



The Association between Hypertension and the Incidence of Type 2 Diabetes Mellitus in Semarang City in 2010-2015

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Abstract

One of the most common causes of mortality related to noncommunicable disease is diabetes mellitus. Driven by the high number of people living with diabetes globally, Indonesia ranks fifth with approximately 19.5 million diabetes cases (IDF, 2021). The nation that is Indonesia's provides the latest statistic that shows the prevalence of diabetes has been increasing over the five-year stretch of 1.5% in 2018 to 1.7% in 2023 for all ages, and for those 15 years and older is 2.0% in 2018 to 2.2% in 2023. Among the 38 provinces of Indonesia, Central Java ranks 8 in for diabetes. In the last calendar year with reports ranging from 2022 to 2023, Semarang City reported a 2.08% increase and the Module 1a (2 diabetes 0% target) has shown no shifts and zero diabetes and obesity (0%) target has been shown. At the same time, many people suffering from type 2 diabetes mellitus continue to suffer from hypertension. This research is going to discuss the epidemiological trends of T2DM and hypertension to understand the link between hypertension and T2DM based on gender and age. This is a quantitative and observational study based on the research of the Semarang City SIMPUS system of the years 2010 to 2015 and analyzed using the univariate method (using frequency distribution) and the bivariate method (using chi-square test). Findings indicate an alarming trend of higher prevalence of comorbid diabetes type 2 and hypertension among women than men.

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INTRODUCTION

Diabetes is among the foremost causes of mortality attributable to non-communicable diseases on a global scale. Diabetes mellitus is a collective term for metabolic disorders caused by impaired insulin secretion or impaired insulin action, or by a combination of the two (Petersmann et al., 2019). Diabetes mellitus can be categorised into four distinct classifications: type 1 diabetes mellitus, type 2 diabetes mellitus, specific diabetes, and gestational diabetes. (IDF, 2021). The risk of type 2 diabetes is determined by the interaction of genetic and metabolic factors (WHO, 2016). The global prevalence of type 2 diabetes is increasing rapidly along with increasing obesity, reduced physical activity, sedentary lifestyle, and unhealthy dietary changes (Schwingshackl et al., 2017).

The global SDGs do target any increase of diabetes or obesity (0% increase) (SDGs, 2019). The figure of adults 20-79 years old living with diabetes is 537 million which is 10.5% of the adult global population in 2021. By 2030, there is a prediction that this figure will increase to 643 million and by 2045 there will be another increase 783 million. This will be a 46% increase in diabetes prevalence. The world population is only expected to increase by 20%.

IDF (2021) says that as of 2021, Indonesia is ranked 5th in the world in the number of diabetes cases among adults 20-79 years old with 19.5 million cases. Diabetes is prevalent in all age groups of Indonesia with a prevalence increase in all age groups from 1.5% in 2018 to 1.7% in 2023, from 2.0% to 2.2% in age group 15 years and older (SKI, 2023). Of the 38 provinces of Indonesia, Central Java is ranked 8th in diabetes prevalence with Semarang City being the most in the province (Dinkes Jateng, 2023). The number of diabetes cases in Semarang City increased from 40,623 in 2022 to 41,468 in 2023 which is an increase of 2.08%. The target of prevalence of diabetes or obesity (0% increase) has not been achieved.

Hypertension frequently coexists with type 2 diabetes mellitus owing to the common risk factors such as obesity, dyslipidemia, insulin resistance and abnormalities in the vascular system as outlined in (Pavlou et al, 2018; Petrie et

al, 2018).

Puskesmas as a public health service facility, which prioritizes promotive and preventive efforts, Every Health Service Facility is required to hold an Electronic Medical Record. The health center management information system (SIMPUS) in Semarang City began to be developed in 2003 and has become an integral part of health services. Until now, 37 health centers in Semarang City have implemented this system. Around 5.86% of the total population of Semarang City is registered as a patient at SIMPUS every year. Therefore, researchers wanted to find out the epidemiological patterns and the relationship between hypertension and the incidence of type 2 diabetes mellitus.

METHOD

The study focuses on secondary data from 2010 to 2015 from the Health Centre Management Information Systems (SIMPUS) in Semarang City. It is, therefore, a quantitative study with an observational study design. Although the aforementioned data is from a longitudinal (cohort-type) data of health service registry, in this case, the design is a retrospective case-control study. In this case, the independent variable is the hypertension, and the dependent variable is the incidence of mellitus diabetes Type 2 (DM type 2).

All registered patients of Puskesmas in Semarang City over the period of 2010-2015 in SIMPUS records are 365,477 patients, and as such, will become the population of this study. There are 11,261 cases and 354,216 controls, all of which were obtained using total sampling technique. The cases are defined as patients with type 2 diabetes mellitus (ICD-10 code E11). The controls were all patients without DM, and were not limited to those with hypertension, thus making sure that the comparison group were individuals who did not have the outcome of interest at all.

This research utilizes patient documentation tables obtained from Puskesmas, as stored in SIMPUS electronic medical records RME, which incorporate Patient ID, diagnosis E11 for type 2 diabetes, and I10 for hypertension, DOB, sex, and examination date. For the case

group, the service history data years 2010–2015 were to have E11, whilst for the control group, to have no E11 was necessary. Exclusions for the two groups pertained to gaps and errors including, but not limited to, Patient ID, date of examination, DOB, diagnosis codes, or contradictory records. Removals of duplicates were performed in advanced data-processing software such as Python and Excel to maintain data consistency and validity.

The study embraces both univariate and bivariate analysis approaches. Univariate analysis serves to define the sample's attributes. Through bivariate analysis using the PheWAS technique, we examine the association between hypertension and type 2 diabetes mellitus. The Chi-square and Fisher's Exact tests are statistically applied, and the association's strength is analyzed using the Odds Ratio. To preserve the findings' accuracy, some records were excluded due to anticipated biases in the analysis stemming from data entry errors.

This is to certify that the research has been ethically cleared under Number: 332/KEPK/FK/KLE/2024.

RESULTS AND DISCUSSIONS

Based on the results of the study from table 1, it shows that the frequency of people with type 2 diabetes mellitus is more women (59.7%) than men (40.3%). The most common cases of type 2 diabetes mellitus are in the age group of 50-59 years, both men and women. The results of this study are in line with research conducted by Muhammad et al. (2019) showing a higher number of cases recorded in women (54.3%) compared to men (45.7%). According to the research of Muhammad et al. (2019), Traditionally, women remain at home to manage the household and are less physically active, whereas men tend to be more physically active and engaged in office work, business, and other tasks such as farming and animal husbandry (Muhammad et al., 2019).

Once women reach the age of 30, they face a higher risk of developing type 2 diabetes mellitus compared to men. This is attributed to physical factors, as women are more likely to experience an increase in body mass index (Zeru

et al., 2021). Post-menopausal syndrome associated with the monthly cycle can lead to easier accumulation of body fat due to hormonal changes, making women more at risk of developing type 2 diabetes mellitus (Kabusu et al., 2019). The results of this study are in line with the research of Muhammad et al. (2019) showing that the highest incidence of diagnosed cases of type 2 diabetes mellitus found was recorded in the age group of 40–59 years, in men (18.96%) and women (24.98%) (Muhammad et al., 2019).

Table 1. Frequency of Type 2 DM (E11) by Gender and Age Group (Years)

Age Group (Years)	Men	Woman
40-49	811	0
50-59	1518	3238
60-69	1002	1675
70-79	383	527
80-89	0	66
>90	0	0

Source: Semarang City SIMPUS Data in 2010-2015

Based on table 2, it can be seen that the frequency of hypertension sufferers by gender and age group can be seen that there are more hypertension sufferers in women (69.64%) than men (30.36%). Based on age group, the most cases of hypertension are in the age group of 50-59 years old, both in the man and woman genders. This is in accordance with Riskesdas in 2018 that hypertension cases in Indonesia occur mostly in women, which is 36.9% compared to men, which is as much as 31.3% (Kemenkes RI, 2018).

Table 2. Hypertension Frequency (I10) Based on Gender and Age Group (Years) at SIMPUS Semarang City

Age Group (Years)	Men	Woman
40-49	1731	5633
50-59	3056	7974
60-69	2673	4716
70-79	1458	2519
80-89	328	417
>90	37	35

Source: Semarang City SIMPUS Data in 2010-2015

The prevalence of hypertension in Central Java also shows that women (40.17%) are higher than men (34.83%) (Dinkes Jawa Tengah, 2022). The National Health and Nutrition Examination

Survey (NHANES) conducted in the US between 2015 and 2016 revealed that hypertension prevalence was higher in men than in women among those aged 19–39 years (9.2% vs. 5.6%) and 40–59 years (37.2% vs. 29.4%). However, among individuals aged over 60 years, the prevalence of hypertension was higher in women than in men (66.8% vs. 58.5%) (Fryar et al., 2015).

In general, men have a greater risk of high blood pressure than women. However, after the age of 50, women tend to have a higher risk as they begin to enter menopause. Women have a higher risk because they begin to enter menopause, which results in decreased estrogen production. Decreased estrogen production is a condition in which the body produces less of the hormone estrogen as we age. Estrogen is a hormone that plays an important role in various bodily functions, including vascular health, menstrual cycle regulation, and bone density.

Decreased estrogen production can affect various aspects of health, such as an increased risk of heart disease, osteoporosis, and changes in the body's hormonal balance. This has an impact on cardiovascular health, leading to a decrease in vascular elasticity (Regitz-Zagrosek et al., 2016). Women who have not entered menopause have the hormone estrogen which functions to increase High Density Lipoprotein (HDL) levels. High levels of High Density Lipoprotein can play a role in preventing atherosclerosis. Atherosclerosis is a buildup of plaque on the walls of blood vessels that can block blood flow and increase the risk of heart disease and stroke. During premenopause, women begin to gradually lose the hormone estrogen, which previously played a role in protecting blood vessels from damage. This process continues with the quality of the hormone estrogen changing with age occurring between the ages of 45 and 55 years known as the menopause period. Arterial stiffness becomes more pronounced in postmenopausal women than in men, thus contributing to an increase in blood pressure. As a result, the prevalence of hypertension tends to be higher in women compared to men (Ghosh et al., 2016).

The highest number of hypertension cases occurs in the age group of 50-59 years (men and women). This phenomenon has been observed in

a study conducted by Putriastuti (2017), which demonstrated that the prevalence of hypertension is higher among women than men (Putriastuti, 2017). Research by Dai et al. (2022) The present analysis is informed by data sourced from the World Health Organization's study on global ageing and adult health (WHO SAGE) shows that the highest proportion of hypertension sufferers by age group is 50-59 years (39.78%) (Dai et al., 2022). It is caused by physiological changes in blood vessels with age, increased cellular oxidative stress, low-grade chronic inflammation (Buford, 2016).

Referring to the data presented in Table 3, it becomes evident that there exists a connection between the occurrence of hypertension and the presence of type 2 diabetes mellitus (classified as E11), with this relationship varying according to gender. Upon conducting a bivariate analysis, the findings indicated that among individuals diagnosed with type 2 diabetes mellitus, the greatest odds ratio (OR) was observed in woman participants who had a history of hypertension and were within the age range of 60 to 69 years. This suggests that older women with high blood pressure may have a heightened likelihood of developing type 2 diabetes compared to other demographic groups. (OR=3.04) and men with hypertension aged 40-49 years (OR=2.98). The findings of the study on the correlation between hypertension and the prevalence of type 2 diabetes mellitus indicated a link between hypertension and the occurrence of type 2 diabetes mellitus in both man and woman subjects within the age range of 40-89 years. This indicates that women aged between 60-69 years who suffer from hypertension are 3.04 times more likely to develop type 2 diabetes mellitus than those who do not have hypertension.

The results of this study are in line with research conducted by (Movahed et al., 2010) showing that there is a relationship between hypertension and type 2 diabetes mellitus. People with hypertension are 4.5 times more likely to develop type 2 diabetes mellitus (Movahed et al., 2010). Hypertension and type 2 diabetes mellitus (Type 2 DM) are often found together and these concomitant events significantly increase the risk of cardiovascular events (Colussi et al., 2020; Przekaz et al., 2022). Hypertension will cause

Table 3. Relationship between Hypertension and the Incidence of Type 2 Diabetes Mellitus by Gender and Age Group in Semarang City SIMPUS Data in 2010-2015

Gender	Age Group (Years)	OR	95% CI		<i>p-value</i>
			Lower	Upper	
Man	40-49	2.98	2.81	3.15	<0.0001
	50-59	2.50	2.38	2.61	<0.0001
	60-69	2.91	2.77	3.04	<0.0001
	70-79	2.66	2.45	2.87	<0.0001
	80-89	-	-	-	-
	90-99	-	-	-	0.6474
Woman	40-49	-	-	-	-
	50-59	2.85	2.78	2.92	<0.0001
	60-69	3.04	2.94	3.15	<0.0001
	70-79	2.79	2.61	2.97	<0.0001
	80-89	2.07	1.57	2.56	<0.0001
	90-99	-	-	-	-

insulin resistance or insulin resistance which is the cause of hyperinsulinemia. And resulting in damage to pancreatic beta cells and type 2 DM occurs (Boehme et al., 2015). Damage to pancreatic beta cells can cause disruptions in insulin production, which plays an important role in regulating blood sugar levels. Pancreatic beta cells are responsible for the production of insulin, a hormone that facilitates the absorption of glucose by body cells. In the event of beta cell damage or impaired function within the pancreas, the body is unable to produce sufficient insulin or to utilise it effectively, which can ultimately result in the development of type 2 diabetes mellitus. (type 2 DM). Hypertension has been demonstrated to have a significant impact on the prevalence of type 2 diabetes mellitus (T2DM), with the underlying mechanism involving the thickening of arterial blood vessels, leading to an increase in blood diameter.

Vessels to finally narrow, this will cause the process of transporting glucose from the blood to be disrupted. Hypertension and type 2 diabetes mellitus are closely linked due to numerous overlapping risk factors. The aforementioned factors comprise excessive body weight, abnormal lipid levels, reduced insulin sensitivity, dysfunction of the blood vessel lining, chronic inflammation within the vascular system, the buildup of fatty plaques in the arteries (atherosclerosis), and dysregulation of the renin-angiotensin system, which plays a pivotal role in blood pressure control. These interconnected mechanisms contribute to the development and progression of both conditions, further

complicating their management and increasing the risk of cardiovascular complications (Pavlou et al., 2018; Petrie et al., 2018). The results obtained from this study are consistent with and support the conclusions drawn in earlier investigations carried out by Arania et al., (2021) Indicating a correlation between gender and the occurrence of type 2 diabetes mellitus (Arania et al., 2021). "Both men and women face an equal risk of developing diabetes until early adulthood. However, after the age of 30, women are at a higher risk of developing type 2 diabetes mellitus compared to men. This is attributed to women's greater susceptibility to an increase in body mass index. Furthermore, hormonal changes following menopause influence fat distribution, which tends to accumulate, further elevating the risk of developing type 2 diabetes mellitus in women (Akalu & Belsti, 2020).

The findings of this study are consistent with the research conducted by Jia et al (2021) The present study demonstrates a substantial correlation between hypertension and type 2 diabetes mellitus, thereby substantiating the hypothesis that there is a significant relationship between the two conditions. Individuals with hypertension had a 0.146 times higher risk of developing type 2 diabetes mellitus (Jia et al., 2021). The findings of this study are consistent with previous research conducted by Kabosu et al., (2019) The findings of this study indicate a strong and meaningful association between elevated blood pressure (hypertension) and the likelihood of developing type 2 diabetes mellitus. The data suggests that individuals with a history

of hypertension are at an elevated risk, with a risk ratio of 3.423 compared to those without a history of high blood pressure. This underscores the potential role of hypertension as a contributing factor to the development of type 2 diabetes mellitus (Bener et al., 2016). The findings of this study are consistent with the research conducted by Milita et al., (2021) A strong and statistically significant association has been identified between a previous diagnosis of hypertension and the likelihood of developing type 2 diabetes mellitus among older adults residing in Indonesia. The analysis indicates that individuals with a history of hypertension face a risk that is approximately 1.960 times greater than that of their counterparts without a documented history of high blood pressure. This finding underscores the substantial impact of hypertension on the onset of type 2 diabetes mellitus in the elderly population (Milita et al., 2021).

The findings of this study are not consistent with the results of the research conducted by Susilawati and Rahmawati, (2021) The present study has demonstrated that there is no relationship between hypertension and the incidence of type 2 diabetes mellitus at the Tugu Depok City Health Center in 2019. Blood pressure that falls into the hypertension category should be watched out. Hypertension will cause insulin resistance or insulin resistance which is the cause of hyperinsulinemia. Finally, it results in damage to pancreatic beta cells and type 2 DM occurs (Kabosu et al., 2019). Hypertension can affect the occurrence of diabetes mellitus (DM) due to the thickening of the walls of arteries which results in a narrowing of the diameter of blood vessels, so that the process of transporting glucose from the blood is inhibited (Sun et al., 2019).

Research by Milita et al., (2021) shows that gender has a significant influence on the occurrence of type 2 diabetes in the elderly in Indonesia (Milita et al., 2021). Men and women have the same risk of developing diabetes until they reach early adulthood. However, after the age of 30, the risk for women becomes higher than for men. Women tend to be more susceptible to type 2 diabetes because physically they have a greater chance of experiencing an increase in body mass index (Chen et al., 2022).

Monthly cycle syndrome after menopause can lead to easier accumulation of body fat due to hormonal changes, This has been demonstrated to be a contributing factor to an increased risk of developing type 2 diabetes in women. (Kabosu et al., 2019). Increased body mass index (BMI), It is particularly noteworthy that those factors which result in obesity have been demonstrated to be closely associated with the risk of developing type 2 diabetes mellitus. Obesity has been shown to induce insulin resistance, where the body does not respond to insulin effectively so that blood sugar levels rise. Body fat that accumulates around the internal organs produces inflammatory substances that affect the body's ability to regulate blood sugar and can damage pancreatic cells that produce insulin. In addition, visceral fat present in the abdomen reduces the body's sensitivity to insulin and interferes with blood sugar regulation mechanisms.

The limitation of this study is that the data in this study cannot represent the population of Central Java Province, so the results of the study do not reflect the health conditions of the entire Central Java Province. And it is only limited to the demographic variables, namely the age group and gender studied.

CONCLUSION

The conclusion of this study is: There is a significant relationship between hypertension and the incidence of type 2 diabetes mellitus in men and women over 40-89 years old. The population most susceptible to developing type 2 diabetes mellitus (T2DM) within the context of the health centre area in Semarang City is comprised of women aged 60-69 years and men aged 40-49 years who are diagnosed with hypertension.

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