabetes. Austral. J. Adv. Nurs. 23 (1), 7.

Gillani, A.H., Islam, F.M.A., Hayat, K., Atif, N., Yang, C.J., Chang, J., et al., 2018. Knowledge, attitudes and practices regarding diabetes in the general population: a cross-sectional study from Pakistan. Int. J. Env. Res. Pub. He. 15

(9). https://doi.org/10.3390/ijerph15091906. doi: ARTN 1906 10.3390/ijerph15091906. PubMed PMID: WOS:000445765600115.

Gurmu, A.E., Teni, F.S., 2014. Knowledge, attitude and practice among diabetic patients on insulin therapy towards the disease and their medication at a university hospital in Northwestern Ethiopia: a cross-sectional study. Int. J. Pharm. Sci. Res. 5, 685–692.

Institute, J.B., 2014. Reviewers Manual. The Joanna Briggs Institute, Adelaide, SA.

Khan, AtaurR, Al-Abdul Lateef, ZakiN, Al Aithan, MohammadA, Bu-Khamseen, MontaserA, Al Ibrahim, Ibrahim, Khan, ShabbirA, 2012. Factors contributing to non-compliance among diabetics attending primary health centers in the Al Hasa district of Saudi Arabia. J. Fam. Commun. Med. 19 (1), 26 http://www.jfcmonline.com/text.asp?2012/19/1/26/94008. https://doi.org/10.4103/2230-8229.94008.

Misbahuddin, M., Hussam, A., Zohair, J., Ziaullah, M., 2018. Anti-diabetic drug utilization patterns in a government hospital in Saudi Arabia. Trop. J. Pharm. Res. 17 (6), 1193–1200.

Park, K., Kim, J.-G., Kim, B.-W., Kam, S., Kim, K.-Y., Ha, S.-W., et al., 2010. Factors that affect medication adherence in elderly patients with diabetes mellitus. Korean Diab. J. 34 (1), 55–65.

Sandip, S., Jogdand, J.D.N., 2013. Knowledge and pattern about medicine use amongst rural people of Maharashtra. Natl. J. Med. Res. 3 (4), 358–361.

Tewahido, D., Berhane, Y., 2017. Self-care practices among diabetes patients in Addis Ababa: a qualitative study. PloS one 12 (1), e0169062.

Wu, L., Zhou, B., Oshiro-Rapley, N., Li, M., Paulo, J.A., Webster, C.M., et al., 2016. An ancient, unified mechanism for metformin growth inhibition in C. elegans and cancer. Cell 167 (7), 1705–18 e13. https://doi.org/10.1016/j.cell.2016.11.055. Epub 2016/12/17. PubMed PMID: 27984722; PubMed Central PMCID: PMCPMC5390486.