Clinical Research

Can glycated hemoglobin act as a reliable glycemic indicator in patients with diabetic chronic kidney disease? evidence from the Northeast of Thailand

Sojib Bin Zaman,[1,2,3] Naznin Hossain,[4] Ahmed E. Rahman,[3] Sheikh M.S. Islam[5,6]

[1] Faculty of Public Health, Khon Kaen University, Khon Kaen, Thailand

[2] Institute of Tropical Medicine and International Health, Charité – University Medicine Berlin, Berlin, Germany

[3] Maternal and Child Health Division, International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b), Dhaka, Bangladesh

[4] Department of Pharmacology, Dhaka Medical College, Dhaka, Bangladesh

[5] Faculty of Medicine, University of Sydney, Sydney, Australia

[6] Cardiovascular Division, The George Institute for Global Health, Sydney, Australia

ABSTRAK

Latar belakang: *Penyakit ginjal kronis (PGK) adalah komplikasi yang sering terjadi pada penyandang diabetes melitus (DM) yang membutuhkan kontrol kadar gula darah (glikemik) yang adekuat.* Glycated hemoglobin *(HbA1c) adalah penanda biologis konvensional untuk memperkirakan status glikemik, namun perannya pada pasien PGK akibat DM masih belum jelas. Oleh karena itu, penelitian ini bertujuan untuk mengetahui apakah pasien dengan HbA1c tinggi berhubungan dengan timbulnya PGK.*

Metode: *Data diperoleh dari registri klinis pasien diabetes yang dirawat di sebuah rumah sakit di sebelah timur laut Thailand. CKD ditentukan berdasarkan perkiraan laju filtrasi glomerulus yaitu LFG<60mL/menit/1.73m^2. Pengukuran antropometri dan biokimia pasien diambil dari rekam medis. Analisis regresi logistik multipel digunakan untuk mengetahui kemungkinan hubungan antara HbA1c dan PGK.*

Hasil: *Dari 4.050 pasien DM, terdapat 1.027 (25,3%) pasien yang memiliki PJK akibat DM. Usia yang lebih tua (adjusted odds ratio (AOR): 4,88, (95% CI: 3,71–6,42) p<0,05), perempuan (AOR: 1,38, 95% CI: 1,05–1,73, p<0,05), dan hipertensi (AOR: 1,52, 95% CI: 1,21–1,91, p<0,05) merupakan faktor risiko terjadinya PGK akibat DM. Akan tetapi, pasien dengan HbA1c tinggi (>6,5%) berhubungan terbalik dengan PGK akibat DM (AOR: 0,66, 95% CI: 0,51–0,86, p<0,05).*

Kesimpulan: *Penelitian ini menemukan pasien dengan HbA1c lebih tinggi tidak berkaitan dengan kejadian PGK akibat DM. Oleh karena itu, penggunaan nilai batas ambang HbA1c pada konvensional penderita PGK akibat DM tidak dapat digunakan di klinis. Peningkatan upaya deteksi status glikemik pada pasien dengan PGK akibat DM perlu diperketat untuk meningkatkan luaran.*

ABSTRACT

Background: Chronic kidney diseases (CKD) is a common microvascular complication in patients with diabetes mellitus (DM) which requires adequate glycemic control. Glycated hemoglobin (HbA1c) is a conventional biomarker to estimate glycemic status, but its role in diabetic CKD patients is unclear. Therefore, this study aimed to determine whether patients with high HbA1c are associated to develop diabetic CKD.

Methods: Data were obtained from a clinical registry of diabetic patients who were treated in a district hospital in the Northeast of Thailand. CKD was defined according to the estimated glomerular filtration rate (eGFR<60mL/min/1.73m^2). Anthropometric and biochemical measurements of the patient were taken by review of medical records. Multiple logistic regression analysis was used to determine the likelihood of the association between HbA1c and CKD.

Results: Among 4,050 participants, 1,027 (25.3%) developed diabetic CKD. Older age (adjusted odds ratio (AOR): 4.88, 95% confidence interval (CI): 3.71–6.42, p<0.05), female (AOR: 1.38, 95% CI: 1.05–1.73, p<0.05), and hypertension (AOR: 1.52, 95% CI: 1.21–1.91, p<0.05) were found as the risk factors of diabetic CKD. However, patients with high HbA1c (>6.5%) were negatively associated with diabetic CKD (AOR: 0.66, 95% CI: 0.51–0.86, p<0.05).

Conclusion: This study found patients with higher HbA1c level were not associated with diabetic CKD. Therefore, using the conventional cut-off values of HbA1c in diabetic CKD patients may be problematic in the clinical settings. Enhanced detection of glycemic status in patients with diabetic CKD is warranted to improve the outcome.

Keywords: Diabetic CKD, eGFR, Glycated hemoglobin, Thailand

pISSN: 0853-1773 • eISSN: 2252-8083 • https://doi.org/10.13181/mji.v26i2.1995 • Med J Indones. 2017;26:102–8
• Received 10 May 2017 • Accepted 12 Jun 2017

Corresponding author: **Sojib Bin Zaman**, sojib@icddrb.org

Chronic kidney disease (CKD) is a frequent microvascular complication among patients with diabetes mellitus (DM). CKD is considered to be the leading cause of renal failure[1] with its high prevalence in South-East Asia.[2] Thailand has experienced the epidemiological transition for the recent years, and non-communicable diseases have come into the limelight to cause significant morbidities and mortalities.[3] Thailand is also connected to the 'stone belt' zone which normally extends from Central Asia to South Asia.[4] Therefore, the rate of kidney disease is high in the North-eastern Thailand.[5] Although all diabetic patients are not at risk to develop CKD, minimal damage to the kidney is frequent.[6] Age, sex, race, positive family history, and high blood pressure are the known risk factors of diabetic CKD. Chronic hyperglycemia due to uncontrolled DM plays the key role to initiate renal vascular complications.[7] However, a previous study reported that diabetic kidney disease could develop with a relatively short duration of diabetes.[8] Adequate diabetic management and glycemic control are essential to prevent diabetic kidney disease and other complications.[9]

Glycated hemoglobin (HbA1c) is one of the essential elements of human red blood cells which acts like the conventional biomarker to estimate glycemia.[10] HbA1c is usually developed by the reduction of glucose with the amino contents of beta chains in hemoglobin A. Thus, HbA1c can reflect glucose status of a person as far as the viability of erythrocyte remains active in the blood. One-time determination of high HbA1c means that glycemic status of a particular patient was not under control for the last three to four months.

The prime target of diabetic care is to control patient's high glycemic which reiterates the demands of using a valid test to detect accurate glycemia in patients with diabetic CKD.[11] Traditionally, clinicians use HbA1c to measure the glycemic status of a diabetic patient, assess the efficacy of treatment, and recommend the appropriate adjustments to lifestyle. Some studies have found that HbA1c might not predict the exact glycemia in CKD patients under the pathophysiological evidence.[12–14] However, these theoretical arguments have created some controversies which need to be justified and proved in real life setting as well.[15] Most of the developing countries use HbA1c as a valid glycemic indicator, and contemporary guidelines advocate the same cut-off point of HbA1c to detect glycemic status in CKD and non-CKD patients.[16] Therefore, it demands an attention to know whether HbA1c can detect the accurate glycemic status in patients with diabetic kidney disease. This study aimed to determine whether patients with high HbA1c are more associated to develop diabetic kidney disease in compared to patients with low HbA1c.

METHODS

Data sources

A hospital-based retrospective data analysis was performed between May 2016 and October 2016. The data were collected from the clinical registry of diabetic patients which was obtained from a district hospital in the northeast of Thailand. This hospital is the secondary referral facility with a catchment population of about 114,588. The study data represented one-year sample involving the yearly check-up investigation records of the patients.

Data collection

This study has used the clinical registry to collect the records of 4,050 patients who were enrolled between 1 January 2015 and 31 December 2015. Among the diabetic patients, the number of CKD and non-CKD patients were 1,027 (25.3%) and 3,023 (74.7%) respectively. Demographic information, biochemical reports, and anthropometric measurements were extracted from the medical records. Age was categorized into two sub-groups according to the Thai retirement age.[21] Occupation was classified as 'farmer,' 'unemployment' and 'different jobs' among the participants. We collected the last recording of HbA1c, LDL-cholesterol, and blood pressure from laboratory investigation reports. Fasting blood samples were used to assess HbA1c and lipid profile levels. Physical measurements and blood pressure were recorded twice to minimize the observer error. The data entry was done by a group of skilled data operator under the active supervision of a data management officer.

Ethical approval

The Ethical Committee of Khon Kaen University (KKU) approved this study (approval no.

HE2247). The Director of the district hospital allowed the researchers to use the hospital data. Retrospective anonymous data were taken from the hospital clinical records, and all participant provided consent to be included in the registry. Hence, the Institutional Review Board of KKU exempted us from obtaining written consents from patients.

Definition of variables and measurements

Diabetes mellitus was defined according to the measurement of fasting blood sugar (FBS >126 mg/dL). For the detection of poor glycemic control among the patients with diabetic kidney disease, this study used the recommended World Health Organization (WHO) cut-off point for HbA1c >6.5%.[17] Body mass index (BMI) was classified into four categories according to the WHO guideline: Underweight (<18.5 kg/m^2), normal (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2) and obese (≥30 kg/m^2). Hypertension was defined according to increase systolic (≥140 mmHg) and/or increase diastolic blood pressure (≥90 mmHg) and/or history of anti-hypertensive medication. High LDL-cholesterol was categorized as LDL ≥130mg/dL according to the guideline of American Association of Clinical Endocrinologists (AACE). Diabetic CKD has been defined based on estimated glomerular filtration rate (eGFR) value (if eGFR <60mL/min/1.73 m^2) according to the clinical guidelines of the National Kidney Disease Outcomes Quality Initiative (NKF KDOQI).[18] Modification of diet in renal disease-four variable (MDRD-4) equation was used to calculate eGFR in the clinical setting.[19]

Statistical analysis

Frequency and proportions were used to present categorical variables. Mean and standard deviation (SD) were used for continuous variables. Differences in variables between the CKD and the non-CKD group were examined by Student t-test for the continuous variables and by chi-squared test for the categorical values. Binary logistic regression analysis was carried to find the association of HbA1c and other risk factors with CKD. Moreover, multiple logistic regression was conducted to determine the likelihood of the association after adjusting for risk factors. Stata version 13 special edition (College Station, Texas, USA) was used for the data analysis. A conventional cut-off value of 0.05 was taken as a statistical significance.

RESULTS

Among the 4,050 patients with diabetes, 1,027 (25.3%) patients developed CKD. The characteristics of the patients are summarized in Table 1 based on presence or absence of CKD. Most of the CKD patients were above 60 years (83%), female (68%), and farmer (67%). Around 30% of participants were overweight, and nobody was categorized as underweight in this study.

Characteristics of diabetic patients with or without CKD

About 79% of CKD patients were presented with high HbA1c values, and 25% were possessed above average LDL-cholesterol level. The mean age (58.78 versus 69.00 years), serum creatinine (0.76 versus 1.52 mg/dL), and LDL-Cholesterol (111.0 versus 109.93 mg/dL) were higher among the CKD group compared to the non-CKD group. However, the mean BMI (25.3 versus 24.3 kg/m^2) and HbA1c (8.6% versus 8.3%) were slightly higher in the non-CKD group.

Association of HbA1c and different risk factors of CKD

From the bi-variable analysis, we found that older age, female sex, occupation, high HbA1c, high blood pressure, and high BMI were associated with CKD. Moreover, these associations were statistically significant. Increased LDL-cholesterol, smoking, and alcohol drinking were not associated with CKD in this study (Table 2). In multivariable analysis, this study found that age more than 60 years, female sex, and hypertension were positively associated with diabetic CKD. After adjusting all the risk factors: age, sex, occupation, LDL, BMI, smoking, and alcohol drinking, this study found that patients with high HbA1c were negatively associated with diabetic CKD (AOR=0.66, 95% CI: 0.51–0.86, P<0.05).

DISCUSSION

This study showed that patients with high HbA1c were not positively associated with diabetic CKD. Our findings support a previous study where HbA1c were not positively associated with the advanced stage of kidney disease.[20] Some studies have suggested that HbA1c might not a good

estimator for the end stage of kidney disease patients.[12–14] Based on the pathophysiological evidence, HbA1c can lose its credibility to measure exact glycemia in diabetic CKD patients.[12–14] There are strong possibilities that CKD creates renal uremia that modifies the longevity of erythrocytes resulting in alteration of HbA1c component.[21] Moreover, normal erythroid precursor cells fail to stimulate erythropoiesis due to the limited response of bone marrow activity with a raised level of parathyroid hormone. On the contrary, activities of hypersplenism can induce the process of red blood cell destruction. Therefore, patients with an advanced stage of CKD develops anemia which causes the shorter lifespan of erythrocyte. Consequently, normal hemoglobin might fail to indicate the exact glycemia. Moreover, CKD patients receive iron, vitamin B12, blood transfusion, and other medications for the purpose of anemia correction. This sort

Table 1. Characteristics of study participants with or without CKD

Characteristics	Non-CKD (n=3023) Number (%)	CKD (n= 1027) Number (%)	p value*
Age, in years			
<60 years	1,730 (57.23)	1781 (7.33)	-
≥60 years	1,293 (42.77)	849 (82.67)	0.001
Mean (SD), years	58.78 (10.30)	69.00 (9.33)	0.01
Gender			
Male	1,114 (36.85)	332 (32.33)	-
Female	1,909 (63.15)	695 (67.67)	0.001
Occupation			
Unemployment	265 (8.77)	191 (18.60)	-
Farmer	1,745 (57.72)	686 (66.80)	0.001
Different jobs	1,013 (33.51)	150 (14.61)	0.001
BMI (n=3934)			
Normal	1,552 (52.63)	635 (63.56)	-
Overweight	1,043 (35.37)	295 (29.53)	0.005
Obese	354 (12.00)	69 (6.91)	0.002
Blood pressure			
Normotensive	1,443 (47.73)	288 (28.04)	-
Hypertensive	1,580 (52.27)	739 (71.96)	0.001
LDL-C (n=3734)			
Normal	2,130 (75.88)	695 (74.97)	-
High	677 (24.12)	232 (25.03)	0.48
Mean (SD)	111.0 (34.51)	109.93 (34.49)	0.89
HbA1c (n=3504)			
Optimal control	390 (14.90)	182 (20.52)	-
Poor control	2,227 (85.10)	705 (79.48)	0.002
Mean (SD)	8.61 (2.18)	8.32 (2.35)	0.04
Smoking			
Non-smoker	2,911 (96.30)	994 (96.7)	-
Current-smoker	112 (3.70)	33 (3.21)	0.37
Alcohol drinking			
Non-drinker	2,984 (98.71)	1,012 (98.5)	-
Current-drinker	39 (1.29)	15 (1.46)	0.49

*p value with $\chi 2$ test (categorical) or student t-test (continuous). SD= standard deviation; HbA1c= glycated hemmoglobin; BMI= body mass index; LDL-C= low density lipoprotein cholesterol

Table 2. Association of different risk factors with diabetic CKD (n=1,027)

Characteristics	COR (95% CI)	AOR †(95% CI)
Age		
≤60 years	ref	ref
>60 years	6.38 (5.28–7.70)*	4.88 (3.71–6.42)*
Sex		
Male	ref	ref
Female	1.22 (1.05–1.42)*	1.38 (1.05–1.73)*
Occupation		
Unemployed	ref	ref
Farmer	0.54 (0.44–0.67)*	0.90 (0.65–1.23)
Different jobs	0.24 (0.15–0.26)*	0.74 (0.49–1.11)
HbA1c		
Optimal control	ref	ref
Poor control	0.67 (0.55–0.82)*	0.66 (0.51–0.86)*
Blood pressure		
Normotensive	ref	ref
Hypertensive	2.34 (2.00–2.74)*	1.52 (1.21–1.91)*
LDL- cholesterol		
Normal	ref	ref
High	1.05 (0.88–1.24)	1.14 (0.88–1.47)
BMI		
Normal	ref	ref
Overweight	0.69 (0.58–0.81)*	0.73 (0.58–0.93)
Obese	0.49 (0.37–0.65)*	0.53 (0.35–0.81)
Smoking		
Non-smoker	ref	ref
Current-smoker	0.86 (0.58–1.28)	0.50 (0.20–1.24)
Alcohol Drinking		
Non-drinker	ref	ref
Current-drinker	1.13 (0.63–1.13)	2.15 (0.77–5.97)

*p value <0.05; †= Adjusted for age, sex, occupation, LDL, BMI, smoking, and alcohol drinking; COR= crude odds ratio; AOR= adjusted odds ratio; HbA1c= glycated hemoglobin; BMI= body mass index

of treatment frequently increases the production of immature red cells which subsequently alter the original hemoglobin structure.[22] The above mentioned multifaceted physiological changes within the hemoglobin structure can compromise the accuracy to measure glycemia.[20]

Blood glucose level can fall in a patient with end-stage renal disease due to malnutrition along with decrease glucose production using the gluconeogenesis pathway. Therefore, physiological changes of insulin secretion occur for these CKD patients. Such insulin usually might get extended half-life and destroy relatively more blood glucose in comparison to regular insulin. Moreover, alterations in insulin metabolism can shorten the lifetime of erythrocytes by changing the characteristics of the hemoglobin content of red blood cells.[22] A few studies also found that the survival of RBC usually decreases in patients who were on dialysis. Thus, increased destruction of erythrocyte might result in producing low HbA1c values.[22] Traditionally, most of the patients suffering from advanced stages of CKD are prescribed with erythropoietin stimulating agents (ESA) by the clinicians. There might be an inverse association of HbA1c with the introduction of erythropoietin medication.[14] Application of these external ESA is responsible for increasing the production of RBC. These RBC get insufficient exposure time to go under the glycosylation process which consequently might lower the HbA1c concentration. Thus, the lower HbA1c level can give a false impression regarding the overall glycemic control.[21]

The risk factors of diabetic CKD vary according to geographical aspect, ethnicity, and racial consideration.[23] In our study, diabetic CKD was more prevalent in older ages (above 60 years) which was similar to a previous communication.[24] This study found that increased age could be a risk factor of renal insufficiency which might result due to degenerative changes in the glomerular tissue. According to this study, hypertensive diabetic patients were 1.5 times more likely to develop CKD which supports a previous communication. Diabetic patients who were farmer or employed showed decrease risk of CKD compared to those who were unemployed. Therefore, patients with high HbA1c level were not associated with diabetic CKD in this study even after adjusted to the risk factors.

It appears that biochemical parameters of the diabetic CKD patients are different from that of the non-CKD patients. HbA1c might not be a reliable indicator to give the correct measurement of glycemic control in diabetic CKD patients. However, setting HbA1c target in patients with CKD needs to be individualized based on the patient's age, lifestyle factors, and clinical assessment.[25] Several studies have suggested that one-time measurement of glycated albumin may be a better alternative to HbA1c test for the CKD patients.[12,13]

This study has certain limitations. It was a single-center study, and we could not collect relevant information regarding the first time diagnosis of DM. Patients were exposed to medications, and it was not possible to obtain the details of medication use, food, and behavior related information. As this was a retrospective secondary data analysis, it is hard to explore the possibility of reverse causality. However, the data were derived from a large clinical registry with an adequate quality control.

In conclusions, to the best of our knowledge, this study was the first to assess the relationship of HbA1c and diabetic kidney disease in Thailand. HbA1c did not appear to estimate the actual glycemia in diabetic patients with CKD. Therefore, using conventional cut-off values of HbA1c in diabetic CKD patients may be problematic in the clinical settings. Future investigations are expected to infer the clinical stage at which HbA1c values get unpredictable and identify methods for better detection of glycemic status in diabetic CKD patients.

Conflict of Interests

The authors affirm no conflict of interests in this study.

Acknowledgment

This research study was partially supported by the German Academic Exchange Service (DAAD). The authors would like to thank Professor Frank P. Schelp and Prof. Pattara Sanchaisuriya, Wilaiphorn Thinkhamrop, and Ina Hammesfahr for their guidance and advices. The authors are also grateful to all the staff from Faculty of Public Health, KKU of Thailand and Institute of Tropical Medicine and International Health Berlin, Germany.

REFERENCES

1. Chittinandana A. Thailand renal replacement therapy registry (TRT Registry) report. J Nephrol Soc Thailand. 2000;6:250–5.
2. van Dieren S, Beulens JW, van der Schouw YT, Grobbee DE, Neal B. The global burden of diabetes and its complications: an emerging pandemic. Eur J Cardiovasc Prev Rehabil. 2010;17(suppl 1):S3–8.
3. Islam SM, Purnat TD, Phuong NT, Mwingira U, Schacht K, Fröschl G. Non-communicable diseases (NCDs) in developing countries: a symposium report. Global Health. 2014;10(1):81.
4. Jha V. End-stage renal care in developing countries: the India experience. Ren Fail. 2004;26(3):201–8.
5. Zaman SB. Detection of Chronic Kidney Disease by Using Different Equations of Glomerular Filtration Rate in Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Analysis. Cureus. 2017;9(6):e1352.
6. Rossing K, Christensen PK, Hovind P, Tarnow L, Rossing P, Parving H-H. Progression of nephropathy in type 2 diabetic patients. Kidney Int. 2004;66(4):1596–605.
7. Bhutani J, Bhutani S. Worldwide burden of diabetes. Indian J Endocrinol Metab. 2014;18(6):868–70.
8. Islam SM, Rawal LB, Mainuddin A, Wahiduzzaman M, Niessen LW. Clinical profile of patients with diabetic nephropathy in a tertiary level hospital in Dhaka, Bangladesh. Arch Med Health Sci. 2015;3(2):191.
9. Nitiyanant W, Chetthakul T, Sang-A-kad P, Therakiatkumjorn C, Kunsuikmengrai K, Yeo JP. A survey study on diabetes management and complication status in primary care setting in Thailand. J Med Assoc of Thai. 2007;90(1):65–71.
10. Koenig RJ, Peterson CM, Kilo C, Cerami A, Williamson JR. Hemoglobin AIc as an indicator of the degree of glucose intolerance in diabetes. Diabetes. 1976;25(3):230–2.
11. Zaman SB, Hossain N. Universal Health Coverage: A burning need for developing countries. J Med Res & Innov. 2017;1(1):18–20.
12. Chujo K, Shima K, Tada H, Oohashi T, Minakuchi J, Kawashima S. Indicators for blood glucose control in diabetics with end-stage chronic renal disease: GHb vs. glycated albumin (GA). J Med Invest. 2006;53(3–4):223–8.
13. Freedman BI, Shenoy RN, Planer JA, Clay KD, Shihabi ZK, Burkart JM, et al. Comparison of glycated albumin and hemoglobin A1c concentrations in diabetic subjects on peritoneal and hemodialysis. Perit Dial Int. 2010;30(1):72–9.
14. Inaba M, Okuno S, Kumeda Y, Yamada S, Imanishi Y, Tabata T, et al. Glycated albumin is a better glycemic indicator than glycated hemoglobin values in hemodialysis patients with diabetes: effect of anemia and erythropoietin injection. J Am Soc Nephrol. 2007;18(3):896–903.
15. Zaman SB, Hossain N, Ahammed S, Ahmed Z. Contexts and Opportunities of e-Health Technology in Medical Care. J Med Res & Innov. 2017;1(2):AV1–AV4.
16. Muktabhant B, Sanchaisuriya P, Sarakarn P, Tawityanon W, Trakulwong M, Worawat S, et al. Use of glucometer and fasting blood glucose as screening tools for

diabetes mellitus type 2 and glycated haemoglobin as clinical reference in rural community primary care settings of a middle income country. BMC Public Health. 2012;12:349.
17. www.who.int [Internet]. Use of glycated haemoglobin (HbA1c) in diagnosis of diabetes mellitus: abbreviated report of a WHO consultation. [update 2011; cited May 2017]. Available form: http://www.who.int/cardiovascular_diseases/report-hba1c_2011_edited.pdf
18. Levey AS, Coresh J, Balk E, Kausz AT, Levin A, Steffes MW, et al. National Kidney Foundation practice guidelines for chronic kidney disease: evaluation, classification, and stratification. Ann Inter Med. 2003;139(2):137–47.
19. Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF, Feldman HI, et al. A new equation to estimate glomerular filtration rate. Ann Inter Med. 2009;150(9):604–12.
20. Vos FE, Schollum JB, Coulter CV, Manning PJ, Duffull SB, Walker RJ. Assessment of markers of glycaemic control in diabetic patients with chronic kidney disease using continuous glucose monitoring. Nephrology (Carlton). 2012;17(2):182–8.
21. Agarwal R, Light RP. Relationship between glycosylated hemoglobin and blood glucose during progression of chronic kidney disease. Am J Nephrol. 2011;34(1):32–41.
22. Ly J, Marticorena R, Donnelly S. Red blood cell survival in chronic renal failure. Am J Kidney Dis. 2004;44(4):715–9.
23. Zaman SB. Importance of learning the public health leadership. Public Health Indones. 2017;3(1):1–3.
24. Srivanichakorn S, Sukpordee N, Yana T, Sachchaisuriya P, Schelp FP. Health status of diabetes type 2 patients in Thailand contradicts their perception and admitted compliance. Prim Care Diabetes. 2011;5(3):195–201.
25. Islam S, Rawal L. Setting HbA1c targets for patients with type 2 diabetes. J Diabetol. 2015;2:5.