Comparison of multiple blood pressure frequency methods with optimum blood pressure measurement among Iranian individuals

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Background: Proper blood pressure (BP) measurement frequency method is less evaluated to optimize hypertension (HTN) status among different nations due to cultural patience variations. The aim of this study was to compare the first (BP_1), second (BP_2), and the mean of first and second ($BP_{1,2}$) and all the three ($BP_{1,2,3}$) with the second and third BP measurements in Iranian individuals. **Materials and Methods:** This cross-sectional study was done on 2264 individuals aged 18 years or more living in Isfahan city, Iran. Their BPs were assessed from right arms by the standard tools and methods after 5 min of rest in a quiet room by a trained staff. The mean second and third readings were considered as reference, and the other aforementioned variables were compared with it. **Results:** The mean age of total population was 40.9 ± 16.1 years (males: 52%). Men had significant higher means of systolic BP (SBP) and diastolic BP (DBP) with any measurement frequency methods than women ($P < 0.001$ and $P = 0.009$). Considerable clinical significant (≥ 5 mmHg) ranges were mostly observed in BP_1 compared with $BP_{2,3}$. SBP_2 and DBP_2 indices showed insignificant differences compared with reference mean. Moreover, abnormal BP levels ($\geq 140/90$ mmHg) were mostly observed in terms of BP_1 measurement with no remarkable variability in BP_2 reading in comparison to the reference. **Conclusion:** Our considerable data suggested that BP_2 could appropriately categorize BP status similar to $BP_{2,3}$ and it may be rational for physicians considering this mean and excluding the first BP measurement as a sole criterion for HTN assessment in Iranian adults. Multiple researches are necessary quantifying appropriate frequencies of BP reading.

Key words: Average, blood pressure, frequency, hypertension, mean

INTRODUCTION

Among noncommunicable diseases, the most common leading cause of death in both developed and developing nations are cardiovascular diseases (CVDs). It had been reported that of 422.7 million cases of CVDs, 17.92 million deaths occurred worldwide due to these diseases from 1990 till 2015.[1] These kinds of diseases cause a great governmental economic burden. For example, the annual direct cost in China was US$ 26.1 billion.[2] Several modifiable and nonmodifiable risk factors have been announced to be effective in CVDs occurrence, including hypertension (HTN), diabetes mellitus (DM),[3] dyslipidemia, smoking, obesity, lack of exercise, age, male gender, and positive family history.[4,5] Among them, the leading contributor is HTN and several studies proved this entity as playing a pivotal role in CVDs' prevalence and mortality.[6,7] Its prevalence and burden were predicted to be 32.3% and US$ 73.4 billion, respectively.[4,8] In Iran, HTN

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prevalence was ranged from 17.3% to 22% based on different study population.[9,10] One important factor existing to categorize persons to hypertensive or normotensive groups is blood pressure (BP) measurement, in which multiple methods have been available these days including ambulatory, home, and office BP monitoring with their own advantages and disadvantages.[11-13] Either underestimation or overestimation in BP measurements could cause complications related to longstanding HTN or extra costs and undesired medication side effects, respectively.[3,14] Furthermore, usual office BP measurements give a poor estimation of individuals' BP because they often measure just one or two times apart.[15] Several guidelines have been made to improve BP measurement accuracy and focus mostly on sitting position or usages of appropriate-sized cuff.[14] Although most of them announced neglecting the first measurement due to its higher level and average the next two ones, there is no general consensus is the frequency of BP measurements.[15,16] To best of our knowledge, there are few studies evaluating the number of BP measurements in each single office visit. For instance, a cross-sectional study done by Oladipo and Adedokun revealed that an average of five readings was excessive as compared to fewer ones to measure accurate BP.[16]

With respect to these inconsistencies and considering the point that appropriate BP measurement frequency might have some association with cultural properties of nations in terms of individuals patience, in this article, we aimed to compare the first (BP_1), second (BP_2) and the mean of first and second ($BP_{1,2}$) and all three ($BP_{1,2,3}$) BP measurements with the average of second and third BP readings as a reference group to define the most proper BP measurement frequencies for accurate HTN diagnosis among Iranian individuals.

MATERIALS AND METHODS

Study participants

This cross-sectional study was performed on individuals living in the third biggest city in central part of Iran, named Isfahan. From August 2015 till March 2016, anyone aged at least 18 years residing in Isfahan city was eligible for the recruitment in our study. Multi-stage random cluster sampling method was used selecting individuals who met inclusion criteria. Detailed methodology of that study published elsewhere.[17] Chosen individuals were invited to the nearest health care clinic. Written consent form was signed by each participant initially, and while they were seated, demographic information was asked. After that, BP was assessed from each individual's both arms three times with 1-min interval in which right arm BPs were considered for further analysis. Any limitations for measuring BP including arm casting or presence of fistula or

shunts in hands or irregular pulses in addition to a history of fasting or being on special diet for weight control at the time of measurement, presence of chronic kidney disease, cancer of any kinds, mental illness, Cushing syndrome, and pheochromocytoma or being pregnant for female participants declaring by each person excluded subjects from the project. Finally, after merging all information, data of 2264 individuals were available to perform analyses. This study was approved by the Ethic Committee, affiliated to Isfahan University of Medical Sciences (IR.MUI.REC.2016.3.790).

Assessment of variables

A validated research-developed questionnaire was utilized gathering information about demographic factors. Questions about age, gender (male/female), education years (0–5, 6–12, and more than 12 years), marital status (single, married, and separated/widow), economic status (poor, moderate, and good), occupation (employed, unemployed, homemaker, student, and retired), and presence of DM, hyperlipidemia (HLP), and current smoking status (yes/no) were asked, while the participants were seated simultaneously. Then, participants were asked to take a rest for 5 min in a quiet room. BP measuring was performed according to the World Health Organization standard criteria in a way that participants were seated on a backed chair without their legs being crossed. Their feet soles were on the floor concurrently with their hands and palms at the heart level and in upward position, respectively.[18,19] The equipment used for assessing BP was digital arm blood pressure (Microlife, Widnau, Switzerland). With 1-min interval, BP was measured three times from their right arms and all numbers were recorded.[17] To minimize the effect of white-coat HTN, personnel measuring BP did not wear white coats and their clothes were like the general population. Average of second and third BP means were defined as reference group and other measurements were calculated and declared as follows: first reading (BP_1), second reading (BP_2), average first and second readings ($BP_{1,2}$), and average first, second and third readings ($BP_{1,2,3}$). Height of participants was measured in centimeters with nonelastic measuring tape locating on the wall. Subjects' weights were assessed in kilograms (Kg) using a digital scale (Soehnle, Nassau, Germany) while they were asked to wear light-weight clothing and took of their shoes. Body mass index was assessed by division of weight in kilograms over height in meter square (Kg/m^2). To increase variability and reliability of data collection, all participants' data were assessed with the same tool and by a fully trained personnel familiar how to work with aforementioned measuring instruments just after receiving an official letter from Isfahan Cardiovascular Research Institute. Furthermore, reading digital numbers were preferred compared with traditional hearing method. Calibration of tools including arm blood pressure, nonelastic

height measurement tape, and digital scale was done via comparing with mercury sphygmomanometer verifying several times on 1–3 individuals, metal tape, and daily 5 Kg weight for control, respectively.

Statistical analysis

Categorical and continuous variables were reported as frequency (percentage) and mean ± standard deviation, respectively. Besides comparison of categorical variables with Chi-square test, comparison of numerical ones was done with independent *t*-test and analysis of variance plus paired *t*-test, as appropriate. All analyses were done using Statistical Package for the Social Sciences (SPSS) version 19 (IBM Corp., Armonk, NY, USA) and $P < 0.05$ was considered statistically significant.

RESULTS

The mean age of dominant male (52%) and female participants in our study was 41.3 ± 16.5 and 40.6 ± 15.8 years, respectively. General characteristics of individuals are provided in Table 1. Women were more obese and had more abnormal lipid levels, less educated, and mostly worked as homemakers. In contrast, men mostly worked as employees and smoked more frequently. There was no significant relation in terms of economic status and the presence of DM across genders.

Table 2 provides information about different BP measurements and their relation with reference BP category. Our data suggested that both systolic and diastolic blood pressures (SBP and DBP) were significantly higher in BP_1 group in comparison to other readings including BP_2, $BP_{1,2}$, $BP_{2,3}$, and $BP_{1,2,3}$ ($P < 0.001$ and $P = 0.009$, respectively). Although both BP_1 indices and $SBP_{1,2}$ and $SBP_{1,2,3}$ showed significant differences from reference BP category, SBP and DBP of second measurement as well as DBP of other readings were not remarkably different with $BP_{2,3}$ indices.

Data about distribution of differences between reference BP measurement ($BP_{2,3}$) and other readings (BP_1, BP_2, $BP_{1,2}$ and $BP_{1,2,3}$) are illustrated in Table 3, revealing that most variabilities in other measurements remained in nonclinical spectrum in both BP indices, and clinically significant (>5 mmHg) difference from the reference mean BP category was mostly observed with measurement considering just the first reading (BP_1).

Table 4 shows differential of all measurements from a constant BP of 140/90 mmHg as well as their comparison with our predefined reference category. Comparing to the first time BP measurement, considering either second time BP or other mean readings ($BP_{1,2}$, $BP_{2,3}$, and $BP_{1,2,3}$) led to categorization of more than 85% and 92% of individuals to

Table 1: Distribution of general characteristics of study participants (*n*=2264)

	Total	Men (*n*=1178)	Women (*n*=1086)	*P*
Age (years)	40.9±16.1	41.3±16.5	40.6±15.8	0.31*
BMI (kg/m²)	26.8±4.7	26.4±4.2	27.3±5.2	<0.001*
Education years (%)				
0-5	467 (20.6)	171 (14.5)	296 (27.3)	<0.001**
6-12	1025 (45.3)	536 (45.5)	489 (45)	
>12	772 (34.1)	471 (40)	301 (27.7)	
Marital status (%)				
Single	436 (19.3)	288 (24.4)	148 (13.6)	<0.001**
Married	1723 (76.1)	877 (74.4)	846 (77.9)	
Separated/widow	105 (4.6)	13 (1.1)	92 (8.5)	
Economic status (%)				
Poor	1016 (44.9)	544 (46.2)	472 (43.5)	0.22**
Moderate	977 (43.2)	488 (41.4)	489 (45.0)	
Good	271 (12.0)	146 (12.4)	125 (11.5)	
Occupation (%)				
Employed	967 (42.7)	851 (72.2)	116 (10.7)	<0.001**
Unemployed	41 (1.8)	34 (2.9)	7 (0.6)	
Homemaker	829 (36.6)	0 (0)	829 (76.3)	
Student	238 (10.5)	125 (10.6)	113 (10.4)	
Retired	189 (8.3)	168 (14.3)	21 (1.9)	
Diabetes mellitus (%)				
Yes	226 (10)	109 (9.3)	117 (10.8)	0.22**
No	2038 (90)	1069 (90.7)	969 (89.2)	
Hyperlipidemia (%)				
Yes	404 (17.8)	189 (16)	215 (19.8)	0.02**
No	1860 (82.2)	989 (84)	871 (80.2)	
Current smoking				
Yes	379 (16.8)	325 (27.8)	54 (5)	<0.001**
No	1872 (83.2)	844 (72.2)	1028 (95)	

*P value resulted from independent *t*-test, **P value resulted from Chi-square test. BMI: Body mass index

SBP <140 and DBP <90 mmHg, respectively. The dominant percentage of abnormal BP (≥140/90 mmHg) was belonged to BP_1 group. Further analysis revealed that both BP indices owning to BP_1 were found to be more abnormal in comparison to the reference range. However, both indices of BP_2 and $BP_{1,2,3}$ as well as $DBP_{1,2}$ categorized BP status like the reference mean ($P > 0.05$).

DISCUSSION

The aim of this study was to compare the first, the second, and the mean of first and second and all three BP measurements with the mean of second and third BP to find the most accurate method which appropriately categorizes individuals based on BP status, according to reference range among Iranian adults. HTN has been demonstrated to be one of the leading causes of CVDs. Therefore, proper HTN diagnosis contributes to decrease expenses and complications due to chronic HTN states or medication side effects in individuals mistakenly classified as normotensives or hypertensive, respectively. Furthermore,

Table 2: Range of multiple blood pressure readings among study population and their relations with mean second and third blood pressure measurement

Readings	BP (mmHg)									P*	P†
	Men			Women			Total				
	Minimum	Maximum	Mean (mean±SD)	Minimum	Maximum	Mean (mean±SD)	Minimum	Maximum	Mean (mean±SD)		
SBP											
BP_1	87	217	126.6±15.7	67	202	117±18.9	67	217	122±18	<0.001	<0.001
BP_2	91	201	123.9±15	76	196	113.9±17.5	76	201	119.1±17		0.23
$BP_{1,2}$	91	209	125.3±14.9	77.5	191.5	115.5±17.7	77.5	209	120.6±17		<0.001
$BP_{2,3}$	90.5	193.5	123.3±14.2	75.5	187.5	113.3±17	75.5	193.5	118.5±16.4		-
$BP_{1,2,3}$	90.6	201.3	124.4±14.3	77	187.3	114.6±17.2	77	201.3	119.7±16.5		0.01
DBP											
BP_1	40	137	76.2±10.2	42	122	70.6±11.1	40	137	73.5±11	0.009	<0.001
BP_2	42	121	75.6±9.9	42	111	69.3±10.3	42	121	72.5±10.6		0.93
$BP_{1,2}$	47.5	117	75.9±9.6	42	115	69.9±10.3	42	117	73±10.4		0.09
$BP_{2,3}$	41	118	75.6±9.7	41.5	113	69.2±9.9	41	118	72.5±10.3		-
$BP_{1,2,3}$	46.3	116	75.8±9.5	41.6	115	69.7±10	41.6	116	72.9±10.2		0.27

*P value resulted from One-way ANOVA, †P value resulted from paired t-test. BP=Blood pressure; SBP=Systolic blood pressure; DBP=Diastolic blood pressure; BP_1=First time BP reading; BP_2=Second time BP reading; $BP_{1,2}$=Mean first and second BP readings, $BP_{2,3}$=Mean second and third BP readings, $BP_{1,2,3}$=Mean first, second, and third BP readings

Table 3: Differences between mean second and third blood pressure readings and other measurements (first time blood pressure reading, second time blood pressure reading, mean first and second blood pressure readings, and mean first, second, and third blood pressure readings)

Readings	Differences 0-5 mmHg, n (%)	Differences ≥5 mmHg, n (%)	Differences (mmHg), mean±SD
SBP			
BP_1	1214 (53.6)	1050 (46.4)	3.47±7.4
BP_2	1998 (88.3)	266 (11.7)	0.59±3.5
$BP_{1,2}$	1765 (78)	499 (22)	2.03±4.2
$BP1_{,2,3}$	2132 (94.2)	132 (5.8)	1.15±2.4
DBP			
BP_1	1727 (76.3)	537 (23.7)	1.00±5.2
BP_2	2162 (95.5)	102 (4.5)	0.03±2.4
$BP_{1,2}$	2110 (93.2)	154 (6.8)	0.51±3
$BP_{1,2,3}$	2223 (98.2)	41 (1.8)	0.33±1.7

SBP=Systolic blood pressure; DBP=Diastolic blood pressure; BP_1=First time blood pressure reading; BP_2=Second time blood pressure reading; $BP_{1,2}$=Mean first and second blood pressure readings; $BP_{2,3}$=Mean second and third blood pressure readings; $BP_{1,2,3}$=Mean first, second, and third blood pressure readings; SD=Standard deviation

this point should be considered that individual patience is a potential factor might be effective in the quality of diagnostic and therapeutic management. Our findings suggested that while most of the BP differences from $BP_{2,3}$ had been remained in nonclinical ranges (0–5 mmHg), more variations of at least 5 mmHg were mostly observed with BP measurement method considering the first time which also showed significant mean differences from the reference group. $BP_{2,3}$ classified more than 90% of SBP and DBP in normal ranges, and the only measurement which showed significantly higher percentages of abnormal indices in comparison to the desired mean was BP_1. Therefore, it might be reasonable to exclude first time BP measurement

as a criterion for the assessment of person's HTN status. Moreover, our remarkable outcomes suggested that sole measuring of second BP indices could appropriately categorize HTN status like the reference range which is most widely used nowadays, especially in terms of lack of patience or possible annoyment of patients due to excessive BP measurements. To best of our knowledge, this was the first study in the literature comparing BP measurement frequency methods in Middle-Eastern population. Regarding to our results, there are few studies quantifying the proper number of office BP readings.[16,20] For instance, Oladipo and Adedokun performed a cross-sectional study on 397 individuals aged at least 18 years. They measured BP for six times with 1-min interval in a single visit. After completion of the procedure, the first measurement had been discarded while other readings were categorized as desired means and compared with each other. Their results revealed that the five reading averages were numerously high for routine BP control in outpatient clinics; there was no significant alteration between the aforementioned mean and any other average readings such as the second and third ones. Quite small sample size and exclusion of the first BP measurement must be taken into account to generalize their findings.[16] A total of 83 individuals were recruited for the study and their BPs were assessed by two methods including usual office BP measurement (3 measurements with 30 s interval plus exclusion of the first reading) and 30-min one (11 readings every 3 min without considering the first one) repeating again 2 weeks later. Although their findings showed a better categorization of BP status with increased frequencies of measurements in the latter method comparing to usual office measurement, small sample size plus possible individual annoying due to high measurement frequencies and probable challenge for executing in actual settings should be considered.[20] In contrast, a study done

Table 4: Distribution of measurements relative to constant blood pressure of 140/90 mmHg and their relations with mean second and third blood pressure readings

Readings	SBP <140 mmHg, n (%)	SBP $\geq$140 mmHg, n (%)	P*
SBP			
$BP_{2,3}$	2041 (90.2)	223 (9.8)	-
BP_1	1928 (85.2)	336 (14.8)	<0.001
BP_2	2010 (88.8)	254 (11.2)	0.1
$BP_{1,2}$	1987 (87.8)	277 (12.2)	0.01
$BP_{1,2,3}$	2017 (89.1)	247 (10.9)	0.2
Readings	DBP <90 mmHg, n (%)	DBP $\geq$90 mmHg, n (%)	P
DBP			
$BP_{2,3}$	2137 (94.4)	127 (5.6)	-
BP_1	2079 (91.8)	185 (8.2)	0.001
BP_2	2118 (93.6)	146 (6.4)	0.2
$BP_{1,2}$	2111 (93.2)	153 (6.8)	0.1
$BP_{1,2,3}$	2125 (93.9)	139 (6.1)	0.4

*P value resulted from Chi-square test. SBP=Systolic blood pressure; DBP=Diastolic blood pressure; BP_1=First time blood pressure reading; BP_2=Second time blood pressure reading; $BP_{1,2}$=Mean first and second blood pressure readings; $BP_{2,3}$=Mean second and third blood pressure readings; $BP_{1,2,3}$=Mean first, second, and third blood pressure readings; BP=Blood pressure

by Kronish *et al.* on 707 healthy adults, in which their BPs were measured six times by two methods including mercury sphygmomanometer for the first three readings with 1–2 min interval and oscillometric device for the next three ones with 2 min interval though three distinct clinical visits with 1-week interval, showed that exclusion of the first BP reading did not cause any significant alterations in the estimation of true BP in neither two models. The order of BP measurement methods and the possibility of human error in manual were some limitations of this study.[3] Large sample size and the kind of BP measurement tool minimizing human error for recording were some of our advantages. Furthermore, personnel dressing looking like general population decreased the likelihood of white-coat HTN. This study was not free from limitations. Our measurements were taken by a digital equipment; therefore, the generalization of the findings to other reading methods including utilization of mercury sphygmomanometer or oscillometric tools should be cautiously done. Moreover, the location of BP measurement might be considered another limitation of the research. Finally, implementation of the current research in one city in Iran should be considered in terms of outcomes extension to other nations.

CONCLUSION

Our results revealed that second BP measurement could classify individuals' HTN status similar to the reference reading and it may be reasonable to announce physicians for consideration of this mean as individual's true BP status in outpatient clinical visits and exclude the first time measurement. Several comprehensive studies required quantifying the exact frequency of BP measurements.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Roth GA, Johnson C, Abajobir A, Abd-Allah F, Abera SF, Abyu G, *et al*. Global, regional, and national burden of cardiovascular diseases for 10 causes, 1990 to 2015. J Am Coll Cardiol 2017;70:1-25.
2. Yang L, Wu M, Cui B, Xu J. Economic burden of cardiovascular diseases in China. Expert Rev Pharmacoecon Outcomes Res 2008;8:349-56.
3. Kronish IM, Edmondson D, Shimbo D, Shaffer JA, Krakoff LR, Schwartz JE. A comparison of the diagnostic accuracy of common office blood pressure measurement protocols. Am J Hypertens 2018;31:827-34.
4. Cohen JD. Hypertension epidemiology and economic burden: Refining risk assessment to lower costs. Manag Care 2009;18:51-8.
5. Alaei Faradonbeh N, Nikaeen F, Akbari M, Almasi N, Vakhshoori M. Cardiovascular disease risk prediction among Iranian patients with diabetes mellitus in Isfahan Province, Iran, in 2014, by using Framingham risk score, atherosclerotic cardiovascular disease risk score, and high-sensitive C-reactive protein. ARYA Atheroscler 2018;14:163-8.
6. Givi M, Sarrafzadegan N, Garakyaraghi M, Yadegarfar G, Sadeghi M, Khosravi A, *et al*. Persian Registry Of cardioVascular diseasE (PROVE): Design and methodology. ARYA Atheroscler 2017;13:236-44.
7. Givi M, Shafie D, Nouri F, Garakyaraghi M, Yadegarfar G, Sarrafzadegan N. Survival rate and predictors of mortality in patients hospitalised with heart failure: A cohort study on the data of Persian Registry Of cardioVascular diseasE (PROVE). Postgrad Med J 2018;94:318-24.
8. Sarki AM, Nduka CU, Stranges S, Kandala NB, Uthman OA. Prevalence of hypertension in low-and middle-income countries: A systematic review and meta-analysis. Medicine (Baltimore) 2015;94:e1959.
9. Eghbali M, Khosravi A, Feizi A, Mansouri A, Mahaki B, Sarrafzadegan N. Prevalence, awareness, treatment, control, and risk factors of hypertension among adults: A cross-sectional study

in Iran. Epidemiol Health 2018;40:e2018020.

10. Mirzaei M, Moayedallaie S, Jabbari L, Mohammadi M. Prevalence of hypertension in iran 1980-2012: A systematic review. J Tehran Heart Cent 2016;11:159-67.

11. Nasothimiou EG, Tzamouranis D, Rarra V, Roussias LG, Stergiou GS. Diagnostic accuracy of home vs. ambulatory blood pressure monitoring in untreated and treated hypertension. Hypertens Res 2012;35:750-5.

12. Kim S, Park JJ, Lee SA, Cho Y, Yoon YE, Oh IY, *et al*. Diagnostic accuracy of manual office blood pressure measurement in ambulatory hypertensive patients in Korea. Korean J Intern Med 2018;33:113-20.

13. Piper MA, Evans CV, Burda BU, Margolis KL, O'Connor E, Whitlock EP. Diagnostic and predictive accuracy of blood pressure screening methods with consideration of rescreening intervals: A systematic review for the U. S. Preventive Services Task Force. Ann Intern Med 2015;162:192-204.

14. Kabakambira JD, Niyonsenga Z, Hategeka M, Igiraneza G, Benurugo G, Lucero-Prisno Iii DE, *et al*. Blood pressure measurement techniques: Assessing performance in outpatient settings of a tertiary-level hospital in Rwanda. J Clin Hypertens (Greenwich) 2018;20:1067-72.

15. Pickering TG, Hall JE, Appel LJ, Falkner BE, Graves J, Hill MN, *et al*. Recommendations for blood pressure measurement in humans and experimental animals: Part 1: Blood pressure measurement in humans: A statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. Circulation 2005;111:697-716.

16. Oladipo I, Adedokun A. Comparison of the average of five readings with averages from fewer readings for automated oscillometric blood pressure measurement in an outpatient clinic. Korean Circ J 2013;43:329-35.

17. Eghbali-Babadi M, Khosravi A, Feizi A, Sarrafzadegan N. Design and implementation of a combined observational and interventional study: Trends of prevalence, awareness, treatment and control hypertension and the effect of expanded chronic care model on control, treatment and self-care. ARYA Atheroscler 2017;13:211-20.

18. Whelton PK, Carey RM, Aronow WS, Casey DE Jr, Collins KJ, Dennison Himmelfarb C, *et al*. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Hypertension 2018;71:1269-324.

19. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, *et al*. 2018 ESC/ESH Guidelines for the management of arterial hypertension: The Task Force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension: The Task Force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension. J Hypertens 2018;36:1953-2041.

20. Scherpbier-de Haan N, van der Wel M, Schoenmakers G, Boudewijns S, Peer P, van Weel C, *et al*. Thirty-minute compared to standardised office blood pressure measurement in general practice. Br J Gen Pract 2011;61:e590-7.