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Original Article

Prediabetes, undiagnosed diabetes, and associated factors in North Sumatra, Indonesia: A community-based study

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Abstract

Diabetes causes disability, morbidity, and cost burden. It develops faster in individuals with prediabetes. Approximately 50% of patients with diabetes remain undiagnosed until physical complications appear. This study aimed to determine the prevalence of prediabetes and undiagnosed diabetes based on fasting blood glucose levels and associated factors in a community in Indonesia. This community-based cross-sectional study applied the convenience sampling technique. Participants included 412 adults without a history of type 2 diabetes. The fasting blood sugar levels of the respondents were measured after fasting for at least eight hours. The American Diabetes Association guidelines were followed to identify individuals with prediabetes and undiagnosed diabetes. The study results revealed a 27% prevalence of prediabetes and a 20% prevalence of undiagnosed diabetes in the respondents. The bivariate analysis did not show any significant difference between the risks of normoglycemia and prediabetes. However, three significantly different diabetes risk variables were identified between normoglycemia and undiagnosed diabetes: age, having experienced elevated blood glucose levels during a health check-up, and having a family member who has diabetes ($p<0.05$). The incidences of prediabetes and undiagnosed diabetes were high among the study population. Therefore, efforts should be made to prevent the development of prediabetes into diabetes and to manage individuals with undiagnosed diabetes to reduce its prevalence and complications in the future.

Keywords: diabetes mellitus, diabetes risk, prediabetes, undiagnosed, Indonesia.

Introduction

Diabetes mellitus has various causes, including a chronic increase in blood glucose levels and impaired metabolism of carbohydrates, proteins, and fats because of abnormal insulin secretion or insulin action [1]. The total number of adults with diabetes worldwide was 366 million in 2011, which increased to 537 million—with a prevalence of 10.5%—by the end of 2021. This number has been continuously increasing. It is estimated that worldwide, by 2030 and 2045, 643 million and 783 million people, respectively, will be afflicted by diabetes. In Indonesia, the number of people with diabetes was 7.3 million in 2011, which increased to 19.5 million—with a prevalence of 10.8%—in 2021. It is estimated that by 2045, this number will be 28.6 million [2].

Diabetes poses burdens such as disability, morbidity, and cost. The most common factor for the burden experienced by people with diabetes is complications in the blood vessels [3]. Diabetic complications develop gradually and can be categorized as microvascular (peripheral nerve, kidney, and retinal disorders) or macrovascular (atherosclerosis, heart attack, and stroke) complications [4, 5]. Complications associated with diabetic foot ulcers (DFUs) are also common [6]. Owing to these issues, people with diabetes experience poor quality of life, substantial healthcare-related costs, and a high risk of death [7, 8]. In Indonesia, the most common

complications include diabetic neuropathy (64%), diabetic retinopathy (42%), microvascular complications (28%), macrovascular complications (16%), and diabetic nephropathy (7%)—in that order [9]. Globally, the total health cost associated with diabetes in 2021 was USD 966 billion [2]. By 2045, it is estimated to reach USD 1,054 million [10].

Prediabetes—also known as intermediate hyperglycemia [2]—could be defined as an increase in blood sugar levels close to that of diabetes but is not categorized as diabetes. Individuals with prediabetes are not affected by diabetes but remain at a high risk of developing similar complications. Globally, the number of individuals with prediabetes was estimated to be 374 million in 2019. Without intervention, prediabetes could progress to diabetes at the rate of 6.8% [11]—in other words, a 20-times likelihood. However, as the symptoms are not severe, they may remain unnoticed for more than a decade [12].

Globally, an estimated 50% of patients with diabetes remain undiagnosed [13, 14] and, therefore, untreated for an extended period, which increases the risk of complications. Additionally, among individuals aged 51 years and older, the symptoms are considered a result of the aging process, and thus, the disease remains undiagnosed [12]. Studies in Kenya and Nigeria have shown that approximately 50% of the population is living with undiagnosed diabetes, and more than 60% of them have reported diabetic retinopathy with a poor prognosis [15]. The number of undiagnosed cases of diabetes is quite high in countries with significant populations of individuals with diabetes—these include Indonesia, India, and China. The highest proportions of undiagnosed cases of diabetes have been reported in Mozambique, Uzbekistan, Indonesia, and Afghanistan.

The total number of undiagnosed cases of diabetes in Indonesia is expected to reach approximately 15 million by 2021—that is, 73.7% of the total population [2]. Prediabetes and undiagnosed diabetes are more prevalent in populations with low education, low income, sedentary lifestyles, unhealthy diets, and barriers to screening for diabetes in developing countries [12].

Individuals with prediabetes or undiagnosed diabetes experience adverse effects on their metabolic health similar to those experienced by individuals with diabetes, although the latter is generally more severe. Inappropriate, or lack of, treatment of prediabetes or undiagnosed diabetes could impose heavy burdens on an individual's health and a country's economy [13]. In the absence of diabetes prevention efforts, annual cases of diabetes will continue to increase, resulting in increased disability and morbidity. Therefore, preventive interventions are required to ascertain diabetes risk factors [16] and identify and screen individuals with prediabetes or undiagnosed diabetes.

In Indonesia, the Ministry of Health has implemented a diabetes prevention and management program called the non-communicable disease-integrated coaching post (*Posbindu* PTM). The *Posbindu* PTM involves community members in the ongoing screening and monitoring of non-communicable diseases. It is conducted in five stages of service, called the 5-table system, with the following activities: registration, interview, physical examination, diagnostic examination, non-communicable disease risk factor identification, education, and follow-up [17]. Screening—this includes measurement of blood pressure, random blood sugar levels, and body mass index—is independently performed by many community members; however, a few of them require assistance from *Posbindu* PTM [18] health workers, such as nurses [17].

Nurses play a crucial role in preventing diabetes and related complications. Among all health professionals, they spend the maximum time performing health services such as assessment, diagnosis, treatment, coordination, and patient education [19]. Their involvement in diabetes prevention programs could alleviate the cost burden and mitigate the symptoms posed by the disease [19]. Diabetes nurses provide care, training, and support via diabetes screening and prevention programs to assist patients in performing self-care. They impart education regarding diet and lifestyle management, as well as diabetes treatment and control [20]. Furthermore, they perform an essential role in diabetes management, including foot examinations and annual routine check-ups. Their other roles include screening, maintaining health to avoid complications, and supporting patients with diabetes. As part of professional healthcare, nurses can promote diabetes prevention in the community using a holistic approach and providing adequate primary nursing care [20]. This study aimed to determine the prevalence of prediabetes, undiagnosed diabetes, and its associated factors in the North Sumatra Province, Indonesia.

Material and methods

This study applied a descriptive cross-sectional design in a sub-district (Deli Tua), a regency (Deli Serdang), and a province (North Sumatra) of Indonesia.

The sample size was determined using the formula of Cochran (1963 for Israel) [21]:

$$N = \frac{Z^2 p.q}{e^2}$$

Z = Z score for confidence level of 95%, $\frac{\alpha}{2} = 1.96$
e = level of precision
p = estimated proportion
q = 1-p.

$$N = \frac{(1.96)^2 (.5)(.5)}{(.05)^2} = 385.$$

The researchers added that more than 7% of the respondents met the non-response criteria. The total number of respondents was (385+27=) 412. The convenience sampling technique was employed because of concerns regarding COVID-19 during data collection. Thus, we selected individuals who were willing to participate. The inclusion criteria included the following: no history of type 2 diabetes, willingness to respond, ability to read and write in Indonesian, and willingness to fast for at least 8 hours.

This study utilized tools developed by Lindström and Tuomilehto [22] to identify diabetes risk factors and a glucometer (Bioptik Technology Inc. Taiwan) to measure the fasting blood glucose levels. Risk factors for diabetes included age, body mass index, abdominal circumference, physical activity, vegetable or fruit consumption, hypertension, increased blood sugar levels, and relatives with diabetes.

An individual is defined as having prediabetes if the fasting blood sugar levels are between 100 and 125 mg/dL and as having diabetes if the fasting blood sugar levels are 126 mg/dL or higher [23]. In this study, individuals were declared to have undiagnosed diabetes if their elevated blood sugar levels met the criteria for diabetes mellitus but had never been diagnosed [14].

Assessment of diabetes risk factors was performed by trained health cadres. Fasting blood glucose levels were checked by trained health workers permanently assigned by the government to provide health services to community members. The study was conducted in a community between May and October 2020.

Data on prediabetes and undiagnosed diabetes were analyzed using descriptive statistics. Furthermore, data on the associated factors were analyzed using statistical inferential methods. Statistical significance was obtained when the p-value was <0.05. SPPS version 23 was used for statistical analysis.

Results

The sample size of 412 included 98 men (24%) and 314 women (76%). Based on the results of fasting blood glucose tests, 216 (53%) respondents had normal blood glucose levels, 113 (27%) had prediabetes, and 83 (20%) had undiagnosed diabetes (Figure 1 and Table 1).

Among the 113 (27%) respondents with prediabetes, 52% were aged <45 years. The percentages of overweight, obese, and centrally obese individuals were 28.3%, 66.4%, and 87.6%, respectively. Physical activity for at least 30 minutes daily (99.1%); consuming vegetables, fruits, or berries every day (59.3%); not taking any medication for hypertension (92.0%); having no history of high blood glucose (99.1%); and no family history of diabetes (85.8%).

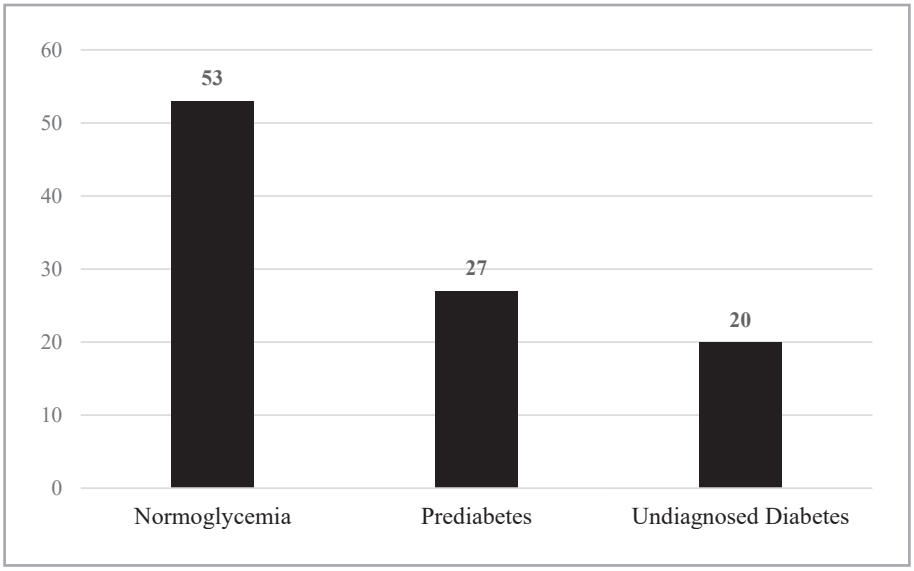

Figure 1: Percentage of normoglycemia, prediabetes, and undiagnosed diabetes (N=412).

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Table 1: Distribution and percentage of normoglycemia, prediabetes, and undiagnosed diabetes by diabetes risk factors from study participants (N=412).

Variable	Total (%)	Normoglycemia (%)	Prediabetes (%)	Undiagnosed diabetes (%)
Age (year)				
<45	179 (43.4)	101 (46.8%)	52 (46.0%)	26 (31.3%)
45–54	101 (24.5)	59 (27.3%)	25 (22.1%)	17 (20.5%)
55–64	93 (22.6)	42 (19.4%)	28 (24.8%)	23 (27.7%)
>64	39 (9.5)	14 (6.5%)	8 (7.1%)	17 (20.5%)
Body mass index (kg/m^2)				
<22	40 (9.7)	25 (11.6%)	6 (5.3%)	9 (10.8%)
22–25	112 (27.2)	63 (29.2%)	32 (28.3%)	17 (20.5%)
>25	260 (63.1)	128 (59.3%)	75 (66.4%)	57 (68.7%)
Waist circumference (cm; men/women)				
<90/80	87 (21.1)	58 (26.9%)	14 (12.4%)	15 (18.1%)
90–98/80–88	141 (34.2)	81 (37.5%)	40 (35.4%)	20 (24.1%)
>98/88	184 (44.7)	77 (35.6%)	59 (52.2%)	48 (57.8%)
Physical activity				
Yes	406 (98.5)	214 (99.1%)	112 (99.1%)	80 (96.4%)
No	6 (1.5)	2 (0.9%)	1 (0.9%)	3 (3.6%)
Consuming vegetables, fruits, or berries				
Every day	249 (60.4)	130 (60.2%)	67 (59.3%)	52 (62.7%)
Not every day	163 (39.6)	86 (39.8%)	46 (40.7%)	31 (37.3%)
Medication for hypertension				
No	380 (92.2)	203 (94.0%)	104 (92.0%)	73 (88.0%)
Yes	32 (7.8)	13 (6.0%)	9 (8.0%)	10 (12.0%)
History of high blood glucose				
No	404 (98.1)	215 (99.5%)	112 (99.1%)	77 (92.8%)
Yes	8 (1.9)	1 (0.5%)	1 (0.9%)	6 (7.2%)
History of family with diabetes				
No	341 (82.8)	186 (86.1%)	97 (85.8%)	58 (69.9%)
Yes: 2nd degree	22 (5.3)	11 (5.1%)	5 (4.4%)	6 (7.2%)
Yes: 1st degree	49 (11.9)	19 (8.8%)	11 (9.7%)	19 (22.9%)

Of the 83 (20%) respondents with undiagnosed diabetes, 69.7% were aged >45 years. The percentages of overweight, obese, and centrally obese individuals were 20.5%, 68.7%, and 81.9%, respectively. Respondents who performed physical activity for at least 30 minutes every day (96.4%); consumed vegetables, fruits, or berries every day (62.7%); did not take any medication for hypertension (88.0%); had no history of high blood glucose (92.8%); and had no family history of diabetes (69.9%) (Table 2).

No significant association was observed between the risk of diabetes and prediabetes. However, there was a significant association between three diabetes risk factors and undiagnosed diabetes: age, having experienced increased blood sugar levels, and having relatives with diabetes ($p<0.05$).

Table 2: Factors associated with prediabetes and undiagnosed diabetes among the respondents (N=412).

Variable	Normoglycemia *versus* prediabetes		Normoglycemia *versus* undiagnosed diabetes	
	X^2	p-value	X^2	p-value
Age (year)	1.82	.610	17.6	.001
BMI (kg/m²)	3.71	.156	2.57	.276
Waist circumference (cm; men/women)	N/A	N/A	N/A	N/A
Physical activity	-	1.00	-	.133
Consuming vegetables, fruits, or berries	-	.906	-	.791
Medication for hypertension	-	.495	-	.092
History of high blood glucose	-	1.00	-	.002
History of family with diabetes	140	.932	11.79	.003

Discussion

Prediabetes

The results revealed a 27% prevalence of prediabetes—this may be due to the unavailability of screening programs in the study area. A study with a similar result was conducted in Paris, France (27.2%) [24] and approximately 84 million (34%) individuals in the U.S. [25]. The results of a secondary data analysis based on national-scale survey data in Indonesia revealed the prevalence as follows: rural areas (44.8%), urban areas (34.9%) [26], Mexican Americans (32%) [27], Catalonia, Spain (39.3%) [28], Mexican Americans (44.2%) [29], Kuwaiti Americans (47.9%) [30], and Shanghai, China (52.3%) [31]. A systematic review of dental settings using random blood glucose levels showed that the estimated proportion of prediabetes was 47.38% [32].

The results of the current study are higher than those of several other studies: in the Danish population (5.8%) [33], a national-scale study in France (7.2%) [34], in Kuwait (11.1%) [35], in Canada (12.4%) [36], in the north-central part of Ethiopia (14.5%) [14], northeast Ethiopia (15.7%) [37], Vietnam (17.9%) [38], Mexico (20.9%) [39], and Luxembourg (25.6%) [40]. A meta-analysis of the population of the eastern Mediterranean region revealed a 12.19% prevalence of prediabetes [41], whereas a systematic review of the East African population suggested a 12.58% prevalence of prediabetes [42].

This study did not identify a significant association between the risk of diabetes and prediabetes; however, a systematic review of East African populations did [42]. Older adults were 1.64 times more likely to develop prediabetes than those aged 18–24; individuals with hypertension were 2.43 times more likely to develop prediabetes; and overweight and obese respondents were 1.7 times more likely to develop prediabetes [42]. According to the results of a cohort study, age was correlated with prediabetes and diabetes, which rapidly increased after age 50 [24].

Insulin resistance causes prediabetes. Insulin resistance is necessary to maintain glucose homeostasis; however, if it persists for an extended period, it can adversely impact the ability of the pancreas to produce sufficient amounts of insulin to maintain normal blood sugar levels [43]. Approximately 5–10% of prediabetes patients develop diabetes [24]. Overall, the condition of prediabetes persistence is preferable to that of diabetes. Nonetheless, it leaves a patient vulnerable to the same diseases experienced by diabetics—for example, diseases of the heart, blood vessels, and so on [44].

For diabetes prevention, lifestyle changes—for example, reducing consumption of carbohydrates—are preferable to lifestyle interventions [45]. With lifestyle modifications, the incidence of prediabetes can decrease by 40–70% [24]. The first step to prevent diabetes is screening to identify abnormal blood glucose levels in overweight or obese individuals and in men over 50 years of age [24].

Undiagnosed diabetes

The results of the current study showed that 20% of the respondents had undiagnosed diabetes. This may be due to the need for greater awareness among the respondents. Similar to this study, the results of a study on a Danish suburban population revealed that more than 20% of people with diabetes remained

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undiagnosed [46]. The results of the study were higher in Paris, France (27%) [24] and northeast Ethiopia (72.5%) [37]. A systematic review of dental settings using random blood glucose levels revealed that the estimated proportion of undiagnosed diabetes was 47.38% [32].

However, many studies have reported a lower prevalence; for instance, a national-scale study in France identified that the prevalence of undiagnosed diabetes was 1.6% [34], immigrants in the U.S. (2%) [47], Russia (3.2%) [48], Catalonia, Spain (3.4%) [28], the north-central part of Ethiopia (4.5%) [14], the Indian population (6.0%) [49], the Danish population (6.1%)—the ratio between the diagnosed and undiagnosed cases was 5.3:0.8 [33]—, Kuwaiti (6.9%) [30], and the Canadian population revealed that 2.8% of the cases of diabetes (7.5%) were undiagnosed [36]. A meta-analysis of an eastern Mediterranean population showed a 5.46% prevalence of undiagnosed diabetes [41].

Additionally, there was a significant association among age, having experienced increased blood sugar levels, and having relatives with diabetes or undiagnosed diabetes ($p<0.05$). Changes in lifestyle and dietary patterns can reduce progression from prediabetes to diabetes. The sooner the diagnosis, the better the likelihood of preventing and mitigating complications by administering antidiabetic medication and changing lifestyle and dietary patterns [34]. People with undiagnosed diabetes usually focus only on other health problems, such as hypertension; therefore, they rarely visit healthcare centers for diabetes. Patients with diabetes show no difference in attendance of general practitioners in the healthcare system based on socioeconomics [46].

This study employed a cross-sectional approach; therefore, the results cannot be used to determine the causal relationships among the variables. Furthermore, the current study has used only the fasting blood sugar levels without following up with HbA1c (or oral glucose tolerance test) to measure blood glucose parameters; therefore, the results can be underestimated.

Conclusion

The current study showed a high prevalence of prediabetes and undiagnosed diabetes in Deli Serdang Regency, North Sumatra, Indonesia. Diabetes risk factors and their relationships with prediabetes and undiagnosed diabetes were identified. Therefore, preventive efforts focusing on modifiable factors are expected to reduce the prevalence of complications. Nurses can play the role of educators in diabetes prevention and management, especially those involved in the *Posbindu* PTM program.

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Conflict of interest

The authors declare no conflict of interest.

Ethics approval

Ethical approval was received from the Institutional Review Board of Universitas Sumatera Utara (number 232/KEP/USU/2020).

Consent to participate

Prior to data collection, all respondents were briefed on the objectives and risks of the study, and thereafter, they signed an informed consent form.

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References

1. Alberti KGMM. The Classification and Diagnosis of Diabetes Mellitus. In: Holt RIG, Cockram CS, Flyvbjerg A, Goldstein BJ, editors. Textbook of Diabetes. 4th ed. UK; 2010. p. 24–30.
2. IDF. IDF Diabetes Atlas. 2021.
3. Chen S, Hou X, Sun Y, Hu G, Zhou X, Xue H, et al. A seven-year study on an integrated hospital-community diabetes management program in Chinese patients with diabetes. Prim Care Diabetes. 2018;12(3):231–7.
4. Larsen TLJ, Jørgensen ME, Pedersen ML, Lund-Andersen H, Valerius M, Juul E, et al. Low prevalence of retinopathy among Greenland Inuit. Int J Circumpolar Health. 2021;80(1):1–5.

5. Bai L. Using Guessing Game to Increase Complication Awareness of Patients with Newly Diagnosed Type 2 Diabetes. Acta Endocrinol. 2018;14(3):401–7.
6. Jiang L, Liu S, Li H, Xie L, Jiang Y. The role of health beliefs in affecting patients' chronic diabetic complication screening: a path analysis based on the health belief model. J Clin Nurs. 2021 Oct;30(19–20):2948–59.
7. Owolabi EO, Goon DT, Ajayi AI, Adeniyi O V., Chu KM. Coverage of diabetes complications screening in rural Eastern Cape, South Africa: A cross-sectional survey. South African Fam Pract. 2022 Apr;64(1):1–6.
8. Park Y shin, Kim SY, Park EC, Jang SI. Screening for Diabetes Complications during the COVID-19 Outbreak in South Korea. Int J Environ Res Public Health. 2022;19(9):5436.
9. Soewondo P, Soegondo S, Suastika K, Pranoto A, Soeatmadji DW, Tjokroprawiro A. The DiabCare Asia 2008 study – Outcomes on control and complications of type 2 diabetic patients in Indonesia. Med J Indones. 2010;19(4):235.
10. Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, et al. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res Clin Pract. 2022 Jan;183(5):109119.
11. Lim SL, Ong KW, Johal J, Han CY, Yap QV, Chan YH, et al. A Smartphone App-Based Lifestyle Change Program for Prediabetes (D'LITE Study) in a Multiethnic Asian Population: A Randomized Controlled Trial. Front Nutr. 2022 Jan 24;8(January):1–10.
12. dos Santos ESM, Máximo RDO, de Andrade FB, de Oliveira C, Lima-Costa MF, Alexandre TDS. Differences in the prevalence of prediabetes, undiagnosed diabetes and diagnosed diabetes and associated factors in cohorts of Brazilian and English older adults. Public Health Nutr. 2021;24(13):4187–94.
13. Fisher-Hoch SP, Vatcheva KP, Rahbar MH, McCormick JB. Undiagnosed diabetes and prediabetes in health disparities. PLoS One. 2015;10(7):1–10.
14. Damtie S, Workineh L, Berhan A, Tiruneh T, Legese B, Getie B, et al. The magnitude of undiagnosed diabetes mellitus, prediabetes, and associated factors among adults living in Debre Tabor town, northcentral Ethiopia: A community-based cross-sectional study. Heliyon. 2023;9(7):e17729.
15. Maseko SN, van Staden D, Mhlongo EM. The Rising Burden of Diabetes-Related Blindness: A Case for Integration of Primary Eye Care into Primary Health Care in Eswatini. Healthcare. 2021;9(7):1–15.
16. Tarigan M, Setiawan, Tarigan R, Imelda F, Jongudomkarn D. Identifying diabetes risks among Indonesians: A cross-sectional study in a community setting. Belitung Nurs J. 2024;10(1):41–7.
17. Ministry of Health. Petunjuk Teknis Pos Pembinaan Terpadu Penyakit Tidak Menular (Posbindu PTM). Jakarta; 2012.
18. Ministry of Health. Petunjuk Teknis Pelaksanaan Pos Pembinaan Terpadu (Posbindu) Bagi Kader. Jakarta; 2019.
19. Moore-harper T, Shubrook JH, Clavo-hall J. Nurses on the Front-Line of Diabetes Prevention. Int J Nurs Heal Care Res. 2023;6(3):1–9.
20. O'Flynn S. Nurses' role in diabetes management and prevention in community care. Br J Community Nurs. 2022 Aug;27(8):374–6.
21. Israel GD. Determining sample size. Tech Rep No PEOD-6 Florida Univ Florida, Inst Food Agric Sci. 2003;
22. Lindström J, Tuomilehto J. The diabetes risk score. A practical tool to predict type 2 diabetes risk. Diabetes Care. 2003;26(3):725–31.
23. ADA. American diabetes association. Standards of medical care in diabetes-2020. Diabetes Care. 2020;43(Supplement 1):S1–212.
24. Hauguel-Moreau M, Hergault H, Cazabat L, Pépin M, Beauchet A, Aïdan V, et al. Prevalence of prediabetes and undiagnosed diabetes in a large urban middle-aged population: the CARVAR 92 cohort. Cardiovasc Diabetol. 2023;22(1):1–8.
25. Zhu Y, Sidell MA, Arterburn D, Daley MF, Desai J, Fitzpatrick SL, et al. Racial/Ethnic Disparities in the Prevalence of Diabetes and Prediabetes by BMI: Patient Outcomes Research To Advance Learning (PORTAL) Multisite Cohort of Adults in the U.S. Diabetes Care. 2019;42(12):2211–9.
26. Dany F, Dewi RM, Tjandrarini DH, Pradono J, Delima D, Sariadji K, et al. The urban-rural distinction of potential determinants for prediabetes in Indonesian population aged ≥15 years: a cross-sectional analysis of Indonesian Basic Health Research 2018 among normoglycemic and prediabetic individuals. BMC Public Health. 2020;20(1):1509.
27. Vatcheva KP, Fisher-Hoch SP, Reininger BM, McCormick JB. Sex and age differences in prevalence and risk factors for prediabetes in Mexican-Americans. Diabetes Res Clin Pract. 2020;159(January):107950.
28. Falguera M, Vilanova MB, Alcubierre N, Granado-Casas M, Marsal JR, Miró N, et al. Prevalence of prediabetes and undiagnosed diabetes in the Mollerussa prospective observational cohort study in a semi-rural area of Catalonia. BMJ Open. 2020;10(1):e033332.
29. Kumar A, Wong R, Ottenbacher KJ, Al Snih S. Prediabetes, undiagnosed diabetes, and diabetes among Mexican adults: findings from the Mexican Health and Aging Study. Ann Epidemiol. 2016;26(3):163–70.
30. Mohammad A, Ziyab AH, Mohammad T. Prevalence of prediabetes and undiagnosed diabetes among Kuwaiti adults: A cross-sectional study. Diabetes, Metab Syndr Obes Targets Ther. 2021;14:2167–76.
31. Yan Z, Cai M, Han X, Chen Q, Lu H. The Interaction Between Age and Risk Factors for Diabetes and Prediabetes: A Community-Based Cross-Sectional Study. Diabetes, Metab Syndr Obes. 2023;Volume 16(January):85–93.
32. Chinnasamy A, Moodie M. Prevalence of Undiagnosed Diabetes and Prediabetes in the Dental Setting: A Systematic Review and Meta-Analysis. Int J Dent. 2020;2020:1–10.
33. Bruun-Rasmussen NE, Napolitano G, Kofoed-Enevoldsen A, Bojesen SE, Ellervik C, Rasmussen K, et al. Burden of prediabetes, undiagnosed, and poorly or potentially sub-controlled diabetes: Lolland-Falster health study. BMC Public Health. 2020;20(1):1711.
34. Lailler G, Fuentes S, Kab S, Piffaretti C, Guion M, Czernichow S, et al. Prevalence and risk factors associated with prediabetes and undiagnosed diabetes in France: The national CONSTANCES cohort. Diabetes Epidemiol Manag. 2023;10(2023):100121.
35. Alkandari A, Alarouj M, Elkum N, Sharma P, Devarajan S, Abu-Farha M, et al. Adult Diabetes and Prediabetes Prevalence in Kuwait: Data from the Cross-Sectional Kuwait Diabetes Epidemiology Program. J Clin Med. 2020;9(11):3420.
36. Hosseini Z, Whiting SJ, Vatanparast H. Type 2 diabetes prevalence among Canadian adults — dietary habits and sociodemographic risk factors. Appl Physiol Nutr Metab. 2019;44(10):1099–104.
37. Endris T, Worede A, Asmelash D. Prevalence of Diabetes Mellitus, Prediabetes and Its Associated Factors in Dessie Town,

 https://doi.org/10.46389/rjd-2024-1745

Northeast Ethiopia: A Community-Based Study. Diabetes, Metab Syndr Obes Targets Ther. 2019;12:2799–809.
38. Phan DH, Vu TT, Doan VT, Le TQ, Nguyen TD, Van Hoang M. Assessment of the risk factors associated with type 2 diabetes and prediabetes mellitus: A national survey in Vietnam. Medicine (Baltimore). 2022;101(41):e31149.
39. Fermín-Martínez CA, Paz-Cabrera CD, Basile-Alvarez MR, Castro PS, Núñez-Luna A, Perezalonso-Espinosa J, et al. Prevalence of prediabetes in Mexico: a retrospective analysis of nationally representative surveys spanning 2016–2022. Lancet Reg Heal - Am. 2023 Dec;28:100640.
40. Bocquet V, Ruiz-Castell M, de Beaufort C, Barré J, de Rekeneire N, Michel G, et al. Public health burden of prediabetes and diabetes in Luxembourg: finding from the 2013–2015 European Health Examination Survey. BMJ Open. 2019;9(1):e022206.
41. Mirahmadizadeh A, Fathalipour M, Mokhtari AM, Zeighami S, Hassanipour S, Heiran A. The prevalence of undiagnosed type 2 diabetes and prediabetes in Eastern Mediterranean region (EMRO): A systematic review and meta-analysis. Diabetes Res Clin Pract. 2020 Feb;160:107931.
42. Asmelash D, Mesfin Bambo G, Sahile S, Asmelash Y. Prevalence and associated factors of prediabetes in adult East African population: A systematic review and meta-analysis. Heliyon. 2023 Nov;9(11):e21286.
43. Robles-Ordaz MD, Gallegos-Aguilar AC, Urquidez-Romero R, Diaz-Zavala RG, Lavandera-Torres MG, Esparza-Romero J. Prevalence of prediabetes and modifiable factors in an ethnic group of Mexico: the Comcáac Project. Public Health Nutr. 2018;21(2):333–8.
44. Bennasar-Veny M, Fresneda S, López-González A, Busquets-Cortés C, Aguiló A, Yañez AM. Lifestyle and progression to type 2 diabetes in a cohort of workers with prediabetes. Nutrients. 2020;12(5):1538.
45. Röhling M, Kempf K, Banzer W, Berg A, Braumann KM, Tan S, et al. Prediabetes conversion to normoglycemia is superior, as is adding a low-carbohydrate and energy deficit formula diet to lifestyle intervention. A 12-month subanalysis of the ACOORH trial. Nutrients. 2020;12(7):1–13.
46. Heltberg A, Andersen JS, Sandholdt H, Siersma V, Kragstrup J, Ellervik C. Predictors of undiagnosed prevalent type 2 diabetes – The Danish General Suburban Population Study. Prim Care Diabetes. 2018;12(1):13–22.
47. Hsueh L, Wu W, Hirsh AT, de Groot M, Mather KJ, Stewart JC. Undiagnosed diabetes among immigrant and racial/ethnic minority adults in the United States: National Health and Nutrition Examination Survey 2011–2018. Ann Epidemiol. 2020 Nov;51:14–9.
48. Bikbov MM, Fayzrakhmanov RR, Kazakbaeva GM, Zainullin RM, Arslangareeva II, Gilmanshin TR, et al. Prevalence, awareness and control of diabetes in Russia: The Ural Eye and Medical Study on adults aged 40+ years. PLoS One. 2019;14(4):1–14.
49. Rajalakshmi R, Vasconcelos JC, Prevost AT, Sivaprasad S, Deepa M, Raman R, et al. Burden of undiagnosed and suboptimally controlled diabetes in selected regions of India: Results from the SMART India population-level diabetes screening study. Diabet Med. 2023;40(10):1–15.