J-STAGE Advance Publication: June 10, 2022
Journal of Oral Science

Original article

Comparison of measured blood pressure levels, hypertension history, oral diseases and associated factors among Thai dental patients

Gyan P. Bajgai[1)], Nis Okuma[2)], Siribang-on P. Khovidhunkit[3)], and Supanee Thanakun[4)]

[1)] Department of Dentistry, Jigme Dorji Wangchuck National Referral Hospital, Thimphu, Bhutan
[2)] Department of Oral Medicine and Periodontology, Faculty of Dentistry, Mahidol University, Bangkok, Thailand
[3)] Department of Advanced General Dentistry, Faculty of Dentistry, Mahidol University, Bangkok, Thailand
[4)] Oral Diagnostic Science Division, College of Dental Medicine, Rangsit University, Pathumthani, Thailand

(Received February 17, 2022; Accepted May 2, 2022)

Abstract

Purpose: To compare blood pressure (BP), hypertension (HT) history, oral diseases, and potentially associated factors among dental patients in Thailand and explore the associations among them.
Methods: This study included 709 patients. Demographic data, BP levels, oral diseases, xerostomia, anxiety, depression, and associated factors were evaluated.
Results: One-third of the patients were male; patients with a history of HT were older than those without ($P < 0.001$). In total, 53 (7.5%) had such a history, and HT was controlled in 29 (54.7%) of them. Patients with possible HT (BP ≥140/90 mmHg; 94 in total, 13.3%) were five times more likely to have a definitive diagnosis of HT than those without possible HT (odd ratio [OR] = 4.95; 95% confidence interval [CI]: 2.76-8.87; $P < 0.001$). They also had an increased tendency to be taking antidyslipidemic (OR = 5.54; 95% CI: 2.90-10.60; $P = 0.001$) or antidiabetic (OR = 4.80; 95% CI: 1.91-12.08; $P = 0.001$) drugs. Male sex ($\beta = 0.156$, $P < 0.001$), higher age ($\beta = 0.299$, $P < 0.001$), higher body mass index ($\beta = 0.410$, $P < 0.001$), and periapical tissue diseases ($\beta = 0.073$, $P = 0.019$) were significantly associated with elevated systolic BP. Severe periodontitis ($\beta = 0.081$, $P = 0.023$) and a comparable association pattern with systolic BP were related to diastolic BP. Multivariate analysis revealed no significant association between BP and tooth loss, xerostomia, smoking, education level, anxiety, or depression.
Conclusion: Dentists play an essential role in screening for undiagnosed and uncontrolled HT. Significant associations were noted between oral inflammatory diseases and high BP.

Keywords: anxiety, blood pressure, oral disease, Thailand

Introduction

High blood pressure (BP) is an important risk factor for cardiovascular disease (CVD) [1]. The global prevalence of high BP is 24.1% among males and 20.1% among females [1]. Although the pooled prevalence of hypertension (HT) among the Southeast Asian population is 33.8% [2], HT prevalence among Thai adults aged ≥15 years is 24.7% (males, 25.6%; females, 23.9%) and the rate of HT unawareness is approximately 45% [3].

In the population of Thailand, HT is diagnosed if the systolic BP (SBP) is ≥140 mmHg and/or the diastolic BP (DBP) is ≥90 mmHg [4]. An association between HT and oral inflammation, especially periodontitis, has been reported [5]. Low-grade systemic inflammation associated with HT and oral diseases is a crucial factor leading to CVD [6]. Although no oral manifestations result directly from HT, medications used to treat HT may cause xerostomia, lichenoid lesions, gingival bleeding, and gingival hyperplasia [7].

Sex, body mass index (BMI), waist circumference, ethnicity, family history, education, socioeconomic level, a high-sodium diet, physical inactivity, stress, depression, smoking, and alcohol consumption play essential roles in HT development [2,7,8]. Because of such common risk factors, an interrelation exists between oral and overall health. However, multiple risk factors associated with HT and differences in genetic background, environment, and lifestyle necessitate accurate information on local populations, and this is also the case for dental patients in Thailand. As no previous study has investigated the dental, periodontal, and oral mucosal diseases present in patients with HT, or their levels of anxiety and depression, there is a need to evaluate the various common confounding factors in such patients with the aim of future control measures.

The present observational study was conducted to determine the extent to which dentists assess BP and HT in Thai dental patients, and to examine possible associations among oral health status, BP, and potentially associated factors to broaden knowledge in this area of research.

Materials and Methods

Study participants

This study was conducted using data from patients' dental records and questionnaires distributed at an Oral Diagnosis Clinic in the Faculty of Dentistry, Mahidol University, Thailand, between April 2018 and January 2020. All patients provided written informed consent for use of their data. The study protocol and consent forms complied with the tenets of the Declaration of Helsinki, and were approved by the Research Ethics Board of the Faculty of Dentistry, Faculty of Pharmacy, Mahidol University (approval number: MU-DT/PY-IRB 2017/028.2504).

Based on a pilot study involving 50 patients at the Oral Diagnosis Clinic, a statistical test with a power of 80% and an alpha value of 5% for sample size determination revealed a requirement of at least 545 individuals for the study. All patients had to be aged ≥18 years for inclusion. The exclusion criteria included the presence of any malignancy; active treatment with immunosuppressants, other anti-inflammatory drugs, chemotherapy, or radiotherapy; pregnancy; and individuals with communication problems.

Demographic data and any family history of HT were recorded. Patients with a history of physician-diagnosed HT or patients who had been taking BP-lowering medication in the previous 2 weeks treated as known cases of HT.

Assessment of BP

BP was measured twice (Automated BP monitor TM2657P, A&D Medical, Tokyo, Japan) at an interval of 10 min in the morning following the Thai guidelines on the treatment of hypertension 2019 [4]. The mean office SBP and DBP were calculated. A mean SBP of 120-129 and/or a mean DBP of 80-84 mmHg is considered normal BP [4]. A mean SBP of 130-139 mmHg and/or a mean DBP of 85-89 mmHg reflects high normal BP, while possible HT is defined as a mean SBP of ≥140 mmHg and/or a mean DBP of ≥90 mmHg [4]. Patients' heart rates were also recorded.

Assessment of dental, periodontal, and oral mucosal diseases

Missing teeth were counted (excluding third molars). The number of teeth with dental caries and diseases affecting pulpal and periapical tissues were noted. The diagnoses of pulpal and periapical tissue diseases were made based on the American Association of Endodontics classification [Patel B. Endodontic Diagnosis, Pathology, and Treatment Planning: 35-48, Springer, 2015].

Correspondence to Dr. Supanee Thanakun, Oral Diagnostic Science Division, College of Dental Medicine, Rangsit University, 52/347 Phahonyothin Rd., Lakhok, Pathumthani 12000, Thailand
Fax: +66-2-997-2200 E-mail: supanee.t@rsu.ac.th

Color figures can be viewed in the online issue at J-STAGE.
doi.org/10.2334/josnusd.22-0057
DN/JST.JSTAGE/josnusd/22-0057

Table 1 Patients' characteristics based on BP and HT history

Variables	Patients (n = 709) Measured BP			P*	HT history	P**
	normal BP (<130 / 85 mmHg) n = 499	high normal BP (≥130-139 / 85-89 mmHg) n = 92	possible HT (≥140 / 90 mmHg) n = 118		known HT (≥140 / 90 mmHg) n = 53	
Age (years)	27 (21, 41)	43 (30, 54)	49 (36, 58)	<0.001	58 (50, 63)	<0.001
Sex						
male	138	32	51	0.003	17	0.878
female	361	60	67		36	
SBP (mmHg)	113 (106, 120)	134 (132, 136)	147 (144, 159)	<0.001	138 (128, 150)	<0.001
DBP (mmHg)	67 (62, 72)	79 (75, 83)	90 (84, 94)	<0.001	78 (73, 87)	<0.001
HR (beat/min)	74 (68,82)	77 (69, 87)	79 (69, 88)	0.006	70 (65, 81)	0.045
BMI (kg/m^2)	21.5 (19.4, 23.5)	24.7 (21.3, 28.9)	26.1 (23.2, 29.0)	<0.001	24.7 (22.0, 28.8)	<0.001
Family history of HT (n = 681)			n = 112		n = 50	
presence	161	38	52	0.013	25	0.049
absence	321	49	60		25	
Smoking (n = 697)			n = 117		n = 53	
never	408	67	81		37	
former	42	14	18	0.006	8	0.151
current	40	9	18		8	
Alcohol consumption (n = 689)			n = 118		n = 51	
never	250	51	61		32	
former	115	24	31	0.627	13	0.132
current	116	15	26		6	
Education level (n = 684)			n = 113		n = 48	
lower than a bachelor's degree	138	36	53		27	
bachelor's degree	311	42	54	0.001	17	0.001
higher than a bachelor's degree	35	9	6		4	
Occupation (n = 657)			n = 103		n = 44	
public service	43	12	13		13	
private	206	40	54	<0.001	16	<0.001
student	169	7	9		0	
others	50	27	27		15	

BP, blood pressure; HT, hypertension; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; BMI, body mass index. *Chi-squared or Kruskal-Wallis test. **Chi-squared or Mann-Whitney U test

Screening for plaque-induced gingivitis or periodontitis was performed using the periodontal screening and recording (PSR) code, and all teeth were examined. The reading for the tooth most severely affected by periodontal disease was recorded in the score [9].

Diagnosed cases of oral mucosal disease were recorded as reported by Fedele et al., including infectious and inflammatory as well as noninfectious and noninflammatory mucosal disease [10].

Assessment of associated factors

Data on education level (higher/lower degree or bachelor), occupation, and exercise frequency (e.g., ≥30 min of aerobic exercise at least three times per week) were collected. Personal habits (e.g., smoking and tobacco use and alcohol consumption: never, former [used to smoke tobacco or drink alcohol but stopped at least 6 months previous to data collection], or current) were recorded. In addition, data on oral health behavior (daily tooth brushing: ≤1 time or ≥2 times) were collected. Salty food consumption behavior was also recorded. Patients who stated that they usually added salt, fish sauce, or soy sauce to their food and were defined as "eating salty foods" [11].

Information about xerostomia was collected by asking the questions reported in the study by Fox et al. [12]. Anxiety and depression scores were measured using the Hospital Anxiety and Depression Scale (Thai version) [13]. A score of 0-7 is considered normal, 8-10 borderline, and 11-21 is considered to indicate anxiety or depression.

BMI was calculated based on patient body weight in kilograms divided by height in meters squared. A BMI of 18.5-22.9 kg/m^2 was considered normal for this population. A BMI of 23.0-24.9 kg/m^2 indicated overweight, whereas a BMI of ≥25 kg/m^2 indicated obesity [14].

Statistical analysis

Statistical analyses were performed using the SPSS 25.0 software package for Windows (IBM Corp., Armonk, NY, USA). The normality of all variables was assessed using the Kolmogorov-Smirnov test. Associations among qualitative data were evaluated using the chi-squared test. Differences across quantitative data were determined using the Mann-Whitney U or Kruskal-Wallis test because of skewed distribution. Multivariate analysis was performed to assess the association of oral health and other potential factors with patients' SBP and DBP. The significance level was two-sided, and differences at $P < 0.05$ were considered significant.

Table 2 Number of patients with an HT history based on possible HT and high normal BP

Possible HT	HT history (n = 709)		
	presence (n = 53)	absence (n = 656)	P*
Yes (≥140 / 90 mmHg) (n = 118)	24 (3.4)	94 (13.2)	<0.001
No (<140 / 90 mmHg) (n = 591)	29 (4.1)	562 (79.3)	

High normal BP	HT history (n = 591)		
	presence (n = 29)	absence (n = 656)	P*
Yes (130-139 and / or 85-89 mmHg) (n = 92)	12 (2.0)	80 (13.5)	0.001
No (<130-139 and / or 85-89 mmHg) (n = 499)	17 (2.9)	482 (81.6)	

*Chi-squared test

Results

Characteristics of participants

In total, 709 patients were recruited. Age, SBP, DBP, heart rate, and BMI were significantly higher in patients with possible HT than in those with normal BP (Table 1). Males were almost twice as likely to have possible HT than females (odds ratio [OR] = 1.77; 95% confidence interval [CI]: 1.18-2.68; P = 0.02). Although >50% of the patients had normal BMI, 120 (16.9%) were overweight and 178 (25.1%) were obese. Patients with obesity were five times more likely to have possible HT than those without

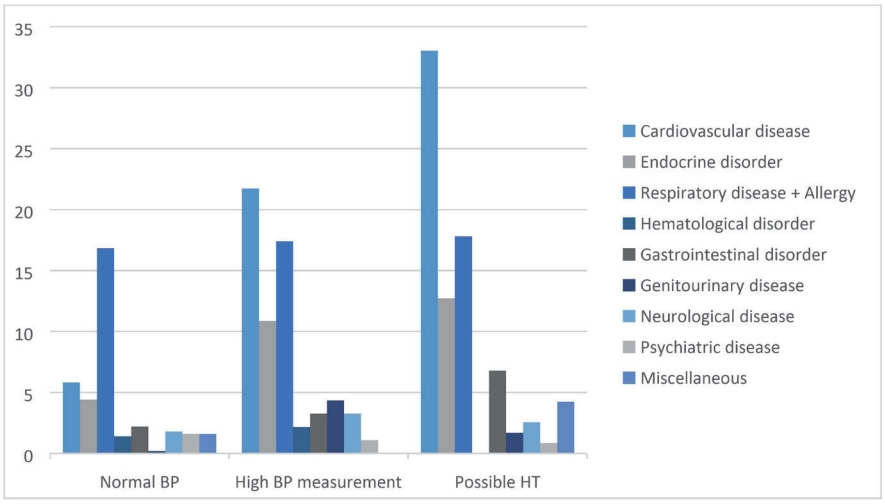

Fig. 1 Percentage of patients having medical conditions based on hypertension definition

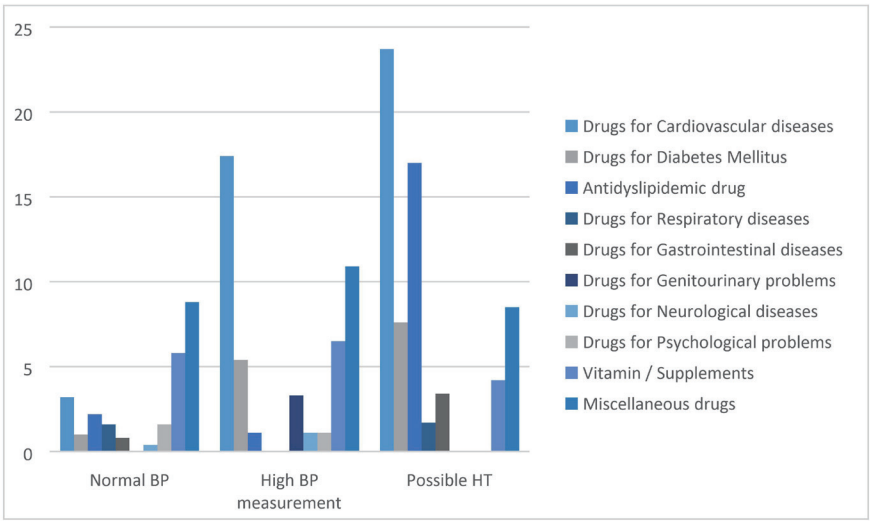

Fig. 2 Percentage of patients with medication use based on hypertension definition

obesity (OR = 5.80; 95% CI 3.76-8.94; $P < 0.001$). Similarly, overweight patients were 3.24 times more likely to have possible HT than normal-weight patients (OR = 3.24; 95% CI: 1.73-6.05, $P < 0.001$). Furthermore, patients with a family history of HT (OR = 1.60; 95% CI: 1.05-2.42; $P = 0.03$), a history of smoking (OR = 1.87; 95% CI: 1.03-3.38, $P = 0.04$), and an education level lower than a bachelor's degree (OR = 2.01; 95% CI: 1.38-3.16; $P = 0.001$) were more likely to have possible HT. Workers were four times more likely to have possible HT than students (OR = 4.20; 95%CI: 2.04-8.63, $P = 0.001$). However, alcohol consumption, exercise, tooth-brushing frequency, or higher salty food consumption showed no significant association with either high BP or history of HT.

When known HT history was analyzed, BMI, education level, and occupation were significantly associated with HT. Patients with a history of HT were older than those without such a history. Patients with obesity were 2.55 times more likely to have a history of HT than those without obesity (OR = 2.55; 95% CI: 1.43-4.56; $P = 0.002$). The tendency to have a history of HT was higher in overweight patients than in normal-weight patients (OR = 3.04; 95% CI: 1.40-6.58; $P = 0.005$). Patients with an education level lower than a bachelor's degree showed a tendency to have a history of HT (OR = 2.80; 95%CI: 1.55-5.08; $P = 0.001$). In addition, workers were as likely to have a history of HT as to have possible HT ($P < 0.001$). However, neither sex nor personal history was associated with HT (Table 1).

BP and HT history

In total, 53 (7.5%) of the study patients had a history of HT; however, only 29 (54.7%) patients had their BP under control (Table 2). In the remaining 24 individuals (45.3%), but BP was not under control (≥140/90 mmHg). Furthermore, the 94 (13.3%) patients with possible HT were five times more likely to have a definitive diagnosis of HT than those without possible HT (OR = 4.95; 95%CI: 2.76-8.87; $P < 0.001$). These patients were informed about the possible risk of having HT and were advised to consult their physicians for definitive diagnosis and management.

The data for 92 (15.6%) patients with high normal BP were analyzed. Among them, 80 patients (87.0%) did not have a history of HT, and only 12 were receiving antihypertensive medication. The patients with high normal BP had a greater risk of having diagnosed HT (OR = 4.25; 95% CI: 1.96-9.24; $P = 0.001$) (Table 2).

Medical status and medication use

Among the 709 patients, 213 (approximately 30%) had comorbidities. The most common medical condition was allergy (27.4%), followed by CVD, HT (12.4%), and endocrine disorders (6.6%) (Fig. 1). All patients with a history of HT were medically compromised; 22.0%, 45.7%, and 51.7% of patients with normal BP, high normal BP, and possible HT concurrently had at least one medical problem, respectively.

Regarding the frequency of drug use (Fig. 2), 60 (8.5%) patients were receiving antihypertensive drugs, 41 (5.8%) antidyslipidemic drugs, and 19 (2.7%) antidiabetic drugs; 29 patients (24.2%) were taking a combination of these drugs (Fig. 3). A significant association was noted between the use of these drugs and BP ($P < 0.001$). Patients with possible HT showed a significantly higher tendency to be receiving antidyslipidemic (OR = 5.54; 95% CI: 2.90-10.60; $P = 0.001$) or antidiabetic (OR = 4.80; 95% CI: 1.91-12.08; $P = 0.001$) drugs. A similar pattern was observed among patients with high normal BP. Patients with a history of HT had a significantly

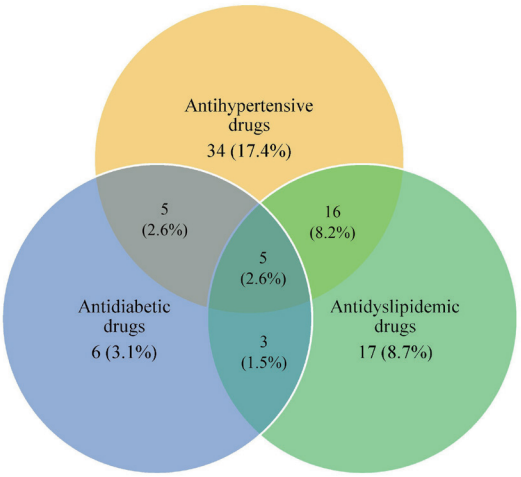

Fig. 3 Percentage of patients receiving antihypertensive, antidyslipidemic, and antidiabetic drugs

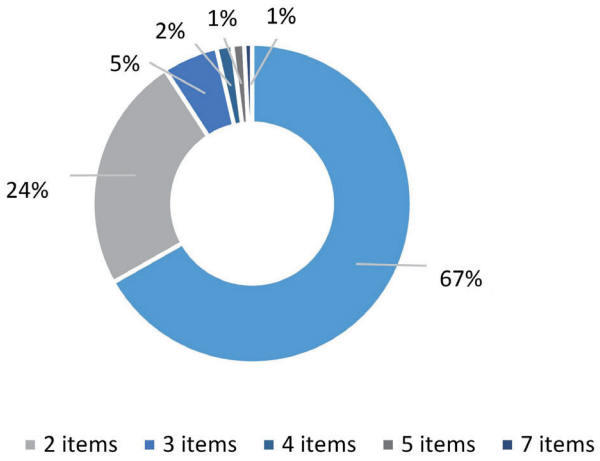

Fig. 4 Percentage of patients who responded "yes" to at least one item from the xerostomia-related questions

Table 3 Oral health of the patients based on BP and HT history

Variables	Patients (n = 709) BP			P*	HT history	P**
	normal BP (<130 / 85 mmHg) n = 499	high normal BP (≥130-139 / 85-89 mmHg) n = 92	possible HT (≥140 / 90 mmHg) n = 118		known HT (≥140 / 90 mmHg) n = 53	
Number of lost teeth	1 (0, 3)	2 (0, 5)	3 (0, 6)	<0.001	4 (2, 8)	<0.001
Number of patients with maximum PSR						
1	9	5	10	<0.001	6	<0.001
2	301	37	40		23	
3	142	33	44		12	
4	47	17	24		12	
Number of teeth associated with various pathologies						
dental caries	1 (0, 4)	1 (0, 3)	2 (0, 4)	0.302	1 (0, 2)	0.012
pulpal disease	0 (0, 1)	0 (0, 1)	0 (0, 1)	0.141	0 (0, 1)	0.067
periapical tissue disease	0 (0, 1)	0 (0, 1)	0 (0, 1)	0.033	0 (0, 1)	0.094
Removable dentures (n = 668)						
presence	47	21	38	<0.001	21	<0.001
absence	425	63	74		29	

PSR, periodontal screening and recording code. *Chi-squared or Kruskal-Wallis test. **Chi-square or Mann-Whitney U test

longer history of antihypertensive, antidiabetic, and antidyslipidemic drug use than those with normal BP (P < 0.001). No significant associations were noted between BP and intake of vitamins, supplements, or other miscellaneous medicines.

Oral health status

Patients with high normal BP, possible HT, or a history of HT had a higher number of lost teeth (P < 0.001), a higher number of teeth with periapical tissue diseases (P = 0.033), and more removable dentures (P < 0.001) than those with normal BP (Table 3). Furthermore, patients with a history of HT showed a higher tendency to have severe periodontitis than those with normal BP (OR = 2.82; 95% CI: 1.38-5.73; P = 0.02). Similarly, patients with possible HT were more predisposed to severe periodontitis than those with normal BP (OR = 2.46; 95% CI: 1.43-4.21; P = 0.001).

A total of 250 (35.3%) patients responded "yes" to at least one of the xerostomia-related questions (Fig. 4). However, no significant association was observed between responses to xerostomia-related questions and a history of HT (P = 0.458) or medication use (P = 0.220). Furthermore, there was no association between BP level and noninflammatory dental diseases or other oral mucosal diseases (data not shown).

Anxiety, depression, and associated factors

Smoking was associated with anxiety (P = 0.013) or depression (P = 0.019). Patients with other medical problems were twice as likely to have higher anxiety than those without other medical problems (OR = 2.05; 95% CI: 1.16-3.60; P = 0.020). However, high BP, history of HT, sex, education level, occupation, xerostomia, and alcohol consumption were not associated with either anxiety or depression.

Table 4 Association of oral health and associated factors with patients' SBP and DBP

Variables	SBP		DBP	
	β	P*	β	P*
Age	0.299	<0.001	0.169	<0.001
Sex (female)	−0.156	<0.001	−0.101	0.006
Body mass index	0.410	<0.001	0.400	<0.001
Education level (>bachelor's degree)	−0.056	0.085	−0.019	0.596
Smoking	0.021	0.528	0.023	0.532
Number of periapical tissue diseases	0.073	0.019	0.069	0.041
Severe periodontitis	0.033	0.315	0.081	0.023
Number of lost teeth	0.019	0.614	0.049	0.228

*Regression analysis

Association of oral health and related factors with BP

Multivariate analysis was used to assess possible associations between various factors and SBP and DBP (Table 4). Male sex, higher age, higher BMI, and periapical tissue diseases were significantly associated with elevated SBP. Severe periodontitis and a comparable pattern of association with SBP was related to DBP. After simultaneous adjustment for all covariates, no associations were noted between SBP or DBP and education level, smoking, pulpal disease, or tooth loss.

Discussion

The present study revealed a significant association between higher BP and oral inflammatory diseases independent of age, sex, and BMI. Patients with higher BP generally had more teeth with periapical tissue disease and more severe periodontitis than those with normal BP. Although no significant differences were noted in the presence oral mucosal disorders, this study investigated all dental, periodontal, and oral mucosal diseases in patients with various BP levels.

The present study confirms the latest global report on elevated BP and HT [1]. Males aged 18-49 years have higher BP than females of the same age in most countries, but patients of both sexes aged ≥50 years have similar mean BP levels [1]. Female predominance has been demonstrated previously in a Thai study [8]. A higher risk for HT in males or females based on these studies' age range, study design, and location differences. In addition, patients with a lower socioeconomic status and low education level show an increased prevalence of high BP [1,15].

The present results are in accordance with previous studies conducted nationally or regionally [2,8,15]. A relationship between high BMI and an increased risk of HT in the Thai population has recently been reported [15]. Thawornchaisit et al. stated that the risk of HT remained unaffected by the presence of a partner, urbanization, socioeconomic status, education level, personal income, household assets, sedentary habits, alcohol drinking, and food intake [15]; of these, the findings regarding the latter three factors were comparable with the present results. In the populations of Western or Southeast Asia, besides sex and BMI, common risk factors include increased waist circumference, smoking, dyslipidemia, and lower education and socioeconomic levels [2,8,15,16]. In the present study, dyslipidemia was prevalent in patients with HT, being consistent with the findings of other studies [8,17,18]. Moreover, the present patients with HT had diabetes as a comorbidity, being similar to a previous report showing that diabetes was associated with an increased risk of high BP [8]. Therefore, the present study has confirmed previously published data for Thai and Asian populations regarding comorbidities [2,19]. Dentists should therefore encourage patients with a normal BMI to maintain a healthy lifestyle.

Most Thai patients with HT are receiving one or two antihypertensive medications per day [8,18], and comparable results were noted in the present study. Antihypertensive drugs were the most prevalent medications used by dental patients. However, only 50% of them had their BP under control. The remaining 50% had a history of HT, and their BP was not under control, as represented by a BP of ≥140/90 mmHg. Previous studies in Thailand or other countries have shown that 54.6-60.5% of patients with HT control their BP based on a target of <140/90 mmHg. [3,8,17,18, World Health Organization, https://www.who.int/news-room/factsheets/detail/hypertension 2021, accessed on 2021-11]. Approximately 24.6-54.4% of Thai patients with HT have uncontrolled BP [8,17,18], which is significantly associated with male sex, higher age, BMI, neck circumference, low-density lipoprotein level, diabetes, and increased antihypertensive drug intake, as well as region of residence, secondary/tertiary care hospitals, sedentary behavior, and missed doctor appointments [8,17]. Some of these factors can be improved by monitoring in dental settings.

The rate of HT unawareness in Thailand is approximately 45%; among patients with no HT history, 16.4% have a BP of ≥140/90 mmHg [3]. The present study demonstrated a similar percentage of patients with undiagnosed HT. Recent Thai guidelines recommend home BP monitoring for appropriate HT diagnosis and management [4,18].

Regarding oral diseases, recent systematic reviews have indicated a positive association between periodontitis and HT [20,21], and a bidirectional relationship has been proposed. HT causes microcirculatory changes in gingival tissue, leading to ischemia and increased periodontal inflammation. Similarly, possible direct effects of periodontal pathogen-related bacteremia, a systemic inflammatory response, and vascular inflammation have also been proposed to mediate vascular dysfunction leading to HT [20,21]. In addition, antihypertensive drug-induced hyposalivation could promote biofilm retention, enhancing the development of periodontal disease. Both categorical and continuous measures of periodontitis have been consistently associated with HT and SBP, independently of common CVD risk factors, and confirmed in patients not taking antihypertensive drugs [21]. Diabetes and HT are reportedly associated with exacerbated periodontal disease [19]. The present findings are in line with previous studies in terms of DBP. The discrepancy between existing results regarding SBP and a previous meta-analysis [20] may be attributable to differences in method, the number of participants, the definition of periodontitis, and the definition of HT. To raise awareness about the association between periodontitis and HT, dentists need to inform patients with periodontitis about its association with HT. Prevention and management of periodontitis would improve oral/overall health and quality of life, consequently helping to prevent/improve HT.

A possible bidirectional association between tooth loss and HT has been reported [16,22-24], although in the present study a higher proportion of patients with increased BP had tooth loss. After adjusting for all covariates, no significant association was noted between tooth loss and BP, being comparable with the finding of a previous study conducted in Malaysia [23]. However, a longitudinal study has reported a positive association between the number of lost teeth and the risk of HT [24]. The most critical finding was that the number of lost teeth (≥8) may be associated with the risk of developing HT [24]. HT was significantly more prevalent in patients with severe tooth loss (≥10) than those with nonsevere tooth loss [16]. Another cross-sectional study conducted in China reported that tooth loss (>15) was associated with severe HT in patients aged ≥50 years [22]. The present results are similar and provide additional information on the positive and dose-dependent association between the number of lost teeth and the increased risk of possible HT.

The present study found that an increased number of teeth with periapical diseases was associated with higher BP. The global prevalence of apical periodontitis is greater in patients with one or more systemic conditions (63%) than in those without such conditions (48%), the most common being diabetes mellitus, CVD, and smoking [25]. However, a previous study has reported a positive association between apical periodontitis and CVD; however, the quality of the existing evidence is moderate to low, and a causal relationship cannot be established [26]. Currently, there is limited evidence for an effect of periapical inflammation on HT development [27]. The host immune system is considered to be fundamentally associated with the development of HT and periapical disease conditions. Dentists should be aware that apical periodontitis may have both local and systemic implications [28]. The presence of chronic endodontic infection may be considered an additive risk indicator for CVD, particularly in patients with active periodontitis and other systemic comorbidities.

This study had some limitations. First, the results cannot be generalized to populations of different ethnicities because the dataset only included the data for Thai patients. Second, the cross-sectional design of this study made it difficult to infer causal relationships. The association between HT and oral diseases, particularly periodontal and periapical tissue diseases, is considered bidirectional. Longitudinal evidence is required to confirm a causal relationship between overall health and oral diseases. Third, the definition of periodontitis based on the PSR code does not fully reflect the classification criteria for periodontitis. Further validated prospective studies assessing the influence of dental treatment on HT are therefore warranted. Despite these limitations, monitoring of HT in dental patients is essential. Dentists play an important role in the screening of undiagnosed and uncontrolled HT. Associations of high BP with oral inflammatory diseases should be determined in all dental patients. Dentists must be aware of the current therapeutic options and possess the ability to educate patients. Collaboration among dentists and physicians is required.

Acknowledgments

The authors appreciate support from the Oral Diagnostic Clinic and the Dental Record Department of Faculty of Dentistry, Mahidol University, with the provision of patients' dental chart records. Partial data gathering by Mr. Suphan Phrombutr, the dental assistant, is acknowledged. The authors also thank Edanz (https://www.edanz.com/ac) for editing a draft of this manuscript.

Conflict of Interest

The authors of this manuscript have no conflicts of interest, real or perceived, to declare in relation to this article, and did not receive any financial or nonfinancial support.

References

1. Zhou B, Perel P, Mensah GA, Ezzati M (2021) Global epidemiology, health burden and effective interventions for elevated blood pressure and hypertension. Nat Rev Cardiol 18, 785-802.
2. Mohammed Nawi A, Mohammad Z, Jetly K, Abd Razak MA, Ramli NS, Wan Ibadullah WAH et al. (2021) The prevalence and risk factors of hypertension among the urban population in southeast asian countries: a systematic review and meta-analysis. Int J Hypertens 2021, 6657003.
3. Roubsanthisuk W, Silaruks S, Ophascharoensuk V, Sirinak C, Phrommayon P (2018) Hypertension in Thailand: a message from the Thai hypertension society on world hypertension day 2017. J Med Assoc Thai 101, 705-706.
4. Kunanon S, Chattranukulchai P, Chotruangnapa C, Kositanurit W, Methavigul K, Boonyasirinant T et al. (2021) 2019 Thai guidelines on the treatment of hypertension: executive summary. J Med Assoc Thai 104, 1729-1738.
5. Darnaud C, Thomas F, Pannier B, Danchin N, Bouchard P (2015) Oral health and blood pressure: the IPC cohort. Am J Hypertens 28, 1257-1261.
6. Hajishengallis G (2015) Periodontitis: from microbial immune subversion to systemic inflammation. Nat Rev Immunol 15, 30-44.
7. Southerland JH, Gill DG, Gangula PR, Halpern LR, Cardona CY, Mouton CP (2016) Dental management in the patient with hypertension: challenges and solutions. Clin Cosmet Invest Dent 8, 111-120.
8. Sakboonyarat B, Rangsin R, Kantiwong A, Mungthin M (2019) Prevalence and associated factors of uncontrolled hypertension among hypertensive patients: a nation-wide survey in Thailand. BMC Res Notes 12, 380.
9. Primal KS, Esther SR, Boehm TK (2014) Periodontal screening and recording (PSR) index scores predict periodontal diagnosis. J Dent App 1, 8-12.
10. Fedele S, Sabbah W, Donos N, Porter S, D'Aiuto F (2011) Common oral mucosal diseases, systemic inflammation, and cardiovascular diseases in a large cross-sectional US survey. Am Heart J 161, 344-350.
11. Puavilai W, Laorugpongse D, Prompongsa S, Sutheerapatranont S, Siriwiwattnakul N, Muthapongthavorn N et al. (2011) Prevalence and some important risk factors of hypertension in Ban Paew District. J Med Assoc Thai 94, 1069-1076.
12. Fox PC, Busch KA, Baum BJ (1987) Subjective reports of xerostomia and objective measures of salivary gland performance. J Am Dent Assoc 115, 581-584.
13. Phabphal K, Sattawatcharawanich S, Sathirapunya P, Limapichart K (2007) Anxiety and depression in Thai epileptic patients. J Med Assoc Thai 90, 2010-2015.
14. Temcharoen P, Kaewboonruang P, Pradipasen M, Srisorachart S (2009) The optimal cut-off points of body mass index which reflect the risk factors of cardiovascular disease in the urban Thai male population. J Med Assoc Thai 92, S68-74.
15. Thawornchaisit P, Looze F, Reid C, Seubsman S, Sleigh A, Sakolchai N (2019) Body mass index and risk of hypertension: 8-year prospective findings from a nationwide Thai cohort study. Glob J Health Sci 11, 91-101.
16. Mendes JJ, Viana J, Cruz F, Pereira D, Ferreira S, Pereira P et al. (2021) Blood pressure and tooth loss: a large cross-sectional study with age mediation analysis. Int J Environ Res Public Health 18, 285.
17. Meelab S, Bunupuradah I, Suttiruang J, Sakulrojanawong S, Thongkua N, Chantawiboonchai C et al. (2019) Prevalence and associated factors of uncontrolled blood pressure among hypertensive patients in the rural communities in the central areas in Thailand: a cross-sectional study. PLoS One 14, e0212572.
18. Montrivade S, Chattranukulchai P, Siwamogsatham S, Vorasettakarnkij Y, Naeowong W, Boonchayaanant P et al. (2020) Hypertension subtypes among Thai hypertensives: an analysis of telehealth-assisted instrument in home blood pressure monitoring nationwide pilot project. Int J Hypertens 2020, 3261408.
19. Furuta M, Fukai K, Aida J, Shimazaki Y, Ando Y, Miyazaki H et al. (2019) Periodontal status and self-reported systemic health of periodontal patients regularly visiting dental clinics in the 8020 promotion foundation study of Japanese dental patients. J Oral Sci 61, 238-245.
20. Muñoz Aguilera E, Suvan J, Buti J, Czesnikiewicz-Guzik M, Barbosa Ribeiro A, Orlandi M et al. (2020) Periodontitis is associated with hypertension: a systematic review and meta-analysis. Cardiovasc Res 116, 28-39.
21. Muñoz Aguilera E, Leira Y, Miró Catalina Q, Orlandi M, Czesnikiewicz-Guzik M, Guzik TJ et al. (2021) Is systemic inflammation a missing link between periodontitis and hypertension? Results from two large population-based surveys. J Intern Med 289, 532-546.
22. Da D, Wang F, Zhang H, Zeng X, Jiang Y, Zhao Q et al. (2019) Association between tooth loss and hypertension among older Chinese adults: a community-based study. BMC Oral Health 19, 277.
23. Hosadurga R, Kyaw Soe HH, Peck Lim AT, Adl A , Mathew M (2020) Association between tooth loss and hypertension: a cross-sectional study. J Family Med Prim Care 9, 925-932.
24. Woo HG, Chang Y, Lee JS, Song TJ (2021) Tooth loss is associated with an increased risk of hypertension: a nationwide population-based cohort study. PLoS One 16, e0253257.
25. Tibúrcio-Machado CS, Michelon C, Zanatta FB, Gomes MS, Marin JA, Bier CA (2021) The global prevalence of apical periodontitis: a systematic review and meta-analysis. Int Endod J 54, 712-735.
26. Jakovljevic A, Duncan HF, Nagendrababu V, Jacimovic J, Milasin J, Dummer PMH (2020) Association between cardiovascular diseases and apical periodontitis: an umbrella review. Int Endod J 53, 1374-1386.
27. Aminoshariae A, Kulild JC, Fouad AF (2018) The impact of endodontic infections on the pathogenesis of cardiovascular disease(s): a systematic review with meta-analysis using GRADE. J Endod 44, 1361-1366.e3.
28. Cintra LTA, Gomes MS, da Silva CC, Faria FD, Benetti F, Cosme-Silva L et al. (2021) Evolution of endodontic medicine: a critical narrative review of the interrelationship between endodontics and systemic pathological conditions. Odontology 109, 741-769.