

ORIGINAL ARTICLE

Prevalence, awareness, treatment and control of hypertension in the elderly population of Singapore

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A comprehensive picture of the management of hypertension in the increasing elderly population in Singapore is lacking. In this study, we assess the prevalence and correlates of hypertension and of awareness, treatment and control of hypertension among 4494 elderly Singaporeans (≥ 60 years) participating in a recent representative survey. The weighted prevalences of hypertension (systolic blood pressure ≥ 140 mm Hg or diastolic blood pressure ≥ 90 mm Hg or current use of antihypertension medication) and of awareness, treatment and control of hypertension were assessed. We assessed the extent of association of these outcomes with socio-demographic (age, gender, ethnicity, education, housing type, living arrangement and social participation) and health (body mass, diabetes and cognitive status) variables using multivariable logistic regression. Nearly three-fourths (73.9%) of participants were found to have hypertension. Of this number, 30.8% were unaware that they had hypertension, 32.0% were not being treated for the disease and 75.9% had suboptimal control of their blood pressure. Among those aware of their hypertension, only 1.9% were untreated. However, nearly two-thirds (64.5%) of treated hypertensives had suboptimal control. Age, gender, ethnicity, education, housing type, body mass and diabetes were significantly correlated with lack of awareness, treatment and control of hypertension. Although the specific 'at-risk' subgroups varied by the outcome, men and Malays had consistently higher odds for all three unfavorable outcomes. There is a need to improve awareness, treatment and especially control of hypertension among elderly Singaporeans. Primary and secondary prevention efforts targeting the elderly and their primary health-care providers are called for, as are regular data collection efforts based on representative samples.

Hypertension Research (2010) 33, 1223–1231; doi:10.1038/hr.2010.177; published online 30 September 2010

Keywords: Asia; blood pressure; health survey; Singapore

INTRODUCTION

Hypertension, a major cardiovascular risk factor,^{1,2} is also the leading risk factor for adult mortality worldwide.³ The elderly constitute an important group in the epidemiology of hypertension. Of all age groups, they have the highest prevalence of hypertension^{4–6} and are at particularly high risk of hypertension-related diseases.^{1,7} In fact, individuals who are normotensive at age 55 have a 90% lifetime risk of developing hypertension.⁸ However, hypertension among the elderly is treatable,^{2,9,10} and lowering blood pressure (BP) among elderly hypertensives, even the very old, can reduce the incidence of major coronary events and stroke.^{1,7,9,11,12} In fact, morbidity and mortality benefits derived from treatment may be even higher and may be appreciated earlier for older hypertensives.^{10,13} However, despite the effectiveness of treatment, studies report that elderly hypertensives have the lowest levels of BP control compared with younger hypertensives, even if they are more aware of their hypertensive status and more likely to be under pharmacological treatment.^{4,6}

Recognizing the elderly as an at-risk population, studies in various countries have documented the prevalence and correlates of hypertension

and of awareness, treatment and control of hypertension among the elderly.^{14–27} These studies suggest considerable heterogeneity for the prevalence of these conditions across elderly subgroups, defined by socio-demographic or health characteristics. Furthermore, neither the prevalence nor the identified correlates are uniform across countries. The variation could result from differences in criteria for defining hypertension and its treatment, but could also reflect variations in demographic and health profiles of the elderly as well as access to health services for chronic disease detection and management across countries. Therefore, it is important to have country-specific data for planning hypertension detection and management services for the elderly, especially for countries that have or will soon have a sizable elderly population.

Singapore is an aging country. The proportion of elderly Singaporeans aged ≥ 60 years (currently around 10%) is projected to double by 2030.^{28,29} However, a comprehensive picture of the management of hypertension among elderly Singaporeans is lacking. Previous studies have not been nationally representative,^{6,16,18} and either do not focus exclusively on the elderly⁶ or only present the prevalence and

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Received 9 April 2010; revised 17 May 2010; accepted 25 June 2010; published online 30 September 2010

correlates of undetected hypertension.¹⁸ The latest Singapore National Health Survey,³⁰ conducted in 2004, did assess the prevalence of hypertension and its treatment in a nationally representative sample, but only subjects <70 years old were included.

Taking advantage of a recent, large, representative survey, the present analyses were conducted to assess the prevalence and correlates of hypertension and of awareness, treatment and control of hypertension among elderly Singaporeans.

METHODS

Singapore Social Isolation, Health and Lifestyles Survey (SIHLS) 2009

The SIHLS, a nationally representative survey of community-dwelling elderly Singaporeans, was conducted in 2009 for the Ministry of Community Development, Youth and Sports. The target sample size was 5000. Assuming a 60% response rate, based on previous surveys of the elderly in Singapore, a random sample of 8400 elderly people stratified by gender, ethnicity and age (divided into 5-year increments: 60–64, 65–69, ..., 85+) according to the 2007 population distribution was drawn from the national database of dwellings. People ≥ 75 years old, Malays and Indians were oversampled by a factor of two to ensure a sufficient number in these subgroups for analysis. A total of 1195 (14.2%) addresses in the sample were found to be invalid. Of the rest, 5000 elderly people were interviewed face to face at their residence with informed consent using a structured questionnaire, yielding a response rate of 69.4%. The nonrespondents (refusal to participate (59.1%) and those who could not be contacted even after a minimum of three household visits (40.9%)) were more likely to be <70 years old and to represent 'other' ethnic groups but were similar in gender distribution compared with respondents. Proxy interviews were conducted for 458 (9.2%) elderly people who were unable to respond due to health reasons.

BP measurement

To insure consistency in BP measurement, interviewers were trained using didactic instruction, training videos and role-plays. Three resting BP measurements approximately 1 min apart were taken for 4494 (89.9%) participants using an electronic BP monitor (Omron HEM-780N, Omron, Kyoto, Japan). The rest ($n=506$), for whom BP could not be measured (refusal; cast/rash/wound/edema/bruise on arm(s)), were excluded from further analysis. Those excluded were more likely to be older, Chinese and have no formal education but were similar in gender distribution to the rest of the sample. Nearly all BP measurements were taken in accordance with the instructions given (left arm and sitting position used for 98.3 and 99.1% of participants, respectively). The mean of the three readings was used to define the systolic BP (SBP) and diastolic BP (DBP) values.

Definitions

The prevalence of BP classes, as defined in the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC-7) guidelines, was assessed: normal (SBP <120 mm Hg and DBP <80 mm Hg), prehypertension (SBP 120–139 mm Hg or DBP 80–89 mm Hg), stage 1 hypertension (SBP 140–159 mm Hg or DBP 90–99 mm Hg) and stage 2 hypertension (SBP ≥ 160 mm Hg or DBP ≥ 100 mm Hg).¹ The classification was based on measured BP (irrespective of treatment status), assigning the participant to the higher category if he/she could be classified into two categories.

In accordance with previous surveys and guidelines, hypertension was defined as 'SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg or (self-reported) current use of anti-hypertension medication'.^{1,14,15,17,19–27} Among hypertensives, those who responded in the negative to 'Have you ever been diagnosed with high blood pressure by a medical professional?' were considered to be unaware and those who responded in the negative to 'Are you presently taking any medicine prescribed by a physician for high blood pressure?' were classified as untreated. Thus, untreated participants included both those unaware of their hypertension and those who were aware but were not receiving any antihypertension medication. The extent of BP control was ascertained among all hypertensives and among treated hypertensives, with SBP and DBP values for defining control varying by (self-reported) diabetes status. For elderly subjects without

diabetes, SBP <140 mm Hg and DBP <90 mm Hg was considered to represent controlled BP, whereas corresponding values for elderly subjects with diabetes were SBP <130 mm Hg and DBP <80 mm Hg, based on JNC-7 guidelines,¹ clinical practice guidelines for hypertension in Singapore³¹ and previous studies.^{19,23} Those exceeding the criteria were considered as having suboptimal BP control.

Correlates

A variety of socio-demographic and health variables, evaluated as potential correlates with hypertension and/or awareness, treatment and control of hypertension in previous studies,^{6,14–27,32} were evaluated as correlates in the present analysis.

The socio-demographic variables included age (60–64 years, 65–74 years and ≥ 75 years), gender, ethnicity, education, housing type, living arrangement (based on household composition) and level of social participation. The three main ethnic groups in Singapore, that is, Chinese, Malay and Indian, were considered in the analysis. Those representing the 'Other' ethnic groups ($n=53$ out of the 4494 with measured BP values) were excluded as their number was too small for meaningful comparison. Education was categorized as none, primary, secondary and >secondary (vocational/technical/junior college/polytechnic/university education). Housing type was classified as public (Housing Development Board housing—further classified by the number of rooms (1 to 2, 3 and ≥ 4))—or private (condominiums) or other (bungalow/terrace house/semidetached house/shophouse). A social participation score was calculated based on frequency of participation (not at all (0), less than once a month (1), every month (2), every week (3), every day (4) in three social activities: attending neighborhood events, eating out and attending a place of worship) and divided into tertiles for the analysis. The health variables were body mass category (body mass index (BMI), based on measured weight and height, was categorized using Asian cutoffs,^{33,34} that is, underweight (<18.5 kg m⁻²), low risk (healthy range; 18.5–22.9 kg m⁻²), moderate/increased risk (23.0–27.4 kg m⁻²) and high risk (≥ 27.5 kg m⁻²), diabetes (doctor-diagnosed, self-reported status) and cognitive status (intact, mild cognitive impairment and moderate/severe cognitive impairment, based on subjects' SPMSQ (Short Portable Mental Status Questionnaire)³⁵ score).

Statistical analysis

Weighted proportion and mean estimates were calculated for categorical and continuous variables, respectively. The presence of a significant difference in means across levels of categorical variables was detected using either an unpaired *t*-test or analysis of variance. An χ^2 test was used for assessing significant difference in proportions across levels of categorical variables. A *P*-value of <0.05 was considered to be statistically significant. Association of potential socio-demographic and health correlates with the presence of hypertension and subjects' awareness, treatment and control of hypertension was ascertained using multivariable logistic regression analysis. The analysis, conducted using SAS for Windows Version 9.2 (SAS, Cary, NC, USA) was weighted using survey-sampling weights to adjust for nonresponse and over-sampling.

Ethical approval

The present analysis, based on de-identified data, was exempted from full review by the institutional review boards of the National University of Singapore and Duke University Health System.

RESULTS

Study population characteristics

The socio-demographic and health characteristics of 4441 elderly Singaporeans (excluding 53 categorized by ethnic group as 'Other') are given in Table 1.

Mean SBP and DBP, and JNC-7 BP classification

Although SBP increased significantly with age, there was a significant decline with age in DBP. In addition, although SBP was similar for

Table 1 Socio-demographic and health characteristics of the study population

Characteristic	Weighted % (n) ^{a,b} N=4441
<i>Age group (in years)</i>	
60–64	33.5 (897)
65–74	42.7 (1758)
≥75	23.8 (1786)
<i>Gender</i>	
Male	45.7 (2027)
Female	54.3 (2414)
<i>Ethnicity</i>	
Chinese	83.4 (3154)
Malay	10.0 (797)
Indian	6.6 (490)
<i>Education</i>	
None	30.0 (1576)
Primary	37.3 (1644)
Secondary	23.8 (900)
More than secondary ^c	8.7 (310)
<i>Housing type</i>	
1–2 room HDB	7.6 (396)
3 room HDB	26.7 (1207)
≥4 rooms HDB	53.0 (2283)
Condominium	5.2 (220)
Other ^d	7.6 (335)
<i>Living arrangement</i>	
Alone/with maid or others	12.0 (513)
With spouse only	18.9 (800)
With both spouse and children	43.5 (1718)
With children only	25.6 (1410)
<i>Social participation</i>	
1st tertile (least)	24.3 (1257)
2nd tertile	43.9 (1868)
3rd tertile (most)	31.8 (1316)
<i>Body mass category</i>	
Underweight (< 18.5 kg m ⁻²)	6.7 (318)
Low risk (healthy range) (18.5–22.9 kg m ⁻²)	32.5 (1387)
Moderate risk (23.0–27.4 kg m ⁻²)	39.7 (1696)
High risk (≥27.5 kg m ⁻²)	18.1 (876)
<i>Diabetes (self-reported)</i>	
Yes	21.5 (1074)
No	78.5 (3367)
<i>Cognitive status</i>	
Intact	83.4 (3413)
Mild CI	9.0 (499)
Moderate/severe CI	4.3 (293)

Abbreviations: CI, cognitive impairment; HDB, Housing Development Board.

^aWeighted column %, adjusted for oversampling and nonresponse using sample survey weights^bPercentages for following variables may not add up to 100% due to missing values: education (n=11), body mass category (n=164) and cognitive status (n=236).^cVocational/Institute of Technical Education/junior college/polytechnic/university and above.^dBungalow/terrace/semidetach/shophouse/other.

men and women, DBP was significantly lower among women. Around half (53.3%) of the elderly people had stage 1 or 2 hypertension as per the JNC-7 BP classification; the proportion increased with age and was higher among men (Table 2).

Prevalence of hypertension and of awareness, treatment and control of hypertension

Nearly three-fourths (73.9%) of community-dwelling elderly Singaporeans had hypertension. Among them, nearly one-third were unaware that they had hypertension (30.8%), 32.0% were untreated and three-fourths (75.9%) had suboptimal BP control. Among those aware, only 1.9% were untreated. However, nearly two-thirds (64.5%) of the treated hypertensives had suboptimal BP control (Figure 1).

The prevalence of hypertension varied across subgroups, rising above 80% among those aged ≥75 years, Malays, those with low social participation, those with moderate/high risk body mass, those cognitively impaired and diabetic subjects. At the same time, some elderly subjects, such as those with secondary or higher education and those residing in condominiums, had a comparatively lower prevalence of hypertension. The prevalence of unaware and untreated hypertensives also varied, with the lowest prevalence among elderly people with diabetes (only 12.9% were unaware and only 13.9% were untreated) and highest among those underweight (44.0% were unaware and 48.4% were untreated). The highest prevalence of suboptimal BP control was observed among Malays (87.8% of all Malay hypertensives and 80.0% of treated Malay hypertensives). The lowest prevalence of suboptimal BP control, for all hypertensives, was in subjects residing in condominiums (68.2%), and for treated hypertensives, it was in underweight subjects (49.1%; Table 3).

Correlates of hypertension and of awareness, treatment and control of hypertension

Although the odds of hypertension were significantly higher among men, those aged ≥65 years, those with moderate/high risk body mass, those with moderate/severe cognitive impairment and those with diabetes, the odds were significantly lower among Indians, those residing in condominiums, those having greater social participation and those underweight. Elderly hypertensives aged ≥65 years, those residing in larger public housing units or condominiums, those with high-risk body mass and those with diabetes were less likely to be unaware or untreated. However, men, Malays and those underweight were more likely to be unaware or untreated. Men and Malays also had higher odds of suboptimal BP control. In addition, higher odds were observed among those aged ≥65 years, those with moderate/high risk body mass and those with diabetes. Increasing educational status, however, was associated with a decrease in the odds of suboptimal BP control (Table 4).

DISCUSSION

This study, arguably the first to comprehensively document the prevalence and correlates of hypertension and of awareness, treatment and control of hypertension among elderly Singaporeans, observed a high prevalence of hypertension (73.9%) and, more importantly, of suboptimal BP control among all hypertensives (75.9%) and among treated hypertensives (64.5%). Age, gender, ethnicity, education, housing type, body mass and diabetes were significant correlates of being unaware of or untreated for hypertension and of suboptimal BP control. Although the specific 'at-risk' subgroups varied by the outcome considered, men and Malays consistently had higher odds for all three unfavorable outcomes.

Table 2 Mean SBP and DBP, and JNC-7 blood pressure class, overall and by age and gender

Variables	Blood pressure (mm Hg), Mean \pm s.d.		JNC-7 blood pressure class ^a Weighted row % ^b (n)			
	SBP	DBP	Normal SBP < 120 and DBP < 80	Pre-HTN SBP 120–139 or DBP 80–89	Stage 1 HTN SBP 140–159 or DBP 90–99	Stage 2 HTN SBP \geq 160 or DBP \geq 100
All (N=4441)	143.2 \pm 22.3	77.7 \pm 11.4	12.3 (484)	34.4 (1448)	32.7 (1440)	20.6 (1069)
<i>Age group^c</i>						
60–64 (N=897)	139.1 \pm 26.8	79.2 \pm 14.0	15.8 (135)	38.0 (334)	32.2 (287)	13.9 (141)
65–74 (N=1758)	144.0 \pm 23.1	78.2 \pm 11.5	11.2 (189)	33.9 (581)	33.0 (570)	21.9 (418)
\geq 75 (N=1786)	147.5 \pm 17.9	74.7 \pm 9.3	9.4 (160)	30.4 (533)	32.8 (583)	27.5 (510)
<i>Gender^d</i>						
Male (N=2027)	143.8 \pm 21.2	78.6 \pm 11.2	9.2 (177)	35.2 (681)	36.5 (713)	19.2 (456)
Female (N=2414)	142.7 \pm 23.1	77.0 \pm 11.5	15.0 (307)	33.8 (767)	29.6 (727)	21.7 (613)

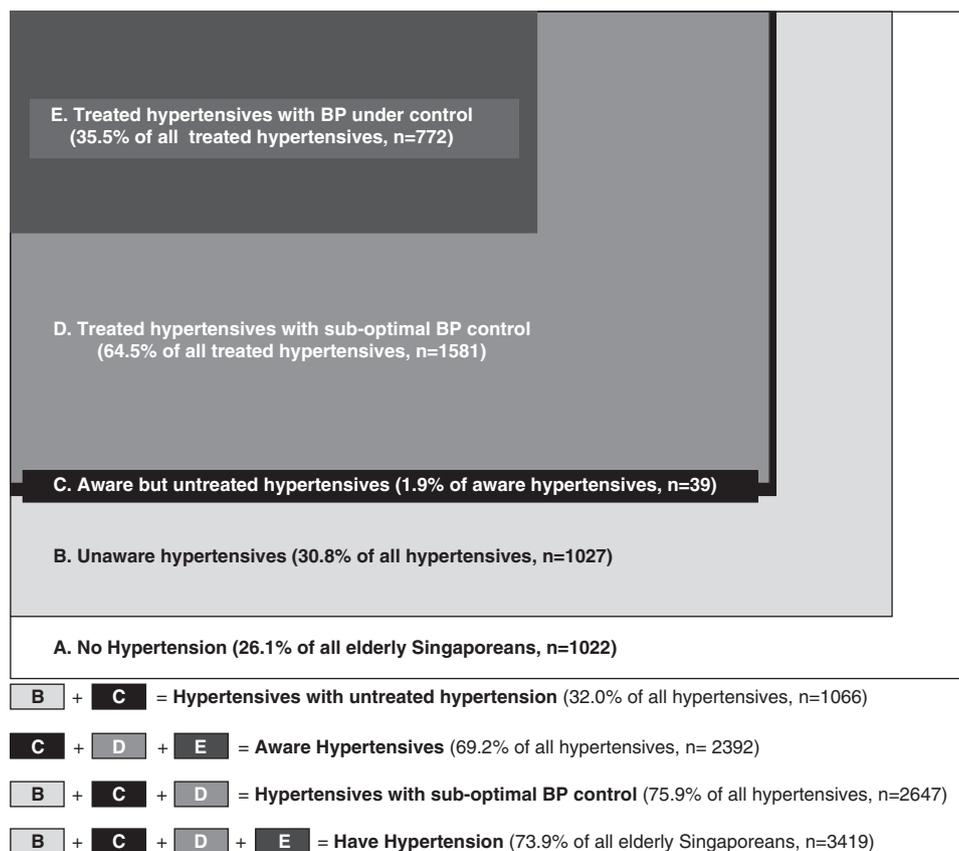
Abbreviations: DBP, diastolic blood pressure; HTN, Hypertension; JNC-7, Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure; SBP, systolic blood pressure.

^aAssigned to higher category if falling into two categories.

^bAdjusted for oversampling and nonresponse using sample survey weights.

^cMean SBP and DBP (ANOVA), and proportion in JNC-7 BP class (χ^2 test) are significantly different ($P < 0.05$) across age categories.

^dMean DBP (unpaired *t*-test), and proportion in JNC-7 BP class (χ^2 test) are significantly different ($P < 0.05$) across gender.

**Figure 1** Hypertension and its awareness, treatment and control among elderly Singaporeans.

The various prevalences, given in Figure 1, do not entirely conform to the classic 'rule of halves,' which states that 'only half of hypertensives are detected (aware), half of which are treated, of which only half achieve adequate BP control.'^{36,37} Nonconformity to the classic rule has been reported for most industrialized countries.³⁶

The prevalence of hypertension and its awareness, treatment and control in studies conducted exclusively among the elderly and using our criteria for defining hypertension is given in Table 5.^{14,15,17,19–27} Although most of these studies reported a lower prevalence of hypertension^{17,20,22–25,27} than what we observed (73.9%), some

Table 3 Weighted prevalence of hypertension, unaware hypertensives, untreated hypertensives, hypertensives with BP not under control, and treated hypertensives with BP not under control by socio-demographic and health variables

Variables	Have hypertension (73.9% (3419)) ^a % (n) ^a	Unaware hypertensives (30.8% (1027)) ^b % (n) ^b	Untreated hypertensives (32.0% (1066)) ^b % (n) ^b	Hypertensives with BP not under control (75.9% (2647)) ^b % (n) ^b	Treated hypertensives with BP not under control (64.5% (1581)) ^c % (n) ^c
<i>Age group (in years)</i>					
60–64	66.0 (600) ^d	36.4 (222) ^d	37.6 (229) ^d	73.5 (453)	57.6 (224) ^d
65–74	74.7 (1325)	29.3 (391)	30.7 (406)	77.5 (1042)	67.6 (636)
≥75	83.7 (1494)	26.8 (414)	28.1 (431)	75.9 (1152)	66.5 (721)
<i>Gender</i>					
Male	74.2 (1541)	34.0 (524) ^d	35.2 (540) ^d	78.3 (1224) ^d	66.7 (684)
Female	73.7 (1878)	28.0 (503)	29.4 (526)	73.8 (1423)	62.9 (897)
<i>Ethnicity</i>					
Chinese	73.3 (2404) ^d	30.3 (695) ^d	31.7 (730) ^d	74.1 (1792) ^d	62.1 (1062) ^d
Malay	81.4 (656)	38.2 (247)	38.8 (250)	87.8 (573)	80.0 (323)
Indian	70.9 (359)	23.8 (85)	24.2 (86)	78.7 (282)	71.9 (196)
<i>Education</i>					
None	78.8 (1276) ^d	28.1 (350)	29.0 (361) ^d	79.0 (1014) ^d	70.4 (653) ^d
Primary	73.5 (1256)	33.0 (417)	34.5 (435)	77.2 (1000)	65.3 (565)
Secondary	72.0 (675)	30.8 (199)	32.6 (209)	71.9 (487)	58.3 (278)
More than secondary	64.4 (205)	31.7 (59)	31.7 (59)	68.9 (141)	54.5 (82)
<i>Housing type</i>					
1–2 room HDB	76.6 (308) ^d	38.8 (121) ^d	41.1 (126) ^d	82.4 (259) ^d	70.0 (133)
3 room HDB	75.7 (947)	31.9 (289)	32.8 (296)	76.8 (741)	65.5 (445)
≥4 rooms HDB	73.4 (1757)	29.7 (509)	30.9 (529)	75.2 (1349)	64.2 (820)
Condominium	66.6 (151)	23.6 (34)	25.3 (36)	68.2 (100)	57.4 (64)
Other	73.9 (256)	30.6 (74)	32.4 (79)	75.3 (198)	63.5 (119)
<i>Living arrangement</i>					
Alone/ with maid or others	72.0 (385) ^d	35.7 (134) ^d	37.3 (140) ^d	77.6 (302)	64.2 (162)
With spouse only	71.9 (601)	30.0 (181)	30.8 (185)	74.4 (455)	63.1 (270)
With both spouse and children	72.2 (1289)	32.1 (404)	32.9 (415)	75.3 (994)	63.2 (579)
With children only	79.1 (1144)	27.1 (308)	29.2 (326)	77.0 (896)	67.6 (570)
<i>Social participation</i>					
1st tertile (least)	81.1 (1038) ^d	28.8 (290)	29.6 (299)	75.3 (798)	64.8 (499)
2nd tertile	73.0 (1425)	30.4 (418)	31.9 (437)	76.6 (1103)	65.7 (666)
3rd tertile (most)	70.0 (956)	33.0 (319)	34.4 (330)	75.4 (746)	62.5 (416)
<i>Body mass category</i>					
Underweight	52.5 (184) ^d	44.0 (78) ^d	48.4 (86) ^d	73.7 (139) ^d	49.1 (53) ^d
Low risk (healthy range)	67.6 (1004)	34.7 (349)	36.0 (361)	72.6 (750)	57.2 (389)
Moderate risk	76.3 (1335)	31.4 (406)	32.6 (418)	78.8 (1070)	68.6 (652) ^d
High risk	87.6 (770)	21.4 (163)	22.3 (169)	75.5 (592)	68.5 (423)
<i>Diabetes (self-reported)</i>					
Yes	86.4 (939) ^d	12.9 (123) ^d	13.9 (131) ^d	80.6 (774) ^d	77.5 (643) ^d
No	70.5 (2480)	36.8 (904)	38.1 (935)	74.3 (1873)	58.5 (938)
<i>Cognitive status</i>					
Intact	72.3 (2561) ^d	31.1 (783)	32.4 (814)	75.3 (1967)	63.5 (1153) ^d
Mild CI	81.0 (418)	29.9 (112)	30.7 (115)	78.3 (328)	68.6 (213)
Moderate/severe CI	86.6 (256)	28.2 (75)	29.3 (78)	82.5 (212)	75.3 (134)

Abbreviations: BP, blood pressure; CI, cognitive impairment; HDB, Housing Development Board.

^aWeighted row % (adjusted for oversampling and nonresponse using sample survey weights) and *n* indicate weighted proportion and number who 'have hypertension' among all elderly in the corresponding row.

^bWeighted row % (adjusted for oversampling and nonresponse using sample survey weights) and *n* indicate weighted proportion and number who have the outcome among those who are in the corresponding row in the 'Have hypertension' column.

^cWeighted row % (adjusted for oversampling and nonresponse using sample survey weights) and *n* indicate weighted proportion and number who have suboptimal BP control among treated hypertensives (that is, among those who have hypertension and are on antihypertension medication).

^dPercentages in different categories of the variable are significantly different (χ^2 test).

Table 4 Adjusted odds ratios and 95% confidence intervals for association of socio-demographic and health variables among elderly Singaporeans with hypertension; hypertension unawareness, untreated hypertension and lack of BP control among hypertensives; and lack of BP control among treated hypertensives

Variables	Hypertension N=4082 ^a	Unaware of hypertension (among hypertensives) N=3137 ^a	Untreated hypertension (among hypertensives) N=3137 ^a	Lack of BP control (among hypertensives) N=3137 ^a	Lack of BP control (among treated hypertensives) N=2153 ^a
<i>Age (in years)</i>					
60–64	1.0	1.0	1.0	1.0	1.0
65–74	1.48 (1.25–1.74)	0.75 (0.62–0.91)	0.76 (0.63–0.92)	1.16 (0.95–1.42)	1.37 (1.09–1.73)
≥75	2.60 (2.04–3.31)	0.60 (0.47–0.77)	0.60 (0.47–0.76)	1.00 (0.77–1.29)	1.33 (1.01–1.77)
<i>Gender</i>					
Female	1.0	1.0	1.0	1.0	1.0
Male	1.31 (1.11–1.54)	1.29 (1.07–1.56)	1.29 (1.07–1.56)	1.67 (1.37–2.04)	1.65 (1.32–2.06)
<i>Ethnicity</i>					
Chinese	1.0	1.0	1.0	1.0	1.0
Malay	1.05 (0.79–1.40)	1.92 (1.47–2.52)	1.84 (1.41–2.41)	2.28 (1.59–3.26)	1.96 (1.33–2.89)
Indian	0.51 (0.38–0.69)	1.02 (0.71–1.48)	0.95 (0.66–1.38)	1.14 (0.79–1.64)	1.18 (0.80–1.75)
<i>Education</i>					
None	1.0	1.0	1.0	1.0	1.0
Primary	1.00 (0.82–1.23)	1.00 (0.81–1.25)	1.06 (0.85–1.31)	0.77 (0.61–0.98)	0.71 (0.55–0.92)
Secondary	1.07 (0.85–1.34)	0.89 (0.69–1.16)	0.95 (0.74–1.23)	0.57 (0.44–0.75)	0.53 (0.39–0.71)
> Secondary	0.85 (0.62–1.15)	0.93 (0.65–1.35)	0.90 (0.62–1.30)	0.49 (0.34–0.72)	0.44 (0.29–0.68)
<i>Housing type</i>					
1–2 room HDB	1.0	1.0	1.0	1.0	1.0
3 room HDB	0.96 (0.69–1.32)	0.70 (0.51–0.97)	0.65 (0.47–0.90)	0.85 (0.58–1.25)	1.08 (0.70–1.67)
≥4 rooms HDB	0.83 (0.61–1.15)	0.65 (0.47–0.90)	0.61 (0.45–0.84)	0.86 (0.59–1.25)	1.13 (0.74–1.74)
Condominium	0.59 (0.38–0.91)	0.50 (0.30–0.84)	0.51 (0.31–0.84)	0.66 (0.39–1.11)	0.96 (0.53–1.72)
Other	0.93 (0.62–1.41)	0.76 (0.49–1.17)	0.74 (0.48–1.14)	1.00 (0.62–1.62)	1.26 (0.73–2.18)
<i>Living arrangement</i>					
Spouse and children	1.0	1.0	1.0	1.0	1.0
Only spouse	0.92 (0.76–1.13)	0.92 (0.73–1.15)	0.91 (0.73–1.14)	0.94 (0.74–1.19)	0.96 (0.74–1.24)
Only children	1.18 (0.95–1.47)	0.96 (0.76–1.21)	1.06 (0.85–1.34)	1.18 (0.92–1.50)	1.16 (0.89–1.52)
Alone/with maid or others	1.04 (0.81–1.34)	1.17 (0.89–1.55)	1.20 (0.91–1.58)	1.28 (0.94–1.73)	1.18 (0.83–1.66)
<i>Social participation</i>					
1st tertile (least)	1.0	1.0	1.0	1.0	1.0
2nd tertile	0.72 (0.58–0.88)	1.00 (0.81–1.23)	1.04 (0.84–1.28)	1.23 (0.99–1.52)	1.25 (0.98–1.58)
3rd tertile (most)	0.61 (0.49–0.77)	1.17 (0.93–1.46)	1.20 (0.96–1.51)	1.19 (0.94–1.51)	1.13 (0.87–1.47)
<i>Body mass category</i>					
Underweight	0.46 (0.35–0.61)	1.38 (0.96–1.99)	1.55 (1.08–2.23)	0.97 (0.65–1.45)	0.65 (0.40–1.06)
Low risk (healthy range)	1.0	1.0	1.0	1.0	1.0
Moderate risk	1.61 (1.37–1.90)	0.87 (0.72–1.05)	0.87 (0.73–1.05)	1.40 (1.15–1.71)	1.56 (1.25–1.96)
High risk	3.57 (2.77–4.60)	0.49 (0.38–0.62)	0.49 (0.39–0.63)	1.02 (0.80–1.29)	1.39 (1.07–1.81)
<i>Diabetes (self-reported)</i>					
No	1.0	1.0	1.0	1.0	1.0
Yes	2.28 (1.84–2.83)	0.26 (0.20–0.32)	0.26 (0.21–0.33)	1.34 (1.09–1.65)	2.21 (1.78–2.75)
<i>Cognitive status</i>					
Intact	1.0	1.0	1.0	1.0	1.0
Mild CI	1.26 (0.94–1.68)	1.08 (0.81–1.44)	1.05 (0.79–1.39)	1.03 (0.76–1.41)	0.96 (0.68–1.35)
Moderate/severe CI	1.87 (1.12–3.12)	1.05 (0.69–1.59)	1.03 (0.68–1.55)	1.45 (0.91–2.32)	1.58 (0.95–2.63)

Abbreviations: BP, blood pressure; CI, Cognitive impairment; HDB, Housing Development Board.

^aComplete case analysis, excluding those with missing values for any covariate.

Table 5 Prevalence of HTN, unaware hypertensives, untreated hypertensives and suboptimal BP control in studies focusing exclusively on the elderly and defining hypertension as 'SBP \geq 140 or DBP \geq 90 or current use of anti-hypertension medication'

First author, year	Country	N	Age	HTN ^a	Among hypertensives				
					Unaware	Untreated ^b	Suboptimal BP control ^c	Suboptimal BP control among treated hypertensives ^c	Untreated among aware ^b
Present study	Singapore	4441	\geq 60	73.90%	30.30%	32.00%	75.9% ^d	64.5% ^d	1.90%
Zhang <i>et al.</i> ²⁷	China	4141	\geq 60	48.50%	24.70%	33.3% ^e	67.90%	51.80%	11.4% ^f
Porapakham <i>et al.</i> ²⁴	Thailand	19374	\geq 60	51.10%	56.10%	84.2% ^f	98.3% ^f	89.40%	63.90%
Hypertension study group, ¹⁷	India and Bangladesh	1203	\geq 60	65.00%	55.30%	60.40%	89.80%	74.40%	11.4% ^f
Kim <i>et al.</i> ¹⁹	Korea	995	\geq 65	68.70%	—	33.90%	83.6% ^d	75.2% ^d	—
Lu <i>et al.</i> ²⁰	Taiwan	1435	\geq 65	60.40%	48.50%	—	—	—	—
Méndez-Chacón <i>et al.</i> ²²	Costa Rica	2800	\geq 60	64.50%	25.10%	—	~50%	—	18.90%
Brindel <i>et al.</i> ¹⁵	France	9090	\geq 65	78.20%	—	—	—	31.00%	—
Skliros <i>et al.</i> ²⁶	Greece	615	\geq 65	69.10%	11.00%	19.1% ^f	60.2% ^f	50.90%	9.00%
Prencipe <i>et al.</i> ²⁵	Italy	1032	\geq 65	64.80%	34.40%	40.50%	89.50%	82.40%	—
Banegas <i>et al.</i> ¹⁴	Spain	4009	\geq 60	68.30%	35.00%	44.70%	83.60%	70.50%	14.90%
McDonald <i>et al.</i> ²¹	USA	3810	\geq 65	70.80%	24.10%	30.70%	66.2% ^f	51.20%	8.7% ^f
Ostchega <i>et al.</i> ²³	USA	5093	\geq 60	58.00%	30.00%	42.00%	79.1% ^{d,f}	64.0% ^d	17.1% ^e
Ostchega <i>et al.</i> ²³	USA	4710	\geq 60	67.00%	26.00%	33.00%	71.2% ^{d,f}	57.0% ^d	9.5% ^f
<i>Studies from Singapore (Note: definition of hypertension is different—see footnotes g and h)</i>									
Ho <i>et al.</i> ¹⁶	Singapore	265	\geq 65	55.5% ^g	28.00%	—	73.40%	—	—
Joshi <i>et al.</i> ¹⁸	Singapore	19848	\geq 65	55.5% ^h	—	—	—	—	—

Abbreviations: BP, blood pressure; DBP, diastolic blood pressure; HTN, hypertension; SBP, systolic blood pressure.

^aSBP \geq 140 or DBP \geq 90 or current use of anti-hypertension medication, unless otherwise indicated.^bCurrently not on antihypertension medication, unless otherwise indicated.^cSBP \geq 140 mm Hg or DBP \geq 90 mm Hg, unless otherwise indicated.^dSBP \geq 140 mm Hg or DBP \geq 90 mm Hg for non-diabetics, and 'SBP \geq 130 mm Hg or DBP \geq 80 mm Hg' for diabetics.^eCurrently not a user of anti-hypertension medication and/or lifestyle change.^fDerived % (not given in the actual paper), calculated based on available numbers and percentages, may be inaccurate as it does not take sampling weight into account.^gNo definition given.^hSBP \geq 140 or DBP \geq 90.

reported a similar prevalence^{14,19,21,23,26} or, in one study,¹⁵ an even higher prevalence. Other than differences in the BP measurement instrument (manual or electronic) and number of readings (two or three) used for defining SBP and DBP, the variation could also reflect differences in demographic (for example, age, gender, ethnicity) and lifestyle (for example, diet, physical activity) profiles and in economic development across countries (prevalence is usually higher in more developed economies³⁸). Although previous studies of the elderly in Singapore have reported a lower prevalence,^{16,18} one of these studies¹⁶ was limited to a single township and the other¹⁸ did not consider use of antihypertension medication in the definition. Another Singaporean study using the same definition of hypertension as we did, although not limited to the elderly, did report a prevalence of hypertension among those aged \geq 65 years that was comparable with our findings.⁶

Similar to previous studies,^{14,16–18,20,22,23,25,26} we observed hypertension to be associated with age, higher BMI and diabetes. We also observed elderly men to be at a higher risk of hypertension, whereas previous studies have reported either no association with gender,^{17,20} or a higher risk for women.^{14,18} Furthermore, although elderly Malays had a higher prevalence of hypertension than elderly Chinese, the relationship disappeared in the adjusted analysis, possibly due to the greater prevalence of diabetes and higher BMI categories among Malays. Previous reports suggest an inverse association between hypertension and socioeconomic status, represented by education and/or income.^{14,17,39} We observed the same, with a lower prevalence

among those with higher education or more spacious housing. However, in the adjusted analysis, only housing remained significant. Interestingly, elderly people with greater social participation had a lower prevalence of hypertension. Previous studies have also reported social participation to be beneficial for various health outcomes, including coronary diseases.^{40,41} Those with moderate/severe cognitive impairment were more likely to be hypertensive, possibly reflecting the fact that hypertension is a risk factor for cognitive impairment and dementia, especially of vascular etiology.^{1,42,43}

The proportions of unaware (30.3%) or untreated (32.0%) hypertensives in this study were lower than most studies from other countries,^{14,17,20,24,25} although a few studies^{21,23,26,27} reported similar or even lower figures. Furthermore, only 1.9% of those aware (that is, diagnosed) were untreated, which is much lower than figures reported from other countries.^{14,17,21–24,27} Previous studies from Singapore reported comparable figures.^{6,16}

The levels of awareness of hypertension and its treatment are contingent on efforts aimed at raising awareness about hypertension (or chronic diseases in general) as well as the efficiency of health-care services in detecting hypertension and initiating treatment. The comparatively lower proportion of unaware or untreated hypertensives in Singapore may be due in part to good awareness and screening programs and to the health-care services in the country. The NHLP (National Healthy Lifestyles Program) has been ongoing in Singapore since 1992.^{44,45} Although hypertension is not its key focus, the program's focus on a healthy lifestyle might have had an indirect

benefit in raising awareness about hypertension. The nationwide awareness and screening program for renal disease risk factors, including hypertension, by the National Kidney Foundation Singapore,^{18,46,47} the Integrated Screening Program^{48,49} and a comprehensive chronic disease management approach at the primary health-care level⁵⁰ are also likely contributors. Even so, there is clearly room for improvement, with 30.3 and 32.0% hypertensives still being unaware of and untreated for the disease, respectively.

Furthermore, the groups of elderly hypertensives who are more likely to be unaware and/or untreated need greater attention. For some such groups, including those <65 years old, those underweight and those without diabetes, the increased risk could reflect complacency on their and/or their health-care providers' part, as these groups may not be traditionally considered to be at risk of hypertension. A related reason could be their lower frequency of contact with the health-care system, allowing less opportunity for diagnosis and treatment. The lower risk among those with higher BMI supports these conjectures. Of even greater concern is the increased risk of being unaware and untreated among men and Malays, who have a high prevalence of hypertension. The greater risk among those of lower socioeconomic status (residing in 1 to 2 rooms public housing) could be due to less access to or use of health-care services; this, however, was not ascertained in this study.

An even greater effort is required to lower BP to defined control levels. Around three-fourths of all hypertensives and 64.5% of treated hypertensives had suboptimal BP control in this study. Furthermore, more than one-third (35.1%) of the latter had stage 2 hypertension, as defined by JNC-7. Even using a cutoff of <140/90 mm Hg for all subjects, the prevalence of suboptimal control remained high (72.0% among all hypertensives and 58.8% among treated hypertensives). A comparison with other studies (Table 5) reveals that suboptimal BP control is not limited to Singapore; most studies report comparable or even higher figures.

Although suboptimal BP control among all hypertensives can be attributed in part to being unaware or untreated, suboptimal BP control among treated hypertensives cannot, and a variety of reasons have been suggested for this fact. These include health system factors such as access and cost, physician factors such as prescription of inadequate medication, doctor-patient communication quality and inadequate awareness of or compliance with guidelines, and patient nonadherence to medication due to reasons such as low (health) literacy, cost, side effects, forgetfulness and lack of knowledge of the disease.^{1,19,27,51-53} These factors, not assessed in this survey, should be explored in future quantitative and qualitative studies.

The use of the average of three BP measures assessed at a single visit (due to time and financial constraints) to define SBP and DBP values might have overestimated the prevalence of hypertension and underestimated the prevalence of awareness and BP control. Many previous population-based surveys also report findings based on BP values measured during a single visit.^{6,15-17,19-22,24,27} Given the survey's cross-sectional design, the identified correlates of hypertension are not necessarily causal risk factors. However, most of the socio-demographic variables we consider must have preceded the development of hypertension. Although our findings can be generalized to community-dwelling elderly Singaporeans, the situation is likely to be different among younger Singaporeans, which can be gauged from other studies and surveys.^{6,30} Classification of individuals as treated or untreated was based on self-reported use of antihypertension medication. Furthermore, information on the number, type and dose of prescribed drugs and on health-care utilization was not collected in the survey, limiting our understanding of reasons for the high prevalence of suboptimal BP control.

This study has several strengths. It is based on a large and representative sample. The response rate of 69.4% was higher than the typical response rate for surveys conducted in this population and age group. The definitions used for hypertension and for awareness, treatment and control of hypertension are based on standard guidelines and have been used extensively in previous studies,^{1,14,15,17,19-27} allowing the comparisons in the discussion above. The BP measures were obtained using electronic BP monitors, possibly reducing inter-observer variability, and in accordance with given instructions for nearly all participants.

The study findings suggest that there is a definite need for improving awareness, treatment and, especially, control of hypertension among elderly Singaporeans. To improve awareness, a specific focus on hypertension, highlighting its high prevalence, easy detection through noninvasive BP measurement and amenability to control, should be considered for the annual campaigns undertaken as part of the NHLPP. The availability of the subsidized Integrated Screening Program^{48,49} should also be promoted. A simultaneous focus on primary prevention through lifestyle modification should be maintained. Health-care providers should be asked to take BP measurements for all elderly patients at all possible encounters. As nearly all hypertensives who were aware of their condition were also under treatment, these measures are also likely to reduce the prevalence of untreated hypertensives.

Health-care providers should strive to attain BP control among all elderly hypertensives under their treatment. Those aged ≥ 65 years, men, Malays, the uneducated, those with higher BMI and those with diabetes mandate greater attention. The reasons for poor control in these subgroups needs to be ascertained in future studies to help providers improve BP control among their at-risk elderly patients. Considering long-term medication cost to be a key impediment to medication compliance and thereby BP control, the Singapore government launched the CDMP (Chronic Disease Management Program) in October 2006.⁵⁴ Under the CDMP, an individual can use his/her compulsory individual medical savings (Medisave) account to pay for consultation and drugs for six diseases, including hypertension. This could possibly enhance detection and control of hypertension among the elderly. Assessment of the impact of such programs or initiatives at the population level requires regular data collection efforts based on representative samples. One possibility is to expand the age base of future National Health Surveys in Singapore, conducted every 6 years, to include all the elderly.

Conclusion

We observed a high prevalence of hypertension among elderly Singaporeans (73.9%) and more importantly, suboptimal BP control among all hypertensives (75.9%) and treated hypertensives (64.5%). Age, gender, ethnicity, education, housing, body mass and diabetes were significant correlates of being unaware of and untreated for hypertension and of suboptimal BP control. Although the specific 'at-risk' subgroups varied by the outcome considered, men and Malays had higher odds for all three unfavorable outcomes. There is a definite need for improving awareness, treatment and, especially, control of hypertension among elderly Singaporeans. Primary and secondary prevention efforts targeting the elderly themselves and their primary health-care providers and regular data collection efforts based on representative samples are indicated.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

The data for this manuscript were collected through a project funded by the Ministry of Community Development, Youth and Sports, Singapore. The analyses were in part funded by a generous grant from the Tsao Foundation, Singapore, and an A*STAR infrastructure grant to the Duke-NUS Program in Health Services and Systems Research.

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