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Ethnic Disparities in Metabolic Syndrome in Malaysia: An Analysis by Risk Factors

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Abstract

Background: This study investigates ethnic disparities in metabolic syndrome in Malaysia.
Methods: Data were obtained from the Malaysia Non-Communicable Disease Surveillance-1 (2005/2006). Logistic regressions of metabolic syndrome health risks on sociodemographic and health–lifestyle factors were conducted using a multiracial (Malay, Chinese, and Indian and other ethnic groups) sample of 2,366 individuals.
Results: Among both males and females, the prevalence of metabolic syndrome amongst Indians was larger compared to both Malays and Chinese because Indians are more likely to exhibit central obesity, elevated fasting blood glucose, and low high-density lipoprotein cholesterol. We also found that Indians tend to engage in less physical activity and consume fewer fruits and vegetables than Malays and Chinese. Although education and family history of chronic disease are associated with metabolic syndrome status, differences in socioeconomic attributes do not explain ethnic disparities in metabolic syndrome incidence. The difference in metabolic syndrome prevalence between Chinese and Malays was not statistically significant. Whereas both groups exhibited similar obesity rates, ethnic Chinese were less likely to suffer from high fasting blood glucose.
Conclusions: Metabolic syndrome disproportionately affects Indians in Malaysia. Additionally, fasting blood glucose rates differ dramatically amongst ethnic groups. Attempts to decrease health disparities among ethnic groups in Malaysia will require greater attention to improving the metabolic health of Malays, especially Indians, by encouraging healthful lifestyle changes.

Introduction

As economic development continues to alter the lifestyle and dietary habits of Malaysia's population, the country is beginning to face many of the public health issues previously associated with economically advanced countries. As with many other developing countries, Malaysia has witnessed a sharp increase in the prevalence of obesity over the past two decades. A comparison of results from the Third National Health and Morbidity Survey (NHMS III) conducted in 2006 with the NHMS II conducted in 1996 revealed that the proportion of overweight individuals increased from 16.6% to 28.6%, whereas obesity prevalence tripled from 4.5% to 14.2%.[1]

The recent increase of overweight and obesity prevalence in Malaysia will likely result in a parallel increase in the prevalence of its associated health risks, such as metabolic syndrome. Metabolic syndrome is defined as a clustering of metabolic abnormalities (abdominal obesity, insulin resistance, dyslipidemia, hypertension, and glucose intolerance) that are positively associated with the risks of cardiovascular diseases and type 2 diabetes mellitus.[2] Already, three of the five leading causes of death in Malaysia are metabolic syndrome related, including diseases of the heart and pulmonary circulation (15.7%), cancer (10.6%), and cerebrovascular diseases (hypertension and stroke, 8.5%), which together account for more than one-third of all medically certified deaths in the country.[3] Other possible health risks posed by metabolic syndrome include the development of polycystic ovary syndrome amongst women, gout, fatty liver disease, cholesterol gallstones, asthma, sleep apnea, and certain forms of cancer.[4–6] Finally, recent studies in developed countries suggest that high healthcare expenses related to metabolic syndrome and/or its related risk factors[7–9] could impose significant pressure on the public health expenditures of developing countries with limited economic resources like Malaysia.[10]

Despite the significance of metabolic syndrome as a major public health concern, data on its prevalence in Malaysia are

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scant. Although studies have addressed factors related to metabolic syndrome in Malaysia,[6,11–13] the samples used in these studies typically are not representative of the Malaysian population. This is especially salient in Malaysia, which exhibits significant health and economic disparities among its major ethnic groups—Malay, Chinese, Indian, and Other-Bumiputera ("Bumiputera" or "Bumi" denotes indigenous ethnic groups native to the Malaysian peninsula and Borneo, which also includes the Malays. Thus, "Other-Bumiputera" refers to other native ethnic groups, not including the Malays).[14–17] Ethnic-based disparities in metabolic syndrome prevalence have been noted in previous studies for developed countries,[18–20] and reducing inequality among citizens of different ethnic groups has been a long-standing goal of policy makers in Malaysia. Therefore, this study uses data from a nationally representative sample of Malaysians to study differences in metabolic syndrome prevalence, as well as differences in the underlying conditions that comprise metabolic syndrome. A better understanding of how metabolic syndrome may vary by sociodemographic and health-and-lifestyle–related factors can provide policy makers with the baseline information needed to monitor and ultimately reduce disparities in metabolic syndrome–related health risks in Malaysia.

Materials and Methods

Data

Data for this study were obtained from the Malaysia Non-Communicable Disease Surveillance-1 (MyNCDS-1) survey, a population-based survey covering each of the 13 states in Malaysia and the federal territory of Kuala Lumpur.[21] Data collection was carried out from September, 2005, to February, 2006, according to a two-stage stratified random sampling procedure to ensure that the sample would be representative of the Malaysian population. Inclusion criteria were adult citizens between 25 and 64 years old across gender and ethnic groups. From a total sample of 3,040 eligible respondents, 2,366 (79.1%) observations were retained for analysis due to missing data and incomplete information.

During the survey, field survey teams described the survey to household members. Upon receiving a verbal consent, each eligible respondent was interviewed to gather sociodemographic information, respondent's medical history, family medical history, and lifestyle behaviors. After this initial interview, written consent was acquired and an appointment arranged for a clinical examination at a designated health clinic. At the clinic, the individual was measured for height without footwear or headwear using a stadiometer. Weight was also measured on a balance beam or Seca beam scale with only light clothing and bare feet. Waist circumference (WC), defined as the smallest circumference between the rib cage and umbilicus, was measured directly over the skin when possible or over light clothing.

Blood pressure (measured in mmHg) was taken using a stethoscope and a mercury-stand sphygmomanometer. Blood pressure was measured multiple times in a quiet room with the temperature at approximately 70°F–74°F (21°C–23°C). Respondents were allowed to rest for 5 min with legs uncrossed before measurement. The lower edge of the cuff was placed on the right arm with palm upward 1.2 cm to 2.5 cm above the inner side of the elbow joint. The level of the cuff was kept at the same level as the heart during measurement. If the first two readings differed by more than 10 mmHg, additional readings were obtained with at least 30 sec apart to allow normal circulation to return to the arm.[21]

After measuring blood pressure, a phlebotomist took 3 mL of blood serum in a vial without anticoagulant for a lipid profile and 2 mL of blood serum in a vial with sodium fluoride (NaF)/oxalate for blood sugar measurement. Fasting blood glucose was measured using an enzymatic assay kit (Glucose Flex reagent cartridge). A dry test was also performed to measure blood glucose. Venous blood was dropped on a glucose strip and measured with a glucometer; the results were given to respondents. A venous plasma sample is preferred to a dry test from capillary blood when diagnosing diabetes and thus the former is used here. Total cholesterol was assayed using enzymatic colorimetric tests with cholesterol esterase and cholesterol oxidase and glycerol phosphate oxidase, respectively.[21]

Study approval was obtained from the National Institute of Health, Ministry of Health Malaysia (registration no. 2646) for data analysis.

Defining metabolic syndrome

Because numerous diagnostic criteria for metabolic syndrome currently exist, we used two of the more common definitions. First, we defined metabolic syndrome according to the most recent guidelines of the International Diabetes Federation (IDF) (MetS-1). An individual is classified as having metabolic syndrome if central obesity was exhibited along with at least two of the following: (1) Elevated triglyceride level (high TGL); (2) reduced high-density lipoprotein cholesterol (low HDL-C); (3) raised blood pressure (high BP); and (4) raised fasting plasma glucose (high FBG).[22] Central obesity, using the suggested WC for Asian/South Asians, was defined as greater than 90 cm for males and 80 cm for females. Because measurement error in WC tends to increase in body mass, we followed IDF guidelines of classifying individuals with a body mass index (BMI) greater than 30 as exhibiting central obesity.[23]

We also considered the metabolic syndrome criteria proposed by the U.S. National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) (MetS-2). Under these guidelines, an individual is diagnosed with metabolic syndrome if s/he exhibits any three of the five aforementioned risk factors (central obesity, high TGL, low HDL, high BP, high FBG) (details of both IDF and ATP III definitions of metabolic syndrome are provided in Table 1).[24] The cutoffs for elevated blood sugar differ slightly between the ATP (110 mg/dL) and IDF (100 mg/dL) guidelines. In the subsequent analysis, we followed the American Heart Association's update to the ATP III and used a FBG cutoff of 100 mg/dL in constructing both metabolic syndrome measures.[25] Because the choice of metabolic syndrome criteria can affect empirical results,[26,27] we repeated the analysis using both metrics.

Explanatory variables

Respondents to MyNCDS-1 were asked to self-report their ethnicity by placing a tick mark next to one of several options. These answers are used to define a series of

Table 1. Definition of Metabolic Syndrome and Constituent Risk Factors According to the IDF and AHA Update to the NCEP ATP III

Central obesity (obese)	Waist circumference as measure of central obesity[a] (male ≥90 cm; female ≥80 cm for Asians) plus any two of the following:
Elevated triglycerides (high TGL)	≥1.7 mmol/L (150 mg/dL) or specific treatment for this lipid abnormality
Low HDL-C (low HDL)	<1.03 mmol/L (40 mg/dL) in males; <1.29 mmol/L (50 mg/dL) in females; or specific treatment for this lipid abnormality
Elevated blood pressure (high BP)	Systolic ≥130 mm Hg or diastolic ≥85 mmHg or treatment of previously diagnosd hypertension
Elevated fasting plasma glucose (high FBG)	Fasting plasma glucose ≥5.6 mmol/L (100 mg/dL) or previously diagnosed type 2 diabetes. If >5.6 mmol/L or 100 mg/dL, oral glucose tolerance test is strongly recommended but is not necessary to define presence of the syndrome
IDF definition of metabolic syndrome (MetS-1)	Central obesity plus at least two other risk factors.
ATP III definition of metabolic syndrome (MetS-2)	At least three risk factors.

Sources: Alberti et al. (2006),[22] Grundy et al. (2004).[25]

[a]If body mass index is >30 kg/m^2, then central obesity can be assumed, and waist circumference does not need to be measured.

IDF, International Diabetes Foundation; NCEP ATP III, National Cholesterol Education Program Adult Treatment Panel III; TGL, triglycerides; HDL-C, high-density lipoprotein cholesterol; BP, blood pressure; FBG, fasting blood glucose.

dichotomous indicator variables: Malay, Chinese, Indian, and Other-Bumi (Kadazan, Murut, Bajau, Melanau, Iban, Bidayuh, Orang Asli). Individuals were also given the option of selecting "Other," which would tend to capture foreign-born citizens as well as individuals of European or mixed-European descent, *e.g.*, the Eurasians of Melaka. Those who selected "Other" were not included in the analysis, because they account for less than 1% of the Malaysian population. It is worth noting that both the Chinese and Indian populations in Malaysia date to several generations, as workers immigrated to Malaysia during the 19th and early 20th centuries to work in mines and on plantations. Although 7% of individuals residing in Malaysia are foreign born, according to the 2000 Census, 64.3% are noncitizens typically classified as migrant workers. Moreover, Indonesians accounted for 70.3% of the approximately 334,000 individuals who migrated to Malaysia between 1995 and 2000. Finally, migrants wishing to gain Malaysian citizenship must have resided in the country for at least 10 of the preceding 12 years.[28] Because our sample is restricted to Malaysian citizens, the overwhelming majority of Chinese and Indians respondents were either born in Malaysia or had lived in the country for a significant portion of their lives.

Age and highest level of formal education are reported in years. Monthly household income (in Ringgit Malaysia, RM1.00 = US$0.30 as of March 25, 2010) was reported in ten intervals: RM0–399, RM400–699, RM700–999, RM1,000–1,999, RM2,000–2,999, RM3,000–3,999, RM4,000–4,999, RM5,000–5,999, RM6,000–9,999, and more than RM10,000. These intervals were converted to continuous values using the midpoints of each interval. Location of residence was denoted by a dichotomous variable that equals 1 if respondents are from a rural area as defined by the Malaysian government: A gazetted area with a population less than 10,000. Marital status (unmarried) was represented by 1 if the respondent was single, divorced, or widowed and 0 if married. Gender of the respondent was denoted by 1 for male and 0 for female. Family history was a binary variable indicating presence/history of hypertension, diabetes, cardio-heart disease, stroke, or sudden death among immediate family members.

In addition to demographic information, data were also collected on several lifestyle behaviors, namely physical activity, consumption of fruits and vegetables, and smoking, that may influence the risk of developing metabolic syndrome or its constituent risk factors. To gauge the level of physical activity, individuals were asked to describe activities at work, travel, and leisure. Individuals self-reported the length of a typical work day and whether work mostly involves standing or sitting. Individuals were also asked about whether work involves moderate activity, the typical number of days that involve moderate activity, and the typical amount of time spent each day in moderate activity at work. Analogous questions regarding vigorous activity at work were also included. Illogical responses (working 24 hr in a typical day) were dropped and inconsistent responses (working 8 hr but engaging in more than 8 hr of vigorous or moderate activity combined) were adjusted by multiplying the number of hours worked by the percentage spent in vigorous activity.

Individuals were then asked similar questions about leisure activities: Is leisure mostly sedentary? Do you engage in moderate leisure activity? How often and for how long do you engage in moderate leisure activity? Do you engage in vigorous leisure activity? How often and for how long do you engage in vigorous leisure activity? Additionally, individuals were asked about modes of transportation, such as how they commuted between home and work, how they went shopping, or how they attended religious activities. Specifically, they were asked if they walked or rode a bicycle for at least 10 min continuously, how many days a week they did so, and how many minutes at a time. Individuals were also asked how much time they spent sitting or reclining in a typical day during all activities except sleep. Finally, individuals were asked about their consumption of fruits and vegetables in a typical week. Individuals provided the number of days they consumed fruit and how many fruits were consumed each day. Similar information was provided for vegetables.

Empirical methods

To better understand the distribution of metabolic syndrome (and each of its component factors) across ethnic groups in Malaysia, a series of logistic regressions was estimated with a set of ethnicity variables: Malays (reference), Chinese, Indians, and Other-Bumis. To explore further the contributory effects of socioeconomic status and health history, as well as control for confounding differences among ethnic groups, a second set of logistic regressions was also estimated, which included the following additional explanatory variables: Years of age and education, monthly household income, location of residence (urban/rural), marital status, gender, and history of family illness. Because the guidelines for metabolic syndrome differ by gender (*e.g.*, central obesity and dyslipidemia cutoffs), we repeated the analysis separately for males and females. This also addressed the potential for differential effects of demographic and socioeconomic attributes by gender.

Results

Summary statistics

Descriptive statistics of variables used in the statistical model are provided in Table 2 by gender and ethnicity. Although the ethnic composition of the sample (57.6% Malays, 18.6% Chinese, 8.9% Indians, and 14.9% Other-Bumis) is representative of the Malaysian population, females are slightly overrepresented.[29] The mean age of respondents is similar across gender and ethnicity. Females of Other-Bumi ethnic background have the lowest mean age at 40.6 years, but among the rest of the sample, mean age ranges fairly narrowly from a low of 42.9 years for Malay females to a high of 45.2 for Chinese females.

In our sample, 30.1% of respondents were diagnosed with metabolic syndrome using the IDF guidelines (MetS-1). In comparison, 36.1% of individuals were classified as having metabolic syndrome using the ATP III guidelines (MetS-2). Central obesity existed in 18.1% of the sample, whereas 41.3% exhibited high BP, 28.8% had high FBG, 40.0% had high TGL, and 40.1% had low HDL.

Under both the IDF and ATP III guidelines, males and females exhibited similar metabolic syndrome prevalence rates: 28.5% and 31.2%, respectively for the former and 37.2% and 35.3%, respectively for the latter. Females were more likely to suffer from central obesity than males (20.7% versus 14.3%) and low HDL (43.0% versus 36.2%). Females, however, were less likely to have high BP (38.2% versus 45.7%) and high TGL (32.8% versus 50.3%). Males and females exhibited similar rates of high FBG, 29.6% and 28.2%.

Using the ATP III guidelines, Chinese (42.4%) and Indians (44.2%) had the highest prevalence of metabolic syndrome among males, whereas Malays (35.5%) and Other-Bumis (33.8%) had the lowest rates. Under the IDF guidelines, however, Indian males (42.3%) exhibited much higher rates compared to Malays (28.1%), Chinese (31.3%), and Other-Bumis (20.0%).

Using the ATP III guidelines for females, metabolic syndrome incidence is similar for Malays (33.8%), Chinese (34.5%), and Other-Bumis (34.2%), whereas the rate for Indian females was substantially higher (45.5%). A similar pattern emerged under the IDF guidelines: Metabolic syndrome prevalence among Malays (29.6%), Chinese (29.9%) and Other-Bumis (30.6%) was similar, whereas the rate for Indians (44.0%) was much higher. Indian females were much more likely to exhibit central obesity compared to females of other ethnic groups (32.1% versus 20.8% over all females) and to suffer from high FBG (40.3% versus 28.1% overall) and low HLD (52.2% versus 43.7% overall).

It is worth noting that measuring obesity by BMI instead of WC did not alter the general findings. Among females, both mean BMI and WC were highest among Indians (27.7 cm and 90.1 cm, respectively). Similarly for males, Indians exhibited the highest mean BMI (25.5) and WC (92.1 cm). In the full sample, the Pearson correlation coefficient between BMI and WC was 0.73, evidence of a strong, positive correlation.

Males in Malaysia tended to receive more years of formal education compared to females (8.1 years versus 7.5 years), although the gender difference was largest among Indians (8.6 years versus 6.5 years). In comparison, the gender gap was only 0.4 year among Malays (8.3 years versus 7.9 years) and 0.6 year among Chinese (8.6 years versus 8.0 years). Malays and Other-Bumis tended to have lower household income than Indians, who tended to have lower household incomes than Chinese. For example, among males, monthly household income for Other-Bumis was roughly RM1200 per month compared to RM1545 for Malays, RM2135 for Indians, and RM2535 for Chinese.

Logistic regression analysis

Results from unadjusted logistic regressions for males and females, including only ethnicity indicator variables, are presented in the top panel of Table 3 (Malay is the reference category). Indians were more likely than Malays to suffer from metabolic syndrome based on either definition: MetS-1 [odds ratio (OR) = 1.89, 95% confidence interval (CI) 1.41–2.55], MetS-2 (OR = 1.55, CI 1.16–2.08). The risks of metabolic syndrome are higher among the Indian population because, as a group, they are more likely to exhibit central obesity (OR = 2.29, CI 1.67–3.14), to have high FBG (OR = 1.76, CI 1.30–2.37), and to exhibit low HDL (OR = 1.41, CI 1.05–1.89). In contrast, Chinese individuals were no more likely than Malays to suffer from metabolic syndrome, largely because the two groups exhibit similar obesity rates. Despite this similarity, Chinese individuals were less likely to have high FBG (OR = 0.72, CI 0.56–0.92) but more likely to have low HDL (OR = 1.25, CI 1.00–1.55). Meanwhile, those of Other-Bumi ethnic background were less likely to be obese (OR = 0.80 CI 0.63–1.01) or have high TGL (OR = 0.80, CI 0.63–1.02, $P < 0.10$), although they are more likely to suffer from low HDL (OR = 1.23, CI 0.97–1.56).

The top panel of Table 4 presents odds ratios from an analogous set of logistic regressions when socioeconomic and demographic variables are included in the analysis. Family history of chronic disease increases the likelihood of metabolic syndrome regardless of how it is defined, (MetS-1 OR = 1.56, CI 1.29–1.88; MetS-2 OR = 1.56, CI 1.30–1.86), central obesity (OR = 1.33, CI 1.12–1.58), high BP (OR = 1.53, CI 1.27–1.83), high FBG (OR = 1.46, CI 1.21–1.77), and low HDL (OR = 1.39, CI 1.17–1.65). Marital status does not have a statistically significant relationship with metabolic syndrome or any of its components except low HDL. Education is generally protective, decreasing the risk of metabolic syndrome (MetS-1 OR = 0.97, CI 0.94–0.99; MetS-2 OR = 0.97, CI 0.95–1.00), obesity (OR = 0.96, CI 0.94– 0.98), and high BP (OR = 0.96, CI 0.93–0.98). Higher household income is associated with increased

TABLE 2. SAMPLE STATISTICS OF DEPENDENT AND EXPLANATORY VARIABLES

	Male					Female					
Variable	*Malay*	*Chinese*	*Indian*	*Other-Bumi*	*All*	*Malay*	*Chinese*	*Indian*	*Other-Bumi*	*All*	*Full sample*
Dependent variables											
MetS-1	0.28	0.31	0.43	0.20	0.29	0.30	0.30	0.44	0.31	0.31	0.30
MetS-2	0.36	0.42	0.44	0.34	0.37	0.34	0.35	0.46	0.35	0.35	0.36
Obese	0.42	0.50	0.66	0.31	0.44	0.59	0.54	0.74	0.59	0.59	0.53
High BP	0.46	0.49	0.34	0.45	0.46	0.39	0.38	0.32	0.38	0.38	0.41
High FBG	0.30	0.20	0.43	0.34	0.30	0.28	0.24	0.40	0.27	0.28	0.29
High TGL	0.49	0.54	0.56	0.48	0.50	0.34	0.34	0.38	0.24	0.33	0.40
Low HDL	0.34	0.41	0.36	0.39	0.36	0.41	0.45	0.52	0.47	0.44	0.41
Continuous explanatory variables											
Education	8.31	8.61	8.58	6.83	8.14	7.87	7.95	6.47	5.92	7.48	7.76
	(4.04)	(3.86)	(4.41)	(5.11)	(4.26)	(4.32)	(4.47)	(4.41)	(4.99)	(4.51)	(4.42)
Age (years)	45.00	45.00	44.01	42.24	44.47	42.89	45.18	43.14	40.63	43.03	43.63
	(10.52)	(10.58)	(9.48)	(10.82)	(10.54)	(10.42)	(10.18)	(9.28)	(10.78)	(10.39)	(10.47)
Monthly house-hold income (RM)	1542.36	2536.17	2133.77	1194.06	1712.61	1471.91	2252.78	1386.19	1194.82	1572.45	1630.80
	(1640.45)	(2260.74)	(1661.11)	(1412.15)	(1791.93)	(1457.10)	(2149.05)	(1435.23)	(1301.45)	(1624.64)	(1697.33)
Binary explanatory variables (yes = 1, no = 0)											
Family history[b]	0.55	0.57	0.77	0.37	0.54	0.56	0.55	0.59	0.48	0.55	0.55
Rural residence	0.53	0.34	0.34	0.69	0.51	0.54	0.31	0.23	0.67	0.49	0.50
Unmarried	0.10	0.17	0.10	0.14	0.12	0.15	0.12	0.16	0.11	0.14	0.13
Malay					0.58					0.57	0.58
Chinese					0.18					0.19	0.19
Indian					0.08					0.10	0.09
Other-Bumi					0.16					0.14	0.15
Other variables used in analysis											
BMI (kg/m^2)	25.02	24.42	25.53	24.10	24.80	26.39	24.61	27.69	25.08	25.99	25.50
	(4.86)	(5.14)	(4.07)	(4.60)	(4.82)	(5.94)	(5.43)	(6.94)	(5.02)	(5.90)	(5.51)
Waist circum-ference (WC)	87.32	89.07	92.12	84.46	87.55	84.01	83.46	90.11	82.93	84.35	85.68
	(11.53)	(11.73)	(8.85)	(9.98)	(11.29)	(11.54)	(11.72)	(14.50)	(10.33)	(11.88)	(11.74)
Sample size	569	179	77	160	985	793	261	134	193	1381	2366

[a]Standard deviations in parentheses.
[b]Family history denotes that an immediate family member has been diagnosed with any of the following: hypertension, diabetes, cardiovascular heart disease, stroke or sudden death.
MetS-1, metabolic syndrome according to International Diabetes Federation guidelines; MetS-2, metabolic syndrome according to National Cholesterol Education Program Adult Treatment Panel III guidelines; BP, blood pressure; FBG, fasting blood glucose; TGL, triglycerides; HDL, high-density lipoprotein; RM, Ringgit Malaysia; BMI, body mass index.

Table 3. Logistic Regression Estimates: Unadjusted Odds Ratios and 95% Confidence Intervals for Ethnicity Variables[a]

Variables	MetS-1	MetS-2	Obese	High BP	High FBG	High TGL	Low HDL
Pooled sample (n = 2,366)							
Malay	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Chinese	1.07	1.16	1.04	1.01	0.72***	1.08	1.25**
	(0.85–1.36)	(0.93–1.45)	(0.84–1.29)	(0.81–1.25)	(0.56–0.92)	(0.87–1.35)	(1.00–1.55)
Indian	1.89***	1.55***	2.29***	0.66***	1.76***	1.20	1.41**
	(1.41–2.55)	(1.16–2.08)	(1.67–3.14)	(0.49–0.90)	(1.30–2.37)	(0.90–1.61)	(1.05–1.89)
Other-Bumi	0.85	0.99	0.80*	0.95	1.09	0.80*	1.23*
	(0.65–1.11)	(0.77–1.27)	(0.63–1.01)	(0.75–1.20)	(0.84–1.41)	(0.63–1.02)	(0.97–1.56)
Male (n = 985)							
Malay	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Chinese	1.16	1.34*	1.39*	1.12	0.60**	1.23	1.33
	(0.81–1.68)	(0.95–1.89)	(0.99–1.94)	(0.80–1.56)	(0.40–0.90)	(0.88–1.72)	(0.94–1.88)
Indian	1.92***	1.44	2.69***	0.59**	1.78**	1.32	1.11
	(1.18–3.12)	(0.89–2.32)	(1.63–4.44)	(0.36–0.97)	(1.09–2.89)	(0.81–2.12)	(0.67–1.81)
Other-Bumi	0.64**	0.93	0.61	0.95	1.21	0.94	1.22
	(0.42–0.98)	(0.63–1.34)	(0.42–0.88)	(0.67–1.35)	(0.83–1.75)	(0.66–1.34)	(0.85–1.76)
Female (n = 1,381)							
Malay	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Chinese	1.01	1.05	0.84	0.94	0.81	1.00	1.19
	(0.75–1.37)	(0.78–1.41)	(0.64–1.12)	(0.70–1.25)	(0.59–1.12)	(0.75–1.35)	(0.90–1.58)
Indian	1.87***	1.64***	2.00***	0.73	1.76***	1.21	1.58**
	(1.29–2.71)	(1.13–2.37)	(1.32–3.01)	(0.49–1.07)	(1.20–2.57)	(0.83–1.77)	(1.09–2.27)
Other-Bumi	1.05	1.04	1.02	0.93	0.99	0.63**	1.26
	(0.74–1.47)	(0.75–1.45)	(0.74–1.40)	(0.68–1.29)	(0.69–1.40)	(0.44–0.91)	(0.92–1.73)

[a]Asterisks indicate levels of statistical significance for difference from 1: ***$P < 0.01$, **$P < 0.05$, *$P < 0.10$. 95% confidence intervals in parentheses. Malay ethnicity is the omitted reference category.

MetS-1, metabolic syndrome according to International Diabetes Federation guidelines; MetS-2, metabolic syndrome according to National Cholesterol Education Program Adult Treatment Panel III guidelines; BP, blood pressure; FBG, fasting blood glucose; TGL, triglycerides; HDL, high-density lipoprotein.

risk of developing metabolic syndrome (MetS-1 OR = 1.11, CI 1.01–1.21; MetS-2 OR = 1.15, CI 1.06–1.25) through increased risk of high TGL (OR = 1.11, CI 1.03–1.20) and low HDL (OR = 1.14, CI 1.05–1.23) levels. It is worth noting that education and income are positively correlated, with a Pearson correlation coefficient of 0.39. However, calculation of the variance inflation factors (VIFs) suggests that joint inclusion of education (VIF = 1.53) and income (VIF = 5.62) does not cause a problem with collinearity.[30]

Although socioeconomic and demographic variables like income, education, and family history of chronic disease all exhibit statistically significant relationships to metabolic syndrome risk, inclusion of these variables does not qualitatively alter the relationship between ethnicity and disease status. After adjusting for these potential confounders, Indians remain significantly more likely to suffer from metabolic syndrome (MetS-1 OR = 1.78, CI 1.31–2.44; MetS-2 OR = 1.49, CI 1.10–2.04), obesity (OR = 2.05, CI 1.48–2.85), high FBG (OR = 1.77, CI 1.30–2.43), and low HDL-C (OR = 1.36, CI 1.01–1.84). Similarly, the Chinese are less likely than Malays to have high FBG (OR = 0.66, CI 0.50–0.86), although they are no less likely to have metabolic syndrome. Individuals of Other-Bumi ethnic background are more likely than Malays to have high FBG (OR = 1.26, CI 0.96–1.65) and, as the naïve model suggests, low HDL-C (OR = 1.33, CI 1.03–1.70).

Analysis by gender

To investigate gender differences in these outcome variables, we also carried out the analysis separately for males and females in our sample. The results, presented in the bottom two panels of Tables 3 and 4, generally show similar patterns across genders. We focused our attention on the regression estimates that included socioeconomic characteristics (second and third panels of Table 4). Neither Chinese males nor females were more likely to suffer from metabolic syndrome relative to their Malay counterparts. In contrast, both Indian males and females were more likely to have metabolic syndrome, although the particular definition of metabolic syndrome does influence the statistical significance of the result. Indian males were more likely than Malay males to exhibit metabolic syndrome as defined under IDF guidelines (MetS-1 OR = 1.67, CI 1.00–2.79), whereas Indian females were more likely than Malay females to exhibit metabolic syndrome under both definitions (MetS-1 OR = 1.74, CI 1.17–2.59; MetS-2 OR = 1.56, CI 1.05–2.32). Indian males (OR = 2.38, CI 1.42–3.99) and females (OR = 1.74, CI 1.13–2.66) were more likely to have central obesity compared to their respective Malay (and Chinese) counterparts.

Family history of chronic disease is positively associated with metabolic syndrome by either definition, though the relationship is stronger among males (MetS-1 OR = 1.87, CI 1.35–2.53; MetS-2 OR = 1.88, CI 1.42–2.49) than females (MetS-1 OR = 1.37, CI 1.07–1.74; MetS-2 OR = 1.37, CI 1.08–1.73). In both males and females, a family history of chronic disease is positively associated with elevated FBG (males, OR = 1.52, CI 1.13–2.05; females, OR = 1.43, CI 1.12–1.84) and low HDL-C (males, OR = 1.58, CI 1.20–2.08; females, OR = 1.30, CI 1.04–1.61).

Table 4. Logistic Regression Estimates: Adjusted Odds Ratios and 95% Confidence Intervals[a]

Variables	*MetS-1*	*MetS-2*	*Obese*	*High BP*	*High FBG*	*High TGL*	*Low HDL*
Pooled sample (*n* = 2,366)							
Ethnicity variables							
Malay	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Chinese	0.96	1.04	0.94	0.97	0.66***	0.97	1.19
	(0.75–1.24)	(0.82–1.32)	(0.75–1.18)	(0.77–1.24)	(0.50–0.86)	(0.77–1.22)	(0.95–1.50)
Indian	1.78***	1.49**	2.05***	0.65**	1.77***	1.18	1.36**
	(1.31–2.44)	(1.10–2.04)	(1.48–2.85)	(0.47–0.91)	(1.30–2.43)	(0.87–1.60)	(1.01–1.84)
Other-Bumi	1.97	1.17	0.86	1.04	1.26*	0.87	1.33**
	(0.73–1.29)	(0.90–1.53)	(0.67–1.10)	(0.80–1.35)	(0.96–1.65)	(0.67–1.12)	(1.03–1.70)
Control variables[b]							
Family history	1.56***	1.56***	1.33***	1.53***	1.46***	1.04	1.39***
	(1.29–1.88)	(1.30–1.86)	(1.12–1.58)	(1.27–1.83)	(1.21–1.77)	(0.87–1.24)	(1.17–1.65)
Rural	1.00	1.07	0.85*	1.30***	1.10	0.87	1.20**
	(0.82–1.21)	(0.89–1.29)	(0.71–1.02)	(1.08–1.57)	(0.91–1.34)	(0.73–1.05)	(1.00–1.43)
Unmarried	1.02	0.90	1.16	0.91	1.16	0.89	0.76**
	(0.77–1.35)	(0.68–1.19)	(0.90–1.50)	(0.69–1.19)	(0.88–1.54)	(0.68–1.15)	(0.59–0.98)
Male	0.85	1.03	0.52***	1.31***	1.03	2.04***	0.72***
	(0.70–1.03)	(0.86–1.24)	(0.44–0.62)	(1.09–1.56)	(0.85–1.24)	(1.72–2.42)	(0.60–0.85)
Education	0.97***	0.97**	0.96***	0.96***	0.99	1.00	0.99
	(0.94–0.99)	(0.95–1.00)	(0.94–0.98)	(0.93–0.98)	(0.96–1.01)	(0.97–1.02)	(0.97–1.01)
Age	1.43***	1.48***	1.22***	1.93***	1.53***	1.20***	1.03
	(1.26–1.60)	(1.30–1.65)	(1.08–1.37)	(1.69–2.16)	(1.35–1.71)	(1.07–1.34)	(0.91–1.15)
Income	1.11**	1.15***	1.04	1.04	1.07	1.11**	1.14***
	(1.01–1.21)	(1.06–1.25)	(0.96–1.12)	(0.95–1.12)	(0.98–1.17)	(1.03–1.20)	(1.05–1.23)
Male (*n* = 985)							
Ethnicity variables							
Malay	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Chinese	1.06	1.26	1.24	1.20	0.54***	1.17	1.30
	(0.71–1.57)	(0.87–1.84)	(0.87–1.79)	(0.83–1.74)	(0.35–0.84)	(0.82–1.68)	(0.90–1.87)
Indian	1.67**	1.23	2.38***	0.62*	1.64*	1.19	0.96
	(1.00–2.79)	(0.74–2.05)	(1.42–3.99)	(0.36–1.05)	(0.99–2.72)	(0.72–1.95)	(0.58–1.61)
Other-Bumi	0.82	1.22	0.73	1.02	1.45*	1.11	1.48**
	(0.52–1.28)	(0.82–1.82)	(0.50–1.09)	(0.70–1.51)	(0.98–2.16)	(0.77–1.61)	(1.01–2.16)
Control variables[b]							
Family history	1.87***	1.88***	1.64***	1.27*	1.52***	1.12	1.58***
	(1.35–2.53)	(1.42–2.49)	(1.25–2.15)	(0.97–1.68)	(1.13–2.05)	(0.86–1.46)	(1.20–2.08)
Rural	1.04	1.18	0.81	1.50***	1.07	0.92	1.20
	(0.77–1.42)	(0.89–1.58)	(0.62–1.07)	(1.13–1.98)	(0.79–1.44)	(0.70–1.20)	(0.90–1.59)
Unmarried	0.90	0.77	1.18	1.24	1.14	0.70*	0.66*
	(0.54–1.50)	(0.48–1.25)	(0.76–1.82)	(0.79–1.95)	(0.70–1.85)	(0.45–1.07)	(0.41–1.05)
Education	0.98	0.99	0.99	0.97*	0.98	1.01	1.02
	(0.94–1.03)	(0.95–1.03)	(0.95–1.03)	(0.93–1.01)	(0.94–1.02)	(0.98–1.05)	(0.98–1.06)
Age	1.54***	1.46***	1.38***	1.89***	1.45***	1.07***	1.08***
	(1.24–1.83)	(1.19–1.73)	(1.13–1.63)	(1.53–2.24)	(1.18–1.72)	(0.88–1.26)	(0.88–1.28)
Income	1.19**	1.20**	1.08	1.02	1.12	1.09	1.13*
	(1.01–1.36)	(1.03–1.36)	(0.94–1.21)	(0.89–1.15)	(0.96–1.28)	(0.95–1.22)	(0.98–1.27)
Female (*n* = 1,381)							
Ethnicity variables							
Malay	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Chinese	0.91	0.89	0.78*	0.81	0.74*	0.85	1.15
	(0.65–1.25)	(0.65–1.23)	(0.58–1.05)	(0.58–1.12)	(0.52–1.04)	(0.62–1.15)	(0.86–1.55)
Indian	1.74***	1.56**	1.74**	0.68*	1.83***	1.13	1.60**
	(1.17–2.59)	(1.05–2.32)	(1.13–2.66)	(0.44–1.04)	(1.23–2.74)	(0.76–1.67)	(1.10–2.34)
Other-Bumi	1.12	1.17	0.99	1.03	1.12	0.69**	1.24
	(0.78–1.62)	(0.82–1.67)	(0.73–1.38)	(0.71–1.48)	(0.77–1.63)	(0.47–1.00)	(0.89–1.72)
Control variables[b]							
Family history	1.37**	1.37***	1.12	1.78***	1.43***	0.99	1.30**
	(1.07–1.74)	(1.08–1.73)	(0.89–1.40)	(1.39–2.27)	(1.12–1.84)	(0.79–1.25)	(1.04–1.61)
Rural	0.98	1.01	0.88	1.19	1.14	0.83	1.22*
	(0.76–1.26)	(0.79–1.29)	(0.70–1.11)	(0.93–1.54)	(0.88–1.47)	(0.65–1.06)	(0.97–1.53)
Unmarried	1.08	0.95	1.17	0.69**	1.14	1.01	0.83
	(0.77–1.53)	(0.68–1.34)	(0.85–1.62)	(0.48–0.99)	(0.80–1.61)	(0.72–1.41)	(0.60–1.14)

(*Table continued* →)

Table 4. (Continued)

Variables	MetS-1	MetS-2	Obese	High BP	High FBG	High TGL	Low HDL
Education	0.95***	0.96**	0.94***	0.95***	0.99	0.99	0.97**
	(0.92–0.98)	(0.93–0.99)	(0.91–0.97)	(0.92–0.98)	(0.96–1.02)	(0.96–1.02)	(0.94–1.00)
Age	1.36***	1.50***	1.10	2.04***	1.61***	1.30***	0.97***
	(1.15–1.57)	(1.27–1.73)	(0.93–1.27)	(1.71–2.37)	(1.35–1.86)	(1.10–1.49)	(0.83–1.12)
Income	1.06	1.11*	1.00	1.06	1.04	1.12**	1.15**
	(0.94–1.18)	(0.99–1.23)	(0.90–1.11)	(0.94–1.17)	(0.92–1.16)	(1.00–1.24)	(1.03–1.26)

Malay ethnicity is the omitted reference category.

[a]Asterisks indicate levels of statistical significance for difference from 1: ***$P<0.01$, **$P<0.05$, *$P<0.10$. 95% confidence intervals in parentheses.

[b]Among the continuous variables (education, age, and income), odds ratios are calculated for changes by 1 year for education, 10 years for age, and RM1,000 for income.

MetS-1, metabolic syndrome according to International Diabetes Federation guidelines; MetS-2, metabolic syndrome according to National Cholesterol Education Program Adult Treatment Panel III guidelines; BP, blood pressure; FBG, fasting blood glucose; TGL, triglycerides; HDL, high-density lipoprotein; RM, Ringgit Malaysia.

Despite these broad similarities, a few notable differences arise. For instance, after adjusting for potential confounders, Indian females are more likely than Malay females to have low HDL-C (OR = 1.60, CI 1.10–2.34), but this relationship is not found among males (OR = 0.96, CI 0.58–1.61). Furthermore, whereas for females education is generally protective against metabolic syndrome (MetS-1 OR = 0.95, CI 0.92–0.98; MetS-2 OR = 0.96, CI 0.93–0.99), central obesity (OR = 0.94, CI 0.91–0.97), high BP (OR = 0.95, CI 0.92–0.98) and low HDL-C (OR = 0.97, CI 0.94–1.00), none of these relationships is statistically significant for males.

Lifestyle behaviors

Table 5 reports information about smoking, physical activity, and diet by gender and ethnicity. Smoking is rare in females, but much more common in males. Over half of Malay males reported smoking, whereas about one-third of Chinese and Indian males were self-reported smokers. Males tended to work about an hour more per day, but were more likely to engage in vigorous and moderate physical activity at work. Within gender, Malays tended to work the shortest amount of time per day. Malay males spent the most time in vigorous physical activity, but the least amount in moderate activity. In contrast, Malay females spent the most time in moderate activity. Indian females spent the least amount of time in vigorous physical activity while Chinese women spent the least amount of time in moderate activity.

Over half of all Malaysians commuted by bike or walking, accounting for between 3 and 6 hr per week. Only Indian males reported less than 50% participation. Proportions were similar for males and females, although males reported about 30–45 min more per week. Among males, Malays were the most likely to bike or walk and spent the most time doing so. Although they were just as likely to bike or walk as other females, Indian females spent the least amount of time doing so. Chinese females

Table 5. Health Behaviors by Gender and Ethnicity[a]

	Males			Females		
	Malay (580)	Chinese (186)	Indian (80)	Malay (845)	Chinese (275)	Indian (151)
Smoker	0.52 [0.50]	0.34 [0.47]	0.28 [0.45]	0.01 [0.11]	0.04 [0.19]	0.02 [0.14]
Physical activity at work						
Minutes/day	457.00 [165.10]	491.90 [160.6]	523.10 [176.2]	425.60 [211.1]	430.60 [183.4]	489.30 [230.8]
% primarily sit	0.73 [0.45]	0.79 [0.41]	0.79 [0.41]	0.93 [0.25]	0.91 [0.29]	0.91 [0.29]
% include vigorous activity	0.27 [0.44]	0.21 [0.41]	0.21 [0.41]	0.06 [0.24]	0.09 [0.28]	0.09 [0.29]
Minutes/week	218.50 [525.2]	169.20 [488.9]	144.60 [360.8]	32.30 [214.2]	50.60 [219.5]	18.20 [71.0]
% include moderate activity	0.35 [0.48]	0.34 [0.47]	0.39 [0.49]	0.28 [0.45]	0.26 [0.44]	0.25 [0.43]
Minutes/week	319.70 [700.6]	445.30 [900.0]	384.70 [731.1]	350.20 [834.3]	308.50 [746.1]	333.50 [831.5]
Physical activity by travel						
% travel by foot or bike	0.54 [0.50]	0.51 [0.50]	0.41 [0.50]	0.52 [0.50]	0.56 [0.50]	0.56 [0.50]
Minutes/week	342.30 [572.2]	320.70 [574.5]	232.70 [482.9]	304.00 [547.5]	290.30 [452.3]	191.20 [346.7]
Physical activity at leisure						
% engage vigorous activity	0.14 [0.34]	0.11 [0.31]	0.08 [0.27]	0.06 [0.24]	0.06 [0.24]	0.04 [0.20]
Minutes/week	53.70 [180.5]	78.70 [411.9]	15.80 [60.2]	22.30 [121.6]	25.80 [142.9]	19.10 [111.8]
% engage moderate activity	0.23 [0.42]	0.23 [0.42]	0.20 [0.40]	0.17 [0.38]	0.20 [0.40]	0.15 [0.35]
Minutes/week	136.70 [342.1]	118.90 [291.5]	83.40 [207.5]	141.30 [454.0]	151.80 [468.0]	124.50 [340.2]
Diet						
Fruit servings/week	6.30 [6.0]	7.37 [7.1]	7.09 [7.1]	7.10 [6.6]	8.90 [7.9]	7.20 [7.5]
Vegetable servings/week	12.00 [7.1]	13.90 [8.3]	14.70 [9.6]	12.30 [7.5]	13.60 [7.8]	11.70 [6.4]

[a]Number of observations in parentheses. Standard deviations in brackets.

were the most likely to bike or walk and allocated only slightly less time than Malay females to these activities.

Males were more likely than females to engage in leisure activities that involve vigorous or moderate physical activity, although none of the gender–ethnic groups reported over 25% participation in either. Malay females allocated roughly the same amount of time to moderately active leisure activities as Malay males, but engaged in only half as much vigorous activity. Indian females engaged in less physically active leisure activities than either Malay or Chinese females.

Among Malays and Chinese, females consumed more fruit servings per week and roughly the same number of vegetable servings than their male counterparts. Indian females, however, consumed the same number of fruit servings, but fewer vegetable servings per week than Indian males.

Compared to Malay females, Malay males were more likely to smoke, engage in vigorous or moderate activity at work, and engage in vigorous leisure activity. They were less likely to primarily sit at work. They also spent more time engaged in vigorous activities both at work and during leisure and more time commuting by bike or walking. Compared to other females, Indian females spent less time engaged in vigorous activity at work, less time commuting by bike or walking, and less time engaged in vigorous or moderate activity during leisure. They also consumed fewer vegetables.

Discussion and Conclusion

The preceding analysis has revealed three important aspects of metabolic syndrome prevalence in Malaysia. First, metabolic syndrome risk is notably higher among the Indian population in Malaysia compared to those of other ethnic groups. This is true among both males and females and generally holds regardless of the criteria used to define metabolic syndrome. We find that their risk is higher principally because they are significantly more likely to be obese and suffer from high FBG and low HDL. This result corroborates findings based on similar cohort samples from neighboring Singapore.[31–33]

We also found that Indian males were less likely than their Chinese and Malay counterparts to exert physical activity when traveling and engaging in less physical activity during leisure. Similarly, Indian females engaged in less physical activity during leisure compared to Malay and Chinese females and were also less likely to travel by foot or bicycle. In addition, Indian females exerted less vigorous physical activity while working.

In terms of policy implications, while screening for obesity and diabetes should be encouraged amongst all Malaysians, particular attention should be paid to Indians. Awareness campaigns or programs could be in the form of the various language-based media (*e.g.*, newspapers, popular magazines, television programs, radio channels), including using celebrities or otherwise notable spokespersons from a particular ethnic group as a role model, to promote awareness of the dangers of developing metabolic syndrome and increase physical activity among Indian Malaysians.

Second, although the risk of developing metabolic syndrome is generally not significantly different between Chinese and Malays, as both groups exhibit similar obesity risk (Chinese males are more likely to exhibit metabolic syndrome under the ATP III criteria, but this is only significant at the 10% level), the latter are nevertheless more likely to suffer from high FBG and thus are at greater risk of developing diabetes. Environmental factors such as differences in diet are suggested as one of the primary contributors of diabetes amongst patients of different ethnicities,[31] thus these results suggest that the type of foods consumed may matter for metabolic health and not only the amount of food consumed.[34,35] For example, we find that among both males and females, Malays consume fewer fruits and vegetables than their Chinese counterparts. A related explanation is that while net caloric balance (caloric intake minus expenditure) may be similar between Malays and Chinese, the levels of intake and expenditure matter for metabolic health.[36]

An alternative explanation for these results is that using the same central obesity standard for all ethnic groups in Malaysia is inappropriate.[37–39] If the central obesity cutoff for metabolic syndrome were lowered for Malays, then the difference in metabolic syndrome incidence between Malays and Chinese would begin to match the difference in diabetes incidence. As a result, metabolic syndrome incidence among Malays would be higher than previous studies have shown. Whether such a change is warranted should be a focus of future research.

Third, similar to results in developed[40–42] and developing[43,44] countries, the risk of metabolic syndrome is negatively associated with education level in Malaysia, a result that is particularly strong for females. This relationship may arise because individuals with better education are generally more aware of the costs of nutrition-related illness, more informed, and more capable of processing health information about prevention of such diseases. As the economy continues to develop and the lifestyles of Malaysians continue to change, education about the health consequences of poor dietary habits and poor lifestyle, such as the lack of physical activity, will likely need to be an important component of public health policy. At the implementation level, subjects with low levels of education and those diagnosed with a clustering of metabolic abnormalities should be targeted in efforts to mitigate further health complications in Malaysia.

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Author Disclosure Statement

The authors declare that no competing financial interests exist.

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