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Original Article

Changes in blood glucose 2 hours after meals in Type 2 diabetes patients based on length of treatment at Hasanuddin University Hospital, Indonesia

Anna Islamiyati, Fatmawati, Nur Chamidah

Departments of Mathematics, Faculty of Natural Sciences, Hasanuddin University and Faculty of Sciences and Technology, Airlangga University, Indonesia

Objectives: To analyze the changing pattern that occurs in glucose two hours after eating from patients with type 2 diabetes. The changing pattern of glucose is shown based on the length of treatment that varies from 3 to 29 days.

Methodology: Data were obtained from medical records of Type 2 diabetes patients while undergoing treatment at the Hasanuddin University Hospital, Indonesia during 2015-2016. The total number of samples was 418 out of 50 patients. The glucose of type 2 diabetes patients is a longitudinal data which modeled through the penalized quadratic spline regression.

Results: There were four patterns of glucose based on length of treatment in which the pattern indicates that the glucose tends to decrease at the beginning of treatment until the second week of treatment. The glucose increases for the third to the fourth week, so that it needs attention from doctors and patients.

Conclusion: The pattern of glucose change two hours after meals based on treatment duration for a month of treatment tends to change in every week. This shows the need for analysis of the pattern of glucose change at each time interval of a particular treatment. (Rawal Med J 202;45:31-34).

Keyword: Glucose, length of treatment, Type 2 diabetes, Quadratic penalized spline.

INTRODUCTION

One of the glucose measurements recommended by the doctors is the measurement of glucose two hours after eating. This aims to control the precision of nutrients and drugs consumed by the patient. A glucose monitoring program in diabetics has shown that glucose increases after having meals.[1] Two hours glucose after meals is one of the glucose measurements that need a special analysis, because it is related to the nutrients that have been consumed by patients at the time. However, fluctuating and non-trend data is difficult to analyze with parametric approaches. On the other hand, the condition of the increasing and decreasing data is a phenomenon that cannot be accepted. However, it should be able to be explored to provide useful information.

Each glucose pattern provides information relating to both the medical treatment and the patient itself. The recent research on diabetes has examined many factors related to glucose for diabetics. These include body weight,[2] knowledge,[3] unhealthy lifestyles,[4] and genetic factors.[5] For data analysis, researchers have used regression models,[6] chi-square,[7] logistics,[8] hazard rates,[9] and meta analysis.[10] However, these studies have not yet looked in detail about patterns of glucose change in a given interval.

We propose a method of a highly flexible nonparametric regression through a longitudinal study of the penalized spline.[11] Penalized spline can be applied in linear, quadratic, cubic, or in other orders.[12] In this study, we proposed a quadratic penalized spline regression. The excellence of the penalized spline is capable to generate smooth regression curves with more accurate patterns of change at certain intervals.[13] In addition, longitudinal studies will consider the effect of repeated measurements of each patient. The aim of this study was to analyze the changing pattern that occurs in glucose two hours after eating from patients with type 2 diabetes.

METHODOLOGY

This is a longitudinal study which analyzed blood glucose data two hours after meals from type 2 diabetes patients coming to Hasanuddin University Hospital, Indonesia. It was obtained from the

medical records in 2015-2016. We selected 50 hospitalized patients who had glucose measured every day. So, the total data which were analyzed is around 418. We examined blood glucose two hours after meals as the response variable and length of treatment as the predictor variable. We did not involve nutrition in data modeling.

Statistical Analysis: The analysis model used is a quadratic penalized spline regression, which is:

$y_{ij} = f(t_{ij}) + \varepsilon_{r.ij}$, where $f_i(t_{ij}) = \sum_{u=0}^{2} \beta_u (t_{ij})^u + \sum_{v=1}^{d} \beta_{(2+v)} (t_{ij} - K_v)_+^2$, $i = 1, 2, \ldots, n$, and $j = 1, 2, \ldots, m_i$.

The shape of the estimation criteria of the quadratic penalized spline is as follows:

$$Q = \underset{\sim}{y}^T \underset{\sim}{y} - 2\underset{\sim}{\beta}^T \mathbf{X} \underset{\sim}{y}^T + \underset{\sim}{\beta}^T \mathbf{X}^T \mathbf{X} \underset{\sim}{\beta} + \underset{\sim}{\lambda}^T \underset{\sim}{\beta}^T \mathbf{D} \underset{\sim}{\beta}.$$

Where $\underset{\sim}{y}$ is the response vector, $\underset{\sim}{\beta}$ is the coefficient regression, X is the X matrix containing the predictor, is the vector of the smoothing parameter, and D is the diagonal matrix (0.1). The optimal model selection method is based on the minimum Generalized Cross Validation (GCV) value.[14]

RESULTS

The age of the patients ranged from 40-85 years with the patient's weight rangeed from 38-85 kg. For the duration of treatment, there were 3-29 days. Glucose 2 hours after meals ranged from 41-580 mg/dL (Table 1).

Table 1. Characteristics of patients with type 2 diabetes.

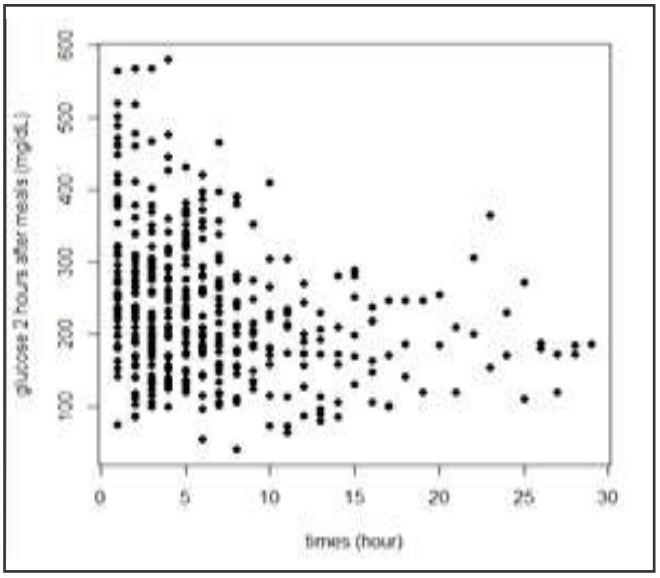
Factor	Minimum	Maximum	Mean±sd
Age	40	85	59.6±10.2
Weight	38	85	59.2±11.8
Length of treatment	3	29	8.36±5.59
Glucose 2 hours after meals	41	580	236.7±97.8

Table 2. The levels of blood glucose two hours after meals based on length of treatment.

Length of treatment (day)	2 hours blood glucose after meals (mg/dL)	mean±sd	Percent
1 – 7	55 – 580	269.8±102.4	56%
8 – 14	41 – 410	193.2±76.1	32%
15 – 21	100 – 289	189.4±58.4	8%
22 – 30	110 – 365	200.6±67.9	4%

The number of patients who stayed in the hospital at the most 7 days was about 56% with average glucose 2 hours after meals 269.8 mg/dL. For 8-14 days of treatment there are about 32% with average glucose 2 hours after meals 193.2 mg/dL (Table 2). Furthermore, blood glucose data were analyzed by nonparametric regression. The first step in the analysis process was the initial data plot. It aimed to look at the trend of data distribution in the *X* and *Y* axes (Fig. 1).

Fig. 1 Plot of glucose two hours after meals data based on length of treatment.

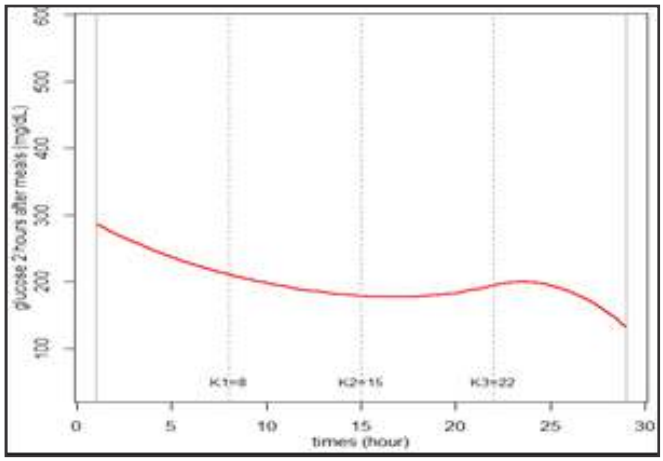


In Figure 1, the interpretation of the pattern of glucose reduction was difficult because of data points that do not form a parametric curve. This pattern looks much more extreme. The data did not establish a pattern spread parametric as we know it in the classic statistical approach.

Penalized spline regression model is the optimal quadratic regression model of a smoothing parameter which provides a minimum GCV value. The minimum value of GCV was 8536.756 at l=0.67. We obtain a regression model of the penalized spline quadratic on glucose 2 hours after a meal that corresponded to the knot point and the optimal smoothing parameter is:

$$y_{ij} = 286{,}65 - 56{,}77 t_{ij} - 126{,}54 t_{ij}^2 - 109{,}58 (t_{ij} - 8)_+^2 - 90{,}47 (t_{ij} - 15)_+^2 - 97{,}82 (t_{ij} - 22)_+^2$$

Fig. 2 Regression curve of the quadratic penalized spline on glucose two hours after meals.



The pattern of changing glucose 2 hours after meals consisted of 4 patterns of change. The first pattern occured on the 1st day until the 8th day. The decrease in glucose continuously occured until the second pattern after day 8 to day 15. The third pattern occured after the 15th day until the 22nd day, in which glucose appeared to increase slowly until the fourth week. The fourth pattern after the 22nd day is glucose keep going down until the patient is discharged from the hospital (Fig. 2).

DISCUSSION

This study is a longitudinal which considered the effect of repetitive time on response. Each patient received inpatient glucose measurements. The patient's age was in the range of 40-85 years. The weight was 38-85 kg with an average weight of about 59.2 kg. This is the age group and body weight susceptible to type 2 diabetes.[15]

Blood glucose data analysis through a model of quadratic spline penalized identified the changing patterns of glucose based on the treatment time. It was able to identify four patterns of glucose changes (Fig. 2). This shows the blood glucose in the first week decreased, so patients choose to be discharged from the hospital. As for patients who are still in the hospital, it is to continue treatment in the second week. They had an average glucose in the second week down to 193.2 mg/dL. This is close to the normal limit of glucose 2 hours after eating (180 mg/dL). The changing pattern of the glucose showed that the effect of diabetes treatment decreased the level of blood glucose in the first and second weeks of treatment.

Other patients continued treatment in the third week. Their average glucose 2 hours after meal was 189.4 mg/dL and it was getting lower than in the previous week. Glucose 2 hours after meals from type 2 diabetic patients was getting normal. The condition of normal glucose of the patient may affect the patient's lifestyle to disobey the rules of care.

Other possibilities, the patient will be bored with the treatment of diabetes. Next, the average glucose in the fourth week was 200.6 mg/dL. This is quite worrying. This is the biggest challenge of diabetes, which is called the awareness of the patient's own self to live a healthy lifestyle.[16] The team of diabetes doctors should monitor and evaluate the usual course of treatment after 2 weeks of hospitalization.

CONCLUSION

Based on the pattern of glucose changes from the quadratic penalized regression, it showed that there was a pattern of increased blood sugar 2 hours after eating that occurred on the 15th to 22nd day of treatment. Therefore, we must examine more closely the patient's condition, medical treatment and the environment together at that time interval.

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Drafting of the article: Anna Islamiyati
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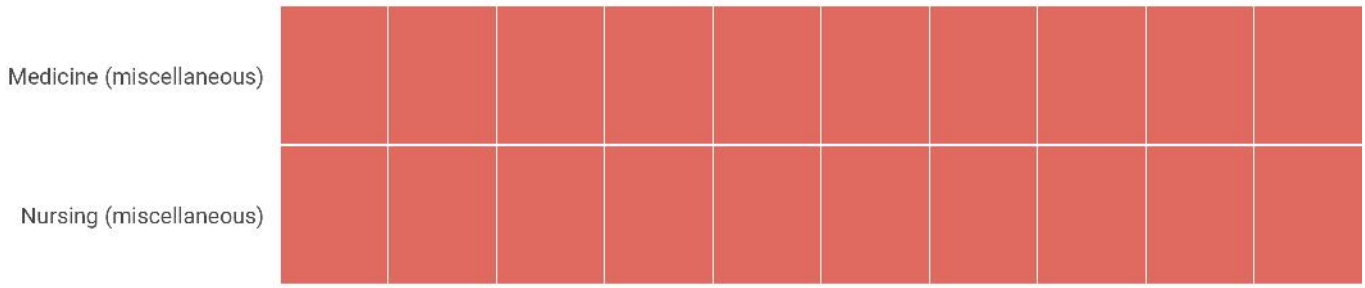

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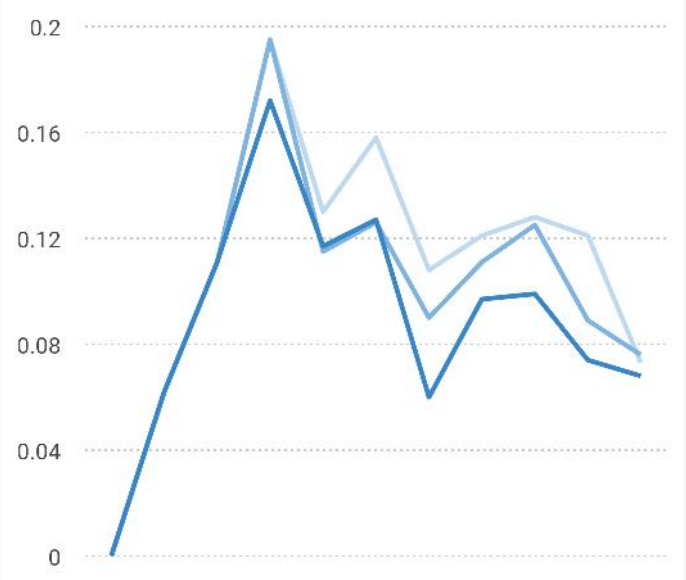

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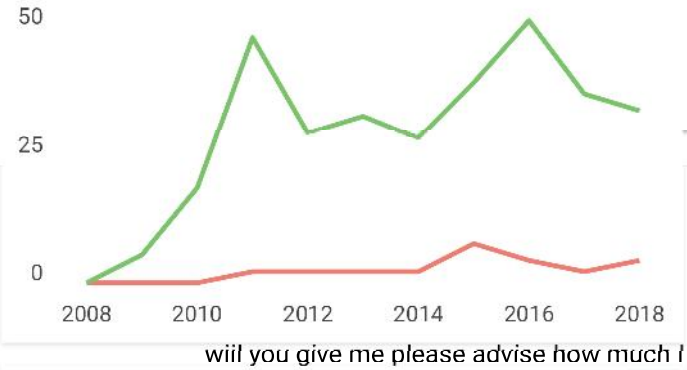

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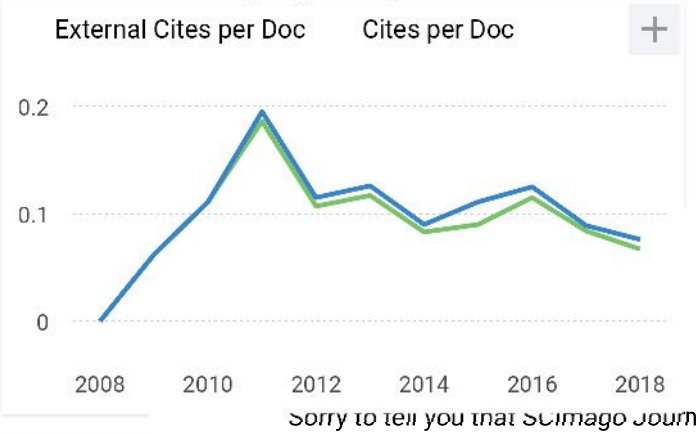

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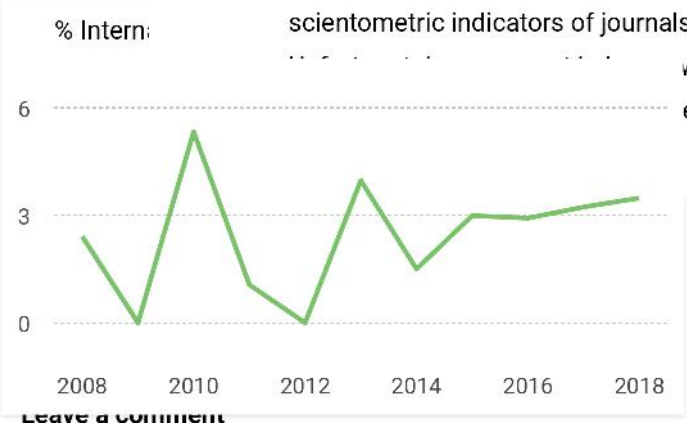

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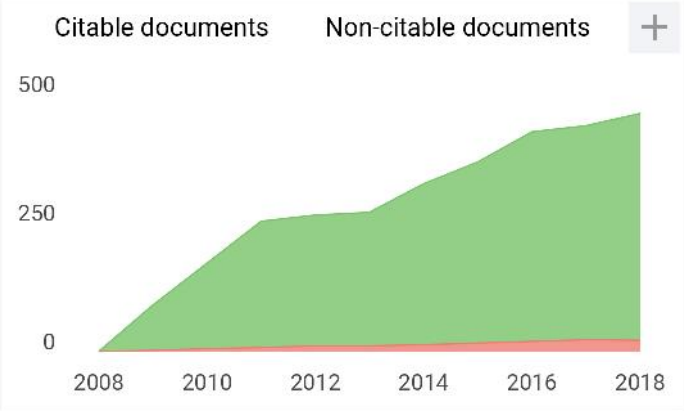

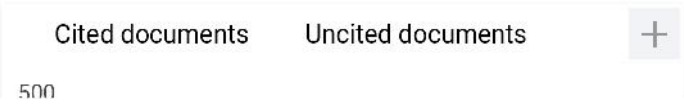

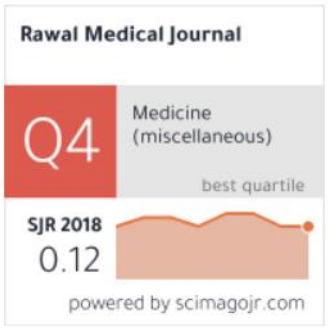

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