Assessing the prevalence of hypertension in populations: are we doing it right?

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Background **Although it is well recognized that the diagnosis of hypertension should be based on blood pressure (BP) measurements taken on several occasions, notably to account for a transient elevation of BP on the first readings, the prevalence of hypertension in populations has often relied on measurements at a single visit.**

Objective **To identify an efficient strategy for assessing reliably the prevalence of hypertension in the population with regards to the number of BP readings required.**

Design **Population-based survey of BP and follow-up information.**

Setting and participants **All residents aged 25–64 years in an area of Dar es Salaam (Tanzania).**

Main outcome measures **Three BP readings at four successive visits in all participants with high BP ($n = 653$) and in 662 participants without high BP, measured with an automated BP device.**

Results **BP decreased substantially from the first to third readings at each of the four visits. BP decreased substantially between the first two visits but only a little between the next visits. Consequently, the prevalence of high BP based on the third reading – or the average of the second and third readings – at the second visit was not largely different compared to estimates based on readings at the fourth visit. BP decreased similarly when the first three visits were separated by 3-day or 14-day intervals.**

Conclusions **Taking triplicate readings on two visits, possibly separated by just a few days, could be a minimal strategy for assessing adequately the mean BP and the prevalence of hypertension at the population level. A sound strategy is important for assessing reliably the burden of hypertension in populations.** ***J Hypertens*** **21:509–517 © 2003 Lippincott Williams & Wilkins.**

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Introduction

While the relationship between blood pressure (BP) and adverse health effects is clearly continuous [1,2], decision-making for clinical treatment relies on a dichotomic classification of people into 'normotensive' and 'hypertensive'. Dichotomous classification is complicated by the large variability in BP measurements over repeated readings [3–5], which relates, among other factors, to a transient elevation of BP associated with an alarm reaction among individuals submitted to BP measurement [6]. Hence, estimates of BP based on readings taken on several successive visits better represent a patient's usual BP level [7,8]. For example, duplicate readings over five visits were found to estimate reliably 24-h ambulatory BP [9]. A study in 271 healthy persons submitted to 14 subsequent readings at two separate visits showed that BP further decreased up to the eighth reading on each of the two visits and later readings better represented BP at rest [10].

The need to base the diagnosis of hypertension on several BP readings made at several visits is emphasized in the current recommendations for clinical practice. The American JNCVI recommendations state that hypertension should be diagnosed on the basis of the average of two or more readings at each of two or more visits after an initial screening visit and that additional readings should be obtained at each visit if the first two readings differ by > 5 mmHg [11]. The British Hypertension Society recommends performing two or more

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readings at each visit on up to four separate occasions [12]. The WHO/ISH guidelines recommend diagnosing hypertension based on multiple pressure measurements, taken on several separate occasions [13].

Despite the recognition that BP estimates based on readings at a first visit are likely to overestimate a person's true BP, the diagnosis of 'hypertension' has relied on only one or two readings at a single screening visit in most epidemiological studies, although a few have relied on repeated readings over two visits [14–17]. The prevalence of hypertension in epidemiologic studies is likely to be overestimated if it is based on too few readings/visits while multiplying the number of visits can substantially increase the costs and inconveniences for individuals and health services. In addition, the variability of BP over repeated readings may differ between different populations and this issue should therefore be examined in various settings to guide sound recommendations for the diagnosis of hypertension.

We therefore examined, in a large sample of the general population of a low-income country, the variability of BP over triplicate BP readings made at each of four successive visits in order to identify an efficient strategy for assessing hypertension reliably at the population level. This is, to our knowledge, the first population-based study to address this issue in a low-income country. We also examined if the decrease in BP over repeated readings differed if the first visits took place at 3-day or 14-day intervals. Finally, we examined if this decrease was associated with a few selected participants' characteristics.

Methods

Dar es Salaam, with over 3 million inhabitants, is the economic center of Tanzania. The Republic of Tanzania is situated on the east coast of Africa, south of Kenya and north of Mozambique. The gross national product per capita of Tanzania was US$ 220 in 1999 and total health expenditures amounted to only US$ 12 *per capita* compared with US$ 1600–3600 in Western European countries [18].

The study took place in five branches of the Temeke district of Dar es Salaam, an area where the population has been enumerated as part of another research program [19,20]. First, a survey of blood pressure and other cardiovascular risk factors was carried out from November 1998 to August 1999. Seventeen local clinical officers visited all homes in the study area and they administered a questionnaire and measured BP and anthropometric variables in all encountered residents aged 25–64 years. The visits in the field were facilitated by 'ten-cell leaders', i.e. the community leaders who administer clusters of '10 adjacent houses' ('*shinas*') and know personally the 100–200 residents living in their respective constituencies. The survey gathered a participation of 9254 (62.2%) of the eligible 14 866 inhabitants aged 25–64 years living in the study area. Methods of the survey, participants' characteristics and the distribution of BP and other risk factors have been reported [21].

All participants who had, on the first BP reading of the survey, systolic BP $\geqslant$ 160 mmHg and/or diastolic BP $\geqslant$ 95 mmHg and/or were under antihypertension treatment were invited to have their BP measured on three additional visits (these persons are referred as 'cases' in this paragraph). For each case included in the follow-up study, a participant with BP $<$ 160/95 mmHg, on the first reading of the survey, and not taking antihypertension treatment was selected to also have BP measured on three additional visits ('controls'). A control was selected immediately after a case was identified and was matched for age ($\pm$ 10 years), sex and household area. All cases and controls were allocated alternatively to a 'cohort A' or a 'cohort B'. BP readings were scheduled to take place 3, 6 and 45 days after the first visit in cohort A and 14, 28 and 45 days after the first visit in cohort B. Participants who had diastolic BP $\geqslant$ 120 mmHg on the third BP at the first visit (survey) were referred to health services and not included in this study (42 of the 9254 participants to the survey). No intervention was provided before the last reading at the fourth visit. The study was approved by the Tanzanian National Institute of Medical Research and by the Tanzanian Commission for Science and Technology. All participants were informed that the study aimed at assessing the prevalence of high BP in the population and were free to participate.

Humeral BP was measured on the left arm with a validated automatic device (Visomat 2; Hestia Pharma, Mannheim, Germany) [22] with subjects in a sitting position. Triplicate readings were made at each of the four visits (i.e. the survey and three follow-up visits). We hereafter use the notation V_xR_y to designate a reading at a specific visit/reading. For example, V1R1 designates the first reading at the first visit and V4R23 designates the average of the second and third readings at the fourth visit. All measurements were made at the participants' homes. The first reading was measured after a rest of $\geqslant$ 5 min and the subsequent readings were taken at intervals of $\geqslant$ 2 min. Weight was measured with a portable electronic scale at a 0.1 kg precision (Planax Automatic ST 500; Terraillon, Paris, France) and height was measured with a portable stadiometer at a 0.5 cm precision. Body mass index (BMI) was calculated as weight divided by height squared (kg/m^2). A wealth score ranging from 0 to 5 was based on the answers to five questions (coded as 0 for 'no' and 1 for 'yes'): availability at home of

electricity (reported by 58.1% of respondents in this study), refrigerator (29.3%), television (24.9%), flush toilet (15.6%) and car (5.8%).

The mean BP values and 95% confidence intervals (95% CI) and the prevalence of high BP were calculated for each visit/reading. Correlation coefficients between successive BP readings were computed to indicate the variability in repeated BP readings at the individual level. Multivariate linear regression was performed to examine the associations between the proportionate decrease in BP over repeated readings and selected variables. Interactions effects were evaluated among variables with a significant main effect. Analyses were performed with Stata 7.0 (Stata Corporation, College Station, Texas, USA). *P* values less than 0.05 were considered significant.

Results

This follow-up study was attended by 653 cases (mean ± SD age: 46.3 ± 8 years, 33% male, 19% on hypertension medication) and 662 controls (37.8 ± 8 years, 29% male), hence a total of 1315 participants. This number does not include 148 persons who participated in the survey but were lost to follow-up. Cohort A included 658 participants (325 cases and 333 controls) and Cohort B included 657 participants (328 cases and 329 controls).

The intervals (mean ± SD) between the first and second visits were 3.0 ± 0.2 days in cohort A and 13.9 ± 0.7 days in cohort B; 3.2 ± 1.1 and 14.0 ± 0.7 days between the second and third visits; and 38.6 ± 2.6 and 17.0 ± 0.9 days between the third and fourth visits. Mean systolic/diastolic BP was not significantly different, for any of the 12 readings (i.e. V1R1, V1R2, V1R3, V2R1, …, V4R3), when comparing BP between participants of cohort A and cohort B (data not shown, available from authors). Therefore, the variability of BP over subsequent visits was analyzed based on pooled data from cohorts A and B.

Table 1 shows selected characteristics of the participants by BP categories. Hypertensive subjects were older than non-hypertensive persons. Approximately one-third of the participants were men. BP on V1R1 differed largely compared to the V4R3 in the three BP groups. Participants under antihypertension treatment were markedly more well off than other participants. This may indicate a selection bias: wealthy persons may be more likely than other persons, in this low-income population, to undergo screening for hypertension and/or afford the costs of antihypertension treatment. Wealthier persons also smoked less often, had higher body mass index, and reported more often to be diabetic.

Correlation coefficients between readings within same visits ranged from 0.82 to 0.93. Correlation coefficients between readings across different visits ranged from 0.68 to 0.83. When BP was based on the average of two readings (R12 or R23) or three readings (R123) at a same visit, the correlation coefficients between estimates at different visits ranged from 0.72 to 0.87. All coefficients were statistically significant. The magnitude of these correlation coefficients was only 'fair', which indicates substantial variability in repeated BP readings in same individuals.

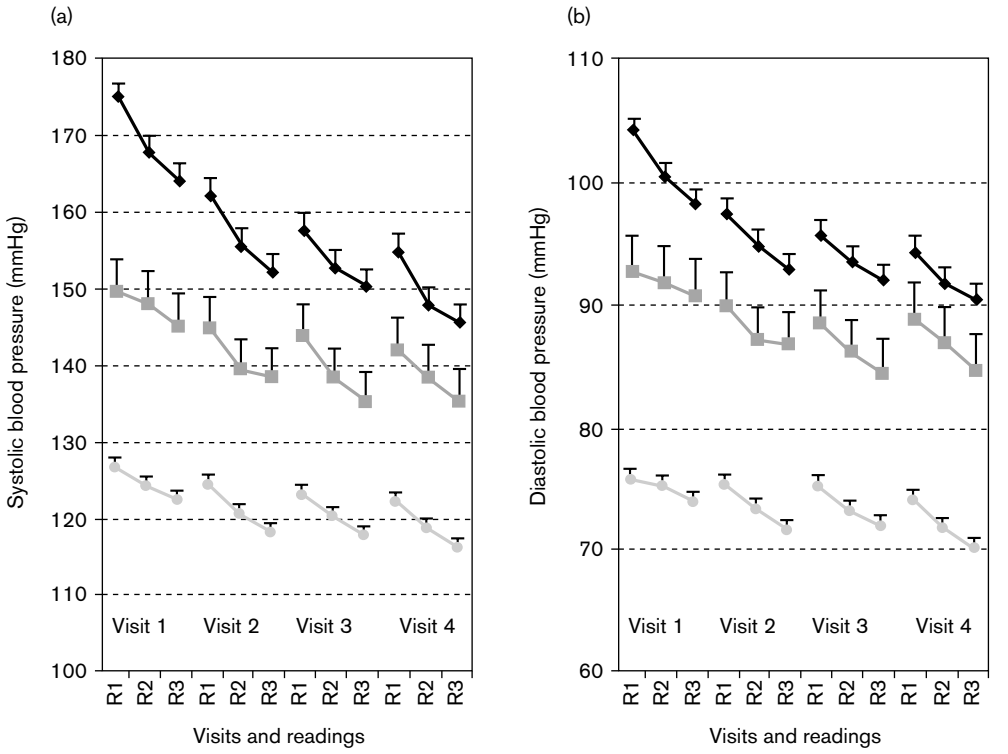
Because participants under treatment can differ from other participants with respect to previous exposure to BP measurement, we examined the BP decrease over repeated visits/readings separately in participants, at V1R1, with BP ⩾ 160/95 mmHg and not under antihypertension treatment (Group I), participants under antihypertension treatment (Group II) and participants with BP < 160/95 mmHg and not under antihypertension treatment (Group III). Figure 1 shows that systolic and diastolic mean BP decreased substantially over

Table 1 Selected characteristics of the participants

	BP at V1R1 ⩾ 160/95 mmHg and no treatment	Under antihypertension treatment	BP at V1R1 < 160/95 mmHg and no treatment	All participants
n	524	129	662	1315
Age (years)	46.0 ± 10.6	47.4 ± 11.4	37.7 ± 8.8	41.9 ± 10.7
Proportion of men (%)	35.9	25.6	29.2	31.5
Body mass index (kg/m^2)	25.9 ± 5.5	28.4 ± 5.1	24.4 ± 5.0	25.4 ± 5.4
Smoking cigarettes daily (%)	12.4	6.2	8.8	10.0
Reporting to be diabetic (%)	1.7	5.5	1.2	1.8
Systolic BP at V1R1 (mmHg)	161.1 ± 20.7	149.8 ± 23.4	120.2 ± 16.0	139.4 ± 27.1
Systolic BP at V4R3 (mmHg)	139.5 ± 20.3	135.6 ± 23.7	110.7 ± 13.7	124.6 ± 22.6
Diastolic BP at V1R1 (mmHg)	101.5 ± 11.1	90.8 ± 16.3	74.4 ± 11.3	86.8 ± 17.4
Diastolic BP at V4R3 (mmHg)	88.9 ± 14.6	84.9 ± 16.2	68.9 ± 11.0	78.4 ± 16.3
Electricity at home (%)	52.9	78.3	58.2	58.1
Refrigerator at home (%)	23.5	51.2	29.7	29.3
Car in household (%)	4.4	14.0	5.3	5.8

V1R1: first reading at first visit; V4R3: third reading at fourth visit. BP, blood pressure.

Fig. 1



Mean blood pressure (BP) and upper 95% confidence interval (CI) over repeated visits/readings. (a) Systolic BP: ◆, persons with systolic BP ⩾ 160 mmHg on the first reading at the first visit (V1R1) and no hypertension treatment ($n = 294$); ■, persons under treatment on V1R1 ($n = 129$); ●, persons with systolic BP < 160 mmHg on V1R1 and no treatment ($n = 892$). (b) Diastolic BP. ◆, diastolic BP ⩾ 95 mmHg on V1R1 and no treatment ($n = 437$); ■, under treatment on V1R1 ($n = 129$); ●, diastolic BP < 95 mmHg on V1R1 and no treatment ($n = 749$).

repeated readings both within and between visits among the three groups of participants. The within-visit decrease (i.e. V1R1–V1R3, V2R1–V2R3, etc) was of a similar magnitude at each of the four visits in the three groups. This decrease was significant in Group I and Group III (95% CI on the figure do not overlap) but only marginally significant in Group II (wider 95% CI due to the small number of participants under treatment). The between-visit decrease (i.e. V1R1–V2R1, V2R1–V3R1, V3R1–V4R1) was substantial between the first and the second visits but smaller between subsequent visits.

As a consequence, the proportionate difference in systolic/diastolic BP between the first reading at the first visit and the third reading at the second visit (V1R1–V2R3) was approximately 80% of the difference in systolic/diastolic BP between the first reading at the first visit and the third reading at the fourth visit (V1R1–V4R3) in the three groups of participants ('ratio', Table 2).

Figure 2 shows that among the participants with high BP based on V1R1 (BP ⩾ 160/95 mmHg, with or without treatment), as few as 48% had high BP based on V2R3 and 43% had high BP based on V4R3. As many as 27% of participants with high BP based on V1R1 had normal BP (BP < 140/90 mmHg) based on V2R3 and 36% based on V4R3. Among lower BP categories (based on V1R1), there was also a trend toward a shift to lower BP categories over repeated readings/visits (data not shown in the Figure). Among subjects with BP of 140–159/90–94 mmHg on V1R1, BP was < 140/90 mmHg in 54% on V1R3, in 80% on V2R3, and in 80% on V4R3 (7% had BP ⩾ 160/95 mmHg on V2R3 and V4R3). Among persons with BP of 120–139/80–89 mmHg on V1R1, BP was < 120/80 mmHg in 38% on V1R3, in 52% on V2R3, and in 61% on V4R3 (BP was ⩾ 140/90 mmHg in 3–4% on V2R3 and V4R3).

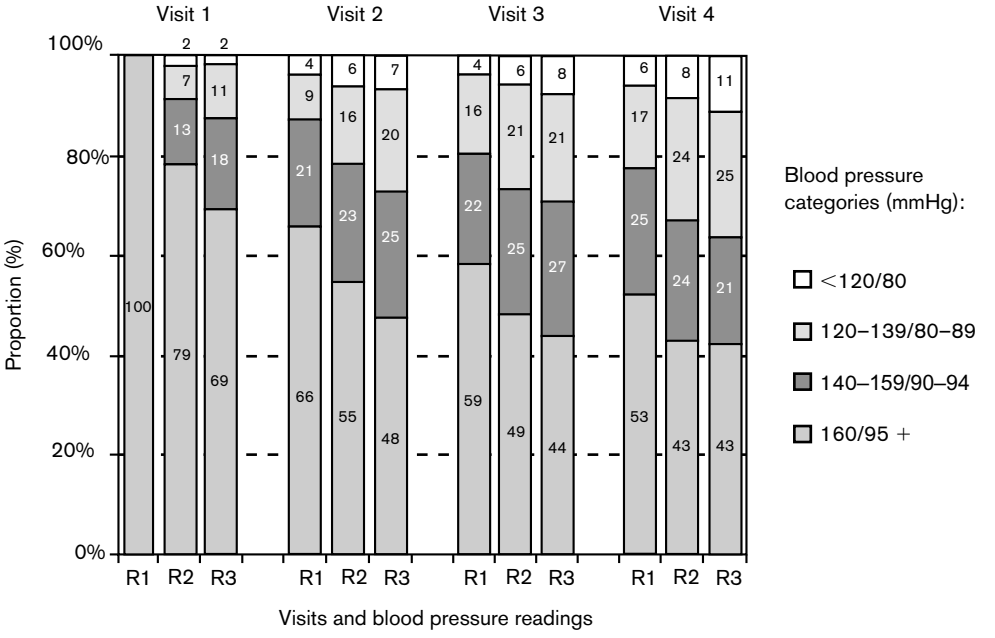
Figure 3 shows the numbers of participants with BP ⩾ 160/95 mmHg among all 1315 participants (referred as 'prevalence' in this paragraph) based on different BP readings at different visits. The prevalence with high BP in the sample does not represent the prevalence in the base population since participants were selected to include as many hypertensive as non-hypertensive persons. However, the decrease in the prevalence of high BP over repeated visits/readings in the study sample is proportionate to the decrease that

Table 2 Average absolute (mmHg) and proportionate decrease (%) in systolic and diastolic blood pressure over repeated readings

		Difference between first and third readings at same visits				Difference between first readings at different visits			
	Units	V1R1 – V1R3[†]	V2R1 – V2R3	V3R1 – V3R3	V4R1 – V4R3	V1R1 – V2R1	V2R1 – V3R1	V3R1 – V4R1	Ratio[‡]
Systolic blood pressure (SBP)									
(I) SBP ⩾ 160 mmHg on V1R1 and no treatment ($n = 294$)	mmHg	11	10	7	9	13	5	3	
	%	6.3	6.1	4.6	5.9	7.3	2.8	1.8	0.78
(II) Under hypertension treatment ($n = 129$)	mmHg	5	6	9	7	5	1	2	
	%	3.0	4.4	6.0	4.7	3.1	0.7	1.3	0.78
(III) SBP < 160 mmHg on V1R1 & no treatment ($n = 892$)	mmHg	4	6	5	6	2	1	1	
	%	3.4	5.0	4.3	4.9	1.7	1.0	0.7	0.81
Diastolic blood pressure (DBP)									
(I) DBP ⩾ 95 mmHg on V1R1 & no treatment ($n = 437$)	mmHg	6	4	4	4	7	2	1	
	%	5.8	4.6	3.8	4.0	6.5	1.8	1.5	0.82
(II) Under hypertension treatment ($n = 129$)	mmHg	2	3	4	4	3	1	0	
	%	2.1	3.5	4.7	4.7	3.0	1.5	−0.4	0.75
(III) SBP < 95 mmHg on V1R1 & no treatment ($n = 749$)	mmHg	2	4	3	4	0	0	1	
	%	2.4	4.9	4.4	5.4	0.5	0.1	1.5	0.74

[†]V1R1, first reading at the first visit; V3R2, second reading at the third visit. [‡]Ratio of the difference in BP between V1R1 and V2R3 (V1R1 – V2R3) to difference in BP between V1R1 and V4R3 (V1R1 – V4R3).

Fig. 2

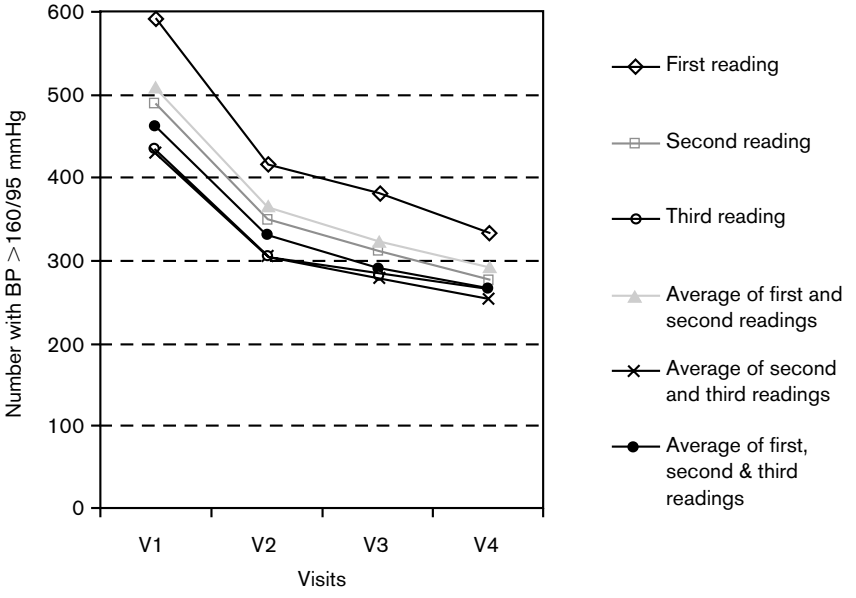


Distribution (%) of selected blood pressure categories over subsequent visits/readings among persons who had BP ⩾ 160/95 mmHg on the first reading at the first visit ($n = 592$).

would have occurred in the general population over repeated visits/readings. Compared with V1R1, the prevalence was lower by 48% based on V2R3 and by 55% based on V4R3. The prevalence based on V2R23 or V2R3 (respectively 305 and 306 participants) was not largely different compared with the prevalence based on readings at the fourth visit (e.g. V4R12: 290 participants, V4R23: 253 or V4R123: 265). For example, the prevalence based on V2R3 or V2R23 was only 21% larger than the prevalence based on V4R23. Based on the average of the three readings at each visit, and with reference to readings at the first visit (V1), the prevalence was lower by 29% based on readings at V2 and by 43% based on readings at V4. Hence, the prevalence based on V2R3 or V2R23 only moderately overestimated the prevalence based on readings at V4.

We then examined the association between the proportionate decrease in BP and selected variables among participants with systolic BP ⩾ 140 mmHg on V1R1

Fig. 3



Number of persons with BP ⩾ 160/95 mmHg among all study participants ($n = 1315$) based on different visits/readings.

($n = 626$) or diastolic BP ⩾ 90 mmHg on V1R1 ($n = 601$). The proportionate/absolute decreases between the first and last of the 12 available readings (V1R1–V4R3) were 14.1%/23.3 mmHg for systolic BP and 13.1%/12.6 mmHg for diastolic BP. Multivariate linear regression (Table 3) indicated a significant inverse association between the proportionate decrease in BP and antihypertension treatment. A weak and less consistent inverse association was found with male sex and older age and no consistent association was found with the wealth score. One can interpret, for example, that the mean proportionate decrease in systolic BP between the first and last readings (V1R1–V4R3) was smaller by 4.12% in persons under treatment compared with persons not under treatment, independent of age, sex, body mass index and wealth score. Overall, the variables considered in the multivariate analyses accounted for less than 5% of the variability in the proportionate decrease of BP over repeated readings.

Discussion

This study shows that BP decreased largely within and between visits. BP decreased substantially between the first and third readings at each of the four visits. The decrease was important between the first and second visits but was small between additional visits. As a consequence, the mean BP based on the third reading at the second visit (V2R3) was not largely higher than the mean BP based on the third reading at the fourth visit (V4R3). Similarly, and with reference to the prevalence based on the first reading at the first visit (V1R1), the prevalence of high BP decreased by as

Table 3 Association between selected factors and proportionate percentage decrease in systolic and diastolic blood pressure over repeated readings in participants with systolic BP ⩾ 140 mmHg ($n = 626$) or diastolic BP ⩾ 90 ($n = 601$) on the first reading at the first visit

	Proportionate difference in BP between:											
	First and third readings at visit one						First reading at visit one and third reading at visit four					
	Systolic BP $R^2 = 0.013$			Diastolic BP $R^2 = 0.026$			Systolic BP $R^2 = 0.042$			Diastolic BP $R^2 = 0.033$		
	β	SE	*P*	β	SE	*P*	β	SE	*P*	β	SE	*P*
Age (10 years)	−0.60	0.34	0.079	−1.31	0.41	0.001	−0.76	0.42	0.071	−1.74	0.50	0.000
Male sex	−1.45	0.76	NS	−1.21	0.94	NS	−2.40	0.94	0.011	−1.93	1.14	0.091
Body mass index (kg/m^2)	−0.02	0.07	NS	−0.04	0.09	NS	−0.08	0.08	NS	−0.11	0.10	NS
Wealth score ⩾ 4[†]	0.66	1.10	NS	0.11	1.36	NS	−2.52	1.36	0.065	0.22	1.64	NS
On treatment for high BP	−2.39	1.06	0.025	−3.42	1.44	0.018	−4.12	1.32	0.002	−3.91	1.73	0.025
Constant	9.38	2.32	0.000	12.72	2.94	0.000	21.53	2.87	0.000	24.39	3.58	0.000

[†]Score ranging from 0 (lowest) to 5 (highest). BP, blood pressure.

much as one half based on either the third reading at the second visit (V2R3) or the last reading at the last visit (V3R4). However, the prevalence of high BP based on readings at the second visit (V2R3 or V2R23) was not much higher than the prevalence based on readings at the fourth visit (V4R3 or V4R23). Our results suggest that the prevalence of high BP based on repeated readings at a second visit will estimate fairly well the true prevalence in the population. Mean BP decreased similarly when the first three visits took place at 3-day or 14-day intervals. This suggests that measuring BP at two visits separated by just a few days can capture most of the decrease of BP over repeated visits/readings. Noticeably, the use of automatic electronic sphygmomanometers in this study prevented several observer-related biases that can occur with standard sphygmomanometry, including systematic error, terminal digit preference, and observer prejudice [23].

The fall in BP over repeated readings was substantial not only in persons with high BP, but also in subjects with low BP. This suggests that the decrease in BP over repeated visits relates mainly to a transient elevation of BP (defense reaction) in persons submitted to BP measurement and only little to a regression to the mean of high BP values. This interpretation is also supported by the finding that the decrease was smaller in persons under treatment, i.e. in persons who are likely to have been more exposed to previous BP measurements. Consistent with other reports [24], we found that sex and age had only modest influence on BP variability.

From a clinical perspective, substantial variability of BP at the individual level – as apparent in our study from only fair correlation between successive BP readings – confirm the need to obtain multiple BP readings over several visits to assess reliably hypertension in individuals [3,7,25]. A minimum number of visits and readings that is sufficient for positively diagnosing hypertension cannot be recommended, as is implicit in current guidelines for clinical practice [11–13], since numerous readings may be needed in some persons before hypertension can be confirmed. However, recording systematically three readings at each visit would permit the exclusion of false-positive cases of hypertension in a larger number of suspected hypertensive persons after only one or two visits, as compared with taking only one or two readings at each visit.

The difficulty of defining hypertension in epidemiologic studies, due to BP variability, is well recognized [4,26,27]. The procedure used to assess the prevalence of hypertension in populations should reliably classify persons as hypertensive and be efficient in view of increased costs and inconveniences associated with repeated visits. Our study suggests that assessing the prevalence of hypertension based on readings at a second visit would largely avoid the overestimation of estimates based on readings at one single screening visit, and only slightly overestimate estimates based on readings at more visits. To minimize the difficulties of a strategy based on two separate visits – compared with a strategy based on a single visit –repeated BP measurements could be obtained in random sub-samples of populations under study and appropriate adjustments performed accordingly.

Which readings should be used when several BP measurements are available from two visits? In the few studies that have relied on BP readings obtained on two visits, the prevalence of hypertension was often based on the average of all readings at all visits. While this strategy does reduce the weight of readings at the first visit – which most overestimate a person's true BP – our findings suggest that prevalence estimates based on only the third reading – or the average of the second and third readings – at a second visit would be more appropriate to reliably estimate the true prevalence of hypertension in the population. A staged approach for assessing hypertension in populations would correspond better to the standard clinical practice whereby hypertension is diagnosed only if high BP persists over successive readings and visits. This approach would also be consistent with JNCVI recommendations [11] to discard screening readings and rely on readings at subsequent visits when assessing hypertension in individual patients.

The decline of BP with subsequent readings (i.e. adaptation) may be, at least in part, culturally-specific, population-specific and method-specific. For example, one could hypothesize that the decrease of BP over successive visits/readings would be sharper in populations with limited previous familiarization with techniques and circumstances of BP measurement – such as in Dar es Salaam – compared with western populations. Also, less reactivity might have been observed in our study due to the fact that the measures were taken at home, rather than at a research office or a medical clinic. Because the few studies that have examined this issue have used different designs and methods, direct comparison is difficult. However, the prevalence of hypertension in a Canadian study in which two BP readings were obtained at each of three visits fell by up to one-half (i.e. as much as in our study) when follow-up information was included [28]. In an American study, the prevalence of hypertension decreased from 20% based on one visit to 9% based on three visits [29]. A study of 804 civil servants in Nigeria noted no greater variability over repeated BP measurements compared to findings in western countries [24]. In the Seychelles, among 155 participants to a population-based survey

who had BP $\geqslant$ 160/95 mmHg at a first visit (based on the average of the two last of three readings) and were unaware of hypertension, only 50 (32%) had such high BP at a third visit taking place within 10 days [30]. These studies suggest that the prevalence of hypertension decreases largely in all populations, possibly by more than one-half, when estimates are based on readings obtained on two or more visits. A decrease of similar magnitude over repeated visits/readings across different populations would imply that a unique procedure could be recommended for the epidemiologic assessment of hypertension in populations. These issues could be addressed decisively by replicating similar systematic studies in other populations and/or by reappraising data from the available studies along a similar analysis protocol.

However, the large and very important literature on morbidity and mortality associated with hypertension has most often relied on BP based on one or two readings at a single visit. Changing the method of measuring BP changes the BP readings for each subject and, consequently, will also change the cardiovascular risk associated with definite BP levels. This issue would deserve proper consideration through appropriate new prospective studies of cardiovascular disease and/or re-analysis of data in the few studies that have relied on several BP readings/visits before recommendations can be made on the value of BP based on subsequent visits to predict cardiovascular events.

Our data stress the need for standard and reliable procedures for the measurement of BP. This is true not only in clinical practice, as generally recommended, but also in epidemiologic studies as suggested in this study. Our findings suggest that taking three readings on two visits, possibly separated by just a few days, could be an efficient strategy for reliably estimating true mean levels of BP and prevalence of hypertension in populations. A reliable estimation of the prevalence of hypertension is important for assessing the true burden of hypertension in populations and for providing a sound basis for control strategies, particularly in developing countries where the burden of non-communicable diseases is increasing in a context of scarce resources.

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