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ORIGINAL RESEARCH

The Contributing Factors to the Risk of Diabetes Mellitus among Indonesian Urban Workers

Mahmudah Mahmudah[1], Nailul Izza[2], Lely Indrawati[2], Astridya Paramita[2], Diah Indriani[1]

[1]*Department of Epidemiology, Biostatistics, Population Studies and Health Promotion, Faculty of Public Health, Universitas Airlangga, Surabaya, Indonesia*
[2]*Research Center for Public Health and Nutrition, National Research and Innovation Agency, Republic of Indonesia, Indonesia*

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Corresponding Author:
Nailul Izza
Research Center for Public Health and Nutrition, National Research and Innovation Agency, Republic of Indonesia, Indonesia
E-mail:
nailul.izza@brin.go.id;
nailulizza17@gmail.com

Abstract

Background: Diabetes mellitus (DM) is a non-communicable disease (NCD) with a high morbidity rate and is the third leading cause of death in Indonesia. Some risk factors are associated with the risk of DM; yet, little is known about the effect of such factors on the occurrence of DM in an urban worker population.
Purpose: This study aimed to examine the impact of some risk factors on the occurrence of DM among workers in urban areas of Indonesia.
Methods: The study used secondary health status data obtained from the 2018 Basic Health Research by the Research and Development Agency, Ministry of Health, Republic of Indonesia, using a cross-sectional approach. The participants consisted of 15,745 urban working adults aged 15-64 years, whose blood glucose levels were examined. The correlation between variables was analyzed using a multivariate logistic regression test.
Results: This study showed that 14.8% of DM patients had hypertension, and 14.9% were obese. The percentage of women with diabetes increased with age, particularly affecting informal workers more frequently. Hypertension (aOR=1.76; 95%CI: 1.56-1.99), central obesity (aOR=1.75; 95%CI: 1.54-1.98), daily smoking (aOR=0.63; 95%CI: 0.53-0.76), and age (aOR=8.9; 95%CI: 5.3-15.7) were identified as significant factors contributing to the risk of DM. However, education, physical activity, the consumption of fruits and vegetables, and employment had no discernible impact.
Conclusion: Hypertension, obesity, daily smoking, and age were associated with an increased risk of DM in urban workers. The study recommends that companies collaborate with *Posbindu* for NCDs to check blood pressure and blood sugar levels regularly, and to measure the height and weight of workers periodically.

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1. Introduction

Non-communicable diseases (NCDs) kill 41 million people each year, equivalent to 71% of all deaths globally. Diabetes mellitus (DM) disease accounts for the fourth most NCD deaths (1.5 million) (Pan American Health Organization & World Health Organization [WHO], 2021). More than three-quarters of all NCD deaths occur in low- and middle-income countries (WHO, 2022). As one of the metabolic diseases, diabetes ranked the sixth most common cause of death in Indonesia in 2020 with approximately 40.08 deaths per 100.000 people (Institute for Health Metrics and Evaluation, 2021). There is also a continuous increase in the number of people with diabetes mellitus (DM) aged 20-79 in Indonesia, which ranks fifth among countries with the highest cases in the world (International Diabetes Federation, 2021). This increase was estimated, ranging from 6.9% in 2013 to 8.5% in 2018 (National Institute of Health Research and Development, 2013, 2019). Similarly, global DM cases were increasing rapidly from 18.69 million cases (9.19%) in 2020 to 19.5 million cases in 2021 and are estimated to increase in 2045 to 40.7 million cases (16.09%) (International Diabetes Federation, 2021; Wahidin et al., 2024).

Globally, the prevalence of type 2 diabetes mellitus (T2DM) is high and continues to increase in all regions. This increase is driven by aging populations, economic development, increased

urbanization, sedentary lifestyles, and greater consumption of unhealthy foods, leading to obesity (International Diabetes Federation, 2021). Several high-risk groups for developing DM are people with low physical activity, hypertension, a history of prediabetes, and age over 45 years (Anjajo et al., 2023; Indonesian Society of Endocrinology, 2021; Vos et al., 2020; Zhao et al., 2024). DM is a chronic disease characterized by elevated blood glucose levels (WHO, 2022), occurring due to insulin secretion abnormalities, function, or resistance. Hypertension can cause insulin resistance by rendering cells insensitive to insulin (Indonesian Society of Endocrinology, 2021; Paleva, 2019; Mancusi et al., 2020). Factors that trigger T2DM and hypertension include hyperinsulinemia, sympathetic nervous system activation, and chronic inflammation. In advanced stages, this leads to increased peripheral vascular resistance, arteriosclerosis, and chronic kidney disease (Pratama-Putra et al., 2019; Usui, 2023). Moreover, cardiometabolic risk factors, including current cigarette smoking (Mengome et al., 2024), low fruit and vegetable intake (Lapuente et al., 2019), low physical activity (Lavie et al., 2019), obesity or central obesity, diabetes, hypertension (HT), and dyslipidemia (Mezhal et al., 2023), could contribute to DM (Zhao et al., 2024).

A study conducted in mainland China reported that overweight, obesity, and central obesity are more common in male migrant workers than men in the general population, although most metabolic risk factors are noticeably less common in migrant workers (Bi et al., 2016). The obesogenic environment causes overnutrition, which in turn causes dysregulation of the metabolic balance and fat accumulation in organs like the liver, skeletal muscles, and endothelium that are not specialized in lipid storage, leading in metabolic disturbances and disorders like insulin resistance, impaired glucose tolerance (IGT), and T2DM (La Sala & Pontiroli, 2020). Obesity and unfavourable lifestyles (smoking, alcohol consumption, physical activity, and diet) are important triggers for the onset of T2DM, and IGT or prediabetes in a study cohort (Schnurr et al., 2020). In urban areas, the decline in quality of life due to changes in lifestyle or eating habits impacts the occurrence of type 2 diabetes (Febriyan, 2020). The occurrence of arteriosclerosis can be reduced by high consumption of fruits and vegetables (Lapuente et al., 2019). Furthermore, a study in Central Africa reported that living in urban areas was also a risk factor for hypertension, diabetes, metabolic syndrome, and high LDL cholesterol level (Mengome et al., 2024). A study previously conducted in 13 clinical sites representing primary and secondary care in rural and urban locations found that the features of patients with T2DM in Indonesia were high BMI, with hypertension and hyperlipidemia as co-morbidities (Soeatmadji et al., 2023).

Hypertension, low physical activity, dislipidemia, prediabetes, unhealthy and unbalanced diet and obesity are DM factors that can basically be modified because they are related to behavior. They are different from biological factors that cannot be modified which are related to race, ethnicity, age, gender, family history of DM, history of giving birth to a baby >4,000 grams, or low birth weight (BBLR) (Ministry of Health Republic of Indonesia, 2022). Studies that specifically discuss the impact of these modifiable factors on the occurrence of DM in urban workers, to the authors' knowledge, have never been conducted in Indonesia. Due to contrasting evidence from the previous studies and limited research on the topic involving Indonesian urban workers, especially in a large population, this study aimed to explore the association of some risk factors with the occurrence of DM in the urban worker population in Indonesia.

2. Methods

2.1. Research design

The study used secondary data on Indonesian health status from the 2018 Indonesian Basic Health Survey (*Riskesdas*), conducted by the Ministry of Health, Republic of Indonesia, which used a cross-sectional, non-intervention design. The individuals interviewed in the survey consisted of all household members in the selected households, following the sampling framework of the 2018 Social Economic Survey by the Central Agency on Statistics (BPS). The data source was a community-based health survey conducted in 34 provinces of Indonesia. Data were collected through blood glucose examination, anthropometric measurement (abdominal circumference), and blood pressure measurements. Structured questionnaires were used as interview tools to collect the data (National Institute of Health Research and Development, 2019).

2.2. Setting and samples

The 2018 Indonesian *Riskesdas* by the National Institute of Health Research and Development (2019) involved 30,000 census blocks (CBs) distributed across all 34 provinces in

Indonesia. Some of the health indicators collected in this survey represented the condition at the provincial level. The survey employed a linear systematic sampling, namely two-stage sampling data collection using the probability proportional to size (PPS) method. In the first stage, CBs in urban and rural areas were used as the primary sampling unit. At stage two, 10 households were selected in each CB using updated basis systematic sampling with implicit stratification. The selection was performed based on the highest level of education completed by the head of the household to maintain the representation of diverse characteristics. Out of the 30,000 CBs, 2,500 CBs were selected from 106 districts for blood tests to represent blood-related indicators at the national level. Finally, this study used data from 15,745 worker respondents in urban areas aged 15-64 years whose blood glucose levels were examined as the analysis units (Figure 1). However, the limitation of this study was that samples from the surveys were not specifically designed to collect data related to the working age group, limiting the equal distribution of samples across Indonesia.

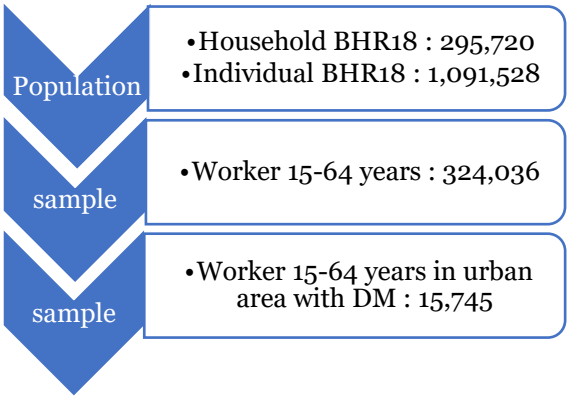

Figure 1. Sampling technique of *Riskesdas*

2.3. Measurement and data collection

The validation of the questionnaires used in the 2018 *Riskesdas* was carried out externally and independently by the Indonesian Health Researchers Association (APKESI), claiming that the questionnaires are valid and reliable, though the results were not stated in the *Riskesdas* report. In addition, the questionnaire's indicators were developed by health-related experts from professional associations, universities, and senior researchers of the National Institute of Health Research and Development, Ministry of Health, and reviewed by international organizations, such as World Health Organization (WHO), United Nations Children Fund (UNICEF), and World Bank (National Institute of Health Research and Development, 2019).

The dependent variable was DM, as defined according to the Indonesian Society of Endocrinology (*PERKENI*)'s criteria. These included fasting blood glucose levels (FBG) ≥126 mg/dL, 2-hour post-prandial blood glucose (PPGB) ≤200 mg/dl, and random blood glucose (RBG) ≥200 mg/dL with symptoms of frequent hunger, thirst, urination, and significant weight loss (Indonesian Society of Endocrinology, 2021). The independent variables included age, gender, education level, employment status, hypertension, obesity, physical activity levels, fruit and vegetable consumption, and smoking. Indrawati et al. (2021) categorized productive ages into five categories, namely 15-24 years, 25-34 years, 35-44 years, 45-54 years, and 55-64 years, which were considered as youth, young adult, adult, middle-aged, and old age, respectively. Subsequently, gender was distinguished between men and women. The level of education was divided into three categories, namely low (uneducated to the end of junior high school), medium (senior high school), and high (university); while employment status was divided into formal (workers, employees, officials, and fixed or paid laborers) and informal (self-employed persons, non-fixed or non-paid laborers, and family workers or unpaid workers).

According to the Joint National Committee (JNC) VII criteria, hypertension occurs when systolic blood pressure is ≥140 mmHg or diastolic blood pressure is ≥90 mmHg. Central obesity is determined based on the abdominal circumference in men >90cm and women >80cm, while the level of physical activity is differentiated into less (light) and sufficient (medium to heavy). The consumption of fruits and vegetables is considered insufficient at <5 servings and sufficient

when it reaches five portions per day. Smoking behavior is grouped into four categories, namely not smoking, daily tobacco smoking, less than daily smoking, and former /past tobacco consumption (National Institute of Health Research and Development, 2019).

Blood pressure was measured using a digital sphygmomanometer, though its specifications were not detailed in the *Riskesdas* report. Measurements were taken twice. The distance between the two measurements was 1-2 minutes. If the results of the first and second measurements had a difference of 10 mmHg (either systolic or diastolic, or both), a third measurement was taken after resting for 10 minutes. Central obesity was assessed using the abdominal circumference, measured on household members aged 15 years and above, except pregnant women, with a measuring tape equipped with centimetre scales. Correct measurement of the abdominal circumference was done by attaching the measuring tape directly to the skin instead of clothes. Blood sugar examination was done using a point-of-care test (POCT) with Accucheck Performa. Meanwhile, fruit and vegetable consumption, physical activity levels, and smoking were obtained through behavioural questionnaires that had been validated for reliability and validity by APKESI (National Institute of Health Research and Development, 2019).

The *Riskesdas* data were obtained by submitting a request letter to the National Institute of Health Research and Development, Ministry of Health, Republic of Indonesia, and by filling out a form based on the available data referring to the questionnaire. The form was accessed from http://layanandata.kemkes.go.id.

2.4. Data analysis

The complex survey design was analyzed by considering the averaged weight factors, primary sampling units, and strata. The number of weighted total samples (n) was used to define the number of samples produced by complex analysis. The initial step in the analysis involved calculating the frequency of each variable. The related independent variables were considered for further analysis. The data were analyzed using the Chi-square test to determine the association between the independent and dependent variables. In the final phase, a multivariate analysis was conducted using logistic regression testing (enter method). The final model included all variables that showed a significant association with DM status, using a significance level of 0.05 as the cut-off point. Subsequently, the adjusted odds ratios (aORs) and 95% confidence intervals (CIs) of all variables were determined. The aOR value indicated the likelihood of risk occurrence for DM. All statistical analyses in this study were performed using SPSS version 15.

2.5. Ethical consideration

The ethics committee of the National Research and Innovation Agency classified this study as not requiring ethical approval. The data collected for the 2018 *Riskesdas* survey were obtained with prior signed informed consent from participants, emphasizing the voluntary and confidential nature of the data collection process. This information can be accessed on the website of the Ministry of Health, Republic of Indonesia (https://layanandata.kemkes.go.id/).

3. Results

3.1. Socio-demographic characteristics of the respondents

Table 1 shows that the prevalence of DM, hypertension, and central obesity among urban workers was 9.3%, 36.1%, and 29.2%, respectively. The majority of the respondents were men (69.5%), had low education (68.4%), and were non-formal workers (60.4%). Based on the age range, workers in the 45-54 years group had the largest proportion, followed by the 35-44 years category. In the behavioral characteristics, the proportions of daily smokers and non-smokers were almost equal, around 40%. Moreover, the majority of respondents reported having sufficient physical activity (77.5%) and insufficient fruit-vegetable consumption (95.1%).

3.2. Relationships between socio-demographic and behavioural characteristics and the occurrence of diabetes mellitus

Table 2 illustrates the related factors of DM. The occurrence of DM was significantly related to age, gender, education, employment, smoking behavior, blood pressure, central obesity, and consumption of fruits and vegetables ($p<0.05$). Furthermore, older people had a higher proportion of DM than younger individuals (16.5% to 1.5% respectively), while women were more predominant (11.8%). There was a greater proportion of hypertension (14.8%) and central obesity

(14.9%) among urban workers, while the proportion of urban workers without DM was more likely to have a habit of sufficient consumption of fruits and vegetables (4.3%). Also, the proportion of non-smokers (11.6%) was higher than those who smoked every day (6.6%), rarely (10.3%), and were former smokers (10.2%).

Table 1. Socio-demographic and behavioral characteristics of the respondents (n=15,745)

Characteristics	f	%
Gender		
Men	10,940	69.5
Women	4,805	30.5
Age (year)		
15-24	981,1	6.2
25-34	2,756	17.5
35-44	4,351	27.6
45-54	4,705	29.9
55-64	2,952	18.8
Education		
High	1,193	7.6
Moderate	3,773	24.0
Low	10,779	68.4
Employment		
Formal	6,228	39.6
Non-formal	9,517	60.4
Diabetes Mellitus		
Yes	1,465	9.3
No	14,280	90.7
Blood pressure		
Normal	10,025	63.9
Hypertension	5,673	36.1
Central Obesity		
No	10,982	70.8
Yes	4,523	29.2
Physical Activity		
Sufficient	12,203	77.5
Insufficient	3,542	22.5
Smoking		
No smoking	6,877	43.7
Daily tobacco smoking	6,677	42.4
Less than daily smoking	1,009	6.4
Former /past tobacco smokers	1,182	7.5
Consumption of fruits and vegetables		
≥5 portions/day (sufficient)	764	4.9
<5 portion/day (insufficient)	14,980	95.1

3.3. The contributing factors to the risk of diabetes mellitus

Table 3 indicates that workers with hypertension or central obesity had a 1.7 times greater risk of developing DM (p=0.000; 95%CI: 1.5-1.9), although it is unclear whether the subjects had diabetes or hypertension first. In addition, as workers aged, the risk of DM increased (p=0.000), especially at the age group of 55-64 years, which had 8.92 times higher risk of developing DM (p=0.000; 95%CI: 5.27-15.71). Compared to non-smokers, daily smokers have a 36.7% lower chance of developing DM, after controlling for other variables (age, blood pressure, and central obesity) (p=0.000; 95%CI: 0.52-0.75).

4. Discussion

Following the research aim to examine the impact of certain risk factors on the occurrence of DM in urban workers, this study showed that hypertension, age, central obesity, and daily smoking were identified as significant factors contributing to the risk of DM. Urban workers with hypertension were more likely to develop DM compared to those with normal blood pressure. Similarly, previous studies have found that hypertension was a risk factor for DM, specifically

T2DM (Ali et al., 2023; Julianti, 2021; Kabosu et al., 2019; Tesfaye et al., 2019). Not only is hypertension more common in patients with diabetes, but diabetes is also more common in hypertensives than in the general population (Hu & Stampfer, 2005). Another study, although not

Table 2. The occurrence of DM according to several risk factors (n=15,745)

Characteristics	Diabetes Mellitus				*p*
	Yes		No		
	f	%	f	%	
Gender					0.000
Men	896	8.2	10,044	91.8	
Women	568	11.8	4,236	88.2	
Age (year)					0.000
15-24	15	1.5	965	98.5	
25-34	96	3.5	2,659	96.5	
35-44	290	6.7	1,060	93.3	
45-54	576	12.2	4,128	87.8	
55-64	486	16.5	2,465	83.5	
Education					0.000
High	116	9.8	1,077	90.2	
Moderate	277	7.3	3,495	92.7	
Low	1,070	9.9	9,708	90.1	
Employment					0.000
Formal	504	8.1	5,724	91.9	
Non-formal	960	10.1	8,556	89.9	
The blood pressure					0.000
Normal	621	6.2	9,404	93.3	
Hypertension	837	14.8	4,835	84.2	
Central Obesity					0.000
No	777	7.1	10,204	92.9	
Yes	671	14.9	3,852	85.1	
Physical Activity					0.747
Sufficient	1,140	9.3	11,062	90.7	
Insufficient	324	9.1	3,217	90.9	
Smoked					0.000
Not smoking	799	11.6	6,078	88.4	
Daily tobacco smoking	440	6.6	6,236	93.4	0.000
Less than daily smoking	104	10.3	905	89.7	0.000
Former /past tobacco smokers	122	10.2	1,060	89.8	0.000
Consumption of fruits and vegetables					0.022
≥ 5 portions/day (sufficient)	89	0.6	675	4.3	
< 5 portion/day (insufficient)	1,375	8.7	13,604	86.4	

Note. Chi-square test, significant at $p>0.05$

Table 3. Multivariate analysis of diabetes mellitus with the risk factors (n=15,745)

Characteristics	*B*	*p*	Adjusted OR	95%CI
Age (year)		0.000		
15-24			Reff	
25-34	2.189		2.101	1.228 – 3.595
35-44	1.817		3.563	2.2113– 6.007
45-54	1.217		6.151	3.642 – 10.390
55-64	0.742		8.925	5.274 – 15.7103
The blood pressure				
Normal			Reff.	
Hypertension	0.568	0.000	1.764	1.563 – 1.992
Central Obesity				
No			Reff.	
Yes	0.559	0.000	1.750	1.544 – 1.982
Smoking				
No smoking			Reff	
Daily tobacco smoking	-0.457	0.000	0.633	0.528 – 0.759
Less than daily smoking	-0.014	0.000	0.986	0.756 – 1.286
Former /past tobacco smokers	-0.277	0.000	0.758	0.583 – 0.985

Note. B=Coefficient beta

showing these correlations in patients with baseline prehypertension and hypertension, stated that the risk of diabetes was considerably higher in those with normal blood pressure at baseline who developed prehypertension or hypertension at 8 years than those with controlled blood pressure (Kim et al., 2015). Insulin resistance can occur in pancreatic beta cells due to hypertension, leading to increased blood glucose levels (Indonesian Society of Endocrinology, 2021). The role of insulin in the body is essential in increasing glucose intake in various cells and regulating carbohydrate metabolism to maintain the balance of blood sugar levels (Tokarz et al., 2018). Hypertension also contributed to the risk of DM through thickening the arterial blood vessels, thus narrowing their diameter (Jia et al., 2024). Generally, diabetic patients with hypertension are at higher risk of developing nephropathy, retinopathy, and microvascular disorders compared to those without high blood pressure. Hypertension has been found in almost half of people with DM, affecting insulin sensitivity and secretion in older adults (Lodhi, 2021).

The findings also indicated that age was a risk factor for DM in urban workers. The analysis revealed that, alongside increasing age, the risk of developing DM also increased, particularly among individuals aged 55-64 years, who had an 8.92 times higher risk compared to those aged 15-24 years. This finding was supported by a study that revealed that the incidence of DM was related to increasing age (Isnaini & Ratnasari, 2018). Increasing the age by approximately 9.4 years increases the risk of developing hypertension and the chances of suffering from DM (Poorolajal et al., 2016). Aging is closely related to the increase in blood glucose levels, resulting in a higher prevalence of diabetes and glucose tolerance disorders (Isnaini & Ratnasari, 2018). The aging process that occurs at age 45 and above results in anatomical, physiological, and biochemical changes in the body, such as an increase in insulin resistance (Kabosu et al., 2019). In contrast, a study found that a history of high blood pressure or age ≥45 years did not affect the occurrence of high pressure in DM patients (Sari et al., 2017). Although a non-modifiable factor significantly influences DM, efforts can be made to address hypertension as an early risk factor by maintaining normal blood pressure levels.

In terms of obesity, the results showed that central obesity significantly influenced the occurrence of DM with a 1.7 times higher risk than those with normal abdominal circumference. Some urban studies pointed out that central obesity increased the risk of DM compared to normal people (Kabosu et al., 2019; Seo et al., 2017). Obesity will cause the body to develop resistance to insulin, which is characterized by reduced ability to take up glucose in fat and muscle (Paleva, 2019). Obesity led to a decrease in insulin production from pancreatic beta cells, resulting in an increase in blood glucose (Al-Goblan et al., 2014). Additionally, there was a decrease in the number and sensitivity of insulin receptors in cells throughout the body, including in muscles (Czech, 2017). Obesity can be influenced by various factors, including genetics or family history (Isnaini & Ratnasari, 2018), emotional factors (Paleva, 2019), and excessive eating patterns (Febriyan, 2020). Therefore, several studies recommend that consuming sufficient amounts of fruits and vegetables (≥ 3 servings a day) has the potential to avoid diabetes mellitus (Niu et al., 2023; Sulistyorini et al., 2023), though a healthy metabolic profile and absence of diabetes risk factors do not merely protect young adults from developing diabetes associated with overweight and obesity (Twig et al., 2014).

Furthermore, the findings reported that smoking behavior provides protection against the risk of diabetes. This result appears to contradict theory and previous studies (Jiang et al., 2019; Kurniawaty & Yanita, 2016; Siahaan et al., 2023). This could be due to several factors. First, there is a confounding effect of other factors (age, obesity). Smokers generally have a lower body weight than non-smokers because nicotine suppresses appetite and increases basal metabolic rate, even though they may have central obesity (InterAct Consortium et al., 2014). Second, a survivor bias/ healthy smoker bias might be involved. Smokers who remain healthy in their productive years may be survivors, who are genetically/metabolically stronger and therefore less directly affected by the adverse effects of smoking. Meanwhile, smokers diagnosed with diabetes may quit smoking immediately, so they are categorized as former/past tobacco smokers or non-smokers at the time of data collection, yielding smoking misclassification. The non-smoking category may include former/past tobacco smokers, some of whom quit due to illnesses (including diabetes). If former/ past tobacco smokers (who are at high risk for diabetes) are included in the non-smoking group, the prevalence of diabetes in the non-smoking group will appear higher, causing distortion. The presence of a time effect, namely a time lag between smoking and diabetes, can lead to a causal relationship that is not actually apparent in cross-sectional designs like this study. DM is a

metabolic disease that develops over the long term. If participants are new or young smokers, the metabolic effects may not be clinically apparent at the time of data collection (Pitoy et al., 2024). However, a study reported that ever-smoked tobacco products had no relationship with the occurrence of hypertension in people with diabetes (Anjajo et al., 2023). The nicotine in cigarettes can cause cell damage, called oxidative stress and inflammation, throughout the body, which may make insulin less effective (Maddatu et al., 2017).

Hypertension, obesity, and aging were significantly associated with the risk of DM in urban areas. This reflected that multimorbidities of non-communicable diseases were a significant problem in low- or middle-income countries (LMICs), with higher prevalence among older people, women, wealthy people, and urban residents (Asogwa et al., 2022). DM has been considered a catastrophic disease that requires long-term treatment and can impose a financial burden on households due to high costs and potential loss of income (Marthias et al., 2021). This condition can lead people into poverty, thereby hindering development. Effective control of DM risk factors, both keeping blood pressure and blood sugar at a normal level, is essential for managing NCDs. Self-control for DM sufferers is vital, whether it is maintaining a healthy lifestyle, being physically active, exercising, or not smoking. DM sufferers who were given self-learning training significantly improved their self-care behavior (Wahyuni et al., 2021), especially for people with a higher education level. These people have more knowledge, so they are more concerned about maintaining health and taking treatment immediately (Lailler et al., 2023). Investing in NCD management is crucial, and the interventions are usually carried out through primary healthcare, especially integrated health posts (*Posbindu*) for NCDs, to strengthen early detection and timely treatment (Ministry of Health Republic of Indonesia, 2012; WHO, 2015). Primary health care providers, such as nurses, play an important role in improving the knowledge and skills of family caregivers in caring for family members, thereby improving the quality of life of patients (Setyoadi et al., 2023). A consultation session with a health care professional, such as a doctor or nurse, might never hurt, as it can help in designing strategies that suit the family's needs and situation.

5. Implications and limitations

The findings of this study have some implications. Nurses play a crucial role in providing education to patients through self-learning and to their family caregivers, thereby increasing knowledge and skills in caring for family members with DM. The role of health workers, especially nurses, in primary health care is vital in improving the knowledge and skills of family caregivers in caring for family members with DM. However, this study has limitations. First, the sampling method, which was based on the *Riskesdas* data, did not specifically represent workers in urban areas, leading to a bias in depicting the representativeness of the urban worker population as the unit of analysis in this study. Second, due to the use of secondary data from a national-scale cross-sectional survey, it was unknown which variables occurred first: DM, hypertension, or central obesity. Respondent characteristics, such as age, gender, education, and employment, were factors that were difficult to control, potentially confounding the multivariate analysis.

6. Conclusion

The study showed that workers living in urban areas with hypertension and obesity had an increased risk of DM. Other significant predictors affecting the occurrence of DM were age and smoking behaviors. This can lead to a reduced quality of life among individuals with DM. Therefore, it is important to manage blood pressure, abdominal circumference, and smoking as these are modifiable behavioral factors. It is recommended that companies collaborate with *Posbindu* for NCDs to regularly monitor blood pressure, blood sugar levels, and conduct anthropometric measurements periodically. Blood sugar screening for individuals over the age of 35 is also needed to support the "beware of diabetes at a young age" campaign, as well as to provide education on balanced nutrition and how smoking worsens diabetes. Furthermore, future studies should pay more attention to grouping variables into appropriate categories, especially smoking-related risk factors, and consider using cohort designs in diabetes-related research.

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Author contribution

MM and NI conceptualized the study and prepared the initial draft and framework. LI, MM, and DI analyzed and interpreted the data. NI, LI, and AP contributed to the manuscript discussion.

Conflict of interest

The authors declare that there are no conflicts of interest.

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