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Sociodemographic factors in relation to hypertension prevalence, awareness, treatment and control in a multi-ethnic Asian population: a cross-sectional study

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ABSTRACT

Objectives Literature suggested that multi-ethnic Western populations experienced differential hypertension outcomes, but evidence is limited in Asia. This study was aimed to determine sociodemographic correlates of hypertension and its awareness, treatment and control among a multi-ethnic Asian population living in Singapore.

Setting We used cross-sectional data of participants from the Multi-Ethnic Cohort (MEC) (n=14 530) recruited in Singapore between 2004 and 2010.

Participants Participants who completed questionnaire and attended health examination, without cardiovascular diseases, cancer, stroke, renal failure, asthma and mental illnesses were included in the study. Multivariable logistic regression models were used to determine sociodemographics factors associated with hypertension, unawareness of having hypertension, untreated and uncontrolled hypertension.

Results Among 10 215 participants (47.2% Chinese, 26.0% Malay and 26.8% Indian), hypertension prevalence was estimated to be 31.1%. Older age, Malay ethnicity, male, lower educational level and being homemaker or retired/unemployed were factors significantly associated with hypertension. Stratified analysis suggested that age and education were consistently associated with hypertension across all ethnic groups. The proportions of being unaware, untreated and uncontrolled were 49.0%, 25.2% and 62.4%, respectively. Ethnicity and younger age were associated with unawareness; younger age, male and lower educational level were associated with untreated hypertension and older age was associated with uncontrolled hypertension.

Conclusions In this study, ethnic differences in relation to hypertension were associated with sociodemographic variability in ethnic groups. Age and educational level were consistent correlates of hypertension in all ethnic groups. Unawareness and uncontrolled hypertension were common in this Asian population and associated with sociodemographic factors. More targeted strategies may be required to overcome the observed disparities.

Strengths and limitations of this study

► This is a large population-based study of a multi-ethnic Asian (Chinese, Malay, Indian) population living in an urban city state with relatively homogeneous living environment.

► The minority ethnic groups (Malay and Indian) were purposively oversampled to increase their representativeness in the study.

► The study used standardised and comprehensive methodologies to capture exposure and outcome data, and the findings were robust after adjustment for potential sociodemographic confounders.

► Due to the cross-sectional design, this study cannot infer causality, and the estimated prevalence of hypertension reported in this study may not be generalisable due to the sampling methodology.

► Participant's exposure to caffeine and alcohol prior to blood pressure measurement was not assessed, and treatment for hypertension was based on self-reported intake of antihypertensive medication.

INTRODUCTION

Hypertension is a major risk factor of cardiovascular disease (CVD) and one of the leading causes of deaths from non-communicable diseases.[1 2] Hypertension is modifiable, yet there are a billions of individuals living with the condition worldwide and are at risk of hypertension-related complications.[3] The current evidence suggests that the public awareness and control of blood pressure (BP) remain challenging,[4 5] and that gaps in hypertension management were attributable to broader social and economic determinants.[6–9]

In most Western countries, the impact of ethnic and socioeconomic disparities on hypertension outcomes has been well established.[10] Literature suggested that racial difference in hypertension prevalence was determined by demographics and

lifestyle variables.[11] A study reported that racial disparities observed in BP were determined by differences in educational level.[12] Educational level and family income are socioeconomic variables that have been well examined in relation with hypertension but the findings in the literature are rather mixed.[11–13]

In Asia, the relationship between sociodemographic and hypertension is understudied. Singapore has a rapidly ageing, urbanised and multi-ethnic Asian population (Chinese, Malays and Indians). Previous studies have emphasised the importance to better understand awareness, treatment and control in order to improve hypertension management in the community.[14 15] To address existing gaps in the evidence, we examined sociodemographic determinants of hypertension, unawareness of having hypertension, untreated and uncontrolled hypertension in the multi-ethnic Asian population in Singapore.

METHODS
Patient and public involvement
The Multi-Ethnic Cohort (MEC) Study is a population-based study in Singapore (n=14 530) with recruitment conducted between 2004 and 2010. The MEC participants were mainly recruited from the existing cohorts between 2004 and 2007, that is, Singapore Prospective Study Programme (SP2) and Singapore Cardiovascular Cohort Study (SCCS2),[16 17] with additional participants recruited between 2007 and 2010. The detailed study methodology can be found on the study webpage (http://blog.nus.edu.sg/sphs/) and the MEC Cohort Profile.[18] Essentially, the study participants were Singaporeans or permanent residents of three ethnic groups (ie, Chinese, Malay and Indian), aged ≥21 years and free from cancer, heart disease, stroke, renal failure, asthma and mental illness. In the recruitment of additional participants, the minority ethnic groups, Malays and Indians, were recruited following a convenience sampling methodology and purposively oversampled through public outreach at community events, mosques and temples as well as referrals from existing cohort members in addition to household visitation. In general, the sample population had a relatively homogenous living condition, that is, all participants were living in Singapore, a city state, where government policies had led to relatively even distributions of public housing, ethnic groups and provision of various health-related infrastructure across the country. The study included individuals who had completed questionnaires and attended health examination. Study procedures were approved by the National University of Singapore Institutional Review Board and SingHealth Centralised Institutional Review Board.

All participants who provided consent to participate in this study were visited at home and were asked to complete an interview-administered questionnaire in English, Chinese or Malay languages. The interview questionnaires collected self-reported sociodemographic information, hypertension diagnosis, medical history and antihypertensive medication use.

Subsequently, they underwent a health examination including repeated BP measurements. Participants were asked to rest for 5 min, then systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured twice using an automated digital monitor (Dinamap Carescape V100, General Electric). If the difference between these two readings of SBP or DBP exceeded 10 mm Hg or 5 mm Hg, respectively, SBP and DBP were measured again and recorded as the third set of readings. For the small number of participants whose BP exceeded the range of the digital monitor, a sphygmomanometer (Accoson, Irvine, United Kingdom) was used.[18] Mean values of the SBP and the DBP were computed for every participant and used in subsequent analyses.

Variables
Outcome variables
Hypertension (among all participants) was defined as either (1) the participant answering 'yes' to the survey question 'has a physician (western trained) or other professional told you that you have high blood pressure?' or (2) having mean SBP ≥140 mm Hg or mean DBP ≥90 mm Hg during the health examination.

Unawareness of hypertension (among hypertensives) was defined as the participant answering 'no' or 'do not know' to the survey question 'has a physician (western trained) or other professional told you that you have high blood pressure?' but having mean SBP ≥140 mm Hg or mean DBP ≥90 mm Hg during the health examination.

Untreated hypertension (among hypertensives who were aware) referred to participants who were aware of having hypertension but were not taking any antihypertensive medication (identified from interviewer recorded lists of drug names and brand names).

Uncontrolled hypertension (among hypertensives who were treated) was defined as participants on antihypertension medication who were found to have a mean SBP ≥140 mm Hg or mean DBP ≥90 mm Hg during the health examination.

Explanatory variables
The explanatory variables included self-reported sociodemographic factors (ie, age, gender, ethnicity, highest educational level obtained, marital status, work status during the past 12 months and average monthly household income). Age at interview was derived from the date of birth. Ethnicity was obtained from participant's identity card and classified into Chinese, Malay and Indian. Highest education level was categorised into three levels: (1) primary school education or lower, (2) secondary school education/Institute of Technical Education/National Technical Certificate and (3) tertiary education or higher. Marital status was dichotomised into currently married or not married (single, divorced, widowed or married but separated from spouse). Work status was classified into three categories: (1) employed (working

adults or full-time studying), (2) homemaker (housewife or non-working individual who manages a home) and (3) retired/unemployed. Participants were asked to provide average monthly household income in Singapore Dollars (1 Singapore Dollar approximates 0.74 US Dollars) by choosing one of the following options: <\$2000, \$2000–\$3999, \$4000–\$5999 or ≥\$6000. An 'unknown' income category was created for participants who refused to report household income.

Statistical analyses

Counts and percentages were presented for categorical variables. Bivariate and multivariable logistic regression analyses were performed to assess the association of each sociodemographic factor with hypertension, unawareness of hypertension and untreated and uncontrolled hypertension, respectively. Multivariable logistic regression analyses were performed by mutually adjusting for all other sociodemographic variables (ie, age, gender, ethnicity, highest educational level attained, marital status, work status during the past 12 months and average monthly household income) excluding the main variable under each investigation. To investigate whether the relationship between sociodemographic factors and hypertension was moderated by ethnicity, interaction effects between ethnicity and sociodemographic factors on hypertension were examined by adding the interaction terms to the multivariable model. A stratified analysis by ethnic group was conducted to explore whether differences in sociodemographics contribute in part to ethnic differences in hypertension. Odds ratios (ORs) and adjusted odds ratios (AORs) were reported with the corresponding 95% Confidence Interval (CI). A p value of <0.05 was considered statistically significant. All statistical analyses were conducted using STATA V.14.0 for Windows .

RESULTS

Among 14530 participants enrolled in the MEC study, 11101 individuals completed survey questionnaires and attended the health examination. After excluding participants with major diseases (ie, cardiovascular diseases (CVD), stroke, transient ischaemic attack, cancer, asthma and mental illnesses), duplicated records and 'Others' ethnic group, our final study population was 10215 individuals of three main Asian ethnic groups, that is, Chinese, Malay and Indian (online-only supplementary).

Participant characteristics

Table 1 lists the sociodemographic characteristics of our study population. The participants comprised 47.2% Chinese, 26.0% Malay and 26.8% Indian. The majority of the participants were aged ≥40 years (68.1%), females (56.7%), had secondary school or higher educational level (73.0%), married (76.0%) and were working or studying full time (68.6%). The average monthly household income was <\$4000 in 48.0% of the participants.

Factors associated with hypertension

Of the 10215 participants included in our analysis (table 1), 31.1% were hypertensives. In this study population, the estimated prevalence of hypertension varied across sociodemographic factors: ethnic group (Malay: 33.1%; Chinese: 31.5%; Indian: 28.5%), age (≥60 years: 72.8%; 50–59 years: 45.7%; 40–49 years: 25.0%; <40 years: 9.0%), gender (male: 33.9%; female: 29.0%), educational level (primary school or lower: 48.3%; secondary: 29.2%; tertiary or higher: 18.5%), marital status (married: 32.9%; not currently married: 25.4%), work status (retired/unemployed: 54.9%; homemaker: 39.1%; working/studying: 25.3%) and monthly household income level (<\$2,000: 35.1%; \$2000–\$3999: 28.3%; \$4000–\$5999: 24.7%; ≥\$6000: 23.9%).

In the multivariable analysis (table 1), most of the sociodemographic factors remained significant, except marital status and household income. Compared with Chinese, the odds of hypertension were higher in Malays (p=0.007), whereas no significant difference was observed between Indian and Chinese (p=0.165). Older age was strongly associated with increased odds of hypertension (overall p<0.001). Multivariable analysis demonstrated that the adjusted odds of hypertension in males compared with females was higher than the unadjusted odds ratio (AOR=1.65 vs COR=1.25). Compared with females, males were more likely to have hypertension (AOR=1.65, 95% CI=1.47 to 1.85). Decreased educational level was associated with higher odds of hypertension (overall p<0.001). Compared with working or studying full time, being homemaker or retired/unemployed significantly increased the odds of hypertension (overall p<0.001). The originally significant relationship between household income and hypertension was eliminated after adjustment for age and educational level.

Significant interactions (p<0.050) were observed between ethnicity and age (p=0.025), gender (p<0.001), work status (p=0.034) and household income (p<0.001). After including these significant interaction terms into the final logistic model, interaction effects remained significant (p<0.050) between ethnicity and age, gender and household income. The addition of ethnicity affected the association between sociodemographic factors and the odds of hypertension.

Factors associated with hypertension stratified by ethnicity

In stratified analysis (table 2), hypertension was present in 31.5% of Chinese, 33.1% of Malay and 28.5% of Indian. The association between sociodemographic factors and the odds of hypertension in each ethnic group was moderated by the interaction effects between ethnicity and age, gender, work status and household income. The adjusted odds ratios of hypertension were higher in older age categories compared with age <40 years, and a similar pattern was observed in each ethnic group. Males had significantly higher odds of hypertension only in Chinese and Indian but not in Malay ethnic. No significant interaction was found between ethnicity and educational

Table 1 Association of sociodemographic factors and hypertension (n=10 215)

Sociodemographic factor	Hypertension					
	Total n	Hypertension n (%)	Unadjusted COR (95% CI)	P value	Adjusted AOR (95% CI)	P value
Ethnicity						
Chinese	4817	1519 (31.5)	1 (Ref.)	**0.001***	1 (Ref.)	**<0.001***
Malay	2659	879 (33.1)	1.07 (0.97 to 1.19)	0.177	**1.18 (1.05 to 1.34)**	**0.007**
Indian	2739	780 (28.5)	**0.86 (0.78 to 0.96)**	**0.006**	0.92 (0.81 to 1.04)	0.165
Age						
<40	3258	292 (9.0)	1 (Ref.)	**<0.001***	1 (Ref.)	**<0.001***
40–49	3187	798 (25.0)	**3.39 (2.94 to 3.92)**	**<0.001**	**3.18 (2.73 to 3.71)**	**<0.001**
50–59	2420	1106 (45.7)	**8.55 (7.40 to 9.88)**	**<0.001**	**7.54 (6.44, to 8.82)**	**<0.001**
≥60	1349	982 (72.8)	**27.18 (22.93 to 32.21)**	**<0.001**	**19.97 (16.47, to 24.23)**	**<0.001**
Gender						
Female	5795	1682 (29.0)	1 (Ref.)		1 (Ref.)	
Male	4419	1496 (33.9)	**1.25 (1.15 to 1.36)**	**<0.001**	**1.65 (1.47, to 1.85)**	**<0.001**
Highest education level						
Primary or lower	2763	1334 (48.3)	1 (Ref.)	**<0.001***	1 (Ref.)	**<0.001***
Secondary	4346	1271 (29.2)	**0.44 (0.40 to 0.49)**	**<0.001**	**0.70 (0.62, to 0.78)**	**<0.001**
Tertiary or higher	3100	573 (18.5)	**0.24 (0.22 to 0.27)**	**<0.001**	**0.59 (0.50, to 0.69)**	**<0.001**
Marital status						
Currently married	7757	2555 (32.9)	1 (Ref.)		1 (Ref.)	
Not currently married	2452	623 (25.4)	**0.69 (0.63 to 0.77)**	**<0.001**	1.11 (0.97 to 1.26)	0.126
Work status						
Working/Studying full time	6972	1766 (25.3)	1 (Ref.)	**<0.001***	1 (Ref.)	**<0.001***
Homemaker	2264	886 (39.1)	**1.90 (1.71 to 2.10)**	**<0.001**	**1.36 (1.19 to 1.56)**	**<0.001**
Retired/Unemployed	930	511 (54.9)	**3.60 (3.13 to 4.14)**	**<0.001**	**1.20 (1.01 to 1.43)**	**0.042**
Monthly household income (SGD)†						
<2000	2277	800 (35.1)	1 (Ref.)	**<0.001***	1 (Ref.)	0.172*
2000–3999	2619	740 (28.3)	**0.73 (0.64 to 0.82)**	**<0.001**	1.07 (0.93 to 1.23)	0.343
4000–5999	1664	411 (24.7)	**0.61 (0.53 to 0.70)**	**<0.001**	1.03 (0.88 to 1.22)	0.691
≥6000	1462	349 (23.9)	**0.58 (0.50 to 0.67)**	**<0.001**	1.13 (0.94 to 1.36)	0.202

COR was derived from bivariate logistic regression model.
AOR was derived from multivariable logistic regression model mutually adjusted for all other sociodemographic factors.
Bolded values are two-sided p values <0.05.
*Overall p value.
†Of all participants, 21.5% did not provide information on their average monthly household income. They have been categorised as 'unknown income' and included for analysis.
AOR, adjusted OR; COR, crude OR; SGD, Singapore Dollar.

level. Educational level was related to hypertension independent of ethnicity. Lower education was consistently associated with higher odds of hypertension in all ethnic groups, and the adjusted odds ratios were almost comparable with the non-stratified analysis (table 1). In terms of work status, the odds of hypertension in homemaker were consistently significant for all ethnic groups and higher for Indians but relatively lower for Chinese and Malays. Significantly higher odds of hypertension in retired/unemployed persisted only among Chinese but not among minorities, Malay and Indian ethnic groups.

Income–hypertension relationship was not found in Chinese and Malay ethnic groups, but Indians having lower income (between $2000 and $3999) were significantly associated with hypertension.

Factors associated with unawareness of hypertension

Among hypertensives, 49.0% were unaware of having hypertension (ie, 48.9% of Chinese, 53.4% of Malay and 44.4% of Indian). In the multivariable analysis (table 3), significant associations of ethnicity and age with unawareness persisted. Indians were less likely to be unaware of

Table 2 Association of sociodemographic factors and hypertension by ethnic groups, that is, Chinese (n=4817), Malay (n=2659) and Indian (n=2739)

Sociodemographic factor	Ethnicity					
	Chinese		Malay		Indian	
	AOR (95% CI)	P value	AOR (95% CI)	P value	AOR (95% CI)	P value
Age						
<40	1 (Ref)	<0.001*	1 (Ref)	<0.001*	1 (Ref)	<0.001*
40–49	**2.50 (1.99 to 3.15)**	**<0.001**	**4.04 (3.03 to 5.38)**	**<0.001**	**3.44 (2.53 to 4.68)**	**<0.001**
50–59	**6.44 (5.10 to 8.15)**	**<0.001**	**8.38 (6.20 to 11.33)**	**<0.001**	**8.26 (6.07 to 11.25)**	**<0.001**
≥60	**14.37 (10.82 to 19.06)**	**<0.001**	**30.53 (20.30 to 45.92)**	**<0.001**	**23.81 (16.40 to 34.56)**	**<0.001**
Gender						
Female	1 (Ref)		1 (Ref)		1 (Ref)	
Male	**1.85 (1.58 to 2.17)**	**<0.001**	1.08 (0.85 to 1.37)	0.527	**1.97 (1.56 to 2.50)**	**<0.001**
Highest education level						
Primary or lower	1 (Ref)	**<0.001***	1 (Ref)	**0.017***	1 (Ref)	**<0.001***
Secondary	**0.65 (0.54 to 0.77)**	**<0.001**	**0.73 (0.59 to 0.91)**	**0.005**	**0.71 (0.57 to 0.88)**	**0.002**
Tertiary or higher	**0.54 (0.43 to 0.67)**	**<0.001**	0.73 (0.52 to 1.04)	0.086	**0.50 (0.36 to 0.68)**	**<0.001**
Marital status						
Currently married	1 (Ref)		1 (Ref)		1 (Ref)	
Not currently married	1.05 (0.87 to 1.27)	0.616	1.00 (0.77 to 1.31)	0.972	1.25 (0.98 to 1.59)	0.074
Work status						
Working/Studying full time	1 (Ref)	**0.0078***	1 (Ref)	0.126*	1 (Ref)	0.066*
Homemaker	**1.30 (1.05 to 1.61)**	**0.015**	**1.29 (1.00 to 1.67)**	**0.048**	**1.37 (1.05 to 1.79)**	**0.021**
Retired/Unemployed	**1.38 (1.06 to 1.78)**	**0.015**	0.97 (0.67 to 1.43)	0.894	1.15 (0.83 to 1.60)	0.398
Monthly household income (SGD)†						
<2000	1 (Ref)	0.391*	1 (Ref)	**<0.001***	1 (Ref)	0.137*
2000–3999	0.88 (0.69 to 1.12)	0.306	1.07 (0.84 to 1.37)	0.593	**1.28 (1.00 to 1.64)**	**0.046**
4000–5999	1.04 (0.80 to 1.36)	0.764	1.02 (0.76 to 1.37)	0.879	0.92 (0.67to 1.25)	0.579
≥6000	1.12 (0.86 to 1.46)	0.401	0.72 (0.47 to 1.11)	0.133	1.20 (0.83 to 1.75)	0.334

Bolded values are two-sided p values <0.05.
COR was derived from bivariate logistic regression model.
AOR was derived from multivariable logistic regression model mutually adjusted for all other sociodemographic factors.
*Overall p value.
†Of all participants, 21.5% did not provide information on their average monthly household income. They have been categorised as 'unknown income' and included for analysis.
AOR, adjusted OR; COR, crude OR; SGD, Singapore Dollar.

having hypertension (AOR=0.80, 95% CI 0.67 to 0.96) when compared with Chinese, while no significant association was observed for Malays. Additionally, participants from older age groups, that is, 50–59 years (AOR=0.58, 95% CI 0.44 to 0.77) and ≥60 years (AOR=0.53, 95% CI 0.39 to 0.72), were less likely to be unaware of having hypertension when compared with adults aged <40 years.

Factors associated with untreated hypertension
Among participants who were aware of having hypertension, 25.2% were untreated for hypertension (ie, 24.7% of Chinese, 23.4% of Malay and 27.7% of Indian). In the multivariable analysis (table 3), older age was associated with much reduced odds of untreated hypertension when compared with age <40 years, that is, 40–49 years (AOR=0.39, 95% CI 0.25 to 0.61), 50–59 years (AOR=0.22,

95% CI 0.14 to 0.34), and ≥60 years (AOR=0.13, 95% CI 0.08 to 0.21). Males remained to have a significantly higher odds of untreated hypertension (AOR=1.51, 95% CI 1.12 to 2.04) when compared with females. With regards to educational level, the direction of the association with untreated hypertension changed in the multivariable analysis, that is, higher educational level was associated with lower odds of being untreated, but only secondary school education was a significant factor (AOR=0.69, 95% CI 0.52 to 0.91) when compared with primary school education.

Factors associated with uncontrolled hypertension
Among participants who were treated for hypertension, 62.4% did not have their hypertension controlled (ie, 65.5% of Chinese, 63.1% of Malay and 56.7% of Indian).

Table 3 Association of sociodemographic factors and unawareness among hypertensives (n=3175), untreated among aware and unaware among those who were aware of hypertension (n=1618)

Sociodemographic factor	Unawareness among hypertensives				Untreated among aware			
	COR (95% CI)	P value	AOR (95%CI)	P value	COR (95% CI)	P value	AOR (95% CI)	P value
Ethnicity								
Chinese	1 (Ref)	0.001*	1 (Ref)	0.0046*	1 (Ref)	0.335*	1 (Ref)	0.520*
Malay	1.19 (1.01 to 1.41)	0.037	1.11 (0.93 to 1.32)	0.258	0.93 (0.70 to 1.24)	0.630	0.87 (0.64 to 1.20)	0.398
Indian	0.83 (0.70 to 0.99)	0.037	0.80 (0.67 to 0.96)	0.018	1.17 (0.89 to 1.52)	0.257	1.05 (0.78 to 1.42)	0.731
Age								
<40	1 (Ref)	<0.001*	1 (Ref)	<0.001*	1 (Ref)	<0.001*	1 (Ref)	<0.001*
40–49	0.89 (0.67 to 1.16)	0.383	0.89 (0.67 to 1.18)	0.403	0.37 (0.24 to 0.57)	<0.001	0.39 (0.25 to 0.61)	<0.001
50–59	0.58 (0.44 to 0.75)	<0.001	0.58 (0.44 to 0.77)	<0.001	0.20 (0.13 to 0.31)	<0.001	0.22 (0.14 to 0.34)	<0.001
≥60	0.50 (0.39 to 0.66)	<0.001	0.53 (0.39 to 0.72)	<0.001	0.12 (0.08 to 0.19)	<0.001	0.13 (0.08 to 0.21)	<0.001
Gender								
Female	1 (Ref)		1 (Ref)		1 (Ref)		1 (Ref)	
Male	1.08 (0.94 to 1.25)	0.259	1.15 (0.96 to 1.37)	0.140	1.68 (1.34 to 2.11)	<0.001	1.51 (1.12 to 2.04)	0.007
Highest education level								
Primary or lower	1 (Ref)	0.007*	1 (Ref)	0.310*	1 (Ref)	0.007*	1 (Ref)	0.033*
Secondary	1.27 (1.09 to 1.48)	0.002	1.13 (0.95 to 1.33)	0.162	1.02 (0.80 to 1.32)	0.849	0.69 (0.52 to 0.91)	0.010
Tertiary or higher	1.21 (1.00 to 1.48)	0.054	1.01 (0.80 to 1.28)	0.937	1.59 (1.17 to 2.15)	0.003	0.83 (0.56 to 1.23)	0.362
Marital status								
Currently married	1 (Ref)		1 (Ref)		1 (Ref)		1 (Ref)	
Not currently married	1.02 (0.85 to 1.21)	0.860	1.09 (0.91 to 1.32)	0.356	0.88 (0.66 to 1.17)	0.367	1.05 (0.76 to 1.45)	0.781
Work status								
Working/Studying full time	1 (Ref)	0.002*	1 (Ref)	0.139*	1 (Ref)	<0.001*	1 (Ref)	0.557*
Homemaker	0.91 (0.77 to 1.07)	0.254	1.12 (0.91 to 1.39)	0.275	0.47 (0.35 to 0.62)	<0.001	0.83 (0.58 to 1.19)	0.316
Retired/Unemployed	0.70 (0.58 to 0.86)	0.001	0.86 (0.69 to 1.08)	0.203	0.49 (0.35 to 0.68)	<0.001	0.88 (0.60 to 1.30)	0.511
Monthly household income (SGD)†								
<2000	1 (Ref)	0.845*	1 (Ref)	0.837*	1 (Ref)	0.001*	1 (Ref)	0.147*
2000–3999	1.00 (0.82 to 1.22)	0.996	0.91 (0.74 to 1.12)	0.391	1.09 (0.80 to 1.48)	0.600	0.87 (0.62 to 1.22)	0.425
4000–5999	1.08 (0.85 to 1.37)	0.530	0.97 (0.75 to 1.25)	0.802	0.79 (0.54 to 1.18)	0.249	0.62 (0.40 to 0.96)	0.031
≥6000	0.95 (0.74 to 1.22)	0.680	0.86 (0.65 to 1.14)	0.296	1.07 (0.73 to 1.58)	0.732	0.76 (0.48 to 1.21)	0.242

AOR was derived from multivariable logistic regression model mutually adjusted for all other sociodemographic factors.
COR was derived from bivariate logistic regression model.
Bolded values are two-sided p values<0.05.
*Overall p value.
†Of all participants, 21.5% did not provide information on their average monthly household income. They have been categorised as 'unknown income' and included for analysis.
AOR , adjusted OR; COR, crude OR; SGD, Singapore Dollar.

Table 4 Association of sociodemographic factors and uncontrolled hypertension among treated (n=1211)

Sociodemographic factor	Uncontrolled among treated			
	COR (95% CI)	P value	AOR (95% CI)	P value
Ethnicity				
Chinese	1 (Ref)	**0.042***	1 (Ref)	0.174*
Malay	0.91 (0.69 to 1.21)	0.526	0.99 (0.72 to 1.35)	0.949
Indian	0.70 (0.53 to 0.93)	**0.013**	0.76 (0.56 to 1.04)	0.084
Age				
<40	1 (Ref)	**<0.001***	1 (Ref)	**<0.001***
40–49	1.78 (0.93 to 3.43)	0.084	1.61 (0.82 to 3.15)	0.163
50–59	2.89 (1.54 to 5.41)	**0.001**	2.54 (1.33 to 4.87)	**0.005**
≥60	6.28 (3.32 to 11.86)	**<0.001**	3.98 (2.01 to 7.91)	**<0.001**
Gender				
Female	1 (Ref)		1 (Ref)	
Male	1.16 (0.91 to 1.46)	0.231	1.35 (0.99 to 1.85)	0.061
Highest education level				
Primary or lower	1 (Ref)	**<0.001***	1 (Ref)	0.239*
Secondary	0.66 (0.51 to 0.86)	**0.002**	0.81 (0.61 to 1.08)	0.150
Tertiary or higher	0.54 (0.38 to 0.75)	**<0.001**	0.74 (0.49 to 1.12)	0.153
Marital status				
Currently married	1 (Ref)		1 (Ref)	
Not currently married	1.12 (0.83 to 1.50)	0.465	1.04 (0.75 to 1.44)	0.811
Work status				
Working/Studying full time	1 (Ref)	**<0.001***	1 (Ref)	0.068*
Homemaker	1.65 (1.26 to 2.16)	**<0.001**	1.34 (0.94 to 1.89)	0.101
Retired/Unemployed	2.93 (2.08 to 4.13)	**<0.001**	1.51 (1.02 to 2.24)	**0.041**
Monthly household income (SGD)†				
<2000	1 (Ref)	**<0.001***	1 (Ref)	**0.028***
2000–3999	0.86 (0.61 to 1.20)	0.372	0.95 (0.66 to 1.35)	0.762
4000–5999	0.77 (0.52 to 1.14)	0.193	0.94 (0.61 to 1.44)	0.767
≥6000	0.65 (0.43 to 0.99)	**0.045**	0.85 (0.53 to 1.36)	0.506

AOR was derived from multivariable logistic regression model mutually adjusted for all other sociodemographic factors.
COR was derived from bivariate logistic regression model.
Bolded values are two-sided p values<0.05.
*Overall p value.
†Of all participants, 21.5% did not provide information on their average monthly household income. They have been categorised as 'unknown income' and included for analysis.
AOR, adjusted OR; COR, crude OR; SGD, Singapore Dollar.

In the multivariable analysis (table 4), only older age and being retired/unemployed remained as significant factors. Higher odds of uncontrolled hypertension were associated with older age. Participants from older age groups, that is , 50–59 years (AOR=2.54, 95% CI 1.33 to 4.87) and ≥60 years (AOR=3.98, 95% CI 2.01 to 7.91) were more likely to experience uncontrolled hypertension when compared with participants aged <40 years. The majority of the retirees and unemployed participants were older adults aged ≥60 years (53.0%). Compared with adults who were working or studying full time, participants who were retired or unemployed (AOR=1.51, 95% CI 1.02 to 2.24) were more likely to have uncontrolled hypertension.

DISCUSSION

This large multi-ethnic Asian cohort study provides valuable insights into sociodemographic determinants of hypertension within relatively homogeneous living environment and access to healthcare. We estimated that approximately one in three participants had hypertension. The strength of the association between sociodemographic factors and hypertension differed across ethnic

groups. In addition to the established sociodemographic risk factors (ie, age and gender), our study adds new evidence about the importance of ethnicity in relation to hypertension. Our stratified analysis suggested that the observed ethnic differences in relation to hypertension was partly attributed to the variability in sociodemographic characteristics of each ethnic group. Educational level rather than household income was an important socioeconomic indicator consistently associated with hypertension within all ethnic groups. Almost half of the hypertensives in our study were unaware of having hypertension and 25% of those who were aware of having hypertension remained untreated. Adults <40 years of age were more likely to be undetected and untreated than older individuals. Male participants were more likely to be untreated than females, and participants with low educational level were more likely to be untreated when compared with those with higher educational level. Among treated participants, more than half did not achieve optimal BP levels and older age was strongly associated with worse BP control.

In agreement with similar studies conducted in other Asian countries[19–22] and Singapore,[14 15] our study further demonstrated that older age is a strong factor associated with hypertension. Ethnic differences in relation to hypertension were observed in our study, consistent with the current literature which was largely conducted in the Western countries.[10 23 24] While the association between Indian ethnicity and hypertension ceased to be significant after the addition of sociodemographic factors, the association between Malay ethnicity and hypertension was statistically significant. The ethnic differences observed in our study were partly explained by the variability in sociodemographic profile within each ethnic group, an interesting finding revealed from the stratified analysis. For instance, Malays and Indians had higher OR than Chinese for every increase in age group. Further, strong associations between gender and hypertension were observed among Chinese and Indian, but not Malay. Higher educational level had been found to be associated with lower prevalence of hypertension in earlier studies,[25 26] and our finding demonstrated that this association was consistent for all ethnic groups. No association between marital status and hypertension was observed in our study. The association between retired/unemployed status and hypertension was significant only among Chinese but not in other ethnic groups. In general, the income–hypertension association was not significant in our study after accounting for age and educational level.

Older participants were more likely to be aware of having hypertension because it is common among the age groups, and health policies may have offered screening opportunity to this subgroup. The literature suggested that minority ethnic groups who were hypertensive were more likely to be aware of their hypertension.[9 23] However, our study observed that Malay ethnic who had greater odds of hypertension did not seem to be sufficiently aware of their condition. Conversely, Indians were

relatively more aware of having hypertension compared with Chinese. The observed ethnic differences in hypertension awareness may be attributable to variations in lifestyle and cultural factors, and perceived benefit of hypertension prevention and control.[27–29]

Although older age was significantly related to hypertension, older participants in our study were more likely to be aware of having hypertension and treated for the condition. But, younger age, male gender and low educational level were significant determinants for untreated hypertension. Another study demonstrated that the measures of education can better explain variation in hypertension and health inequalities.[12] Low educational attainment may directly or indirectly influence the treatment and control of hypertension through lack of understanding about disease prevention, healthy lifestyle, perceived discrimination, among others.[25] Evidence suggested that education is a critical component of health and it is important to incorporate educational element in public health promotion and reducing health disparities.[30 31] Older age was significantly associated with uncontrolled hypertension in our study. This finding is consistent with the current evidence[32 33] but also contrasts with other findings which suggested that older adults had better control of BP.[4 20] Lack of control of BP among older adults in our population could due to ageing-related physiological changes, comorbidity and variation in response to treatment among older adults.[34] Social factors such as living in social exclusion, limited peer support and not having sufficient knowledge to cope with their hypertension condition may also affect their BP control.[35]

Strengths and limitations

This study has a number of strengths. First, it is based on a large population-based study of a multi-ethnic Asian population living in an urban city state. Second, the study used standardised and comprehensive methodologies to capture exposure and outcome data. Third, we had purposively oversampled minority ethnic groups and recruited a large number of study participants to cover a wider age range and diverse sociodemographic profile. Fourth, the findings of this study were robust after adjustment for potential sociodemographic confounders. However, we noted that the study has several important limitations. First, because the study design is cross-sectional, we cannot infer causality and determine the risk of hypertension. Further, this study adopted a convenience sampling methodology. Hence, the ethnic differences observed in this study may not be representative of the general Singapore population. In addition, we excluded individuals with established cardiovascular or cerebrovascular diseases, which are known outcomes of hypertension, to avoid influences on hypertension medication intake and adherence. Thus, the estimated prevalence of hypertension reported in this study would probably have underestimated the true population prevalence. Despite these limitations with regards to the generalisability of our findings, this study provides important and

novel real-life information related to awareness, treatment and control of hypertension in a multi-ethnic Asian population residing in a relatively homogenous living condition. Second, the classification of participants as being treated for hypertension was based on self-reported intake of antihypertensive medication, and a participant's compliance to medication was not determined. Third, participants were advised to fast for 8–12 hours before attending health examination. However, assessment on participants' exposures to caffeine and alcohol prior to BP measurements was not carried out, hence this study was not able to rule out that some participants may have been exposed to them. Fourth, BP of participants was measured on only one occasion during the health examination. However, standard BP measurement protocols were used, and multiple BP measurements were taken to minimise measurement error. Fifth, some participants did not provide information about average monthly household income. To overcome this limitation, we had classified them as a separate category (ie, 'unknown income' group) and included them for analyses. Unmeasured confounding cannot be adjusted for in our study. Although the results are not generalisable to the Singapore population, our findings contributed new insights to the study of hypertension in multi-ethnic urban Asian population. Future more in-depth prospective studies may be useful to examine underlying mechanisms that contribute to differential hypertension outcomes, and uncover the segments of population who may benefit from active prevention and early treatment strategies.

CONCLUSION

In this study, ethnic differences observed in hypertension were associated with sociodemographic variability within ethnic groups. Age and educational level were consistent correlates of hypertension in all ethnic groups. Unawareness and uncontrolled hypertension were common in this Asian population and associated with sociodemographic factors. More targeted strategies may be required to overcome the observed disparities.

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