

# No further decrease in blood pressure when the interval between readings exceeds one hour

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**Objective** The assessment of blood pressure (BP) in individuals is traditionally based on a few BP readings obtained at intervals of just a few minutes. We examined if increasing intervals between BP readings on one visit would have an impact on the BP estimates.

**Methods** We conducted an examination survey of cardiovascular risk factors in the general population aged 25–64 years in Seychelles (Indian Ocean), attended by 1255 of 1565 eligible participants. BP was measured once shortly after participants' arrival to the study centers (BP1) and twice before discharge, 15–351 min later (BP2, BP3; separated by 2 min).

**Results** Mean (standard error) BP1 was 135.1 (0.7)/87.9 (0.4) mmHg, BP2: 130.7 (0.6)/85.1 (0.4) mmHg and BP3: 128.4 (0.6)/83.9 (0.3) mmHg. The difference in BP between the first and the last measurements ( $\Delta$ BP1–BP3) was, respectively, 5.8 (1.3)/2.6 (0.9) mmHg for a time interval between BP1 and BP3 of 15–60 min, 6.3 (0.5)/3.9 (0.3) mmHg for 61–120 min, 6.9 (0.6)/4.1 (0.4) mmHg for 121–240 min and 7.4 (0.7)/4.3 (0.5) mmHg for 241–351 min (*P*-trend for systolic/diastolic BP: 0.15/0.49). In multivariate analysis, both systolic and diastolic  $\Delta$ BP were associated with the initial BP level and the female sex but not with time (in minutes) between BP readings (for systolic/diastolic BP, *P*=0.12/0.34).

## Introduction

Accuracy of blood pressure (BP) measurement is crucial for the diagnosis and treatment of hypertension [1,2]. BP varies largely and tends to decrease over repeated readings both within and between visits [3–5]. Therefore, the diagnosis of hypertension should be based on multiple BP measurements taken on several visits [6,7].

In epidemiological studies, BP is most often measured based on one set of readings on one single visit, mainly for practical reasons [8–11]. BP is therefore higher than the 'true' BP, defined by Pickering [12] as 'the mean level over prolonged periods' and the prevalence of hypertension – particularly mild hypertension – is overestimated when estimates are based on a few readings obtained on one visit [11].

The decrease in BP over subsequent readings within a few minutes is well known [5,13–16]. In participants

**Conclusion** The decrease in subsequent BP readings obtained did not differ whether the time interval between BP measurements was larger or smaller than 1 h. This indirectly suggests that extending the time interval between repeated BP readings on one single visit is unlikely to be a valid, alternative strategy to the recommendation of gathering BP readings on several, separate visits to define hypertension. *Blood Press Monit* 13:85–89 © 2008 Wolters Kluwer Health | Lippincott Williams & Wilkins.

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submitted to 14 readings over 15 min, the BP decreased up to the eighth reading and the last reading of the series better represented BP at rest [14]. It is also known that the decrease in BP over subsequent readings occurs again on subsequent visits a few days later [14]. In a population-based study, systolic/diastolic BP measured over a time interval of 25 min decreased by 10/1 mmHg [13]. In patients with hypertension systolic/diastolic BP measured every other minute during 16 min decreased by 11.6/4.3 mmHg and 75% of the decrease occurred within the first 10 min, whereas only a minor decrease in BP was observed during the last 16 min of a 1-h supine rest [16].

To our knowledge, no study has systematically examined trends in BP over time intervals between readings on a same visit that exceeded 1 h. We hypothesized that a large time interval between BP readings (i.e. > 1 vs. < 1 h) would be associated with a larger BP decrease. If true, this could imply that measuring BP over such long

time intervals on one visit could better approximate the 'true' BP ('the mean level over prolonged periods') [12]. We therefore compared the difference in BP readings obtained on one visit at time intervals ranging from 15 to 360 min in a population-based survey, and we analyzed selected determinants of the BP decrease.

## Methods

### The Seychelles Heart Study III

The study took place in the Republic of Seychelles (Indian Ocean). A large majority of the population is of African descent with minorities of European, Indian, Chinese and mixed descent. Seychelles has experienced rapid socio-economic development over the last three decades and the national gross domestic product per capita, in real terms, rose from US\$ 2927 in 1980 to US\$ 5239 in 2004 [17]. We showed earlier a high prevalence of several cardiovascular risk factors, including elevated BP [17–19].

The Seychelles Heart Study III was aimed at assessing the distribution and prevalence of the main cardiovascular/noncommunicable diseases risk factors and related lifestyles in the population of Seychelles [17]. The study was conducted between June and December, 2004.

### Participants

The study was designed as a cross-sectional survey of the general adult population. A simple age-stratified and sex-stratified random sample of all residents aged 25–64 years was included. A total of 1565 were eligible of which 1255 participated in the study (participation rate: 80%). The study protocol had been approved by the local research committee after ethical and technical reviews. All participants were free to take part and gave written informed consent.

### Measurements

BP was measured on the right arm in a seated position. Cuff width was adapted to the arm circumference. One BP reading was obtained with a validated oscillometric automated device (Omron HEM757 M5-I [20]; Omron Healthcare Europe BV, Hoofddorp, The Netherlands) upon arrival (first reading, BP1; 5–30 min after arrival) and twice before being discharged from the study centers (two readings, BP2 and BP3, separated by a 2-min interval). Measurements taken just before discharge occurred 15–360 min after arrival at the study center. Heart rate (HR) was recorded with the automated device. During the time interval, participants stayed in a calm and secluded waiting room, most often seated and they were submitted, in different sequential orders, to a blood sample collection, an administered structured questionnaire (socio-demographic variables, lifestyles and diet) and, for participants aged 45 years and above and a small random sample of participants aged 35–44 years, an ultrasonography of the carotid and femoral arteries.

The participants' BP measurements were taken between 7:30 and 16:00 h, with the majority of participants' measurements taken between 8:00 and 12:00 h. Extended stay over the afternoon was limited to a few randomly selected participants as all ultrasound examinations were done by only one examiner. The first BP measurements were taken in fasting state, whereas the last BP readings were taken after the participants had had a snack (after blood drawing, between 7:30 and 10:00 h). Drinking water was available at all times. Smoking was not allowed. Participants could read magazines or watch TV (set at a low sound volume). No large circadian change in BP was expected. During the time interval, three additional BP readings were obtained with a mercury sphygmomanometer at unrecorded time (when participants were submitted to a questionnaire) and these readings are not considered in this study. The results gathered in the survey were discussed with the participants after the last BP reading was recorded.

### Statistical analysis

Mean BP and HR were calculated for each BP reading. Differences in mean values over several categories were tested with analysis of variance. The difference in BP ( $\Delta$ BP) between the first (BP1) and the third readings (BP3) was computed as  $\Delta$ BP = BP1 – BP3. Difference between mean  $\Delta$ BP according to categories of HR ( $> 90$  vs.  $\leq 90$ /min) was tested with unpaired *t*-test. Pearson correlation coefficients between systolic/diastolic  $\Delta$ BP and time (in minutes) between readings were calculated. Trends in  $\Delta$ BP across time intervals between readings (15–60, 61–120, 121–240 and 241–360 min) were tested using the Cuzick method [21]. Multivariate linear regression models were fitted to examine the associations between  $\Delta$ BP and selected variables, that is, time (in minutes) between BP readings, sex, age, BP and HR. Models were fitted separately for systolic and diastolic  $\Delta$ BP. The relationship between the difference in BP between the first two readings (i.e. BP1–BP2) and time interval (in minutes) between the two readings was also analyzed. *P* values of less than 0.05 were considered statistically significant. Analyses were carried out with Stata 8.2 (StataCorpLP, College Station, Texas, USA).

### Results

Table 1 shows mean BP and HR of the participants. Data on BP and time intervals between the three considered BP readings were available in the case of 1217 participants. Mean time interval between the first and third readings was 2.8 h (SD: 0.9) (range: 15–351 min). Mean BPs were, respectively, BP1: 135.1 (0.7)/87.9 (0.4) mmHg, BP2: 130.7 (0.6)/85.1 (0.4) mmHg and BP3: 128.4 (0.6)/83.9 (0.3) mmHg ( $P < 0.001$  for a difference between readings). In all age groups and in both sexes, BP and HR decreased from the first to the third readings.

**Table 1 Mean blood pressure (BP1, BP2, BP3) and heart rate (HR1, HR2, HR3) at three subsequent readings taken on a single visit**

	Age (years)	N	SBP1 (mmHg)	DBP1 (mmHg)	HR1 (/min)	SBP2 (mmHg)	DBP2 (mmHg)	HR2 (/min)	SBP3 (mmHg)	DBP3 (mmHg)	HR3 (/min)
Men	25–34	122	128.9 (1.5)	82.7 (1.1)	67.2 (1.1)	126.2 (1.3)	81.3 (0.9)	65.2 (1.0)	124.0 (1.2)	79.6 (0.9)	65.0 (1.0)
	35–44	128	135.2 (1.5)	87.3 (1.1)	70.8 (1.2)	130.5 (1.3)	85.0 (1.0)	69.0 (1.1)	128.8 (1.3)	84.0 (0.9)	69.0 (1.1)
	45–54	152	141.5 (1.6)	91.9 (1.1)	74.0 (1.1)	137.8 (1.4)	88.9 (1.0)	71.7 (1.0)	135.6 (1.5)	87.8 (1.0)	71.6 (1.0)
	55–64	140	149.5 (2.0)	94.0 (1.1)	77.2 (1.2)	143.5 (1.8)	90.1 (1.2)	74.8 (1.3)	141.1 (1.8)	89.1 (1.1)	73.9 (1.2)
Women	25–34	149	116.0 (1.1)	80.2 (0.9)	76.3 (1.0)	114.3 (0.9)	78.1 (0.8)	73.7 (0.9)	112.6 (0.9)	76.7 (0.8)	74.3 (0.9)
	35–44	172	124.0 (1.2)	84.3 (0.9)	77.4 (1.0)	121.9 (1.1)	82.8 (0.8)	74.2 (0.8)	119.0 (1.1)	81.7 (0.8)	73.5 (0.8)
	45–54	177	137.7 (1.9)	90.2 (1.1)	75.8 (1.0)	131.8 (1.6)	86.4 (1.0)	71.1 (0.9)	129.4 (1.6)	85.6 (1.0)	71.5 (0.9)
	55–64	174	147.1 (1.9)	91.6 (1.0)	76.3 (1.1)	139.2 (1.7)	87.1 (1.0)	72.2 (1.0)	136.3 (1.6)	86.1 (0.9)	71.7 (1.0)

Standard error is shown enclosed within brackets.  
DBP, diastolic blood pressure; SBP, systolic blood pressure.

A decrease in BP over subsequent readings was observed in participants in all BP categories. This decrease was greater in participants with higher than lower BP levels at the first reading: ΔBP (mmHg) was 0.4 (0.5)/0.2 (0.4), 4.8 (0.5)/2.4 (0.3), 8.1 (0.6)/4.8 (0.4) and 13.7 (0.9)/8.8 (0.5) in the BP categories ‘optimal’, ‘normal’, ‘stage 1 hypertension’ and ‘stage 2 hypertension’, respectively (*P* for trend: < 0.001/ < 0.001). ΔBP was larger in older than younger participants.

HR decreased significantly from 74.7 (0.4) to 71.7 (0.4)/min between the first and the second readings (*P* < 0.001). HR was 71.5 (0.4)/min at the third reading (*P* = 0.20 vs. second reading). In participants with HR > 90/min at the first reading, ΔBP was larger than in those with HR ≤ 90/min: 11.4 (0.9)/5.5 (0.6) mmHg versus 6.1 (0.3)/3.8 (0.2) mmHg (*P* < 0.001/ < 0.05).

Table 2 shows ΔBP according to the time interval between BP1 and BP3. BP decreased significantly between the first and the last readings. For both systolic and diastolic BP, ΔBP tended to increase across time interval categories, albeit not significantly (*P* for trend: 0.15/0.49). The unadjusted Pearson correlation coefficients between ΔBP and time (in minutes) were 0.03 (*P* = 0.22) for systolic BP and 0.04 (*P* = 0.17) for diastolic BP.

Table 3 shows the multivariate linear regression coefficients between ΔBP and selected factors. Systolic ΔBP was directly associated with BP level (*P* < 0.001) and female sex (*P* < 0.001). Diastolic ΔBP was directly associated with the initial BP level (*P* < 0.001) and the female sex (*P* < 0.05). HR and ΔBP were not associated with time interval (in minutes) between readings (*P* = 0.12 and 0.34, respectively).

In addition to examining the relationship of ΔBP = BP1–BP3 by time interval between these measurements, we also examined the relationship between the difference between BP1 and BP2 by time interval. Results were virtually identical, which is consistent with the fact that BP2 was measured just 2 min before BP3

**Table 2 Mean difference in blood pressure between the first and the last blood pressure readings (ΔBP) in relation to time interval between the readings**

Time interval (min)	15–60	61–120	121–240	241–360	<i>P</i> for trend
N	68	416	409	321	
Systolic ΔBP (mmHg)	5.8 (1.3)	6.3 (0.5)	6.9 (0.6)	7.4 (0.7)	0.15
Diastolic ΔBP (mmHg)	2.6 (0.9)	3.9 (0.3)	4.1 (0.4)	4.3 (0.5)	0.49

Standard error is shown enclosed within brackets.

**Table 3 Association between the difference in blood pressure between the first and the last blood pressure readings (ΔBP) and selected characteristics**

	Systolic ΔBP (mmHg)			Diastolic ΔBP (mmHg)		
	Regression coefficient	SE	<i>P</i>	Regression coefficient	SE	<i>P</i>
Time interval <sup>a</sup> (min)	-0.007	0.005	0.12	-0.003	0.003	0.34
Female sex	2.5	0.6	<0.001	1.0	0.4	0.016
Age (years)	-0.04	0.03	0.12	-0.02	0.02	0.20
BP1 <sup>b</sup> (mmHg)	0.27	0.01	<0.001	0.28	0.02	<0.001
Heart rate at BP1 (/min)	0.011	0.021	0.61	-0.024	0.015	0.10

SE, standard error.

<sup>a</sup>Time interval: minutes between the first and the last BP reading.

<sup>b</sup>BP1: blood pressure at the first reading.

(so that BP1–BP3 is very close to BP1–BP2). Correlation coefficients between systolic ‘BP1–BP3’ and ‘BP1–BP2’ were 0.84 for systolic BP and 0.79 for diastolic BP (*P* < 0.001) respectively.

### Discussion

We found that BP decreased substantially over subsequent BP readings taken on one visit, as expected [5,13–16], but this decrease was not larger when the time interval between BP readings was larger than 1 h as compared with a shorter time interval. This finding suggests that taking BP readings over an extended time interval on one visit is unlikely to improve the estimation of actual BP (‘the mean level over prolonged periods’) [12] as compared with the estimation based on a few readings of BP taken over shorter time intervals.

One could speculate that the number of repeated BP readings *per se* (rather than the time interval between the

readings) is the main reason underlying the decrease in BP over subsequent BP readings, perhaps owing to familiarization with the BP device and the measurements procedures. Participants submitted to 16 readings obtained over a short interval of 15 min showed a decrease in BP up to the eighth reading [14]. On the other hand, the BP did not decrease further over three subsequent readings separated by 15–60-s intervals after an initial 5-min rest [15].

A limitation of our study is that the time interval between the first and last readings was not allocated randomly to the participants. The time interval tended to be larger in older participants, perhaps owing to the longer time needed for completing the other study investigations (e.g. an ultrasound was carried out in participants aged 45 years and above). Multivariate analysis, however, showed that the BP decrease between the first and last readings was not associated with time interval between the readings, irrespective of age and BP level. Participants were submitted to a questionnaire, blood tests and ultrasound (for some); they were given a snack and they could also walk around the study centers and talk to each other. This situation may be more busy (although not necessarily) as compared with other similar epidemiological studies. But overall, this situation could be described as calm and quiet and certainly much less active compared with a working day. This may however limit the comparability of our findings with studies in which BP was repeatedly measured in participants not submitted to any additional exam.

A decrease in BP over subsequent readings was observed in all BP categories but the decrease was greater in participants with high rather than low BP. This suggests that the decrease in BP over time intervals/readings is not fully accounted for by regression to the mean of elevated BP values, but that this BP decrease also reflects a true transient elevation of BP (alert reaction) in participants submitted to BP measurement, irrespective of their BP level [22,23]. This finding is consistent with a similarly large decrease in BP over repeated readings found in participants with treatment than without treatment [5], whereas treated participants are likely to have been exposed to a larger number of BP measurements and be less prone to an alert reaction.

In some patients, a decrease in BP over repeated readings can reflect a white-coat effect [23]. The white-coat effect differs from an 'alert reaction' in that the former is largely elicited by the person taking the BP measurements, whereas the latter is elicited by the measurements procedure itself. Hence, measurement of BP outside of the physician's office and using an automated device could reduce the white-coat effect [24,25]. The influence of both the person taking measurements and the equipment used to measure BP are exemplified by the

findings that BP readings are lower when measured by nurses and/or by using ambulatory BP monitoring as compared with BP measurement carried out by physicians [26]. In our setting, BP was measured with an automated device operated by trained research officers dressed in nonmedical outfits in premises located outside of a hospital. One could therefore consider that the white-coat effect was likely to be largely prevented. As the participants underwent several investigations between the first and the last BP readings, however, we cannot rule out a stressor effect on BP readings, which could have reduced the observed decrease in BP over subsequent readings.

The automated device that we used to assess BP has been adequately validated [20,27] and is recommended for clinical use [28]. The average difference in BP (standard deviation) between the automated device and the mercury sphygmomanometer was as low as  $-0.9$  (5.8)/ $-0.8$  (4.8) mmHg for systolic/diastolic BP [20]. The absence of a significant systematic bias in readings with this device supports the view that our findings would not have been different had the measurements been collected using a mercury sphygmomanometer.

One strength of this study is the large sample size and the population-based design, which increases the external validity of our results. To our knowledge, no study had previously assessed the decrease in subsequent BP and its determinants with the time interval between the readings exceeding 1 h. The variability of BP over serial readings may, however, differ across populations and could possibly be greater in populations where participants are less familiarized with routine BP measurement, for example, in some developing countries [5]. Most inhabitants of Seychelles have already experienced BP measurement as BP is measured fairly systematically during all medical visits in health centers [29] and 80% of the participants reported a medical visit to a health center over the past 12 months.

Finally, as we did not measure BP repeatedly over the first 0–15 min, we cannot test the magnitude of a decrease in BP over a short time interval. In particular, we cannot determine if a decrease in BP over subsequent readings taken at short intervals (e.g. 1–2-min intervals) would be different from the decrease that we observed over long time intervals between the readings.

In conclusion, our findings suggest that the estimation of BP in individuals, based on several readings on one visit, is not different whether it is based on time intervals between the readings below or above 1 h. These results have several implications. In epidemiological studies, resources are limited and it is difficult to impose on generally healthy participants the inconvenience of

having to attend additional visits. Participants, however, might not mind waiting for an hour or two in the context of a study, typically when they are requested to undergo several investigations. Implicitly, our findings suggest that measuring BP several times over a long time interval on one single visit may not constitute a valid, alternative strategy to the recommended need for gathering multiple BP readings on several visits to define hypertension. Further studies should examine if the decrease in BP over repeated readings and/or time relate more to the 'number' of readings or to the 'time interval' between the readings.

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## References

- O'Brien E, Asmar R, Beilin L, Imai Y, Mancia G, Mengden T, et al. On behalf of the European Society of Hypertension Working Group on Blood Pressure Monitoring. Practice guidelines of the European Society of Hypertension for clinic, ambulatory and self blood pressure measurement. *J Hypertens* 2005; **23**:697–701.
- Stergiou GS. How to cope with unreliable office blood pressure measurement? *Am J Hypertens* 2005; **18**:1519–1521.
- Glock CY, Vought RL, Clark EG, Schweitzer MD. Studies in hypertension. Variability of daily blood pressure measurements in the same individuals over a three-week period. *J Chronic Dis* 1956; **4**:469–476.
- Armitage P, Fox W, Rose GAQ. The variability of measurement of casual blood pressure: II survey experience. *Clin Sci* 1966; **30**: 337–344.
- Bovet P, Gervasoni JP, Ross AG, Mkamba M, Mtasiwa DM, Lengeler C, et al. Assessing the prevalence of hypertension in populations: are we doing it right? *J Hypertens* 2003; **21**:509–517.
- Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA* 2003; **289**: 2560–2572.
- 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.
- Cooper R, Puras A, Tracy J, Kaufman J, Asuzu M, Ordunez P, et al. Evaluation of an electronic blood pressure device for epidemiologic studies. *Blood Press Monit* 1997; **2**:35–40.
- Wolf-Maier K, Cooper RS, Banegas JR, Giampaoli S, Hense HW, Joffres M, et al. Hypertension prevalence and blood pressure levels in 6 European countries, Canada, and the United States. *JAMA* 2003; **289**:2363–2369.
- Cooper RS, Wolf-Maier K, Luke A, Adeyemo A, Banegas JR, Forrester T, et al. An international comparative study of blood pressure in populations of European vs. African descent. *BMC Med* 2005; **3**:2.
- Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. *Lancet* 2005; **365**:217–223.
- Pickering TG, Shimbo D, Haas D. Ambulatory blood-pressure monitoring. *N Engl J Med* 2006; **354**:2368–2374.
- Van Loo JM, Peer PG, Thien TA. Twenty-five minutes between blood pressure readings: the influence on prevalence rates of isolated systolic hypertension. *J Hypertens* 1986; **4**:631–635.
- Andre JL, Petit JC, Gueguen R, Deschamps JP. Variability of arterial pressure and heart rate measured at two periods of 15 min to 15 days intervals. *Arch Mal Coeur Vaiss* 1987; **80**:1005–1010.
- Yarows SA, Patel K, Brook R. Rapid oscillometric blood pressure measurement compared to conventional oscillometric measurement. *Blood Press Monit* 2001; **6**:145–147.
- Sala C, Santin E, Rescaldani M, Magrini F. How long shall the patient rest before clinic blood pressure measurement? *Am J Hypertens* 2006; **19**:713–717.
- Bovet P, Shamlaye C, Gabriel A, Riesen W, Paccaud F. Prevalence of cardiovascular risk factors in a middle-income country and estimated cost of a treatment strategy. *BMC Public Health* 2006; **6**:9.
- Bovet P, Shamlaye C, Kitua A, Riesen WF, Paccaud F, Darioli R. High prevalence of cardiovascular risk factors in the Seychelles (Indian Ocean). *Arterioscler Thromb* 1991; **11**:1730–1736.
- Perret F, Bovet P, Shamlaye C, Paccaud F, Kappenberg L. High prevalence of peripheral atherosclerosis in a rapidly developing country. *Atherosclerosis* 2000; **153**:9–21.
- El Assaad MA, Topouchian JA, Asmar RG. Evaluation of two devices for self-measurement of blood pressure according to the international protocol: the Omron M5-I and the Omron 705IT. *Blood Press Monit* 2003; **8**: 127–133.
- Cuzick J. A Wilcoxon-type test for trend. *Stat Med* 1985; **4**:87–90.
- Mancia G, Parati G, Pomdiossi G, Grassi G, Casadei R, Zanchetti A. Alerting reaction and rise in blood pressure during measurement by physician and nurse. *Hypertension* 1987; **9**:209–215.
- Parati G, Mancia G. Assessing the white-coat effect: which blood pressure measurement should be considered? *J Hypertens* 2006; **24**: 29–31.
- Gerin W, Marion RM, Friedman R, James GD, Bovbjerg DH, Pickering TG. How should we measure blood pressure in the doctor's office? *Blood Press Monit* 2001; **6**:257–262.
- Myers MG, Valdivieso MA. Use of an automated blood pressure recording device, the BpTRU, to reduce the 'white coat effect' in routine practice. *Am J Hypertens* 2003; **16**:494–497.
- Campbell NR, Culleton BW, McKay DW. Misclassification of blood pressure by usual measurement in ambulatory physician practices. *Am J Hypertens* 2005; **18**:1522–1527.
- O'Brien E, Pickering T, Asmar R, Myers M, Parati G, Staessen J, et al. International protocol for validation of blood pressure measuring devices in adults. *Blood Press Monit* 2002; **7**:3–17.
- dabl educational trust, <http://www.dableducational.org/index.html> [Accessed 18 March 2007].
- Aubert L, Bovet P, Gervasoni JP, Rwebogora A, Waeber B, Paccaud F. Knowledge, attitudes, and practices on hypertension in a country in epidemiological transition. *Hypertension* 1998; **31**: 1136–1145.