Urbanization in Indonesia and its impact on non-communicable diseases: a clinical, epidemiological, and immunological study

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Chapter 5

LIFESTYLE AND CLINICAL RISK FACTORS IN RELATION WITH THE PREVALENCE OF DIABETES IN THE INDONESIAN URBAN AND RURAL POPULATIONS: THE 2018 INDONESIAN NATIONAL HEALTH SURVEY

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ABSTRACT

Aims: To investigate the differences between the Indonesian urban and rural populations in the presence of lifestyle and clinical risk factors and their relation with the prevalence of diabetes.

Methods: Using the 2018 Indonesian Basic Health Survey data, the diagnosis of diabetes was based on the combination of known diabetes, i.e., a previous history of diabetes or use of anti-diabetes medication, and unknown diabetes based on blood glucose criteria according to American Diabetes Association 2022 guidelines. We performed logistic regression analyses separately for the urban and rural populations to examine the association of lifestyle and clinical factors with prevalent diabetes.

Results: Our study comprised 17,129 urban and 16,585 rural participants. Indonesian urban population was less physically active [proportion differences (95% confidence interval/CI): -11.8% (-13.5; -0.1)] and had a lower proportion of adequate fruit and vegetable intake [-0.8% (-1.5; -0.1)], than the rural population. Higher participants with obesity [12.8% (11.4; 14.1)] were also observed in urban compared to rural population. Although there were no differences in the total prevalence of diabetes between the two populations [10.9% (10.4; 11.5) vs. 11.0% (10.4; 11.7) for urban and rural, respectively], the prevalence of known diabetes was twice higher in the urban [proportion (95%CI): 3.8% (3.5; 4.2)] than in the rural population [1.9% (1.6; 2.1). Physical inactivity was associated with the prevalence of diabetes, especially in urban population [prevalence odds ratio (95%CI): 1.15 (1.01; 1.31) and 1.05 (0.89; 1.24) for urban and rural, respectively). Overweight/obesity, abdominal obesity, hypertension, and dyslipidemia were risk factors for prevalent diabetes in both populations.

Conclusions: Indonesian rural population showed relatively better lifestyle and clinical profiles than their urban counterparts. However, no differences were observed between the two populations in the relation between risk factors and diabetes. Special attention needs to be addressed to the high prevalence of undiagnosed and untreated diabetes in Indonesia.

INTRODUCTION

The prevalence of diabetes is increasing worldwide, from 8.3% in 2011 to 10.5% in 2021, and is projected to become 12.2% in 2045.[1] Currently, more than 80% of people with diabetes live in low and middle-income countries (LMICs) and the greatest relative increase in the prevalence of diabetes is expected to occur in middle-income countries.[1,2] Indonesia is the fourth most populated LMIC with a rising prevalence of diabetes. With more than 19 million people suffering from diabetes in 2021, it ranked as the 5th highest country of people with diabetes in the world, compared to the 7th in 2019.[1]

Diabetes causes significant morbidity and mortality [3] and is an established risk factor for other diseases such as cardiovascular diseases,[4] end-stage renal diseases,[5] and cancers.[6] In 2016, diabetes became the third leading cause of disability-adjusted life year (DALY) in Indonesia.[7] Diabetes not only has deleterious effects on an individual and society level, but also has become a national economic burden due to its high health care costs.[8]

The worldwide prevalence of diabetes was estimated to be higher in urban (12.1%) than in rural (8.3%) areas.[2] The rapid socio-economic development in many LMICs that promote rapid urbanization and influence the environmental and social changes, may lead to an increase in diabetes prevalence.[9] Previous studies have shown that urbanization is associated with relatively unhealthy dietary patterns [10] and less physical activity,[11] resulting in surplus of energy that will be stored as body fat.[12] This excess storage of body fat may result in obesity and consequent low-grade inflammatory state and insulin resistance, which eventually could lead to type 2 diabetes (T2D).[13] Our previous study in the Indonesian young adult population showed a higher prevalence of obesity, in the urban compared to the rural population.[10]

Besides obesity, previous studies also showed that hypertension and dyslipidemia differed greatly in prevalence between rural and urban populations.[14,15] Apart from the lifestyle and biological determinants mentioned above, the level of education, type of employment, and socio-economic status usually differs between urban and rural populations [16] and could potentially influence the incidence of diabetes.[17] We hypothesized that these urban-rural discrepancies in lifestyle, clinical, and socio-demographic factors contribute to the differences in the prevalence of diabetes between these two populations. Therefore, the aim of our study was to investigate the differences in these risk factors between Indonesian urban and rural populations and their relationship with the prevalence of diabetes (**Supplementary Figure 1**).

METHODS

Study design and population

To investigate the objectives mentioned above, the data from The 2018 Indonesian Basic Health Survey (Riset Kesehatan Dasar, RISKESDAS) was used in this cross-sectional study. RISKESDAS is a five-yearly national health survey conducted by the Ministry of Health, Indonesia, the latest in 2018. This survey incorporated questionnaires and biomedical data collection to evaluate the prevalence of communicable and non-communicable diseases, as well as the health-related risk factors in the Indonesian population.

The 2018 RISKESDAS population comprises 1,017,290 individuals of all ages, of whom 713,783 were ≥15 years old during the time the survey was commenced. This present study included non-pregnant individuals aged ≥15 years who were randomly sampled for blood glucose measurement (n=37,135). Individuals with missing data on clinical factors (body mass index, waist circumference, systolic/diastolic blood pressure, and lipid profile) and lifestyle factors (physical activity level, fruit and vegetable intake, smoking status, and alcohol consumption) were excluded. This study was approved by and registered in the National Institute of Health Research and Development (NIHRD), Ministry of Health, Republic of Indonesia.[18]

Data collection

The design for the data collection and selection of respondents in the 2018 RISKESDAS was integrated with the data from The National Economic Survey held by The Indonesian Central Bureau Statistics (Biro Pusat Statistik/BPS). A detailed explanation of the methodological sampling has been described previously.[19,20] Briefly, the participants were selected using a multistage systematic random sampling design. By considering urban-rural distribution using the 2010 BPS criteria,[21] 30.000 survey blocks were randomly selected from 34 provinces, each consisting of 10 census buildings. From each census building, one household was randomly selected. All household members of each selected household were asked to participate in the survey. A set of multiple blocks interviewer-assisted questionnaires were used to record data on socio-demographics, history of diseases, and behavioral/lifestyle determinants.[22] The participants who underwent biomedical data collection, including blood glucose measurements, were randomly selected from 2500 census blocks across 26 provinces, with 1446 urban and 1054 rural sites representing the overall Indonesian population.[19,20]

Assessment of socio-demographic determinants

Age, sex, marital status, level of education, employment status, and type of employment were obtained using standardized questionnaires. The level of education was categorized as low (no formal education after primary school); intermediate (high school); and high (college/university). The type of employment was categorized as currently in education, unemployed/retired, working in the formal sector (civil servant, army, police, private employee, entrepreneur), and working in the informal sector (farmer, fisherman, labor, driver, domestic helper). A socio-economic status score was based on the ownership of household assets, as well as average income and expenditure, from the data previously obtained by BPS and was divided into quintiles. A higher number represents a higher socio-economic status.[23] The urban and rural areas were defined based on the criteria established by BPS in 2010,[21] including population density/km^2, farming household percentage, and availability/ accessibility for urban-related facilities (school, market, shop, hospital, movie theatre, hotel, and percentage of household with telephone or electricity). Each criteria has a certain score and a total score ≥10 was considered an urban area, and people living in those areas were considered member of the urban population (**Supplementary Table 1**).

Assessment of lifestyle factors

Physical activity was measured by the adapted Short Questionnaire to Assess Health-Enhancing (SQUASH) physical activity integrated into the RISKESDAS questionnaire, as the frequency and duration of moderate and vigorous activity within four domains, which were restructured to hours per week of metabolic equivalents.[24] Being physically active was defined as moderate to vigorous physical activity (MVPA) of ≥30 minutes/day for 5 days or ≥150 minutes/week.[25]

In the RISKESDAS questionnaire, fruit and vegetable intake was measured as the number of portions eaten per day, with display cards of common dishes provided by the interviewers as visual aids.[22] The recommended intake for fruits and vegetables is ≥400 grams/day or ≥5 portions/day.[25]

Smoking status was assessed as never, former, and current smoker. Additionally, the pack-years of smoking was calculated by multiplying the number of packs of cigarettes smoked per day by the number of years the person smoked. Alcohol consumption was estimated by the number of portion glasses per day, with display cards as visual aids, summed across all types of alcohol and restructured to the unit of alcohol per day.[22]

Assessment of clinical factors

Body weight was measured by a calibrated digital FESCO™ weight scale to the nearest 0.1 kg. Body height was measured without shoes using a calibrated, vertically fixed tape measure to the nearest 0.1 cm. BMI was calculated by dividing body weight (kg) by the square of height (m2) and categorized based on the WHO criteria for the Asia-Pacific population [26] Waist circumference was measured halfway between the iliac crest and the lowest rib using a flexible steel tape measure to the nearest 0.1 cm (SECA Model 201, Seca Gmbh Co, Hamburg, Germany).[20]

Blood pressure was obtained by a digital sphygmomanometer at the left arm and upright sitting position after 5 minutes of rest (HEM-7200, Omron Healthcare Co, Ltd, Kyoto, Japan). The average of three measurements was used for analysis. Hypertension was defined as systolic blood pressure (SBP) ≥140 mmHg and/or diastolic blood pressure (DBP) ≥90 mmHg or previous diagnosis of hypertension with current use of anti-hypertensive medications.[27] Serum total, HDL-, and LDL-cholesterol, as well as triglyceride levels were measured using standard clinical chemistry methods (Roche® enzymatic assay).[19] Based on the criteria from The Indonesian Society of Endocrinology 2021, dyslipidemia was defined as one or more of the following criteria: total cholesterol ≥200 mg/dL, LDL-cholesterol ≥130 mmHg, HDL-cholesterol <40 mmHg in men or <50 mmHg in women, and triglyceride ≥150 mg/dL.[28]

Assessment of diabetes status

The definition of diabetes was based on the combination of known diabetes, i.e., a previous diagnosis of diabetes or use of anti-diabetes medication, and unknown diabetes based on blood glucose criteria according to the American Diabetes Association (ADA) 2022 guidelines for the diagnostic criteria of diabetes, which include one or more of the following [29]: fasting plasma glucose (FPG) ≥126 mg/dL, OR 2-hour plasma glucose (2h-PG) ≥200 mg/dL during oral glucose tolerance test (OGTT), OR random blood glucose ≥200 mg/dL with classic symptoms of hyperglycemia or hyperglycemia crisis. In the survey, random, fasting, and 2-hour post OGTT blood glucose were measured using capillary blood samples (Accu-Chek Performa, Roche Diagnostics GmbH, Mannheim, Germany). HbA1c was not measured during the survey.

Statistical analysis

All analyses in our study were weighted towards municipality/provincial density to correct for the differences in geographical density and urban/rural distribution across the 34 provinces in Indonesia.[20] As a result of the weighted analyses, percentages and proportions were given instead of the number of participants.

Study population characteristics and diabetes prevalence were presented for the Indonesian urban and rural populations. Continuous variables were summarized as mean with standard deviation (SD) for normally distributed data and median (25th, 75th percentile) for non-normally distributed data. Categorical variables were presented as proportions with 95% confidence intervals (95% CI). Additionally, the differences between urban and rural population were presented as mean or proportion differences with 95% CI.

We performed multivariable logistic regression analyses to calculate odds ratios (OR) with 95% confidence intervals, stratified by the urban and rural population to examine the associations between lifestyle and clinical determinants with the total prevalence of diabetes. The associations between lifestyle factors and diabetes were adjusted for socio-demographic determinants (age, sex, education, occupation, marital status, and socio-economic status) and BMI. The associations between clinical factors and diabetes were adjusted for socio-demographic, lifestyle factors, and BMI. The lifestyle and clinical factors were both modeled as continuous and as categorical variables based on known cut-offs from previous literatures. All continuous variables were modeled based on their actual unit, except for MVPA duration and smoking pack-years, which used per standardized (SD) unit for better interpretation. For lifestyle factors, the behaviors that are considered a part of a healthy lifestyle based on national guidelines recommendation [25] will serve as reference. These include as follows: physically active, defined as ≥150 minutes/week (≥30 minutes/day for 5 days) of moderate-vigorous physical activity; adequate intake of fruits and vegetables, defined as intake of ≥5 portions/day; never smoker; and no alcohol consumption.

To examine the differences between the populations within one analysis, we generated new categorical variables for the combinations of each risk factor and the population, using the non-exposed ('healthy') urban population as the reference. All analyses were performed using STATA (version 16.0, StataCorp, College Station, TX, USA).

RESULTS

Socio-demographic, lifestyle, and clinical factors in Indonesian urban and rural populations

In this study, we included 33,714 participants (17,129 urban and 16,585 rural) who were non-pregnant and ≥15 years old from the 2018 RISKESDAS database after excluding participants without blood glucose measurements and with missing data on lifestyle and clinical factors (**Figure 1**). The rural Indonesian population was slightly older than its urban counterpart. More participants in the urban population had a higher education [proportion difference (95% confidence interval/CI): 5.5% (4.8; 6.3)] and were in the highest quintile of socio-economic status [23.4% (21.4; 25.3)] compared to rural population. In terms of lifestyle factors, the rural population was more physically active [-11.8% (-13.5; -0.1)] and more often had an adequate fruit and vegetable intake [-0.8% (-1.5; -0.1)] than the urban population. In comparison with the urban population, the rural population more often were current smokers (**Table 1**).

BMI and waist circumference were higher in urban than rural population. This also applied to the proportion of participants with obesity, either by BMI categories (40.7% vs. 28.9%, for urban and rural, respectively) or abdominal obesity criteria (41.2% for urban and 28.4% for rural population). Systolic blood pressure was higher in rural compared to urban population, and the opposite was observed for DBP, resulting in no differences of hypertension status between the two groups. In addition, no differences were observed for total cholesterol, LDL-cholesterol, HDL-cholesterol, and triglyceride levels between the two populations. Nevertheless, the proportions of hypercholesterolemia, high LDL-cholesterol, hypertriglyceridemia, and dyslipidemia were higher in the urban than in the rural population. (**Table 1**).

Diabetes prevalence in the Indonesian urban and rural populations

There were no differences in the total prevalence of diabetes between Indonesian urban and rural population [proportion (95%CI): 10.9% (10.4; 11.5) and 11.0% (10.4; 11.7) for urban and rural, respectively]. Nevertheless, the proportion of individuals with a previous diabetes diagnosis and using anti-diabetes medication was twice as high in the urban population [3.8% (3.5; 4.2)] than in the rural population [1.9% (1.6; 2.1]. This resulted in a relatively high prevalence of undiagnosed and untreated diabetes, especially in the rural population [7.1% (6.7; 7.6) in urban and 9.1% (8.6; 9.8) in rural population] (**Figure 2**).

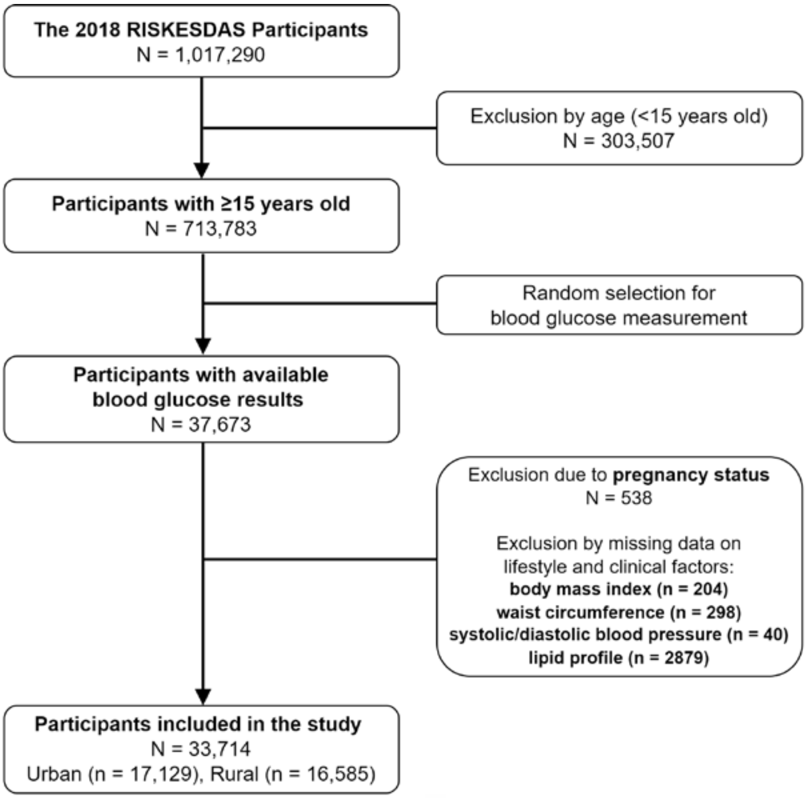

Figure 1. Flow chart for the inclusion of study participants using the data from The 2018 Indonesian Basic Health Survey.

Table 1. Differences in socio-demographic characteristics, lifestyle factors, and clinical factors between Indonesian urban (n = 17,129) and rural (n = 16,585) population.

	Urban (55%)	Rural (45%)	Differences[13] (95 CI)
Socio-demographic			
Age, years	42.6 (14.9)	44.5 (16.7)	-1.8 (-2.2; -1.4)
Sex (% men)	50.3 (49.6; 51.0)	50.5 (48.8; 50.1)	-0.2 (-1.1; 0.7)
Level of education (% high[1])	8.2 (7.5; 8.9)	2.6 (2.3; 3.0)	5.5 (4.8; 6.3)
Type of employment (% informal sector[2])	26.4 (25.2; 27.5)	53.0 (51.7; 54.2)	-26.7 (-28.3; -24.9)
Marital status (% married)	73.8 (73.0; 74.6)	79.1 (78.3; 79.8)	-5.3 (-6.4; -4.2)
Socio-economic status (% highest/5th quintile)	32.9 (31.2; 34.7)	9.5 (8.7; 10.4)	23.4 (21.4; 25.3)
Lifestyle Factors			
Physically active (%)	73.5 (72.1; 74.9)	85.3 (84.2; 86.3)	-11.8 (-13.5; -0.10)
Moderate-vigorous physical activity duration* (hours/week)	11.5 (2; 28)	21 (7; 42)	-8.1 (-9.1; -7.1)
Adequate fruit and vegetable intake (%)	3.4 (3.0; 3.8)	4.2 (3.6; 4.9)	-0.8 (-1.5; -0.1)
Fruit and vegetable intake* (portion/day)	1.4 (0.9; 2.1)	1.4 (1.0; 2.6)	-0.2 (-0.2; -0.1)
Smoking behaviour (% current smoker)	31.8 (30.9; 32.7)	37.1 (36.2; 37.9)	-5.3 (-6.5; -4.0)
Pack years*[3]	10.1 (4.2; 19.2)	12 (5.8; 21.5)	-1.7 (-2.5; -0.9)
Alcohol consumption (% current drinker)	2.2 (2.0; 2.5)	1.7 (1.5; 2.0)	0.5 (0.1; 0.9)
Quantity*[4] (unit alcohol/day)	0.2 (0.1; 1.0)	0.3 (0.1; 1.5)	0.2 (-0.5; 1.0)
Clinical Factors			
BMI (kg/m2)	24.4 (4.7)	23.1 (4.6)	1.3 (1.2; 1.4)
BMI categories[5] (%)			
Underweight (<18.5 kg/m2)	9.3 (8.8; 9.9)	11.9 (11.3; 12.6)	-2.6 (-3.4; -1.7)
Normo-weight (18.5-22.9 kg/m2)	33.1 (32.2; 34.0)	44.1 (43.2; 45.1)	-11.1 (-12.3; -9.8)
Overweight (23.0-24.9 kg/m2)	16.8 (16.2; 17.4)	15.0 (14.4; 15.6)	1.8 (1.0; 2.7)
Obesity (≥25.0 kg/m2)	40.7 (39.8; 41.7)	28.9 (28.0; 29.8)	12.8 (11.4; 14.1)
Waist circumference, cm	81.8 (11.8)	77.7 (12.2)	4.1 (3.7; 4.5)
Men	81.3 (10.8)	76.3 (10.3)	5.0 (4.5; 5.6)
Women	82.3 (12.7)	79.2 (13.9)	3.1 (2.6; 3.6)
Abdominal obesity[6] (%)	41.2 (40.1; 42.2)	28.4 (27.5; 29.3)	12.8 (11.4; 14.1)
Men	24.5 (23.2; 25.7)	10.4 (9.6; 11.3)	14.0 (12.5; 15.5)
Women	58.1 (56.8; 59.3)	46.7 (45.4; 48.0)	11.4 (9.5; 13.2)
Systolic blood pressure, mmHg	131.3 (23.0)	132.7 (25.0)	-1.4 (-2.1; -0.8)
Diastolic blood pressure, mmHg	84.6 (12.4)	83.9 (13.2)	0.7 (0.3; 1.1)
Hypertension[7] (%)	40.2 (39.2; 41.1)	39.3 (38.3; 40.3)	0.9 (-0.5; 2.2)
Total cholesterol, mmol/L	4.7 (1.0)	4.6 (1.1)	0.1 (0.1; 0.1)
Hypercholesterolemia[8] (%)	29.9 (29.0; 30.8)	26.4 (25.5; 27.3)	3.5 (2.2; 4.7)
LDL-cholesterol, mmol/L	3.2 (0.8)	3.1 (0.9)	0.1 (0.1; 0.1)
High LDL-cholesterol[9] (%)	38.7 (37.7; 39.7)	35.0 (34.0; 36.0)	3.7 (2.2; 5.1)
HDL-cholesterol, mmol/L	1.2 (0.3)	1.2 (0.3)	0.0 (-0.0; 0.0)
Low HDL-cholesterol[10] (%)	40.6 (39.6; 41-6)	41.2 (40.2; 42.2)	-0.6 (-2.0; 0.9)
Triglyceride, mmol/L	1.5 (1.1)	1.4 (1.0)	0.1 (0.1; 0.1)
Hypertriglyceridemia[11] (%)	28.4 (27.5; 29.2)	25.7 (24.8; 26.5)	2.7 (1.5; 3.9)
Dyslipidemia[12] (%)	69.5 (68.7; 70.4)	68.0 (67.1; 68.9)	1.5 (0.3; 2.8)
Random blood glucose, mmol/L	6.2 (2.4)	6.1 (2.4)	0.1 (-0.0; 0.2)
Fasting blood glucose, mmol/L	5.7 (1.8)	5.6 (1.6)	0.1 (0.1; 0.2)
2-hour glucose post OGTT, mmol/L	8.1 (2.9)	8.1 (2.9)	-0.0 (-0.2; 0.1)

Data were presented as mean (SD) for normally distributed continuous variables and median (25th-75th percentiles) for not- normally distributed continuous variables. Categorical variables were presented as percentage (95% confidence interval). Results were based on analyses weighted towards geographical density across 34 provinces in Indonesia.

*not-normally distributed continuous variables

[1]High education level includes participants who currently studying or having degree in college or university.

[2]Informal sector employment includes farmer, fisherman, labor, driver, and domestic helper

[3]calculated from individuals who smoke.

[4]calculated from individuals who drink alcohol.

[5]BMI categories were based on the WHO cut-offs for Asian population.

[6]Ethnic-Specific (Asian) waist-circumference cut-offs for abdominal obesity were >90 cm for men and >80 cm for women.

[7]Hypertension was defined as systolic blood pressure >140 mmHg AND/OR diastolic blood pressure >90 mmHg OR previous hypertension diagnosis with current use of anti-hypertensive medications.

[8]Hypercholesterolemia was defined as total cholesterol levels ≥5.2 mmol/L ((≥200 mg/dL).

[9]High LDL-cholesterol was defined as LDL-cholesterol levels ≥3.4 mmol/L (≥130 mg/dL).

[10]Low HDL-cholesterol was defined as HDL-cholesterol levels <1.0 mmol/L (<40 mg/dL) in men or <1.3 mmol/L (<50 mg/dL) in women.

[11]Hypertriglyceridemia was defined as triglyceride levels ≥1.7 mmol/L (≥150 mg/dL).

[12]Dyslipidemia was defined based of one or more of the following criteria: total cholesterol ≥200 mg/dL, OR LDL-cholesterol ≥130 mg/dL, OR low triglyceride (≥150 mg/dL), OR low HDL-cholesterol (<40 mg/dL in men or <50 mg/dL in women).

[13]Differences were calculated as values in urban minus values in rural. For not normally distributed continuous variables, the differences were calculated using mean and standard error to obtain the mean differences and its 95% confidence intervals.

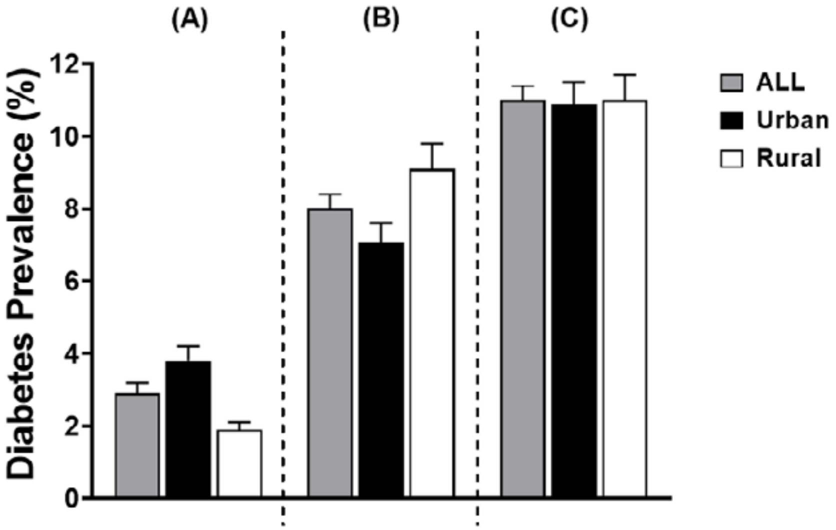

Figure 2. The prevalence of diabetes between Indonesian urban and rural population, A. Known (previously diagnosed and treated) diabetes; B. Unknown (undiagnosed and untreated) diabetes; C. Total prevalence* *The combination of prevalence of known diabetes and unknown diabetes using blood glucose criteria as follows: fasting plasma glucose (FPG) ≥126 mg/dL or 7 mmol/L, OR 2-hour plasma glucose (2h-PG) ≥200 mg/dL or 11.1 mmol/L after an oral glucose tolerance test (OGTT), OR random blood glucose ≥200 mg/dL or 11.1 mmol/L with classic symptoms of hyperglycemia or hyperglycemia crisis.

Lifestyle factors and prevalent diabetes in Indonesian urban and rural populations

Longer duration of moderate/vigorous physical activity was associated with lower risk of prevalent diabetes [prevalence odds ratio (95% confidence interval): 0.91 (0.85; 0.98) for urban and [0.94 (0.89; 1.00) for rural population, per 1 SD unit=21.4 hours/week] (**Table 2A**). The results were similar when using categorical variables in the models, showing a higher risk of prevalent diabetes with physical inactivity, especially in the urban population (**Table 2B**). In contrast with majority of previous findings, we found a positive correlation between fruit and vegetable intake with prevalent diabetes in the urban population (**Table 2A**). Although, sensitivity analysis showed a possible confounding of sex, age, and BMI in this association since additional adjustment for these factors resulted in the attenuation of the ORs (**Supplementary Tables 2 and 3**). Additionally, in this urban population, inverse associations between smoking pack-years and alcohol consumption with the prevalence of diabetes were also observed (**Table 2A**). Moreover, when compared to the non-smoker group, current smoker was inversely associated with prevalent diabetes in urban and rural populations (**Table 2B**). Further sensitivity analysis showed that this current smoker group has a lower BMI and higher proportion of men than the non-smoker group in both populations (**Supplementary Tables 4 and 5**).

Clinical factors and prevalent diabetes in Indonesian urban and rural populations

All clinical factors, either modelled as continuous or as categorical variables, were associated with prevalent diabetes both in urban and rural populations (**Table 3A and 3B**).

The differences in the association of lifestyle and clinical factors with diabetes prevalence between Indonesian urban and rural populations

In comparison with the urban-physically active group, a higher prevalence odds ratio of diabetes was observed for urban-inactive [prevalence OR (95%CI): 1.17 (1.03; 1.33) but not for the rural-inactive group (0.97, 0.81; 1.16). No differences were observed between urban and rural populations who did not consume adequate fruit and vegetable compared with the urban-adequate group as the reference category. There were also no differences between urban and rural current smokers in comparison with the urban reference group (**Figure 3A**).

With regard to clinical factors, the urban and rural populations with overweight or obesity had higher prevalence ORs than the urban-normo-weight reference group, although there were no differences between the two groups [1.79 (1.56; 2.06) vs. 1.84 (1.57; 2.15) for urban-overweight/obese and rural-overweight/obese, respectively]. Similar patterns were observed for all other clinical factors, showing no differences in the prevalence ORs of diabetes between the urban and rural populations with clinical risk factors compared to the urban population without risk factor (**Figure 3B**). Additionally, it can be observed that when compared with the urban population without lifestyle or clinical risk factors, the rural population without risk factors had a higher risk of prevalent diabetes. Further analyses showed that this rural population without risk factors was somewhat older than the urban reference group (**Supplementary Table 6**).

Table 2A. Association of lifestyle factors as continuous variables with prevalent diabetes in Indonesian urban and rural population.

Variables	Model[3]	Prevalence Odds Ratio (95%CI)	
		Urban	Rural
Moderate/vigorous physical activity,	Crude OR	0.86 (0.81; 0.92)	0.90 (0.85; 0.95)
per 1 SD=21.4 hours/week	Model 1	0.92 (0.87; 0.99)	0.97 (0.91; 1.02)
	Model 2	0.92 (0.86; 0.98)	0.96 (0.90; 1.02)
	Model 3	0.91 (0.85; 0.98)	0.94 (0.89; 1.00)
Fruit and vegetable intake (portion/day)	Crude OR	1.11 (1.07; 1.14)	1.01 (0.97; 1.05)
	Model 1	1.08 (1.04; 1.12)	1.01 (0.97; 1.05)
	Model 2	1.07 (1.03; 1.11)	1.02 (0.97; 1.06)
	Model 3	1.06 (1.02; 1.11)	1.01 (0.96; 1.05)
Smoking[1],	Crude OR	1.35 (1.23; 1.49)	1.26 (1.15; 1.37)
per 1 SD=15.2 pack-years	Model 1	0.97 (0.85; 1.11)	1.05 (0.93; 1.19)
	Model 2	0.94 (0.81; 1.10)	1.01 (0.88; 1.17)
	Model 3	0.94 (0.81; 1.10)	1.00 (0.86; 1.16)
Alcohol consumption[2] (unit alcohol/day)	Crude OR	0.87 (0.78; 0.96)	1.01 (0.91; 1.11)
	Model 1	0.85 (0.78; 0.93)	1.02 (0.95; 1.10)
	Model 2	0.86 (0.77; 0.96)	1.02 (0.95; 1.10)
	Model 3	0.86 (0.76; 0.96)	1.02 (0.95; 1.10)

Data were presented as prevalence odds ratio (OR) and its 95% confidence interval (CI).
[1]calculated from individuals who smoke.
[2]calculated from individuals who drink alcohol.
[3]Model for adjustment:
Model 1: adjusted for age and sex.
Model 2: adjusted for model 1 + other socio-demographic determinants (education, employment, marital, and socio-economic status).
Model 3: adjusted for model 2 + body mass index
SD: standardized unit

Table 2B. Association of lifestyle factors as categorical variables with prevalent diabetes in Indonesian urban and rural population.

Variables	Urban				Rural			
	Crude OR	Model 1[1]	Model 2[2]	Model 3[3]	Crude OR	Model 1[1]	Model 2[2]	Model 3[3]
Moderate/vigorous physical activity								
- Active	1	1	1	1	1	1	1	1
- Inactive	1.24	1.13	1.12	1.15	1.10	0.98	1.00	1.05
	(1.11; 1.40)	(1.00; 1.28)	(0.99; 1.28)	(1.01; 1.31)	(0.95; 1.28)	(0.84; 1.14)	(0.85; 1.18)	0.89; 1.24)
Fruit and vegetable intake								
- Adequate	1	1	1	1	1	1	1	1
- Not adequate	0.82	0.94	1.00	1.00	0.85	0.81	0.79	0.82
	(0.62; 1.07)	(0.71; 1.26)	(0.73; 1.36)	(0.73; 1.36)	(0.66; 1.08)	(0.63; 1.05)	(0.60; 1.04)	(0.62; 1.07)
Smoking								
- Never smoke	1	1	1	1	1	1	1	1
- Former smoker	1.26	0.98	0.96	0.96	0.93	0.85	0.89	0.89
	(1.06; 1.49)	(0.80; 1.20)	(0.77; 1.21)	(0.77; 1.20)	(0.72; 1.20)	(0.64; 1.13)	(0.66; 1.20)	(0.66; 1.20)
- Current smoker	0.52	0.56	0.57	0.61	0.55	0.62	0.63	0.68
	(0.45; 0.60)	(0.46; 0.67)	(0.47; 0.70)	(0.50; 0.74)	(0.48; 0.63)	(0.51; 0.76)	(0.51; 0.78)	(0.55; 0.84)
Alcohol consumption								
- Non-drinker	1	1	1	1	1	1	1	1
- Drinker	0.47	1.00	0.95	0.91	0.42	0.86	0.82	0.85
	(0.29; 0.76)	(0.61; 1.64)	(0.55; 1.64)	(0.53; 1.58)	(0.24; 0.75)	(0.48; 1.55)	(0.44; 1.54)	(0.46; 1.59)

Data were presented as prevalence odds ratio (OR) and its 95% confidence interval (CI).

[1]Model 1: adjusted for age and sex.

[2]Model 2: adjusted for model 1 + other socio-demographic determinants (education, employment, marital, and socio-economic status)

[3]Model 3: adjusted for model 2 + body mass index

Table 3A. Association of clinical factors as continuous variables with prevalent diabetes in Indonesian urban and rural population.

Variables	Model[1]	Prevalence Odds Ratio (95%CI)	
		Urban	Rural
BMI (kg/m²)	Crude OR	1.06 (1.05; 1.07)	1.06 (1.05; 1.07)
	Model 1	1.06 (1.05; 1.07)	1.06 (1.05; 1.08)
	Model 2	1.06 (1.05; 1.07)	1.06 (1.05; 1.08)
	Model 3	1.06 (1.05; 1.07)	1.06 (1.05; 1.08)
Waist circumference (cm), per 5 unit increase	Crude OR	1.19 (1.16; 1.21)	1.15 (1.12; 1.18)
	Model 1	1.15 (1.13; 1.18)	1.14 (1.11; 1.17)
	Model 2	1.15 (1.12; 1.17)	1.14 (1.11; 1.17)
	Model 3	1.14 (1.12; 1.17)	1.14 (1.11; 1.16)
	Model 4	1.11 (1.07; 1.15)	1.11 (1.07; 1.15)
Systolic blood pressure (mmHg), per 10 unit increase	Crude OR	1.25 (1.23; 1.27)	1.20 (1.17; 1.22)
	Model 1	1.12 (1.10; 1.15)	1.10 (1.08; 1.13)
	Model 2	1.12 (1.10; 1.15)	1.10 (1.07; 1.13)
	Model 3	1.12 (1.10; 1.15)	1.09 (1.07; 1.12)
	Model 4	1.10 (1.08; 1.13)	1.07 (1.05; 1.10)
Diastolic blood pressure (mmHg), per 5 unit increase	Crude OR	1.15 (1.12; 1.17)	1.15 (1.13; 1.18)
	Model 1	1.09 (1.07; 1.12)	1.11 (1.09; 1.13)
	Model 2	1.10 (1.08; 1.12)	1.10 (1.08; 1.13)
	Model 3	1.10 (1.07; 1.12)	1.10 (1.08; 1.12)
	Model 4	1.07 (1.05; 1.09)	1.07 (1.05; 1.10)
Total cholesterol (mmol/L)	Crude OR	1.67 (1.58; 1.75)	1.49 (1.42; 1.58)
	Model 1	1.40 (1.33; 1.48)	1.30 (1.23; 1.38)
	Model 2	1.40 (1.32; 1.49)	1.30 (1.22; 1.37)
	Model 3	1.40 (1.33; 1.49)	1.29 (1.22; 1.37)
	Model 4	1.37 (1.29; 1.45)	1.25 (1.18; 1.32)
LDL cholesterol (mmol/L)	Crude OR	1.66 (1.56; 1.76)	1.49 (1.40; 1.58)
	Model 1	1.40 (1.32; 1.49)	1.30 (1.22; 1.39)
	Model 2	1.39 (1.30; 1.48)	1.30 (1.22; 1.39)
	Model 3	1.39 (1.29; 1.48)	1.30 (1.21; 1.38)
	Model 4	1.34 (1.25; 1.43)	1.23 (1.15; 1.32)
HDL cholesterol (mmol/L)	Crude OR	0.65 (0.54; 0.78)	0.82 (0.67; 0.99)
	Model 1	0.35 (0.29; 0.43)	0.47 (0.38; 0.58)
	Model 2	0.36 (0.29; 0.44)	0.46 (0.37; 0.57)
	Model 3	0.34 (0.28; 0.42)	0.45 (0.36; 0.55)
	Model 4	0.40 (0.32; 0.50)	0.52 (0.42; 0.65)
Triglyceride (mmol/L)	Crude OR	1.32 (1.25; 1.40)	1.32 (1.24; 1.41)
	Model 1	1.30 (1.22; 1.39)	1.32 (1.24; 1.40)
	Model 2	1.31 (1.23; 1.41)	1.32 (1.24; 1.41)
	Model 3	1.33 (1.24; 1.42)	1.33 (1.25; 1.42)
	Model 4	1.28 (1.20; 1.37)	1.28 (1.20; 1.36)

Data were presented as prevalence odds ratio (OR) and its 95% confidence interval (CI).
[1]Model for adjustment:
Model 1: adjusted for age and sex.
Model 2: adjusted for model 1 + other socio-demographic determinants (education, employment, marital, and socio-economic status).
Model 3: adjusted for model 2 + lifestyle determinants (physical activity, fruit and vegetable intake, smoking behaviour, and alcohol consumption).
Model 4: adjusted for model 3 + body mass index.

Table 3B. Association of clinical factors as categorical variables with prevalent diabetes in Indonesian urban and rural populations.

Variables	Urban					Rural				
	Crude OR	Model 1	Model 2	Model 3	Model 4	Crude OR	Model 1	Model 2	Model 3	Model 4
BMI categories[1]										
- Underweight (<18.5 kg/m2)	0.72 (0.56; 0.95)	0.74 (0.57; 0.97)	0.78 (0.58; 1.03)	0.77 (0.59; 1.03)		1.10 (0.92; 1.32)	0.94 (0.79; 1.13)	0.95 (0.79; 1.15)	0.96 (0.79; 1.16)	
- Normo-weight (18.5-22.9 kg/m2)	1	1	1	1		1	1	1	1	
- Overweight (23.0-24.9 kg/m2)	1.60 (1.35; 1.89)	1.58 (1.33; 1.87)	1.53 (1.27; 1.84)	1.51 (1.25; 1.81)		1.31 (1.10; 1.55)	1.31 (1.10; 1.57)	1.29 (1.07; 1.56)	1.27 (1.06; 1.54)	
- Obese (≥25.0 kg/m2)	2.05 (1.80; 2.34)	1.99 (1.73; 2.29)	1.98 (1.71; 2.30)	1.94 (1.67; 2.25)		1.82 (1.59; 2.07)	1.80 (1.56; 2.07)	1.80 (1.55; 2.10)	1.77 (1.52; 2.05)	
Abdominal obesity[2]										
- No	1	1	1	1	1	1	1	1	1	1
- Yes	2.46 (2.22; 2.73)	2.09 (1.86; 2.34)	2.08 (1.84; 2.35)	2.05 (1.81; 2.31)	1.70 (1.46; 1.97)	2.00 (1.78; 2.24)	1.77 (1.56; 2.01)	1.75 (1.54; 2.00)	1.72 (1.51; 1.95)	1.30 (1.11; 1.52)
Hypertension[3]										
- No	1	1	1	1	1	1	1	1	1	1
- Yes	3.12 (2.82; 3.46)	1.90 (1.69; 2.13)	1.88 (1.66; 2.12)	1.85 (1.63; 2.09)	1.66 (1.46; 1.88)	2.47 (2.22; 2.76)	1.73 (1.54; 1.95)	1.68 (1.49; 1.90)	1.66 (1.47; 1.88)	1.49 (1.31; 1.68)
High total cholesterol[4]										
- No	1	1	1	1	1	1	1	1	1	1
- Yes	2.51 (2.26; 2.79)	1.76 (1.57; 1.98)	1.74 (1.54; 1.96)	1.75 (1.55; 1.97)	1.65 (1.46; 1.87)	2.12 (1.89; 2.38)	1.59 (1.41; 1.80)	1.55 (1.36; 1.76)	1.54 (1.36; 1.75)	1.44 (1.27; 1.63)
High LDL-cholesterol[5]										
- No	1	1	1	1	1	1	1	1	1	1
- Yes	2.10 (1.89; 2.33)	1.56 (1.40; 1.74)	1.54 (1.37; 1.73)	1.54 (1.37; 1.73)	1.44 (1.28; 1.62)	1.76 (1.58; 1.96)	1.42 (1.27; 1.59)	1.39 (1.24; 1.57)	1.39 (1.24; 1.56)	1.29 (1.14; 1.44)
Low HDL-cholesterol[6]										
- No	1	1	1	1	1	1	1	1	1	1
- Yes	1.41 (1.27; 1.56)	1.56 (1.41; 1.74)	1.56 (1.40; 1.75)	1.59 (1.43; 1.78)	1.46 (1.30; 1.64)	1.41 (1.27; 1.56)	1.46 (1.31; 1.63)	1.48 (1.32; 1.66)	1.50 (1.33; 1.68)	1.39 (1.24; 1.56)
High triglyceride[7]										
- No	1	1	1	1	1	1	1	1	1	1
- Yes	2.16 (1.94; 2.41)	2.01 (1.79; 2.26)	2.06 (1.82; 2.32)	2.09 (1.85; 2.36)	1.90 (1.68; 2.15)	1.96 (1.75; 2.20)	1.88 (1.67; 2.12)	1.87 (1.65; 2.12)	1.88 (1.66; 2.13)	1.71 (1.51; 1.94)
Dyslipidemia[8]										
- No	1	1	1	1	1	1	1	1	1	1
- Yes	2.38 (2.08; 2.72)	1.95 (1.70; 2.23)	1.92 (1.66; 2.22)	1.95 (1.69; 2.26)	1.75 (1.51; 2.04)	1.76 (1.54; 2.01)	1.55 (1.35; 1.77)	1.54 (1.34; 1.77)	1.54 (1.34; 1.78)	1.39 (1.21; 1.60)

[1]BMI categories were based on the WHO cut-offs for Asian Population
[2]Ethnic-Specific (Asian) waist-circumference cut-offs for abdominal obesity were >90 cm for men and >80 cm for women.
[3]Hypertension was defined as systolic blood pressure >140 mmHg AND/OR diastolic blood pressure >90 mmHg OR previous hypertension diagnosis with current use of anti-hypertensive medications.
[4]High total cholesterol (hypercholesterolemia) was defined as total cholesterol levels ≥5.2 mmol/L ((≥200 mg/dL).
[5]High LDL-cholesterol was defined as LDL-cholesterol levels ≥3.4 mmol/L (≥130 mg/dL).
[6]Low HDL-cholesetrol was defined as HDL-cholesterol levels <1.0 mmol/L (<40 mg/dL) in men or <1.3 mmol/L (<50 mg/dL) in women.
[7]Hypertriglyceridemia was defined as triglyceride levels ≥1.7 mmol/L (≥150 mg/dL).
[8]Dyslipidemia was defined based of one or more of the following criteria: total cholesterol ≥200 mg/dL, OR LDL-cholesterol ≥130 mg/dL, OR low triglyceride (≥150 mg/dL), OR low HDL-cholesterol (<40 mg/dL in men or <50 mg/dL in women).
Model 1: adjusted for age and sex.
Model 2: adjusted for model 1 + other socio-demographic determinants (education, employment, marital, and socio-economic status).
Model 3: adjusted for model 2 + lifestyle determinants (physical activity, fruit and vegetable intake, smoking behavior, and alcohol consumption).
Model 4: adjusted for model 3 + body mass index

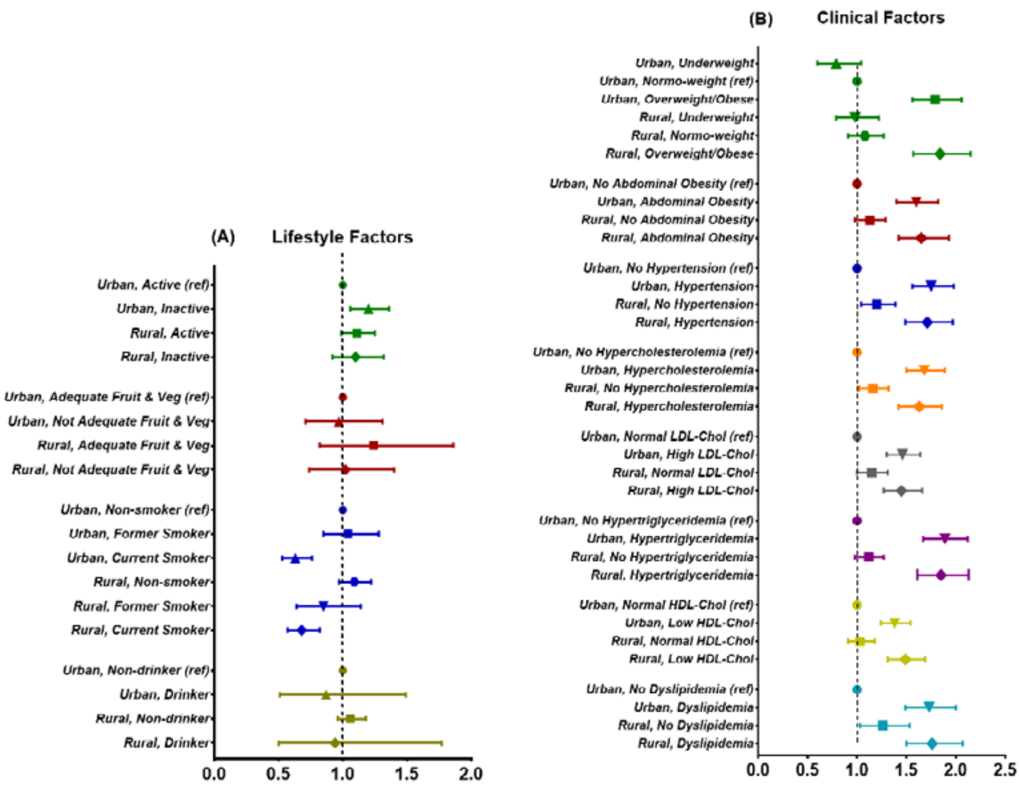

Figure 3. The differences in the association of lifestyle (A) and clinical (B) factors with prevalent diabetes between Indonesian urban and rural population. Data were presented as prevalence odds ratio (OR) with its 95% confidence interval (95%CI) compared with the reference category (ref), i.e., urban population without risk factors.
For models in A, Associations were adjusted for age, sex, socio-demographic determinants (level of education, type of employment, marital status, and socio-economic status), and body mass index (BMI).
For models in B, associations were adjusted for age, sex, socio-demographic determinants (level of education, type of employment, marital status, and socio-economic status), lifestyle factors (moderate/vigorous physical activity, fruit and vegetable intake, smoking, and alcohol consumption), and BMI.
Inactive was defined as moderate/vigorous physical activity <150 minutes/week.
Not adequate fruit and vegetable intake was defined as fruit and vegetable consumption <5 portions/day.
BMI categories were based on the WHO cut-offs for Asian population: underweight (BMI <18.5 kg/m2), normo-weight (BMI 18.5-22.9 kg/m2), and overweight/obese (BMI ≥23.0 kg/m2).
Ethnic-Specific (Asian) waist-circumference cut-offs for abdominal obesity were >90 cm for men and >80 cm for women.
Hypertension was defined as systolic blood pressure >140 mmHg AND/OR diastolic blood pressure >90 mmHg OR previous hypertension diagnosis with current use of anti-hypertensive medications.
Hypercholesterolemia was defined as total cholesterol levels ≥5.2 mmol/L ((≥200 mg/dL).
High LDL-cholesterol was defined as LDL-cholesterol levels ≥3.4 mmol/L (≥130 mg/dL).
Low HDL-cholesetrol was defined as HDL-cholesterol levels <1.0 mmol/L (<40 mg/dL) in men or <1.3 mmol/L (<50 mg/dL) in women.
Hypertriglyceridemia was defined as triglyceride levels ≥1.7 mmol/L (≥150 mg/dL).
Dyslipidemia was defined based of one or more of the following criteria: total cholesterol ≥200 mg/dL, OR LDL-cholesterol ≥130 mg/dL, OR low triglyceride (≥150 mg/dL), OR low HDL-cholesterol (<40 mg/dL in men or <50 mg/dL in women).

DISCUSSION

In this study utilizing the data from RISKESDAS 2018, we observed several differences in lifestyle and clinical determinants between Indonesian urban and rural population aged ≥15 years old. Compared with the urban population, the rural population had a better profile of lifestyle and clinical factors. Whereas there was no difference in the total prevalence of diabetes between the populations, a higher prevalence of previously diagnosed diabetes individuals using anti-diabetes medication was observed in the urban than in the rural population. In terms of lifestyle, physical inactivity was a risk factor for diabetes, and most strongly in the urban population. Whereas overweight/obesity, abdominal obesity, hypertension, and dyslipidemia were all risk factors for diabetes in both populations, there were no differences in the relation between these risk factors and the prevalence of diabetes between the urban and rural population.

The observed higher physical activity levels in rural compared to urban population had been shown in previous study.[30] This finding could be explained by the greater proportion of individuals in rural areas who work in the informal sector, which need more physical work, as shown in our previous study.[31] Our study also confirmed that longer duration of MVPA in a week is inversely associated with diabetes and physical inactivity is associated with higher risk of diabetes, which were more pronounced in the urban population. This could be explained by previous findings that leisure time, but not occupational physical activity, is associated with a lower risk of diabetes.[32]

Contrary to the finding from previous study,[33] we observed a positive association between fruit and vegetable consumption and diabetes in the urban population. One potential explanation for this finding may be reverse causation due to the cross-sectional nature of our study: patients with diabetes may have adjusted their diet after the diagnosis of diabetes. In addition, in our urban population, sex, age, and BMI seemed strong confounding factors in this association. More women, with higher age and BMI were observed for the highest tertile of fruit and vegetable intake compared to the lowest tertile. Furthermore, the types of fruit or vegetable and serving methods were not evaluated in this study. Previous study showed that certain types fruits or vegetables and juices were positively associated with diabetes.[33,34]

The finding of current smokers that is inversely associated with diabetes compared to the non-smoker group was also reported to be confounded by sex and BMI by several previous studies.[35,36] Indeed, in our study, the current smoker group had a lower BMI and male predominance compared with the non-smokers. Although, adjustment for sex and BMI did not fully attenuate the associations. The observed inverse association between alcohol consumption and diabetes in the urban population supports the findings from previous studies showing that light/moderate drinking might lower the risk of diabetes.[37,38] However, this finding must be interpreted carefully since current drinkers may represent a small selective group of the Indonesian urban population who drink alcohol, and may have a lower risk of diabetes because of other reasons than alcohol consumption.

The higher BMI and waist circumference, as well as the higher proportion of obesity in urban compared to rural population observed in the current study, confirmed the finding from our previous study.[10] Our present study also found these adiposity indices and obesity are positively correlated with diabetes in both populations, similar to what had been observed previously.[39,40] In addition, higher blood pressure and hypertension status as well-established clinical risk factors for diabetes,[39,41] were also confirmed in this study for both urban and rural populations. Subsequently, as reported before,[15] our study also showed a higher prevalence of hypercholesterolemia, high LDL-cholesterol, hypertriglyceridemia, and dyslipidemia in the urban than rural population. In concordance with the finding from previous study,[42] our study also observed positive associations between these lipid abnormalities and prevalent diabetes.

Interestingly, although rural population had a better lifestyle and clinical profile than the urban population, there were no differences in the associations with diabetes between the two populations, except for physical activity. Nevertheless, it must be noted there is an alarming increase of BMI in the rural areas of low-middle income countries, possibly due to transition from undernutrition to complex malnutrition with over consumption of low-quality calories,[43] which may lead to increased future rates of diabetes in rural populations. Our previous studies also support this postulate, showing more unfavorable metabolic changes in rural compared to urban subjects, when exposed towards short-term high-fat high-calories diet intervention,[44] as well as a relatively long-term urban lifestyle.[10]

We observed no differences in the prevalence of total diabetes between urban and rural population. This supports the finding from The 2014 Indonesia Family Life Survey (IFLS) which showed a similar pattern (7.5% in urban vs. 6.8% in rural population) using HbA1c measurement.[45] Interestingly, another study using the same IFLS database reported a twice higher prevalence of known diabetes in the Indonesian urban compared to the rural population (2.9% vs. 1.4%, for urban and rural, respectively), similar to what was found in our current study.[46]

Based on the findings from our current study and The 2014 IFLS database, we could observe that majority of individuals with diabetes in Indonesia were undiagnosed and untreated, especially in the rural population. The higher proportion of undiagnosed and untreated diabetes observed in the rural population might be due to several factors: limited availability and difficulties to access of healthcare facilities,[47,48] relatively poor socio-economic factors requiring prioritization of household resources for needs other than health,[45] and the lower level of education may lead to a lack of knowledge in the importance of diabetes screening.[49] In addition, this number of undiagnosed diabetes in Indonesia is higher than the global prevalence of 44%, as reported by IDF in 2021.[1] Strikingly, compared with the 2007 Indonesian Basic Health Survey report showing approximately 74% out of the 5.7% Indonesian population with diabetes being undiagnosed,[50] there has been no improvement in the last decade regarding undiagnosed diabetes in Indonesia. Thus, concrete actions need to be taken by all related stakeholders to improve this condition since diabetes is associated with many health complications,[51] even worse if left untreated or sub-optimally managed.[52,53] In the long term, this could lead to deleterious outcomes and an even higher burden on the Indonesian health and economic system.

The relatively large number of participants and nationally representative data are some of the strengths of our current study. Thus, the findings in this study could be generalized to the whole Indonesian population. Another added point offered by this study is the attempt to evaluate the magnitude of differences between urban and rural population on the association of lifestyle and clinical factors with diabetes. Our study also has some limitations that need to be considered. First, the unavailability of HbA1c data for diabetes diagnosis might lead to an underestimation of the total prevalence of diabetes in our study. Second, the observational and cross-sectional design of this study does not allow to evaluate the temporal relationship between exposures and outcome and may lead to reverse causation and residual confounding that may explain the unexpected associations between certain lifestyle factors with diabetes. Third, the possibility of information bias, including social desirability bias, and possible measurement error, could not be fully excluded in this study. Fourth, the unavailability of lipid lowering agent usage data might cause an underestimation of the prevalence of dyslipidemia/lipid-associated disorders. Lastly, there are other factors that might differ characteristically and in the association with diabetes between rural and urban population but not included in this study, such as consumption of high-risk foods,[54] macronutrients intake,[55] pollution,[56] parasitic infection,[57] and psychological stress.[58]

In conclusion, our study showed a better profile of lifestyle and clinical factors in the Indonesian rural compared to the urban population. Although there were no differences in the total prevalence of diabetes between the two populations, a high proportion of undiagnosed and untreated diabetes was observed, especially in the rural population. Moderate/vigorous physical activity needs to be encouraged more in the Indonesian population. Although there were no differences in the associations between clinical risk factor and diabetes between the two populations, all risk factors were associated with higher prevalence of diabetes. All these findings warrant extensive action, along with supportive government health policies, to overcome the diabetes pandemic in the Indonesian population. In particular, attention needs to be addressed to the high prevalence of undiagnosed and untreated diabetes in Indonesia.

Author contributions

Conceptualization: F.K., F.S.S., R.dM.; Methodology: F.K., F.S.S., S.T., D.L.T, E.S., R.dM.; Data acquisition: F.K., D.L.T, E.Y., T.J.E.T, D.S.H., P.S.; Formal analysis: F.K., F.S.S.; Supervision: E.S., P.S., R.dM.; Writing – original draft: F.K.; Writing – review and editing: F.S.S., S.T., D.L.T, E.Y., T.J.E.T, D.S.H., P.S., E.S., R.dM.

Conflict of Interest

The authors declare that they have no conflict of interest.

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SUPPLEMENTARY MATERIALS

Supplementary Table 1. The 2010 Indonesian Central Bureau Statistics criteria for defining urban and rural areas in Indonesia.

Criteria				Availability/accessibility for urban-related facilities		
Population density/km²	Score	Farming household percentage	Score	Urban-related facilities	Criteria	Score
<500	1	>70.00	1	a. Kindergarten	• Yes OR <2.5 km	1
500 – 1249	2	50.00 – 69.99	2	b. Junior high school	• >2.5 km	0
1250 – 2499	3	30.00 – 49.99	3	c. Senior high school		
2500 – 3999	4	20.00 – 29.99	4	d. Market	• Yes OR <2.0 km	1
4000 – 5999	5	15.00 – 19.99	5	e. Shops	• >2.0 km	0
6000 – 7499	6	10.00 – 14.99	6	f. Movie theatre	• Yes OR <5.0 km	1
7500 – 8499	7	5.00 – 9.99	7	g. Hospital	• 5.0 km	0
> 8500	8	<5.00	8	h. Hotel/Pool/Nightclub/	• Yes	1
				Massage parlors/Salon	• No	0
				i. Percentage of house-hold	• ≥8.00	1
				with telephone	• <8.00	0
				j. Percentage of house-hold	• ≥90.00	1
				with electricity	• <9000	0

Total score ≥10 was categorized as urban area.

Supplementary Table 2. Age, sex, and BMI between tertiles of fruit and vegetable intake in Indonesian urban and rural population.

	Lowest tertile	Mid-tertile	Highest tertile
		URBAN	
Age*, years old	41.4 (15.2)	42.6 (14.5)	43.9 (14.7)
Sex, %male	54.6 (53.2; 56.0)	50.2 (48.9; 51.6)	46.1 (44.8; 47.4)
BMI*, kg/m^2	23.8 (4.6)	24.5 (4.7)	24.9 (4.8)
Fruit and vegetable intake#, portion/day	0.6 (0.4; 0.9)	1.4 (1.1; 1.6)	2.7 (2.1; 3.6)
		RURAL	
Age*, years old	45.2 (17.6)	43.7 (16.5)	44.5 (16.0)
Sex, %male	52.0 (50.7; 53.4)	49.5 (48.1; 50.9)	50.1 (49.0; 51.2)
BMI*, kg/m^2	22.7 (4.5)	23.2 (4.7)	23.4 (4.7)
Fruit and vegetable intake#, portion/day	0.7 (0.4; 1.0)	1.3 (1.1; 1.5)	3 (2.3; 3.7)

*normally distributed continuous variable, presented as mean and its standard deviation.
#non-normally distributed continuous variable, presented as median (25th, 75th percentile)
BMI: body mass index

Supplementary Table 3. Association between fruit and vegetable intake tertiles and prevalent diabetes in Indonesian urban and rural population adjusted for sex, age, and BMI.

Fruit and vegetable intake tertiles	Crude OR	Adjusted for sex	Adjusted for age	Adjusted for BMI	Adjusted for sex, age & BMI
			URBAN		
Lowest tertile	1	1	1	1	1
Mid-tertile	1.14 (0.99; 1.31)	1.12 (0.97; 1.29)	1.12 (0.97; 1.30)	1.09 (0.95; 1.26)	1.07 (0.92; 1.24)
Highest tertile	1.44 (1.26; 1.65)	1.40 (1.23; 1.60)	1.37 (1.19; 1.57)	1.36 (1.19; 1.55)	1.26 (1.09; 1.45)
			RURAL		
Lowest tertile	1	1	1	1	1
Mid-tertile	0.93 (0.81; 1.07)	0.91 (0.79; 1.05)	0.98 (0.85; 1.14)	0.95 (0.82; 1.10)	0.95 (0.82; 1.09)
Highest tertile	0.97 (0.85; 1.11)	0.96 (0.84; 1.10)	1.01 (0.88; 1.16)	0.96 (0.84; 1.10)	0.96 (0.84; 1.10)

Data were presented as prevalence odds ratio (OR) and its 95% confidence interval (CI).

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Supplementary Table 4. Age, sex, BMI, and pack-years between the three categories of smoking habit in Indonesian urban and rural population.

	Non-smoker	Former smoker	Current smoker
		URBAN	
Age*, years old	41.8 (15.9)	49.0 (14.5)	42.6 (12.7)
Sex, %male	22.1 (21.1; 23.1)	83.5 (81.1; 85.7)	95.1 (94.4; 95.8)
BMI*, kg/m2	25.1 (5.1)	24.6 (4.6)	22.9 (3.7)
Pack-years#	0	14.4 (6.5; 30)	9.6 (4.0; 18.6)
		RURAL	
Age*, years old	43.1 (17.5)	51.0 (16.5)	45.8 (15.0)
Sex, %male	18.6 (17.7; 19.6)	87.1 (84.3; 89.5)	96.4 (95.8; 96.9)
BMI*, kg/m2	24.0 (5.2)	22.6 (4.4)	21.7 (3.4)
Pack-years#	0	16.2 (8.4; 28.2)	12 (5.7; 21)

*normally distributed continuous variable, presented as mean and its standard deviation.
#non-normally distributed continuous variable, presented as median (25th, 75th percentile)
BMI: body mass index

Supplementary Table 5. Association between smoking habit and prevalent diabetes in Indonesian urban and rural population adjusted for sex, age, and BMI.

Smoking categories	Crude OR	Adjusted for sex	Adjusted for age	Adjusted for BMI	Adjusted for sex, age & BMI
			URBAN		
- Non-smoker	1	1	1	1	1
- Former smoker	1.26	1.32	0.88	1.30	0.97
	(1.06; 1.49)	(1.10; 1.60)	(0.74; 1.05)	(1.09; 1.54)	(0.79; 1.19)
- Current smoker	0.52	0.55	0.49	0.59	0.60
	(0.45; 0.60)	(0.46; 0.66)	(0.43; 0.57)	(0.51; 0.68)	(0.50; 0.73)
			RURAL		
- Non-smoker	1	1	1	1	1
- Former smoker	0.93	1.12	0.70	0.99	0.85
	(0.72; 1.20)	(0.85; 1.50)	(0.54; 0.90)	(0.76; 1.28)	(0.64; 1.13)
- Current smoker	0.55	0.69	0.49	0.61	0.67
	(0.48; 0.63)	(0.56; 0.84)	(0.43; 0.56)	(0.54; 0.70)	(0.55; 0.81)

Data were presented as prevalence odds ratio (OR) and its 95% confidence interval (CI).

Supplementary Table 6. Age, sex, and BMI among the groups generated from the interaction between urban/rural and clinical factors.

Groups	Age	Sex (%male)	BMI
BMI Categories			
- Urban, Underweight	37.6 (18.6)	64.7 (62.1; 67.3)	17.1 (1.0)
- Urban, Normo-weight	41.5 (15.9)	60.1 (58.8; 61.4)	20.9 (1.2)
- Urban, Overweight/Obese	44.1 (13.1)	42.3 (41.3; 43.3)	27.6 (3.9)
- Rural, Underweight	46.7 (21.4)	62.6 (60.4; 64.8)	17.2 (1.2)
- Rural, Normo-weight	44.6 (17.4)	62.1 (60.9; 63.2)	20.8 (1.3)
- Rural, Overweight/Obese	43.7 (14.0)	35.6 (34.5; 36.7)	27.0 (3.7)
Abdominal Obesity			
- Urban, No abdominal obesity	40.6 (15.3)	64.6 (63.6; 65.5)	21.7 (3.0)
- Urban, Abdominal obesity	45.5 (13.4)	29.9 (28.7; 31.1)	28.3 (4.3)
- Rural, No abdominal obesity	44.2 (17.3)	63.2 (62.4; 64.0)	21.2 (3.1)
- Rural, Abdominal obesity	45.0 (14.5)	18.6 (17.4; 19.8)	27.8 (4.3)
Hypertension			
- Urban, No hypertension	37.9 (14.0)	52.8 (51.8; 53.8)	23.4 (4.3)
- Urban, Hypertension	49.7 (13.6)	46.6 (45.3; 47.8)	25.9 (4.9)
- Rural, No hypertension	40.2 (16.1)	54.9 (54.0; 55.8)	22.2 (4.2)
- Rural, Hypertension	51.0 (15.1)	43.8 (42.7; 44.9)	24.3 (4.9)
Hypercholesterolemia			
- Urban, No hypercholesterolemia	40.0 (14.9)	53.4 (52.5; 54.3)	23.8 (4.7)
- Urban, Hypercholesterolemia	48.8 (12.9)	43.0 (41.6; 44.5)	25.6 (4.7)
- Rural, No hypercholesterolemia	42.4 (16.8)	54.0 (53.2; 54.8)	22.7 (4.4)
- Rural, Hypercholesterolemia	50.3 (14.3)	40.8 (39.3; 42.3)	24.2 (4.9)
High LDL-Cholesterol			
- Urban, Low/normal LDL-cholesterol	39.8 (15.1)	53.0 (52.1; 53.9)	23.6 (4.6)
- Urban, High LDL-cholesterol	47.2 (13.4)	46.0 (44.8; 47.3)	25.6 (4.8)
- Rural, Low/normal LDL-cholesterol	42.3 (17.1)	53.9 (53.0; 54.8)	22.5 (4.4)
- Rural, High LDL-cholesterol	48.5 (14.8)	44.3 (43.0; 45.6)	24.2 (4.9)
Hypertriglyceridemia			
- Urban, No hypertriglyceridemia	41.3 (15.4)	46.4 (45.5; 47.3)	23.8 (4.7)
- Urban, Hypertriglyceridemia	46.0 (12.9)	60.1 (58.7; 61.5)	26.0 (4.4)
- Rural, No hypertriglyceridemia	43.5 (17.0)	48.1 (47.2; 48.9)	22.6 (4.5)
- Rural, Hypertriglyceridemia	47.2 (15.2)	57.7 (56.2; 59.2)	24.4 (4.8)
Low HDL-Cholesterol			
- Urban, High HDL-cholesterol	43.3 (15.3)	55.2 (54.2; 56.2)	23.5 (4.5)
- Urban, Low HDL-cholesterol	41.7 (14.2)	43.1 (41.9; 44.4)	25.6 (4.8)
- Rural, High HDL-cholesterol	45.8 (16.7)	58.4 (57.4; 59.3)	22.3 (4.2)
- Rural, Low HDL-cholesterol	42.5 (16.3)	39.3 (38.1; 40.5)	24.2 (5.0)
Dyslipidemia			
- Urban, No dyslipidemia	38.8 (15.5)	55.6 (54.1; 57.0)	22.5 (4.4)
- Urban, Dyslipidemia	44.3 (14.3)	48.0 (47.1; 48.9)	25.2 (4.7)
- Rural, No dyslipidemia	42.8 (17.5)	60.3 (58.9; 61.8)	21.6 (3.8)
- Rural, Dyslipidemia	45.2 (16.2)	45.9 (45.1; 46.8)	23.8 (4.8)

Data were presented as mean (standard deviation) for age and BMI variables; meanwhile proportion and its 95% confidence interval for sex variable.
BMI: body mass index

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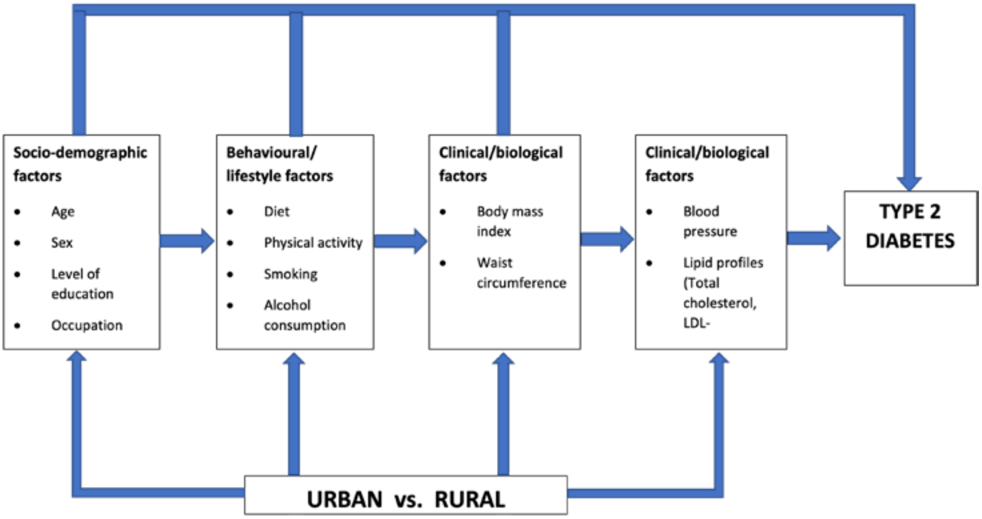

Supplementary Figure 1. Conceptual framework and hypothesis diagram of the association between socio-demographic, lifestyle, and clinical factors with diabetes in the urban and rural populations.

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