Predictors of Glycemic Control among Patients with Type 2 Diabetes in Western China: A Multi-center Cross Sectional Study

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The prevalence of type 2 diabetes mellitus (T2DM) is increasing rapidly in China. Glycemic control is vital in this patient population. We designed a cross-sectional questionnaire to investigate glycemic control and associated factors in T2DM patients in Western China. The survey included patients’ medical history, blood glucose status, and therapeutic medications, as well as demographic data. The Chi-square test, Fisher’s exact test, and logistic regression were performed to analyze the data. The STROBE checklist was used to check the procedure. Among 510 T2DM patients included in this study, 47.5% of them had blood glucose control within the normal range, defined as glycated hemoglobin A1c (HbA1c) ≤7% or fasting plasma glucose (FPG) <7.0 mmol/L. The mean age of participants was 60.58 ± 11.20 years, with a male to female ratio of 1.02 : 1. Glycemic control was significantly associated with region (p < 0.001), comorbidities (p < 0.001), monitoring frequency (p = 0.002), treatment with insulin (p = 0.003), and medication compliance (p < 0.001). Logistic regression analysis showed that unsuccessful glycemic control was significantly related to wealthier residence (p < 0.001), more comorbidities (p = 0.017), monitoring frequency (p = 0.003), and medication in-compliance (p < 0.001). These results suggested that the level of glycemic control among T2DM patients in Western China was poor. It is necessary to carry out health management and nursing of diabetic patients from community, family and patients jointly.

Key words diabetes mellitus; glycemic control; health management

INTRODUCTION

The global prevalence of diabetes among adults over age 18 increased from 4.7% in 1980 to 8.5% in 2014. The prevalence of diabetes has particularly been rapidly increasing in middle- and low-income countries. In China, there were 114.4 million diabetic patients (20–79 years old) in 2017, ranking the country first of diabetic patients population in the world. The Chinese government issued the “Healthy China 2030” Planning Outline in 2016, which aimed to promote the health of Chinese citizens over the following 15 years. The plan proposed that China would achieve basic full coverage of management intervention in patients with hypertension and diabetes by 2030, and achieve health management of chronic disease throughout the entire life of the Chinese population.

Background Glycemic control is the key to treating diabetic patients, and the benefits have been validated in several studies. In China, previous large-scale investigations have primarily been limited to patients’ epidemiological status such as the prevalence of diabetes and rate of glycemic control. A cross-sectional national survey in 2010 found that 39.7% of 98658 treated diabetic patients in China had adequate glycemic control, a rate which was lower than that of Brazil (51%), Latin America (43.2%), and Denmark (49%). Other studies assessed risk factors for adequate blood glucose control, focusing on the socioeconomic and demographic effects. These studies did not, however, obtain the treatment situation, which therefore limits the robustness of the multivariate analyses. In this critical period of the Chinese government’s emphasis on chronic disease management, cross-sectional surveys based on individual characteristics are rare. Because of the vast size of China, different regions have their own unique characteristics of economic development, resource distribution, and diet habits. As a result, the epidemiology of patients with diabetes may vary. Changes in eating habits, such as a weight loss program or a Mediterranean diet, and moderate exercise could improve glycemic control in type 2 diabetes mellitus (T2DM) patients.

Shaanxi province is located in western China, and its economic development lags behind that of the eastern region. Health resources in Shaanxi province are relatively scarce, and the typical diet is dominated by carbohydrates. Likely as a result of these factors, the prevalence of diabetes from 2003 to 2013 increased nearly 3 times in urban areas compared to approximately 10 times in rural areas.

The aim of our study was to investigate the glycemic control and explore factors associated with poor glycemic control among T2DM patients in Shaanxi, western China.

MATERIALS AND METHODS

Study Design In 2017, the population in Shaanxi province was 38.35 million, ranking 4th among the 12 western provinces. It ranked 11th for Gross Domestic Product (GDP) per capita among a sample of 31 provinces and 3rd among 12 provinces in the west. Looking at a geographical location, population size, and economic situation, Shaanxi province is a good representative of the 12 western Chinese provinces in...
terms of health status.

Multistage sampling was used in this study. We first used a typical sampling method to assess the geographical environment and economic development in each region in Shaanxi province. The provinces were then divided into 3 regions (northern Shaanxi, central Shaanxi, southern Shaanxi) and 1 provincial capital city (Xi’an). Based on the average GDP per capita among all eleven cities in Shaanxi province, in addition to choosing a provincial capital city (Xi’an), Yulin (384.862 billion yuan, high GDP), Baodi (226.516 billion yuan, middle GDP), and Ankang (113.377 billion yuan, low GDP) were selected as representative cities from each of the three regions. (The high GDP must be more than 230 billion yuan, the medium GDP must be from 120 to 230 billion yuan, and the low GDP must be less than 120 billion yuan. Among the eleven cities, there are three cities with high GDP per capita, four with medium GDP, and four with low GDP.) In the second step, simple random sampling was used to select in patients with T2DM in primary, secondary, and tertiary hospitals in each city. A face-to-face questionnaire survey was conducted in our investigation. For competent patients, we recommended them to fill out the questionnaire by themselves. Those older patients gave answers orally to study staff who wrote them down. And the questions contain single choice and multiple choice.

Respondents Based on the latest diabetic prevalence rate (11.7%) from 2013 and the provincial population data, there are about 4.49 million diabetic patients in Shaanxi province. Using the Raosoft Sample Size Calculator (Raosoft, Inc., WA, U.S.A., 2004, http://www.raosoft.com/samplesize.html), we assumed 95% as the confidence level, 50% as the margin of error, and our 578 respondents were ultimately required. The number of questionnaires in each selected city was estimated based on the proportion of the population (9.6 million in Xi’an; 3.4 million in Yulin; 3.8 million in Baodi; 2.7 million in Ankang). The survey was then conducted in these cities from May to July 2018. Inpatient diabetic patients in primary, secondary, and tertiary hospitals were selected as the research subjects. (Primary hospitals are primarily medical and health institutions that directly provide medical care, prevention, health care and rehabilitation services to communities with a certain population (≤100000). The secondary hospital is a regional hospital that provides medical and health services to multiple communities (≥100000), and is a technical center for regional medical prevention. Tertiary hospitals are hospitals that provide medical and health services across regions, provinces, cities, and across the country. They are medical prevention technology centers with comprehensive medical, teaching, and scientific research capabilities.)

Subject selection was based on the admission diagnosis. Inclusion criteria for patients with diabetes were fasting blood glucose ≥7.0 mmol/L or 2-h postprandial blood glucose ≥11.1 mmol/L, >18 years of age, voluntary enrollment, and informed consent. Exclusion criteria included type 1 diabetic patients, gestational diabetes mellitus patients, and patients who could not understand and respond to the questions because of mental or psychological problems.

Data Collection The questionnaire was divided into 3 portions as described below. The first part contained basic demographic information including sex, age, educational background, type of medical insurance, disease duration, geographic region, hospital level, and comorbidities. The second part included information on blood glucose, such as glycemic control and monitoring frequency. The last portion was information on the patient’s therapeutic regimen, including therapeutic medications, medication compliance, and difficulties encountered during treatment. Questions about difficulties encountered by patients were multiple-choice and included questions about difficulty with diet control, missed medication doses, unaffordable cost, and non-adherence to the long process of treatment. Based on this information, we calculated the number of encountered difficulties per patient. The primary outcome for the questionnaire was patient glycemic control. Patients recalled their blood glucose measurements of laboratory testing within the past 3 months. If there were multiple blood glucose monitoring results during this period, the most recent measurement was used. Successful glycemic control was defined as glycated hemoglobin Alc (HbA1c) ≤7% or fasting plasma glucose (FPG) <7.0mmol/L.

Data Analysis EpiData 3.1 (EpiData Association, Odense, Denmark) was used to enter information from the questionnaires using a double data entry method to ensure data accuracy. Descriptive statistics were used for continuous numerical variables. Data were shown as the mean standard deviation or percentage. The Chi-square test and Fisher’s exact test were used to test for significant differences between glycemic control and various patient data points. Factors affecting glycemic control were assessed using univariate and multivariate binary logistic regression to compute odds ratios (OR) with 95% confidence intervals (CI). For numerical variables, the Wilcoxon rank-sum test was used. Differences were considered to be significant if the p-value was less than 0.05. All statistical analyses were performed using Microsoft Office Excel 2013 (Microsoft Corporation, Redmond, WA, U.S.A.) and the statistical software SPSS version 18.0 (SPSS Inc., Chicago, IL, U.S.A.).

RESULTS

Demographics Five hundred sixty-nine questionnaires of the 578 distributed were returned. After removing inconsistent logic throughout and missing items from the questionnaire, the effective response rate was 88.24% (510/578) (Fig. 1).

Table 1 shows the demographic characteristics of respondents. The mean age of the participants was 60.58 ± 11.20 years and the ratio of males to females was 1:0.2:1. Patients over age 60 accounted for 57.26, and 60.45% of those elderly over age 60 have poor glycemic control. The majority (86.28%) did not receive university education. Four hundred eight out of 510 (80%) T2DM patients have one or more comorbidities.

Relationship between Glycemic Control and Patients’ Demographic Information As shown in Table 2, patients having blood glucose control within the normal range accounted for 47.5% of the total. Glycemic control was significantly associated with region (p < 0.001), comorbidity (p < 0.001), monitoring frequency (p = 0.002), insulin dependence (p = 0.003), and medication compliance (p < 0.001). However, age, gender, educational background, type of medi-
The number of unsuccessful glycemic control patients in Yulin (N = 52, 19.40%) and Baoji (N = 74, 27.61%) was higher than successful ones (N = 19, 7.85% and N = 42, 17.36%, respectively). As long as patients had one or more comorbidities, the number of people with unsuccessful glycemic control was higher than that of successful ones. Among patients who had poorly controlled blood glucose, nearly half of them had one comorbidity (49.63%), moreover, nearly 90% had at least one or more comorbidities (88.43%). The majority of respondents monitor their blood glucose 1–3 times per week or 1–3 times per month (289/510, 56.67%). However, the number of patients who measured their blood glucose one or more times daily was small (120/510, 23.5%). Among these daily-monitoring patients, most were unsuccessful in their glycemic control (74/120, 61.67%). In those patients using insulin, there were more people with poor glycemic control than with good control. However, for patients with successful glycemic control, the number not using insulin was twice that of those on insulin (N = 211, 66.14% vs. N = 108, 33.86%). Among patients who took medication according to a doctor’s advice, more patients successfully controlled their blood glucose (79.75% vs. 55.22%). Although there was no statistically significant difference between educational background and glycemic control, we found a tendency for patients with higher educational levels to have better glycemic control. For those who encountered difficulty during treatment, the number of patients with poor glycemic control was higher than those with good control for each specific difficulty. Regardless of whether the glycemic control was successful, the most common difficulties encountered by patients were, in order, diet control, long treatment process, forgetting to take medicine and unaffordable cost.

### Logistic Analysis of Unsuccessful Glycemic Control and Influencing Factors

We explored several factors that may have influenced glucose levels in those patients who were unsuccessful in achieving glycemic control (Table 3). A multivariate binary logistic regression analysis showed that region, number of comorbidities, monitoring frequency, and medication compliance were all factors that influenced glycemic control in T2DM patients.

We found that patients living in Yulin (odds ratio (OR) = 4.832, 95% confidence interval (CI) 2.227–10.483) and Baoji (OR = 2.413, 95% CI 1.223–4.761) had a significantly higher risk of having unsuccessful glycemic control. Patients who had more comorbidities (OR = 1.303, 95% CI 1.048–1.619) were more likely to have blood glucose out of the normal range. Our questionnaire asked patients’ frequency of blood
glucose monitoring. Those that monitored daily or 1–4 times per year were more likely to have successful blood glucose. With respect to medication compliance, patients who take medicine according to their doctor’s advice (OR = 0.480, 95% CI 0.167–1.376) had a slightly higher chance of having successful glycemic control. However, those taking medicine...
casually when they thought of it had a significantly higher risk of unsuccessful glycemic control.

**DISCUSSION**

A total of 88.24% of patients who completed the questionnaire were enrolled in the study, and 47.5% of them had blood glucose control within the normal range. Our study showed that region, comorbidities, monitoring frequency, insulin use, and medication compliance were significantly associated with glycemic control. The multivariate logistic analysis showed that there was a significant relationship between unsuccessful glycemic control and wealthier residence, more comorbidities, monitoring frequency, and medication incompliance.

As a representative province in Western China, Shaanxi province had a higher glycemic control rate (47.5%) than that of the country as a whole (39.7%). Our glycemic control finding was lower than other countries such as Brazil (51%) and Denmark (49%). The U.S. National Health and Nutrition Examination Survey reported that the proportion of U.S. patients reaching adequate glycemic control was 55.7%. Nowadays, people pay more attention to the prevention and control of chronic diseases around the world. And scientific research result of clinical practice tends to lag behind the current situation. So the gap between China and other countries in glycemic control rate among T2DM patients may be greater than we showed. With the issue of the “Healthy China 2030” Planning Outline, it is essential and urgent to achieve chronic disease health management intervention.

### Table 3. Logistic Analysis of Unsuccessful Glycemic Control and Influencing Factors among 510 Participants with T2DM in Shaanxi, China, 2018

| Factor                      | Multivariate analysis | p-Value |
|-----------------------------|-----------------------|---------|
|                             | Adjusted odds ratio (95% CI) |         |
| Sex                         | 0.687                 |         |
| Female                      | Reference             |         |
| Male                        | 1.089 (0.718–1.653)   | 0.687   |
| Age                         | 1.013 (0.990–1.036)   | 0.266   |
| Educational background      | 0.545                 |         |
| Bachelor degree or above    | Reference             |         |
| Primary school or below     | 1.291 (0.576–2.894)   | 0.535   |
| Junior high school          | 1.346 (0.670–2.707)   | 0.404   |
| Senior high school          | 1.642 (0.823–3.275)   | 0.159   |
| Type of medical insurance   | 0.232                 |         |
| NCMS                        | Reference             |         |
| Urban employees             | 0.782 (0.446–1.371)   | 0.390   |
| Urban residents             | 0.587 (0.318–1.082)   | 0.088   |
| Disease duration, yrs       | 1.003 (0.968–1.040)   | 0.858   |
| Region                      | >0.001                |         |
| Ankang                      | Reference             |         |
| Xi’an                       | 1.305 (0.724–2.352)   | 0.375   |
| Yulin                       | 4.832 (2.227–10.483)  | <0.001  |
| Baoji                       | 2.413 (1.223–4.761)   | 0.011   |
| Hospital level              | 0.369                 |         |
| Tertiary hospital           | Reference             |         |
| Primary hospital            | 0.715 (0.408–1.254)   | 0.242   |
| Secondary hospital          | 1.000 (0.587–1.703)   | 0.999   |
| Comorbidity, number         | 1.303 (1.048–1.619)   | 0.017   |
| Monitoring frequency of blood glucose | 0.005 |         |
| 1–4 times/year              | Reference             |         |
| Other                       | 1.442 (0.511–4.070)   | 0.489   |
| 1 time/d                    | 1.615 (0.633–4.117)   | 0.316   |
| 2–3 times/d                 | 3.491 (1.439–8.472)   | 0.006   |
| 1–3 times/week              | 2.782 (1.153–6.709)   | 0.023   |
| 1–3 times/month             | 1.556 (0.604–4.006)   | 0.360   |
| Medication compliance       | <0.001                |         |
| Never take medicine         | Reference             |         |
| Take medicine according to doctor’s advice | 0.480 (0.167–1.376)   | 0.172   |
| Increase or decrease the dosage on own | 1.560 (0.499–4.882) | 0.445   |
| Take medicine when you think of it | 2.377 (0.717–7.878) | 0.157   |
| Insulin injection           | 0.145                 |         |
| Yes                         | Reference             |         |
| No                          | 0.713 (0.452–1.124)   | 0.145   |
| Number of difficulties      | 1.070 (0.885–1.292)   | 0.486   |
nity attention. They were both the main diseased age group of diabetes and a high-risk group of poor glycemic control patients. Referring to chronic diseases and health management, the elderly are the main research object of this problem.22) Family care and help for patients is also essential. Family members could supervise the diabetic patient in taking medications or injecting insulin. Family can also help detect problems in a timely fashion and consult the community chronic disease management department. Research has confirmed that impaired glycemic control in elderly diabetic patients aggravates diabetes-associated complications such as depression, impaired cognition, and poor self-care behavior.23,24) If communities can screen for complications promptly, detection and treatment can happen sooner, strengthening the chronic disease management of elderly patients.

When looking at geographic region, patients who live in Xi’an, Ankang, and Baoji had significantly better glycemic control than those in Yulin. According to the 2017 Population Development Report of Shaanxi Province, Yulin, Baoji and Ankang had high, middle and low GDP per capita respectively. A cross-sectional survey performed in France concluded that people with diabetes reporting financial difficulties were more likely to have poorer glycemic control.25) The Systematic review also showed that people with lower socioeconomic status had higher HbA1c levels.26) Therefore, our findings regarding economic situation and glycemic control were inconsistent with the previous study. This discrepancy may be the result of uneven distribution of medical resources and different emphasis on medical management. The uneven distribution of medical resources among cities is mainly reflected in the number of health institutions, beds, and medical technical personnel (Lecensed Doctors and Registered Nurses). For instance, there are 5928 health institutions in Xi’an, which is much larger than the 2897 health institutions in Ankang.

Interestingly, we found that a small proportion of patients who monitored blood glucose daily were more likely to have unsuccessful blood glucose control. This suggests that patients who more frequently monitor their blood glucose do not necessarily have better blood glucose control. The International Diabetes Federation and the Chinese Diabetes Society recommended that self-monitoring of blood glucose (SMBG) in non-insulin-treated diabetes patients should be based on the individual state of illness.27,28) Regimens of SMBG may differ in frequency according to the blood glucose status of individual patients. In order to increase patients’ acceptance of SMBG, the specific scheme should have the least frequent monitoring to effectively track blood glucose. This would not only provide information about recent blood glucose changes, but also reduce the economic burden to patients.

Similar to previously published studies, our study showed that patients with poor compliance with diabetes medications had worse glycemic control.29) We also found that the main reasons that patients were unable to comply with medication regimens were the economic burden caused by insulin, a lack of social support, and fingertip pain. These reasons were consistent with previous studies.30,31) Community support plays an important role in the management of chronic diseases.32) Appropriate nursing interventions should be taken to reduce pain during blood glucose monitoring. Another barrier was that patients did not have a clear understanding of their medication scheme. When a patient’s medication or dose is adjusted, community health workers should explain the change and its benefits in detail. As another community health intervention would be to actively publicize and provide education surrounding the importance of combination drug treatment and diet and exercise for glycemic control. These efforts may attract patients’ attention and help them overcome the difficulties of the treatment of diabetes.

There were several limitations to this study. Firstly, the design of a cross-sectional study could reflect patients’ status at a certain stage but does not prove causation. Additionally, our research on blood glucose control mainly focused on factors such as blood glucose monitoring and treatment, not taking into account cardiovascular diseases, low-density lipoprotein, or other biochemical indicators. Thirdly, we relied on patient recall of blood glucose measurements within the past 3 months, and we found that some patients had not measured their blood glucose in this time frame. Thus, the results solely relied on the most recent blood glucose measurements, which may be far from 3 months.

CONCLUSION

In conclusion, glycemic control was poor overall among T2DM patients in Western China. Area of residence, comorbidities, frequency of blood glucose monitoring, and medication compliance were factors associated with poorer glycemic control. It is necessary to carry out health management of diabetic patients from the community, family and patients jointly.

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Author Contributions Xiang Y, Wang N, and Feng B designed the present study. Xiang Y and Ren B drafted the manuscript. Xiang Y, Chen Y, and Niu R contributed to data collection and performed data analysis.

Conflict of Interest The authors declare no conflict of interest.

REFERENCES

1) WHO. “Media centre: diabetes.”: http://www.who.int/en/news-room/fact-sheets/detail/diabetes/, accessed 29 July, 2019.
2) Danaei G, Finucane MM, Lu Y, Singh GM, Cowan MJ, Paciorek CJ, Liu JK, Farzadfar F, Kliang YH, Stevens GA, Rao M, Ali MK, Riley LM, Robinson CA, Ezzati M. National, regional, and global trends in fasting plasma glucose and diabetes prevalence since 1980: systematic analysis of health examination surveys and epidemiological studies with 370 country-years and 2.7 million participants. Lancet, 378, 31–40 (2011).
3) Mannucci E, Decembrini I, Lauria A, Pozzilli P. Is glucose control important for prevention of cardiovascular disease in diabetes? Diabetes Care, 36 (Suppl. 2), S259–S263 (2013).
4) Skyler JS, Bergenstal R, Bower RO, Buse J, Deedwania P, Gale EA, Howard BV, Kirkman MS, Kosiborod M, Reaven P, Sherwin RS. Intensive glycemic control and the prevention of cardiovascular events: implications of the ACCORD, ADVANCE, and VA diabetes trials: a position statement of the American Diabetes Association and a scientific statement of the American College of Cardiology.
Foundation and the American Heart Association. Diabetes Care, 32, 187–192 (2009).

5) Patel A, MacMahon S, Chalmers J, et al. Intensive blood glucose control and vascular outcomes in patients with type 2 diabetes. N. Engl. J. Med., 358, 2560–2572 (2008).

6) Xu Y, Wang L, He J, et al. Prevalence and control of diabetes in Chinese adults. JAMA, 310, 948–959 (2013).

7) Chen R, Ji L, Chen L, et al. Glycemic control and vascular outcomes in patients with type 2 diabetes mellitus at a public referral hospital in rio de Janeiro, Brazil: demographic and clinical factors. Journal of Endocrinology and Metabolism, 7, 61–67 (2017).

8) Lozovey N, Lamback E, Mota R, Caarls MB, Neto LV. Epidemiology of diabetes in adults aged 35 and older from Shanghai, China. BioMed. Environ. Sci., 29, 408–416 (2016).

9) Ruan Y, Yan QH, Xu JY, Yang QD, Yao HH, Li R, Shi Y. Epidemiology of diabetes in adults aged 35 and older from Shanghai, China. Biomed. Environ. Sci., 29, 408–416 (2016).

10) Atif M, Saleem Q, Babar ZU. Association between the Vicious Cycle of Diabetes-Associated Complications and Glycemic Control among the Elderly: A Systematic Review. Medicine (Kaunas), 54, 53 (2018).

11) Du GL, Su YX, Yao H, Zhu J, Ma Q, Tuerdi A, He XD, Wang L, Wang ZQ, Xiao S, Wang SX, Su LP. Metabolic risk factors of type 2 diabetes mellitus and correlated glycemic control/comlications: a cross-sectional study between rural and urban uygur residents in xinjiang uygur autonomous region. PLOS ONE, 11, e0162611 (2016).

12) Xu S, Sun F, Xu W, Jiao K, Shi B, Xie X, Wang Y, Zhu M, Ji Q. Simultaneous control of blood glucose, blood pressure, and lipid among drug-treated Type 2 diabetes patients from Shaanxi province, North-Western China: a multicenter study. Niger. J. Clin. Pract., 19, 784–792 (2016).

13) Zheng SL, Chen ZC, Yan L, Chen LH, Cheng H, Ji LN. Determinants for inadequate glycemic control in Chinese patients with mild-to-moderate type 2 diabetes on oral antidiabetic drugs alone. Chin. Med. J. (Engl.), 124, 2461–2468 (2011).

14) Rock CL, Flint SW, Pakiz B, Taylor KS, Leone AF, Brolje K, Heath DD, Quintana EL, Sherwood NE. Weight loss, glycemic control, and cardiovascular disease risk factors in response to differential diet composition in a weight loss program in type 2 diabetes: a randomized controlled trial. Diabetes Care, 35, 1167–1172 (2012).

15) Del Chierico F, Vernocchi P, Dallapiccola B, Putignani L. Mediterranean diet and health: food effects on gut microbiota and disease control. Int. J. Mol. Sci., 15, 11678–11699 (2014).

16) Lai S, Gao J, Zhou Z, Yang X, Xu Y, Zhou Z, Chen G. Prevalences and trends of chronic diseases in Shaanxi Province, China: evidence from representative cross-sectional surveys in 2003, 2008 and 2013. PLOS ONE, 13, e0202886 (2018).

17) Shaanxi Provincial Bureau of Statistics. “2017 Population Development Report of Shaanxi Province.” <http://www.shaanxijit.gov.cn/site1/html1/126/131/18051.htm>, accessed 29 July, 2019.

18) Hoerger TJ, Segel JE, Gregg EW, Saadidine JB. Is glycemic control improving in U.S. adults? Diabetes Care, 31, 81–86 (2008).

19) Wu H, Lu N. Informal care and health behaviors among elderly people with chronic diseases. J. Health Popul. Nutr., 36, 40 (2017).

20) Chen R, Ji L, Chen L, et al. Intensive blood glucose control and vascular outcomes in patients with type 2 diabetes. N. Engl. J. Med., 358, 2560–2572 (2008).

21) Del Chierico F, Vernocchi P, Dallapiccola B, Putignani L. Mediterranean diet and health: food effects on gut microbiota and disease control. Int. J. Mol. Sci., 15, 11678–11699 (2014).

22) Lai S, Gao J, Zhou Z, Yang X, Xu Y, Zhou Z, Chen G. Prevalences and trends of chronic diseases in Shaanxi Province, China: evidence from representative cross-sectional surveys in 2003, 2008 and 2013. PLOS ONE, 13, e0202886 (2018).

23) Shaanxi Provincial Bureau of Statistics. “2017 Population Development Report of Shaanxi Province.” <http://www.shaanxijit.gov.cn/site1/html1/126/131/18051.htm>, accessed 29 July, 2019.

24) Hoerger TJ, Segel JE, Gregg EW, Saadidine JB. Is glycemic control improving in U.S. adults? Diabetes Care, 31, 81–86 (2008).

25) Wu H, Lu N. Informal care and health behaviors among elderly people with chronic diseases. J. Health Popul. Nutr., 36, 40 (2017).

26) Del Chierico F, Vernocchi P, Dallapiccola B, Putignani L. Mediterranean diet and health: food effects on gut microbiota and disease control. Int. J. Mol. Sci., 15, 11678–11699 (2014).

27) International Diabetes Federation Clinical Guidelines Taskforce and International SMBG Working Group. “Global guideline on self-monitoring of blood glucose in noninsulin treated type 2 diabetes; 2009.” <https://www.idf.org>, accessed 1 March, 2011.

28) Chinese Diabetes Society. Guidelines for the prevention and treatment of type 2 diabetes in China (2013 edition). Chinese Journal of Endocrinology and Metabolism, 30, 893–942 (2014).

29) Mayberry LS, Osborn CY. Family support, medication adherence, and glycemic control among adults with type 2 diabetes. Diabetes Care, 35, 1239–1245 (2012).

30) Gourzoulidis G, Kourlaba G, Stafylas P, Giamouzis G, Parissis J, et al. Prevalence and control of diabetes in adults aged 35 and older from Shanghai, China. Biomed. Environ. Sci., 29, 408–416 (2016).

31) Ruan Y, Yan QH, Yang QD, Yao HH, Li R, Shi Y. Epidemiology of diabetes in adults aged 35 and older from Shanghai, China. Biomed. Environ. Sci., 29, 408–416 (2016).

32) Palma E, Rehman S, Babar ZU. Association between the Vicious Cycle of Diabetes-Associated Complications and Glycemic Control among the Elderly: A Systematic Review. Medicine (Kaunas), 54, 53 (2018).

33) Gruner A, Markle-Reid M, Fisher K, Reimer H, Ma X, Ploeg J. Comorbidity burden and health services use in community-living older adults with diabetes mellitus: a retrospective cohort study. Can. J. Diabetes, 40, 35–42 (2016).

34) Birks SA, Fosse-Edorh S, Fagot-Campagna A, Detournay B, Bihani H, Eschwage L, Gautier A, Druet C. Impact of socio-economic position on health and quality of care in adults with Type 2 diabetes in France: the Entred 2007 study. Diabet. Med., 32, 1438–1444 (2015).

35) Bijlsma-Rutte A, Rutters F, Elders PJM, Bot SDM, Nijpels G. Socio-economic status and HbA1c in type 2 diabetes: a systematic review and meta-analysis. Diabetes Metab. Res. Rev., 34, e3008 (2018).

36) International Diabetes Federation Clinical Guidelines Taskforce and International SMBG Working Group. “Global guideline on self-monitoring of blood glucose in noninsulin treated type 2 diabetes; 2009.” <https://www.idf.org>, accessed 1 March, 2011.

37) Chinese Diabetes Society. Guidelines for the prevention and treatment of type 2 diabetes in China (2013 edition). Chinese Journal of Endocrinology and Metabolism, 30, 893–942 (2014).

38) Mayberry LS, Osborn CY. Family support, medication adherence, and glycemic control among adults with type 2 diabetes. Diabetes Care, 35, 1239–1245 (2012).

39) Gourzoulidis G, Kourlaba G, Stafylas P, Giamouzis G, Parissis J, et al. Prevalence and control of diabetes in adults aged 35 and older from Shanghai, China. Biomed. Environ. Sci., 29, 408–416 (2016).

40) Palma E, Rehman S, Babar ZU. Association between the Vicious Cycle of Diabetes-Associated Complications and Glycemic Control among the Elderly: A Systematic Review. Medicine (Kaunas), 54, 53 (2018).