

# Analyzing Glycemic Index amongst Individual with Prediabetes after 1 Year Follow Up

NIKEN SD KUSUMANINGRUM<sup>1)</sup>, MUHAMMAD MUIN<sup>2)</sup>

<sup>1</sup>Adult Nursing Division, Department of Nursing, Faculty of Medicine, Diponegoro University  
email: [niken.safitridk@fk.undip.ac.id](mailto:niken.safitridk@fk.undip.ac.id)

<sup>2</sup>Community Nursing Division, Department of Nursing, Faculty of Medicine, Diponegoro University  
Email: [aq1lafw@gmail.com](mailto:aq1lafw@gmail.com)

## ABSTRACT

**Aim:** To analyze the progression of glycemic status of individual in Semarang.

**Methods:** Data on progression of prediabetes was gathered from 23 individuals, who were followed for 12 months. Progression to diabetes and/ or normal glucose tolerance were calculated descriptively and also using the correlation.

**Results:** Results showed that the progression varied. The majority of individuals were on the state of prediabetes, whereas there 1 individual (4.3%) has develop to diabetes. Based on statistical analysis, the correlation between demographic characteristics and glycemic status were not significant. However, clinically it should be considered that all demographic characteristic in individual were important.

**Conclusion:** It is concluded that glycemic status have to monitor periodically in order to know how it is progressed.

**Keywords:** Blood Glucose, Diabetes Mellitus, Glycemic Status, Impaired Fasting Glucose, Prediabetes

---

## INTRODUCTION

Prediabetes is a condition in which blood glucose levels are above normal, but have not met the standards for diagnosing diabetes mellitus<sup>1,2,3</sup>. This condition can continue to become type 2 diabetes if it is not handled properly. Lifestyle and adequate treatment should be organized appropriately in order to prevent the progression of prediabetes.

Early detection of diabetes will guide to control the blood sugar levels, when it is diagnosed earlier<sup>4</sup>. Several recommendations for prediabetes screening and diagnostics have been issued. However, many differences regarding the criteria for Impaired Fasting Glucose (IFG)<sup>6</sup> and Impaired Glucose Tolerance (IGT) still occur. Besides that, previous study has also recommended HbA1c as a form of screening for prediabetes<sup>6,7</sup>.

Prediabetes shows no signs or symptoms. As a result, individuals are not aware with this condition of him. People with prediabetes who can eventually develop into diabetes often experience disruption in work productivity such as not having a permanent job, being absent from work, and unable to work due to complications followed. Thus, comprehensive management of patients can optimize quality of life.

Based on the description of the background, identification of changes in glycemic status in individuals needs to be done. This article aims to present the proportion of changes in glycemic status in individuals.

## METHODS

This study was a longitudinal study with a descriptive research design approach. In its implementation, the study was carried out step by step, starting with non-invasive screening and followed by diagnostic testing. Follow-up was carried out within 1 year to see the changes that occur

in individuals with pre-diabetes. This study has been completed within 2 years.

Non-probability sampling using consecutive sampling technique was carried out to gather the data. These individuals were selected from 21 public health center in the Semarang which were determined by stratified sampling.

In the first year data was collected from 105 respondents, of which 23 were identified as having prediabetes. In second year, data was taken from 23 respondents who had been identified prediabetes in the first year. Non-invasive screening is also done by filling out the questionnaire that include medical history and questions about diabetes risk factors. The question included age, weight and height, abdominal circumference, family health history, and gender.

Oral Glucose Tolerance Test (OGTT) and HbA1c was performed on respondents who met the criteria and based on random blood glucose examination. Respondents with blood glucose levels  $\leq 126$  mg / dL are then scheduled to go to Prodia Clinical Laboratories in Semarang City. The results of invasive examinations include fasting GTT levels, 2 hours GTT, and HbA1c values.

**Data analysis:** The data obtained were then analyzed to determine the frequency distribution and percentage of each measured variable. Some data were also analyzed in the mean  $\pm$  standard deviation (SD). The results obtained are displayed in the form of frequency distribution tables.

**Ethical considerations:** Ethical approval was obtained from Medical and Health Research Ethics Committee (MHREC) of Faculty of Medicine Gadjah Mada University - Dr. Sardjito General Hospital Ref.: KE/FK/719/EC/2016. Informed consent form was also signed by each respondent.

## RESULTS AND DISCUSSION

A total of 105 respondents have participated in this study. Respondents' demographic characteristics are summarized in Table 1. More respondents were women (66.7%) than male. The mean age was  $38.57 \pm 14.84$  (SD) years. The results showed that out of the total respondents, more than twenty per cent of respondents were in prediabetes. Although it just a little, but it need to be overcome.

The glycemic status is determined based on the American Diabetes Association (ADA) standard<sup>8</sup>. It is based on fasting blood glucose levels, blood glucose levels 2 hours after 75 gr oral glucose loading, and HbA1c. Prediabetes is divided into 4 categories, namely (1) Impaired Fasting Glucose (IFG), (2) Impaired Glucose Tolerance (IGT), (3) IFG and IGT, and (4) HbA1c<sup>9,10,11</sup>. IFG is determined when fasting plasma glucose levels are in the range 100 - 125 mg / dL, while the IGT is glucose level after 2 hours glucose loading in the range 140 - 199 mg / dL. The HbA1c examination was determined to be prediabetes if the value was in the range of 5.7 - 6.4%. Moreover, diabetes were categorized if fasting GTT levels were  $\geq 126$  mg / dL, 2 hours GTT  $\geq 200$  mg / dL, and HbA1c  $\geq 6.5\%$

Table 1. Demographic Characteristic (n =105)

Characteristics	n	%
Age (years), mean $\pm$ SD	$38.57 \pm 14.84$	
<b>Gender</b>		
Male	35	33.3
Female	70	66.7
BMI (kg/ m <sup>2</sup> ), mean $\pm$ SD	$23.82 \pm 4.48$	
Waist circumference (cm), mean $\pm$ SD	$83.13 \pm 11.34$	
Physical Activity (Every day)	58	55.2
Vegetables and Fruits consumption (Every day)	51	48.6
Hypertension History (Yes)	19	18,1
History of Increase Blood Glucose Level (Yes)	3	2.9
<b>Family History with Diabetes Mellitus</b>		
Mother	10	9.5
Father	11	10.5
Brother	2	1.9
Sister	3	2.9
Others	9	8.6
Have a baby born with $\geq 4.1$ kg	4	5.97
Fasting Plasma Glucose (mg/dL), mean $\pm$ SD	$87.13 \pm 15.99$	
< 110 mg/dL	101	96.2
110 – 125 mg/dL	2	1.9
$\geq 126$ mg/dL	2	1.9
2-h PG (mg/dL), mean $\pm$ SD	$117.79 \pm 42.85$	
< 140 mg/dL	85	81
140 – 199 mg/dL	16	15.2
$\geq 200$ mg/dL	4	3.8

BMI = body mass index; SD = standard deviation; 2-h PG = 2 hour plasma glucose

Table 2. Glycemic status of respondents in the First Year (n= 105)

Diagnosis criteria	n	%
Normal glucose tolerance (NGT)	78	74.29
Prediabetes	23	21.90
Undiagnosed Diabetes mellitus (DM)	4	3.81
<b>Total</b>	<b>105</b>	<b>100</b>

Table 3: Glycemic Status of Individual with Prediabetes (n=23)

Characteristics	Frequency		Total
	n	%	
<b>Fasting Plasma Glucose (mg/dL), mean <math>\pm</math> SD</b>	23	100	$94.83 \pm 23.96$
< 110 mg/ dL	18	78.3	
110 – 125 mg/dL	4	17.4	
$\geq 126$ mg/dL	1	4.3	
<b>2-h PG (mg/dL), mean <math>\pm</math> SD</b>	23	100	$158.43 \pm 30.78$
< 140 mg/dL	8	34.8	
140 – 199 mg/dL	13	56.5	
$\geq 200$ mg/dL	2	8.7	
<b>HbA1c, mean <math>\pm</math> SD</b>	23	100	$5.47 \pm 0.4$
< 5.7%	14	60.9	
5.7 – 6.4%	9	39.1	
<b>Kategori Prediabetes</b>			
GDPT	0	0	
TGT	13	56.52	
GDPT dan TGT	3	13.04	
HbA1c	4	17.39	
Lainnya	3	13.04	

From table 3, we can see that more than half of prediabetes respondents were in the category of IFG (56.52%). The results of the average fasting GTT and HbA1c examination were in the normal range ( $94.83 \pm 23.96$ ;  $5.47 \pm 0.4$ ). However, if viewed from a 2-hour GTT, the results of the study showed that it was in the range of prediabetes ( $158.43 \pm 30.78$ ).

According to the American Diabetes Association (ADA), pre-diabetes is defined as a glycemic condition in which blood glucose levels exceed normal conditions but have not reached glucose levels in diabetes mellitus<sup>11</sup>. An examination to find out this condition is called the Oral Glucose Tolerance Test (OGTT) which produces fasting blood glucose levels and blood glucose levels after 2 hours glucose loading<sup>12</sup>.

Increased fasting blood glucose levels are found in someone with impaired glucose regulation or IFG is if fasting blood glucose levels are 100-125 mg/ dl and are called diabetes if the blood glucose level is  $\geq 126$  mg/ dl (American Diabetes Association, 2015b). While an increase in blood glucose levels 2 hours after glucose loading of

140-199 mg/ dl is found in someone with impaired glucose tolerance or TGT, and if blood glucose levels 2 hours after glucose loading  $\geq 200$  mg/ dl are called diabetes. Someone with IFG and / or IGT is called prediabetes<sup>11,13,14</sup>. The development of prediabetes into diabetes varies greatly. Several studies have been carried out and give different results for each category of prediabetes experienced, some of which show a lower or even higher proportion than others<sup>15</sup>. The study of prediabetes and its predictors, called CURES, resulted in an incidence of prediabetes of 29.5 per 1000 people/ year. Among these populations in prediabetes, 58.9% turned to diabetes<sup>16</sup>.

The results of this study indicate that the proportion of IGT is greater than IFG, HbA1c, or a combination of IFG and IGT. The results of this study support the results of a study in Depok, West Java which showed that the proportion of IGT was 24.15%, higher than the other categories of prediabetes<sup>17</sup>. In addition, the 2013 National survey also noted that IGT had more numbers than IFG (36.6%; 29.9%)<sup>18</sup>. In fact, the World Health Organization (WHO) also reports that the prevalence of IGT is greater than IFG<sup>14</sup>. However, the results of this study are different from the results of the 2009 Diabetes Care Program of Nova Scotia survey which stated that the prevalence of IFG (6.2%) was higher than the prevalence of IGT (5.3%)<sup>19</sup>. The differences that arise from each phenomenon and the characteristics of this disease are influenced by several conditions. The results of previous studies, in Germany, stated that work stress has an effect on this condition<sup>20,21</sup>. In addition, other studies also revealed that when viewed from race and sex can show varying results on blood glucose levels [22]. The proportion of IGT that is quite high in this study can be caused because most of the respondents are women with an average age of  $46.96 \pm 14.31$ . According to ADA, with increasing age, women are at higher risk of IGT than men because of a decrease in estrogen levels<sup>11</sup>.

IGT has the potential to become diabetic and significantly increase the risk of death. IGT has the potential to become diabetes 6 times greater than normal glucose tolerance. In addition, IGT increases the risk of death 1.48 times higher than normal glucose tolerance<sup>14</sup>. With the results of research showing that individuals with IGT occupy the highest proportion (56.52%), this condition is very important to watch out for.

A total of 23 respondents participated in this study. The majority of respondents were female (60.9%) with an average obesity and central obesity ( $25.65 \pm 4.25$ ;  $88.843 \pm 8.25$ ).

Table 4: Glycemic Status Changes of Respondents with Prediabetes (n = 23)

Glycemic State	Total	
	n	%
Prediabetes to NGT	4	17.4
Prediabetes	18	78.3
Prediabetes to DM	1	4.3

Within 1 year of examination and without any intervention/ treatment, 18 respondents (78.3%) remained in prediabetes status. In addition, there were 4 respondents (17.4%) who showed improvement in blood glucose levels,

which was a category of Normal Glucose Tolerance (NGT). However, there was 1 respondent (4.3%) who actually fell in the DM condition.

When viewed from changes in glycemic status in this study, it was found that the majority of respondents (78.3%) were in the fixed category in the condition of prediabetes. In addition, despite the small proportion, which is 4.3%, there are also individuals who show changes in prediabetes to diabetes. Observations made only for 1 year. This is also one of the things affecting the results obtained.

The results of the study note that the average development of prediabetes to diabetes lasts around 2.5 years<sup>23</sup>. But in other studies, it was stated that the range of development of prediabetes ranged from 3.1 to 6.7 years<sup>24</sup>.

The results of a study by Nichols et al revealed that FBG levels of 90-94 mg / dl were at risk of developing type 2 diabetes by 49%. Whereas in individuals with fasting blood glucose levels of 95-99 mg / dl, they have a risk of 2.33 times as type 2 diabetes compared to 85 mg / dl<sup>15</sup>. In Abdul Gani et al study, one with prediabetes with blood glucose levels 1 hour after loading glucose  $> 155$  mg / dl risked diabetes by 7.4% and increased to 14.3% when accompanied by metabolic syndrome<sup>25</sup>.

Prediabetes is a condition of hyperglycemia that is between normal glucose tolerance and diabetes, or a condition in which blood glucose levels are higher than normal, but lower than the diabetes threshold<sup>26,27</sup>. Prediabetes includes Impaired Glucose Tolerance (IGT)/ Impaired Fasting Glucose (IFG)<sup>28,29</sup>.

Prediabetes can develop into type 2 diabetes and increase the risk of cardiovascular disease<sup>30,31</sup>. In addition, as many as 70% of prediabetes sufferers will develop type 2 diabetes<sup>2</sup>. As many as 5-10% of people with prediabetes will suffer from diabetes every year, however prediabetes can return to normoglycemia and remain prediabetes<sup>29</sup>. The study also states that a person with prediabetes with IGT only takes less than 3 years to develop diabetes<sup>32,33</sup>. Prediabetes is enforced if there is IFG and / or IGT

## CONCLUSION

It is concluded that most individuals remain in the prediabetes category. The development of prediabetes to diabetes only occurs in 4.3% of individuals.

**Funding:** Diponegoro University had supported the funding of this study.

**Acknowledgement:** Authors acknowledge and thank to all respondents participated in this study. Thank also delivered to Prodia Clinical Laboratory for analyzing the blood sample.

**Conflict of interest:** The authors declared no potential conflict of interest respect to the research, authorship, and/ or publication of this article.

## REFERENCES

1. Canadian Diabetes Association. Prediabetes. 2013 p. 1–2.
2. American Diabetes Association. Standards of Medical Care in Diabetes — 2015. Diabetes Care. 2015;38 (Supple(January):S1–94.
3. National Institute of Diabetes and Digestive and Kidney Disease. Diagnosis of diabetes and prediabetes. Natl Inst

- Diabetes Dig Kidney Dis. 2014;
4. Soewondo P. Harapan Baru Penyandang Diabetes Mellitus pada Era Jaminan Kesehatan Nasional 2014 \*. 2014;2(1):245–50.
  5. Cheng C, Kushner H, Falkner BE. The utility of fasting glucose for detection of prediabetes. *Metabolism* [Internet]. 2006 Apr [cited 2016 Jan 26];55(4):434–8.
  6. Olson D., Rhee M., Herrick K, Ziemer D., Twombly J., Phillips LS. Screening for Diabetes and Prediabetes With Proposed A1c-Based Diagnostic Criteria. *Diabetes Care*. 2010;33(10):2184–9.
  7. Tentolouris N, Lathouris P, Lontou S, Tzemos K, Maynard J. Screening for HbA1c-defined prediabetes and diabetes in an at-risk greek population: performance comparison of random capillary glucose, the ADA diabetes risk test and skin fluorescence spectroscopy. *Diabetes Res Clin Pract* [Internet]. 2013 Apr [cited 2016 Feb 10];100(1):39–45.
  8. Dedoussis G V, Manios Y, Kourlaba G, Kanoni S, Lagou V, Butler J, Papoutsakis C, Scott RA, Yannakoulia M, Pitsiladis YP, Hirschhorn JN, Lyon HN. An age-dependent diet-modified effect of the PPAR $\gamma$  Pro12Ala polymorphism in children. *Metabolism* [Internet]. 2011 Apr;60(4):467–73.
  9. Drouin P, Blicke JF, Charbonnel B, Eschwege E, Guillausseau PJ, Plouin PF, Daninos JM, Balarac N, Sauvanet JP. Diagnosis and classification of diabetes mellitus. Porte D, Sherwin RS, Baron A, editors. *Diabetes Care* [Internet]. 2009;32(Supplement\_1):S62–7.
  10. Lipska KJ, Inzucchi SE, Van Ness PH, Gill TM, Kanaya A, Strotmeyer ES, Kostor A, Johnson KC, Goodpaster BH, Harris T, De Rekeneire N. Elevated HbA1c and fasting plasma glucose in predicting diabetes incidence among older adults: Are two better than one? *Diabetes Care*. 2013;36(12).
  11. American Diabetes Association. 2015 American Diabetes Association (ADA) Diabetes Guidelines; Summary Recommendations from NDEI. *Am Diabetes Assoc*. 2015;38(sup1):1.
  12. Chowdhury AMR, Bhuiya A, Chowdhury ME, Rasheed S, Hussain Z, Chen LC. The Bangladesh paradox: exceptional health achievement despite economic poverty. *Lancet* [Internet]. 23AD Nov 29;382(9906):1734–45.
  13. Garber AJ, Handelsman Y, Einhorn D, Bergman D a, Bloomgarden ZT, Fonseca V, Garvey WT, Gavin JR, Grunberger G, Horton ES, Jellinger PS, Jones KL, Lebovitz H, Levy P, McGuire DK, Moghissi ES, Nesto RW. Diagnosis and management of prediabetes in the continuum of hyperglycemia: when do the risks of diabetes begin? A consensus statement from the American College of Endocrinology and the American Association of Clinical Endocrinologists. *Endocr Pract*. 2008;14(7):933–46.
  14. World Health Organization. Definition and diagnosis of diabetes mellitus and intermediate hyperglycaemia: Report of a WHO/IDF Consultation. Geneva; 2006.
  15. Nichols GA, Hillier TA, Brown JB. Normal fasting plasma glucose and risk of type 2 diabetes diagnosis. *Am J Med*. 2008;121(6):519–24.
  16. Anjana RM, Rani CSS, Deepa M, Pradeepa R, Sudha V, Nair HD, Lakshmi Priya N, Subhashini S, Binu VS, Unnikrishnan R, Mohan V. Incidence of Diabetes and Prediabetes and Predictors of Progression Among Asian Indians: 10-Year Follow-up of the Chennai Urban Rural Epidemiology Study ( CURES ). *Diabetes Care*. 2015;38(August):1441–8.
  17. Yunir E, Waspadji S, Rahajeng E. The pre-diabetic epidemiological study in Depok, West Java. *Acta Med Indones*. 2009;41(4):181–5.
  18. Indonesian Ministry of Health. Profil Kesehatan Indonesia. 2014.
  19. Diabetes Care Program of Nova Scotia. Upstream screening and community intervention for prediabetes and undiagnosed type 2 diabetes. 2009;
  20. Jarczok MN, Koenig J, Li J, Mauss D, Hoffmann K, Schmidt B, Fischer JE, Thayer JF. The association of work stress and glycemic status is partially mediated by autonomic nervous system function: Cross-sectional results from the Mannheim Industrial Cohort Study (MICS). *PLoS One*. 2016;11(8).
  21. Li J, Jarczok MN, Loerbroks A, Schöllgen I, Siegrist J, Bosch JA, Wilson MG, Mauss D, Fischer JE. Work stress is associated with diabetes and prediabetes: Cross-sectional results from the MIPH industrial cohort studies. *Int J Behav Med*. 2013;20(4).
  22. Gujral UP, Mohan V, Pradeepa R, Deepa M, Anjana RM, Mehta NK, Gregg EW, Narayan KM. Ethnic variations in diabetes and prediabetes prevalence and the roles of insulin resistance and  $\beta$ -cell function: The CARRS and NHANES studies. *J Clin Transl Endocrinol*. 2016;4:19–27.
  23. Yokota N, Miyakoshi T, Sato Y, Nakasone Y, Yamashita K, Imai T, Hirabayashi K, Koike H, Yamauchi K, Aizawa T. Journal of Diabetes and Its Complications Predictive models for conversion of prediabetes to diabetes. *J Diabetes Complications* [Internet]. 2017;31(8):1266–71.
  24. Kim C, Kim H, Kim E, Bae S, Choe J, Park J. Risk of progression to diabetes from prediabetes defined by HbA1c or fasting plasma glucose criteria in Koreans. *Diabetes Res Clin Pract* [Internet]. 2016;118:105–11.
  25. Study B. Concentration and the Risk for Future Type. 2009;32(2).
  26. Mata-Cases M, Artola S, Escalada J, Ezkurra-Loyola P, Ferrer-García JC, Fornos JA, Gírbés J, Rica I. Consensus on the detection and management of prediabetes. Consensus and Clinical Guidelines Working Group of the Spanish Diabetes Society. *Rev Clínica Española* (English Ed [Internet]. 2015 Mar [cited 2015 Oct 28];215(2):117–29.
  27. Shahady EJ. Diabetes and Prediabetes : New Guidelines for Diagnosis and Controversy Over Treatment Goals. 2011;(August).
  28. Bansal N. Prediabetes diagnosis and treatment: A review. *World J Diabetes* [Internet]. 2015;6(2):296.
  29. Tabák AG, Herder C, Rathmann W, Brunner EJ, Kivimäki M. Prediabetes: a high-risk state for diabetes development. *Lancet* (London, England) [Internet]. 2012 Jun 16 [cited 2016 Jan 18];379(9833):2279–90.
  30. Calanna S, Scicali R, Di Pino A, Knop FK, Piro S, Rabuazzo AM, Purrello F. Lipid and liver abnormalities in haemoglobin A1c-defined prediabetes and type 2 diabetes. *Nutr Metab Cardiovasc Dis* [Internet]. 2014 Jun [cited 2016 Jan 11];24(6):670–6.
  31. Graham E, Gariépy G, Burns RJ, Schmitz N. Demographic, lifestyle, and health characteristics of older adults with prediabetes in England. *Prev Med* (Baltim) [Internet]. 2015 Aug [cited 2015 Oct 12];77:74–9.
  32. Bae JC, Rhee EJ, Lee WY, Park SE, Park CY, Oh KW, Park SW, Kim SW. Optimal range of HbA1c for the prediction of future diabetes: a 4-year longitudinal study. *Diabetes Res Clin Pract* [Internet]. 2011 Aug [cited 2016 Jan 25];93(2):255–9.
  33. Heianza Y, Hara S, Arase Y, Saito K, Fujiwara K, Tsuji H, Kodama S, Hsieh SD, Mori Y, Shimano H, Yamada N, Kosaka K, Sone H. HbA1c 5.7-6.4% and impaired fasting plasma glucose for diagnosis of prediabetes and risk of progression to diabetes in Japan (TOPICS 3): a longitudinal cohort study. *Lancet* (London, England) [Internet]. 2011 Jul 9 [cited 2016 Jan 25];378(9786):147–55.