

# Glycemic control in Kuwaiti people with treated diabetes

Ameera Abdullah<sup>1\*</sup>, Abdullah Alkandari<sup>1\*‡</sup>, Joseph C. Longenecker<sup>2</sup>, Sriraman Devarajan<sup>1</sup>,  
Ahmad Alkhatib<sup>1,3</sup>, Rihab Al-Wotayan<sup>3</sup>, Qais Al-Duwairi<sup>1</sup> and Jaakko Tuomilehto<sup>1,4</sup>

<sup>1</sup>Dasman Diabetes Institute, Kuwait City, Kuwait

<sup>2</sup>Faculty of Medicine and Faculty of Public Health, Kuwait University, Kuwait

<sup>3</sup>School of Health and Life Sciences, Teesside University, United Kingdom

<sup>3</sup>Ministry of Health, Kuwait

<sup>4</sup> Department of Public Health Solutions, National Institute for Health and Welfare, Helsinki,  
Finland

\*These authors contributed equally to this work

## ‡Correspondence:

Dr. Abdullah Alkandari, Dasman Diabetes Institute, PO Box 1180, Dasman 15462, Kuwait. Email:

[abdullah.alkandari@dasmaninstitute.org](mailto:abdullah.alkandari@dasmaninstitute.org) Tel: +965 2224 2999 Ext. 2253

**Keywords:** diabetes, glycemic control, Kuwait, Arab

**Word count:** 2,537

**Tables and figure:** 4 tables + 1 figure

20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40

**ABSTRACT**

**Background:** Diabetes is prevalent in Kuwait. We aimed to assess the level of glycemic control in Kuwaiti adults with diabetes.

**Method:** The World Health Organization’s STEPS non-communicable disease risk factor survey was conducted in Kuwait in 2014. Participants’ demographics, medical history, physical measurements and blood biochemistry were assessed. A total of 2,561 Kuwaiti men and women aged 18-69 years completed all three survey steps. Glycemic control in 278 individuals with diabetes who were on glucose-lowering medication was determined using the US National Institutes of Health guidelines of fasting plasma glucose (FPG)  $\leq 7.2$  mmol/l and the American Diabetes Association guidelines of glycated hemoglobin (HbA1c)  $< 7\%$  (53 mmol/mol).

**Results:** Adequate glycemic control in people with drug-treated diabetes was 34.5% when determined by HbA1c, 37.8% when determined by FPG level, and 24.5% when both criteria were met. Mean body-mass index and fasting serum triglycerides were significantly higher, and serum high-density lipoprotein-cholesterol were significantly lower in individuals with an inadequate glycemic control than in those with adequate control. Women with diabetes were almost twice as likely to have inadequate HbA1c levels as men with diabetes (OR, 1.9, [95% CI, 1.03, 3.5]).

**Conclusions:** Glycemic control in Kuwaiti people with treated diabetes is low. A systemic, multi-disciplinary public health approach is needed to improve diabetes education and adherence to treatment.

41

## 42 INTRODUCTION

43 Diabetes is a growing worldwide health concern and the prevalence is particularly high in  
44 the Middle East and North Africa (MENA). According to International Diabetes Federation,  
45 diabetes prevalence is 8.8% globally and 10.8% in the MENA region [1]. In Kuwaiti adults aged 18  
46 to 69 years, the age-adjusted prevalence of diabetes is 18.8% according to the latest survey [2].  
47 The prevalence of diabetes-associated disorders in Kuwait such as obesity, hypertension and  
48 dyslipidemia is also high [3, 4]. Additionally, the socioeconomic burden of diabetes in Kuwait is  
49 high; the estimated cost of treating diabetes and its complications in Kuwait is \$2,000 annually  
50 per person with diabetes [5].

51 The effective management of diabetes is essential for maintaining health and quality of  
52 life, preventing the progression to complications due to diabetes and avoiding excessive costs of  
53 treating people with diabetes. Healthy diet, physical activity and pharmaceutical interventions,  
54 in combination, are the most common approaches for diabetes management [6-8]. Effective  
55 diabetes management is primarily defined by adequate glycemic control, as measured by  
56 glycated hemoglobin (HbA1c) and/or fasting plasma glucose (FPG) levels [9, 10]. It is also  
57 important to manage dyslipidemia, hypertension, smoking and other risk factors associated with  
58 the development of complications and increased mortality [11]. Uncontrolled glycemic levels  
59 increase the risk of micro- and macrovascular complications and several other complications in  
60 various organs [12]. However, the proportion of people with diabetes achieving desired glycemic

61 targets is generally poor [13]. In the countries of the Arabian Gulf, adequate glycemic control  
62 ranges from 15% to 41% [14], but population-based studies in the region are rare.

63 A World Health Organization (WHO) STEPwise non-communicable disease health survey  
64 was conducted in Kuwait on a representative sample of Kuwaiti adults in 2014 [4]. We have  
65 previously reported on the prevalence of diabetes [2] and obesity [3] in this population. This  
66 study reports on the level of glycemic control in Kuwaiti adults under treatment for diabetes.

## 67 **METHODS**

### 68 ***Survey design***

69 A cross-sectional population health survey entitled the Eastern Mediterranean  
70 Approaches to Non-Communicable Diseases (EMAN) was conducted in Kuwait between March  
71 and September 2014. The survey was conducted by the Ministry of Health and supported by the  
72 WHO, as has been previously described [2]. Briefly, data was collected using the STEPwise  
73 approach to Surveillance methodology (STEPS) [4, 15] which consisted of 3 consecutive steps: 1)  
74 demographics and medical history, 2) physical measurements and 3) blood biochemistry. In Step  
75 1, participants self-reported their medical history and medication, including insulin, although no  
76 distinction was made between type 1 and type 2 diabetes.

77 The Public Authority for Civil Information prepared a random national sample of Kuwaiti  
78 citizens aged 18 to 69 years from eight age- and sex-stratified groups (18-29, 30-44, 45-59 and  
79 60-69 years). The survey target sample was 4,391 participants (inflated for expected non-  
80 participation) and 3,915 participants completed the first two steps. The number of participants  
81 who completed all three steps, including anthropometric measures and obtaining a valid FPG and

82 HbA1c measurements, was 2,561. The age-standardized prevalence of diabetes in this population  
83 was 18.8%, as has been previously reported [2]. The number of individuals with diabetes who  
84 self-reported receiving glucose-lowering drug treatment for diabetes was 278. There were 15  
85 people who self-reported having diabetes but were not receiving drug treatment for diabetes.  
86 They were not included in this analysis that evaluated the efficacy of treatment.

### 87 ***Data collection***

88           Height and weight were measured using the electronic Growth Management Scale. Body  
89 mass index (BMI) was calculated by dividing a person's weight in kilograms by the square of  
90 height in meters. Waist and hip circumference were determined using a Miotape. Central  
91 adiposity was determined using waist-to-hip ratio (WHR). Of the 278 individuals with diabetes in  
92 this study, 264 had a recorded BMI and 253 had a recorded waist-hip ratio. A mercury  
93 sphygmomanometer with a universal cuff was used on the right arm in a sitting position to  
94 determine blood pressure (BP). Participants' BP was measured three times and they rested for 3  
95 minutes between each measurement. The mean of the second and third measurements was  
96 taken for analysis. Venous blood samples were collected after a 12 hour fast in sodium fluoride  
97 vacutainer and serum separator tubes for lipid profile and FPG measurements. Whole blood was  
98 sampled in EDTA tubes for HbA1c measurements. Blood samples were immediately centrifuged  
99 after sample collection and examined by an Auto-analyzer Architect within 6 hours. Blood  
100 biochemistry analysis was conducted by the laboratory of the Kuwait Cancer Control Center  
101 Clinical Laboratory using standard clinical laboratory techniques and quality control procedures.

102

103

104

105 ***Standards***

106 Diabetes was defined as FPG >7.0 mmol/l or HbA1c  $\geq$ 6.5% (48 mmol/mol) or use of  
107 glucose lowering drugs [16]. Treated diabetes was determined by self-reported current  
108 treatment with physician-prescribed glucose lowering drugs. The criteria used for adequate  
109 control of diabetes were the National Institute of Health (NIH) guidelines for FPG  $\leq$ 7.2 mmol/l  
110 ( $\leq$ 130 mg/dl) [10] and the American Diabetes Association (ADA) guidelines for HbA1c <7% (53  
111 mmol/mol) [9]. Obesity was defined as BMI  $\geq$ 30 kg/m<sup>2</sup> and overweight was defined as BMI 25-  
112 29.9 kg/m<sup>2</sup> [17]. Elevated WHR was defined as  $\geq$ 0.9 for men and  $\geq$ 0.85 for women.

113 ***Statistical analysis***

114 Statistical analysis was performed using GraphPad Prism 8 and IBM SPSS Statistics version  
115 25. Two-tailed t-tests, the Chi-square test and the Chi-square test for trend were used as  
116 appropriate. Binary logistic regression models were used to assess associations between  
117 sociodemographic, lifestyle and medical factors and glycemic control. Statistical significance was  
118 determined by  $p < 0.05$ .

119 ***Ethical Considerations***

120 This study was approved by the Ministry of Health Standing Ethics Committee for the  
121 Coordination of Medical and Health Research. Written informed consent was obtained from each  
122 participant. The study adhered to the Declaration of Helsinki ethical standards.

123

## 124 RESULTS

125 Treatment was received by 94.9% (278/293) of individuals with known diabetes. Of the  
126 278 individuals with diabetes under treatment, 60% were women and 40% were men (Table 1).  
127 Mean age was 51.1 years, mean BMI was 33.1 kg/m<sup>2</sup> and mean systolic and diastolic blood  
128 pressure was 129 mmHg and 82 mmHg, respectively. Insulin was prescribed to 45.7% of the  
129 diabetic patients (127/278); 52.2% were also receiving anti-hypertensive medication (145/278)  
130 and 47.1% were receiving lipid-lowering medication (131/278). Over two thirds (180/264) were  
131 obese and 11.2% (31/278) were smokers. Over 70% had an elevated waist-hip ratio (178/253).  
132 Men had significantly higher mean diastolic blood pressure (p=0.02) and smoking prevalence  
133 (p<0.0001) than women. Women were more obese (p=0.01), had significantly higher BMI  
134 (p=0.002) and fasting serum HDL levels (p=0.02) than men.

135 Approximately a third (34.5%, 95% CI 31.6, 37.5) of Kuwaitis with diabetes under glucose-  
136 lowering treatment had adequate glycemic control as measured by HbA1c (<7%) (Figure 1A). An  
137 almost similar percentage (37.8%, 95% CI 34.8, 40.8) had adequate FPG levels (≤7.2mmol/l). Less  
138 than a quarter (24.5%, 95% CI 21.9, 27.3) of the patients under treatment had both adequately  
139 controlled HbA1c and FPG levels; 10% (28/278) had controlled HbA1c only and 13% (37/278) had  
140 controlled FPG only (Figure 1B). Mean BMI (p=0.0005) and fasting serum triglycerides (p=0.02)  
141 were significantly lower and fasting high-density lipoprotein (HDL, p=0.03) was significantly  
142 higher in Kuwaitis with an adequate HbA1c compared with those with an uncontrolled HbA1c

143 (Table 2). Mean BMI ( $p=0.03$ ) and fasting triglycerides ( $p=0.0003$ ) were also significantly lower in  
144 individuals with adequate FPG levels.

145 The proportion of men with diabetes with HbA1c  $<7\%$  was 43.2%, significantly higher than  
146 the 28.7% found in women with diabetes ( $p=0.013$ , Table 3). Patients treated with insulin also  
147 had lower proportion of adequate glycemic control (25.2%) than patients treated with oral  
148 glucose-lowering drugs only (42.5%,  $p=0.003$ ). Except for individuals with a normal BMI and men  
149 with normal WHR, every population subgroup had a majority of people with diabetes with poor  
150 glycemic control. Kuwaiti women with diabetes were almost twice as likely to have poor HbA1c  
151 levels as men (Odds Ratio, OR = 1.9,  $p=0.04$ ) (Table 4). Patients on insulin were also twice as likely  
152 to have both poor HbA1c (OR = 2.7,  $p=0.001$ ) and FPG levels (OR = 1.9,  $p=0.02$ ) as those treated  
153 with oral drugs. Patients who were obese or had an elevated waist-to-hip ratio tended to have  
154 higher inadequate HbA1c levels, although this increase did not reach statistical significance.

## 155 **DISCUSSION**

156 In this cross-sectional survey from 2014, we found that although the proportion of drug  
157 treatment for diabetes was high (95%) among people with known diabetes, most Kuwaiti adults  
158 with diabetes under glucose-lowering drug treatment had poor glycemic control. Only 35% had  
159 adequate HbA1c levels and 38% had adequate FPG levels. Almost half of diabetic patients were  
160 prescribed insulin, indicating that treatment with oral antidiabetic drugs had not been successful  
161 for reasons unknown in this survey. Mean BMI and fasting serum triglycerides were significantly  
162 higher and fasting serum HDL was significantly lower in individuals with poor glycemic control.  
163 Adequate glycemic control was significantly higher in men with diabetes compared with women.



164           Although glycemic control in Kuwait overall was found to be low in this study, when  
165 comparing our results to previous studies, it appears to have been improving with time.  
166 Approximately 30% of patients attending a specialist diabetes medical and research center in  
167 Kuwait between 2011 and 2014 had an HbA1c <7% [18]. A study analyzing data from the Kuwait  
168 Diabetes Register reported that only 26% of Kuwaiti diabetic patients had an HbA1c <7% in 2012  
169 [19], while in Kuwait in 2010 glycemic control was reportedly between 19% [20, 21] and 21% [22].  
170 This apparent improvement in glycemic control is in keeping with other findings from the Arabian  
171 Gulf countries. In Saudi Arabia, adequate glycemic control improved from 21% in 2004 [23] to  
172 32% in 2013 [24], in Oman from 23% in 2007 [25] to 35% in 2013 [26], in Bahrain from 15% in  
173 2004 [27] to 32% in 2010 [28], and in the UAE from 31% in 2006 [29] to 38% in 2016 [30]. In  
174 Qatar, glycemic control was 31% in 2015 [31].

175           Despite the improvement, levels of glycemic control in the Arabian Gulf countries falls  
176 behind Europe and North America [21]. In the US, almost 60% of adults with diabetes achieved  
177 HbA1c <7% in 2010 [32]. Glycemic control differed by ethnicity; non-Hispanic whites achieved  
178 higher levels of glycemic control than non-Hispanic blacks and Mexican Americans [32]. In  
179 Europe, a cross-country analysis reported glycemic control to be over 50%, although there was  
180 considerable inter-country variation [33]. In Asia, glycemic control was reported to be 45% in  
181 Japan [34], 39% in South Korea [35], 32% in China [36], 31% in India [37], 23% in Bangladesh [38],  
182 22% in Malaysia [39] and 15% in the Philippines [40]. In a population survey in Mauritius, glycemic  
183 control in people with diabetes based on HbA1c was 19% in 2009, and had improved to 22% in  
184 2015, but still remained poor [41]. A recent analysis of data from diabetes clinics across nine  
185 countries outside North America and Europe did not find improvement in glycemic control from

186 2006 to 2015 on average [42]. However, there was heterogeneity among the countries: the  
187 proportion of patients who reached the target of HbA1c <7% increased in Argentina, India, Japan,  
188 Russia and South Africa, but not in Australia, Hong Kong, Saudi Arabia and Uganda. Among all the  
189 clinical services, South Africa had the lowest glycemic control with only 10% and 17% in 2006 and  
190 2015, respectively. This study also showed that the introduction of newer classes of glucose-  
191 lowering drugs did not improve glycemic control.

192 Being overweight or obese is associated with poor glycemic control in people with  
193 diabetes [43]. In this study, over two thirds of individuals treated for diabetes were obese. The  
194 only subgroup with over 50% of adequate glycemic control comprised individuals with normal  
195 weight (BMI <25kg/m<sup>2</sup>) and in men with normal WHR. The prevalence of overweight and obesity  
196 is high in Kuwait [3] and the surrounding region [44]. High calorie diets, sugar-sweetened  
197 beverages, low physical activity, sedentary lifestyle, genetic factors and some cultural barriers  
198 are among contributing factors to the obesity epidemic in the Middle East [45].

199 We found glycemic control to be less in women than men, findings consistent with recent  
200 studies on type 2 diabetes in South Korea [35] and type 1 diabetes in Italy [46]. Although the  
201 prevalence of diabetes is higher in Kuwaiti men than women [2], the prevalence of obesity and  
202 mean BMI are higher in Kuwaiti women, and Kuwaiti women are also less physically active than  
203 men [3]. In this study, obesity levels and mean BMI were significantly higher in Kuwaiti women  
204 being treated for diabetes than in men, which suggest that a targeted high-risk obesity  
205 prevention approach may benefit women with concurrent obesity and poor glycemic control.

206 Hypertension is also highly prevalent in Kuwait in general [4] and in Kuwaiti people with  
207 diabetes [47]. Over half of individuals receiving glucose lowering drug treatment in this study  
208 were also receiving antihypertensive drug treatment. Hypertension is associated with worsening  
209 complications of diabetes, and improvement in blood pressure leads to a reduction in both  
210 macrovascular and microvascular complications in patients with diabetes [48]. Almost half of  
211 people with diabetes in this study were also receiving treatment for dyslipidemia, and elevated  
212 fasting triglycerides and low HDL levels were significantly more common in those with poor  
213 glycemic control. Poor lipid profiles have been previously reported to be associated with poor  
214 glycemic control in other studies [34, 49, 50].

215 Other factors that contribute to poor glycemic control are poor diabetes education and  
216 poor adherence to treatment. There is a general lack of diabetes education in the Middle East  
217 [51]. In Kuwait, most diabetic patients do not adhere to diet or exercise advice [52], and over a  
218 quarter of patients do not fully adhere to their prescribed glucose lowering medication [53].  
219 Many patients do not consider diabetes to be a chronic condition with serious health implications  
220 [54]. Treating and controlling co-morbidities, as well as improving education and adherence to  
221 treatment, are essential to improving glycemic control. Recent studies have also highlighted the  
222 benefit of benchmarking and target setting in improving diabetes care [55, 56].

223 The WHO STEPS study strengths included the representative, population-based sample  
224 and its standardized measurement techniques. However, in this study only Kuwaiti nationals  
225 were surveyed, whereas Kuwaiti has a large, multi-ethnic, expatriate majority [57]. Previous  
226 studies on glycemic control in Kuwait have only included Kuwaiti nationals as well [19, 20, 22].

227 Diabetes prevalence among expatriates in Kuwait is reportedly to be even higher than amongst  
228 Kuwaiti nationals [47]. The WHO STEPS survey did not distinguish between type 1 and type 2  
229 diabetes, but it can be assumed that the proportion of people with type 1 diabetes is likely less  
230 than 10% of all individuals with diabetes in this study. Other limitations include the lack of  
231 longitudinal measurements or measures of adherence to medication and lifestyle treatments.  
232 We did not have information about the names of drugs and their doses, and therefore we could  
233 not assess the quality of specific prescribed treatments. Nonetheless, this study showed that the  
234 introduction of newer classes of glucose-lowering drugs did not improve glycemic control (Table  
235 x).

236 Many factors contribute to the poor glycemic control levels found in this study in Kuwait.  
237 Of note, the very high prevalence of treatment among known diabetes in this study (95%)  
238 suggests that the diabetes population has a very high degree of access to diabetes services in  
239 Kuwait, although glycemic control should be improved. The Ministry of Health can use these data  
240 to tailor interventions focused on prescribing physicians and people with diabetes, to improve  
241 glycemic control from both directions. Also, in view of the extraordinarily high prevalence of  
242 diabetes in Kuwait, a holistic public health approach is needed to decrease the prevalence of  
243 diabetes and associated co-morbidities and to better educate people with diabetes on the  
244 importance of maintaining a healthy diet, physical activity and adherence to prescribed  
245 medication. The next STEPS survey in Kuwait is planned for 2020, and it will be possible to assess  
246 if improvements in glycemic control continues among people with diabetes.

## 247 **DISCLOSURES**

248 The authors declare no conflicts of interest.

## 249 **ACKNOWLEDGEMENTS**

250 Dr. Ameera Abdullah and Dr. Abdullah Alkandari performed the data analysis and drafted  
251 the manuscript. Dr. Joseph Longenecker prepared the STEPS dataset for analysis, including data  
252 cleaning and recoding variables. Dr. Qais Al-Duwairi was the Chairperson of the Kuwait STEPS  
253 National Coordinating Committee, and Dr. Rihab Al-Wotayan was the Principal Investigator of the  
254 STEPS study. Dr Ahmad Alkhatib critically revised the manuscript and contributed to the initial  
255 study concept. All authors were involved in the critical evaluation, scientific input, and approval  
256 of the final manuscript. The STEPS survey was funded by the Kuwaiti Ministry of Health and  
257 supported by the World Health Organization. We thank the members of the national and regional  
258 committees and the field work teams involved in the survey. Biochemical measurements were  
259 conducted in the clinical laboratories of the Kuwait Cancer Control Center Clinical Laboratory.

## 260 **REFERENCES**

- 261 1. Cho, N.H., et al., *IDF Diabetes Atlas: Global estimates of diabetes prevalence for 2017*  
262 *and projections for 2045*. Diabetes Res Clin Pract, 2018. **138**: p. 271-281.
- 263 2. Alkandari, A., et al., *The prevalence of pre-diabetes and diabetes in the Kuwaiti adult*  
264 *population in 2014*. Diabetes Res Clin Pract, 2018. **144**: p. 213-223.
- 265 3. Weiderpass, E., et al., *The Prevalence of Overweight and Obesity in an Adult Kuwaiti*  
266 *Population in 2014*. Frontiers in Endocrinology, 2019. **10**(449).
- 267 4. Ministry of Health: State of Kuwait, *Eastern Mediterranean Approach for Control of Non*  
268 *Communicable Diseases Survey of Risk Factors for Chronic Non Communicable Diseases,*  
269 *State of Kuwait*. 2015.
- 270 5. International Diabetes Federation, *IDF Diabetes Atlas, 8th edn*. 2017.
- 271 6. American Diabetes Association, *4. Lifestyle Management: Standards of Medical Care in*  
272 *Diabetes-2018*. Diabetes Care, 2018. **41**(Suppl 1): p. S38-S50.
- 273 7. American Diabetes Association, *8. Pharmacologic Approaches to Glycemic Treatment:*  
274 *Standards of Medical Care in Diabetes-2018*. Diabetes Care, 2018. **41**(Suppl 1): p. S73-  
275 S85.

- 276 8. Davies, M.J., et al., *Management of Hyperglycemia in Type 2 Diabetes, 2018. A*  
277 *Consensus Report by the American Diabetes Association (ADA) and the European*  
278 *Association for the Study of Diabetes (EASD)*. Diabetes Care, 2018. **41**(12): p. 2669-2701.
- 279 9. American Diabetes Association, 6. *Glycemic Targets: Standards of Medical Care in*  
280 *Diabetes-2018*. Diabetes Care, 2018. **41**(Suppl 1): p. S55-S64.
- 281 10. NIH: National Institute of Diabetes and Digestive and Kidney Diseases. *Diabetes*  
282 *overview, managing diabetes*. 2016; Available from: [https://www.niddk.nih.gov/health-](https://www.niddk.nih.gov/health-information/diabetes/overview/managing-diabetes)  
283 [information/diabetes/overview/managing-diabetes](https://www.niddk.nih.gov/health-information/diabetes/overview/managing-diabetes).
- 284 11. Garber, A.J., et al., *Consensus Statement by the American Association of Clinical*  
285 *Endocrinologists and American College of Endocrinology on the Comprehensive Type 2*  
286 *Diabetes Management Algorithm--2016 Executive Summary*. Endocr Pract, 2016. **22**(1):  
287 p. 84-113.
- 288 12. Stratton, I.M., et al., *Association of glycaemia with macrovascular and microvascular*  
289 *complications of type 2 diabetes (UKPDS 35): prospective observational study*. BMJ,  
290 2000. **321**(7258): p. 405-12.
- 291 13. Blonde, L., et al., *Gaps and barriers in the control of blood glucose in people with type 2*  
292 *diabetes*. Diab Vasc Dis Res, 2017. **14**(3): p. 172-183.
- 293 14. Al-Rasheedi, A.A., *Glycemic Control among Patients with Type 2 Diabetes Mellitus in*  
294 *Countries of Arabic Gulf*. International Journal of Health Sciences, 2015. **9**(3): p. 345-350.
- 295 15. The World Health Organization, *STEPwise approach to surveillance (STEPS)*. 2014.
- 296 16. The World Health Organization, *Definition and diagnosis of diabetes mellitus and*  
297 *intermediate hyperglycaemia: Report of a WHO/IDF consultation*. 2006.
- 298 17. World Health Organization, *Obesity: preventing and managing the global epidemic*.  
299 2000.
- 300 18. Qaddoumi, M., et al., *The Status of Metabolic Control in Patients With Type 2 Diabetes*  
301 *Attending Dasman Diabetes Institute, Kuwait*. Frontiers in Endocrinology, 2019. **10**(412).
- 302 19. Channanath, A.M., et al., *Glycaemic control in native Kuwaiti Arab patients with type 2*  
303 *diabetes*. Prim Care Diabetes, 2018. **12**(6): p. 526-532.
- 304 20. Al-Taweel, D.M., A.I. Awad, and B.J. Johnson, *Evaluation of adherence to international*  
305 *guidelines for treating patients with type 2 diabetes mellitus in Kuwait*. Int J Clin Pharm,  
306 2013. **35**(2): p. 244-50.
- 307 21. Khunti, K., et al., *Achievement of guideline targets for blood pressure, lipid, and*  
308 *glycaemic control in type 2 diabetes: A meta-analysis*. Diabetes Res Clin Pract, 2018.  
309 **137**: p. 137-148.
- 310 22. Al-Ibrahim, A.A.H., *Factors Associated with Compliance to Diabetes Self-care Behaviors*  
311 *and Glycemic Control Among Kuwaiti People with Type 2 Diabetes*. 2012: University of  
312 Maryland.
- 313 23. Al-Hussein, F.A., *Diabetes control in a primary care setting: a retrospective study of 651*  
314 *patients*. Ann Saudi Med, 2008. **28**(4): p. 267-71.
- 315 24. Al-Rasheedi, A.A., *The Role of Educational Level in Glycemic Control among Patients with*  
316 *Type II Diabetes Mellitus*. Int J Health Sci (Qassim), 2014. **8**(2): p. 177-87.
- 317 25. Venugopal, S., et al., *Hemoglobin A1c in Muscat, Oman - A 3 year study*. Oman Med J,  
318 2008. **23**(3): p. 170-2.

- 319 26. Al Balushi, K.A., et al., *Glycemic control among patients with type 2 diabetes at a primary*  
320 *health care center in Oman*. Prim Care Diabetes, 2014. **8**(3): p. 239-43.
- 321 27. Al Khaja, K.A., R.P. Sequeira, and A.H. Damanhori, *Comparison of the quality of diabetes*  
322 *care in primary care diabetic clinics and general practice clinics*. Diabetes Res Clin Pract,  
323 2005. **70**(2): p. 174-82.
- 324 28. Al-Baharna, M.M. and D.L. Whitford, *Clinical audit of diabetes care in the bahrain*  
325 *defence forces hospital*. Sultan Qaboos Univ Med J, 2013. **13**(4): p. 520-6.
- 326 29. Al-Kaabi, J., et al., *Assessment of dietary practice among diabetic patients in the United*  
327 *arab emirates*. Rev Diabet Stud, 2008. **5**(2): p. 110-5.
- 328 30. Alawadi, F., et al., *Glycemic Control in Patients with Diabetes across Primary and Tertiary*  
329 *Government Health Sectors in the Emirate of Dubai, United Arab Emirates: A Five-Year*  
330 *Pattern*. Oman Med J, 2019. **34**(1): p. 20-25.
- 331 31. Saleh, M.S.N., et al., *Quality of Life Predictors and Glycemic Control among Type 2*  
332 *Diabetic Patients Attending Primary Health Care Centers in Qatar*. Primary Health Care,  
333 2016. **6**(2).
- 334 32. Selvin, E., et al., *Trends in prevalence and control of diabetes in the United States, 1988-*  
335 *1994 and 1999-2010*. Ann Intern Med, 2014. **160**(8): p. 517-25.
- 336 33. Stone, M.A., et al., *Quality of care of people with type 2 diabetes in eight European*  
337 *countries: findings from the Guideline Adherence to Enhance Care (GUIDANCE) study*.  
338 Diabetes Care, 2013. **36**(9): p. 2628-38.
- 339 34. Hu, H., et al., *Hba1c, Blood Pressure, and Lipid Control in People with Diabetes: Japan*  
340 *Epidemiology Collaboration on Occupational Health Study*. PLoS One, 2016. **11**(7): p.  
341 e0159071.
- 342 35. Choe, S.A., et al., *Women are less likely than men to achieve optimal glycemic control*  
343 *after 1 year of treatment: A multi-level analysis of a Korean primary care cohort*. PLoS  
344 One, 2018. **13**(5): p. e0196719.
- 345 36. Ji, L.N., et al., *Glycemic control among patients in China with type 2 diabetes mellitus*  
346 *receiving oral drugs or injectables*. BMC Public Health, 2013. **13**: p. 602.
- 347 37. Unnikrishnan, R., et al., *Glycemic control among individuals with self-reported diabetes*  
348 *in India--the ICMR-INDIAB Study*. Diabetes Technol Ther, 2014. **16**(9): p. 596-603.
- 349 38. Latif, Z.A., A. Jain, and M.M. Rahman, *Evaluation of management, control, complications*  
350 *and psychosocial aspects of diabetics in Bangladesh: DiabCare Bangladesh 2008*.  
351 Bangladesh Med Res Counc Bull, 2011. **37**(1): p. 11-6.
- 352 39. Mafauzy, M., Z. Hussein, and S.P. Chan, *The status of diabetes control in Malaysia:*  
353 *results of DiabCare 2008*. Med J Malaysia, 2011. **66**(3): p. 175-81.
- 354 40. Jimeno, C., L. M Sobrepeña, and R. C Mirasol, *DiabCare 2008: Survey on Glycaemic*  
355 *Control and the Status of Diabetes Care and Complications Among Patients with Type 2*  
356 *Diabetes Mellitus in the Philippines*. Vol. 50. 2012.
- 357 41. Tabesh, M., et al., *Meeting American Diabetes Association diabetes management*  
358 *targets: trends in Mauritius*. Diabet Med, 2017. **34**(12): p. 1719-1727.
- 359 42. Tabesh, M., et al., *Diabetes management and treatment approaches outside of North*  
360 *America and West Europe in 2006 and 2015*. Acta Diabetol, 2019. **56**(8): p. 889-897.

- 361 43. Bae, J.P., et al., *Obesity and glycemic control in patients with diabetes mellitus: Analysis*  
362 *of physician electronic health records in the US from 2009-2011*. J Diabetes  
363 Complications, 2016. **30**(2): p. 212-20.
- 364 44. G. B. D. Eastern Mediterranean Region Obesity Collaborators, *Burden of obesity in the*  
365 *Eastern Mediterranean Region: findings from the Global Burden of Disease 2015 study*.  
366 Int J Public Health, 2018. **63**(Suppl 1): p. 165-176.
- 367 45. Abuyassin, B. and I. Laher, *Diabetes epidemic sweeping the Arab world*. World J  
368 Diabetes, 2016. **7**(8): p. 165-74.
- 369 46. Maiorino, M.I., et al., *Gender-differences in glycemic control and diabetes related factors*  
370 *in young adults with type 1 diabetes: results from the METRO study*. Endocrine, 2018.  
371 **61**(2): p. 240-247.
- 372 47. Channanath, A.M., et al., *State of diabetes, hypertension, and comorbidity in Kuwait:*  
373 *showcasing the trends as seen in native versus expatriate populations*. Diabetes Care,  
374 2013. **36**(6): p. e75.
- 375 48. *Treatment of Hypertension in Adults With Diabetes*. Diabetes Care, 2003. **26**(suppl 1): p.  
376 s80-s82.
- 377 49. Mullugeta, Y., et al., *Dyslipidemia associated with poor glycemic control in type 2*  
378 *diabetes mellitus and the protective effect of metformin supplementation*. Indian J Clin  
379 Biochem, 2012. **27**(4): p. 363-9.
- 380 50. Chan, W.B., et al., *Triglyceride predicts cardiovascular mortality and its relationship with*  
381 *glycaemia and obesity in Chinese type 2 diabetic patients*. Diabetes Metab Res Rev,  
382 2005. **21**(2): p. 183-8.
- 383 51. Alsairafi, Z.K., et al., *Patients' management of type 2 diabetes in Middle Eastern*  
384 *countries: review of studies*. Patient Prefer Adherence, 2016. **10**: p. 1051-62.
- 385 52. Serour, M., et al., *Cultural factors and patients' adherence to lifestyle measures*. Br J Gen  
386 Pract, 2007. **57**(537): p. 291-5.
- 387 53. Al-Majed, H., Ismael, A., Al-Khatlan, H., El-Shazly, M. , *Adherence of Type-2 Diabetic*  
388 *Patients to Treatment*. Kuwait Medical Journal, 2014. **46**(3): p. 225-232.
- 389 54. O'Connor, P.J., B.F. Crabtree, and M.K. Yanoshik, *Differences between diabetic patients*  
390 *who do and do not respond to a diabetes care intervention: a qualitative analysis*. Fam  
391 Med, 1997. **29**(6): p. 424-8.
- 392 55. Hermans, M.P., et al., *Benchmarking is associated with improved quality of care in type 2*  
393 *diabetes: the OPTIMISE randomized, controlled trial*. Diabetes Care, 2013. **36**(11): p.  
394 3388-95.
- 395 56. Simmons, R.K., et al., *Does training of general practitioners for intensive treatment of*  
396 *people with screen-detected diabetes have a spillover effect on mortality and*  
397 *cardiovascular morbidity in 'at risk' individuals with normoglycaemia? Results from the*  
398 *ADDITION-Denmark cluster-randomised controlled trial*. Diabetologia, 2017. **60**(6): p.  
399 1016-1021.
- 400 57. The Public Authority For Civil Information, *Statistical Reports*. Accessed December 2017.

401

402



403

404

405

406

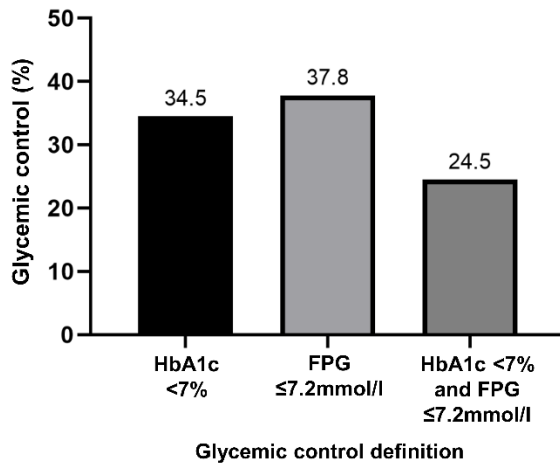
407

**Table 1:** Demographic and selected clinical information of 278 Kuwaiti patients with treated diabetes<sup>†</sup>

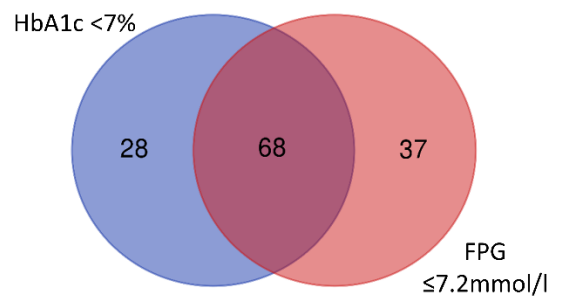
Participant Characteristics	Total	Men	Women	p
	Patients, n (row %)	111 (40)	167 (60)	
Age (years)	51.1 ± 11.7	50.1 ± 12	51.8 ± 11.4	0.23
BMI (kg/m <sup>2</sup> )	33.1 ± 6.65	31.6 ± 5.6	34.2 ± 7.08	0.002
Systolic blood pressure (mmHg)	129 ± 15.1	131 ± 15.2	128 ± 14.9	0.17
Diastolic blood pressure (mmHg)	82 ± 9.7	83 ± 10.9	80 ± 8.6	0.02
Fasting plasma glucose (mmol/L)	9.42 ± 4.26	9.25 ± 4.16	9.54 ± 4.33	0.59
HbA1c (%)	8.17 ± 2.24	7.85 ± 2.21	8.38 ± 2.24	0.06
Fasting serum HDL (mmol/L)	1.18 ± 0.28	1.1 ± 0.26	1.24 ± 0.28	<0.0001
Fasting serum LDL	2.96 ± 0.97	2.87 ± 0.85	3.01 ± 1.04	0.24
Fasting serum triglycerides (mmol/L)	1.84 ± 1.23	2.01 ± 1.57	1.73 ± 0.93	0.06
Fasting serum total Cholesterol (mmol/L)	5.0 ± 1.12	4.9 ± 1.02	5.0 ± 1.19	0.24
Waist-hip ratio (WHR)	0.91 ± 0.09	0.94 ± 0.1	0.89 ± 0.07	<0.0001
Obesity (%)	68.2%	59.4%	74.1%	0.01
Elevated WHR (%)	70.4%	70%	70.6%	0.92
Smoking (%)	11.2%	27%	0.6%	<0.0001
Use of insulin (%)	45.7%	44.1%	46.7%	0.67
Use of anti-hypertensive medication (%)	52.2%	45.9%	56.3%	0.09
Use of lipid lowering medication (%)	47.1%	45%	48.5%	0.57

<sup>†</sup>Values represent mean ± standard deviation, or frequencies. Obesity defined as a ≥BMI 30kg/m<sup>2</sup>. Elevated waist-hip ratio defined as ≥0.9 for men and ≥0.85 for women. P values assessed by two-tailed t-tests or the Chi-square test as appropriate. Of the 278 diabetes patients in this study, 264 had a recorded BMI and 253 had a recorded waist-hip ratio.

**A Adequate glycemic control**



**B Adequate glycemic control**



**Figure 1:** (A) The proportion of people with treated diabetes achieving adequate glycemic control as measured by HbA1c, FPG and both. n=278. (B) A Venn diagram of the number of people with diabetes achieving glycemic control as measured by HbA1c and FPG. n=133

**Table 2:** Demographic and selected clinical parameters of individuals with treated diabetes with and without adequate control<sup>†</sup>

Participant Characteristics	HbA1c		p	FPG		p
	HbA1c <7% (n=96)	HbA1c ≥7% (n=182)	-	FPG ≤7.2 mmol/l (n=105)	FPG >7.2 mmol/l (n=173)	-
Age (years)	50.1 ± 12.7	51.6 ± 11.1	0.29	49.8 ± 12.5	51.8 ± 11.1	0.17
BMI (kg/m <sup>2</sup> )	31.2 ± 6.11	34.2 ± 6.71	0.0005	32 ± 6	33.8 ± 6.96	0.03
Systolic blood pressure (mmHg)	128 ± 16	130 ± 14.5	0.36	128 ± 14.9	130 ± 15.2	0.25
Diastolic blood pressure (mmHg)	82 ± 9.74	81 ± 9.74	0.42	82 ± 9.71	82 ± 9.79	0.99
Fasting plasma glucose (mmol/L)	6.5 ± 1.96	11.0 ± 4.33	<0.0001	5.7 ± 0.93	11.7 ± 3.86	<0.0001
HbA1c (%)	6.0 ± 0.59	9.3 ± 1.87	<0.0001	6.6 ± 1.35	9.1 ± 2.14	<0.0001
Fasting serum HDL (mmol/L)	1.23 ± 0.31	1.16 ± 0.26	0.03	1.21 ± 0.26	1.17 ± 0.29	0.28
Fasting serum LDL	2.87 ± 0.71	3.00 ± 1.08	0.29	2.98 ± 1.19	2.94 ± 0.82	0.71
Fasting serum triglycerides (mmol/L)	1.61 ± 0.87	1.97 ± 1.37	0.02	1.5 ± 0.77	2.05 ± 1.41	0.0003
Total Cholesterol (mmol/L)	4.9 ± 0.87	5.0 ± 1.23	0.21	4.9 ± 1.32	5.0 ± 0.98	0.27
Waist-hip ratio - Men	0.93 ± 0.14	0.95 ± 0.06	0.25	0.94 ± 0.14	0.94 ± 0.06	0.93
Waist-hip ratio - Women	0.87 ± 0.07	0.89 ± 0.07	0.2	0.88 ± 0.07	0.89 ± 0.08	0.21

<sup>†</sup>Values represent mean ± standard deviation or frequencies. P values assessed by two-tailed t-tests.

**Table 3:** Frequency of glycemic control by demographic and clinical information<sup>†</sup>

Characteristic	Prevalence of Glycemic Control (%)			
	HbA1c <7%	p	FPG ≤7.2 mmol/l	p
All	34.5%		37.8%	
Sex		0.01		0.44
Men	43.2%		40.5%	
Women	28.7%		35.9%	
Age		0.56		0.22
18-29	44.4%		50.0%	
30-44	37.3%		43.1%	
45-59	31.4%		35%	
60-69	36.2%		36.2%	
Use of insulin		0.003		0.14
Yes	25.2%		33.1%	
No	42.5%		41.7%	
Anti-hypertensive medication		0.63		0.95
Yes	35.9%		37.9%	
No	33.1%		37.6%	
Lipid-lowering medication		0.57		0.90
Yes	32.8%		38.2%	
No	36.1%		37.4%	
Smoking		0.19		0.15
Smokers	45.2%		25.8%	
Non-smokers	33.2%		39.3%	
Obesity		0.07		0.60
Normal weight	54.5%		40.9%	
Overweight	35.5%		41.9%	
Obese	32.2%		37.8%	
Waist-Hip Ratio		0.06		0.62
Normal	44.0%		42.7%	
Elevated	31.5%		39.3%	
Waist-Hip Ratio – Men		0.004		0.22
Normal	66.7%		53.3%	
Elevated	35.7%		40.0%	
Waist-Hip Ratio – Women		0.98		0.70
Normal	28.9%		35.6%	
Elevated	28.7%		38.9%	

<sup>†</sup>P values assessed Chi-square test of Chi-square test for trend as appropriate. Normal weight defined as BMI ≥25 kg/m<sup>2</sup>, overweight defined as BMI 25-29.99kg/m<sup>2</sup> and obesity defined as a BMI >30kg/m<sup>2</sup>. Elevated waist-hip ratio defined as ≥0.9 for men and ≥0.85 for women.

**Table 4:** Logistic regression models with glycemic control as the dependent variable<sup>†</sup>

Characteristic	Comparison	Odds Ratio of HbA1c $\geq$ 7%				Odds Ratio of FPG $>$ 7.2 mmol/l			
		beta	OR	CI (95%)	P	Beta	OR	CI (95%)	p
Women	Men	0.64	1.9	[1.0, 3.5]	0.04	0.41	1.5	[0.8, 2.7]	0.16
Age $\geq$ 50 years	Age $<$ 50 years	-0.25	0.8	[0.3, 2.0]	0.61	0.88	2.4	[0.9, 6.4]	0.08
Obesity (BMI $\geq$ 30kg/m <sup>2</sup> )	Non-Obese	0.44	1.6	[0.8, 2.9]	0.16	0.13	1.1	[0.6, 2.0]	0.67
Elevated waist-hip ratio	Normal WHR	0.43	1.5	[0.9, 2.8]	0.15	0.01	1.0	[0.6, 1.8]	0.97
Current Smoking	Non-Smoking	0.32	1.5	[0.8, 2.5]	0.30	0.39	1.5	[0.8, 2.6]	0.17
Use of insulin	Non-use	0.98	2.7	[1.5, 4.7]	0.001	0.62	1.9	[1.1, 3.2]	0.02
Use of antihypertensive drugs	Non-use	-0.47	0.6	[0.3, 1.2]	0.14	-0.041	1.0	[0.5, 1.7]	0.89
Use of lipid lower drugs	Non-use	0.24	1.3	[0.7, 2.6]	0.42	-0.032	1.0	[0.6, 1.7]	0.91

<sup>†</sup>OR=odds ratio, CI=confidence interval. Full model, n = 251.