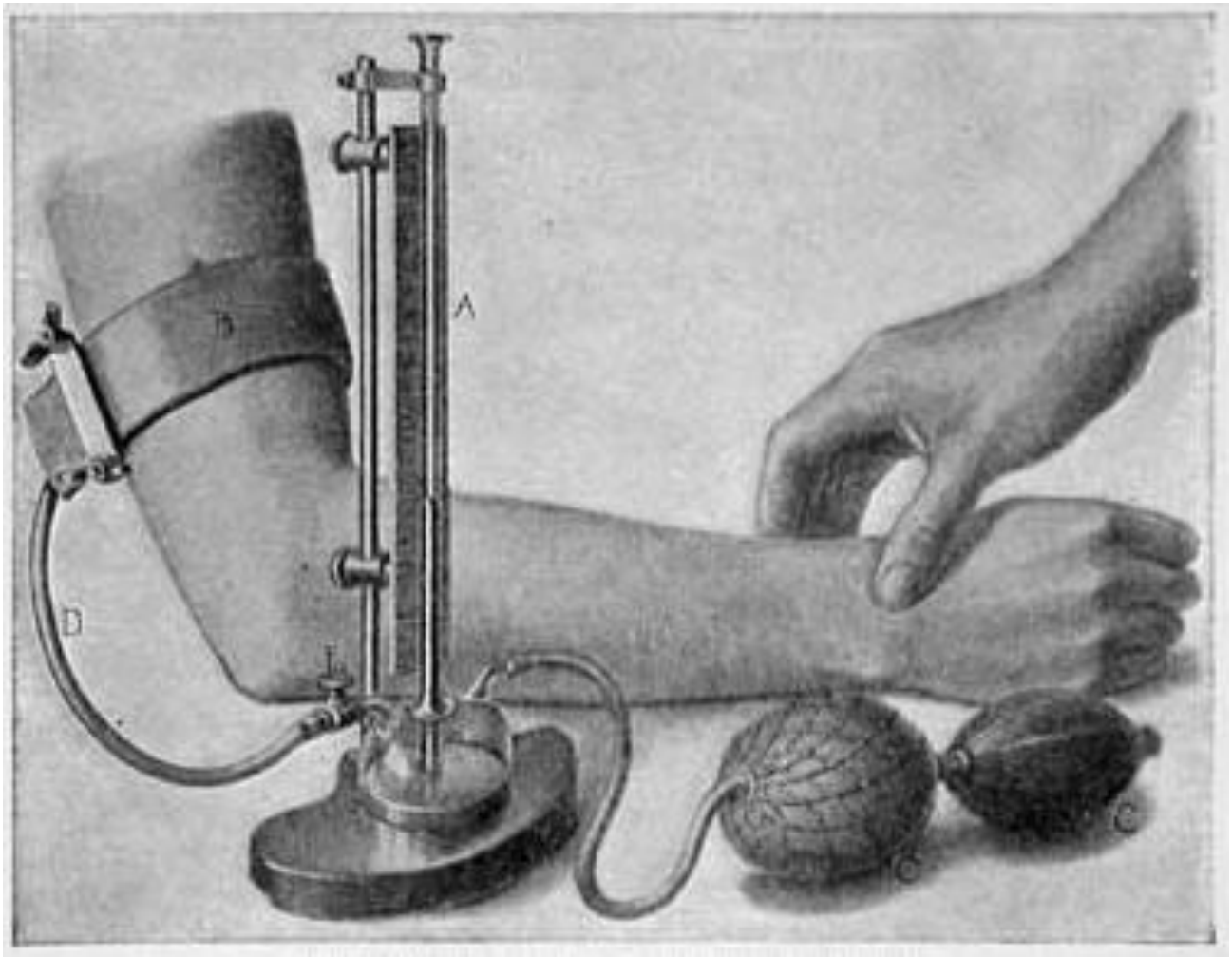
Current Topics in Hypertension

- BP variability vs. average daily BP -

조선의대
정중화

Riva Rocci sphygmomanometer

- Mercury; SBP -



Gazetta Medical di Torino 1896;47:901-6 and 1001-17.

HBP invariably lower than OBP

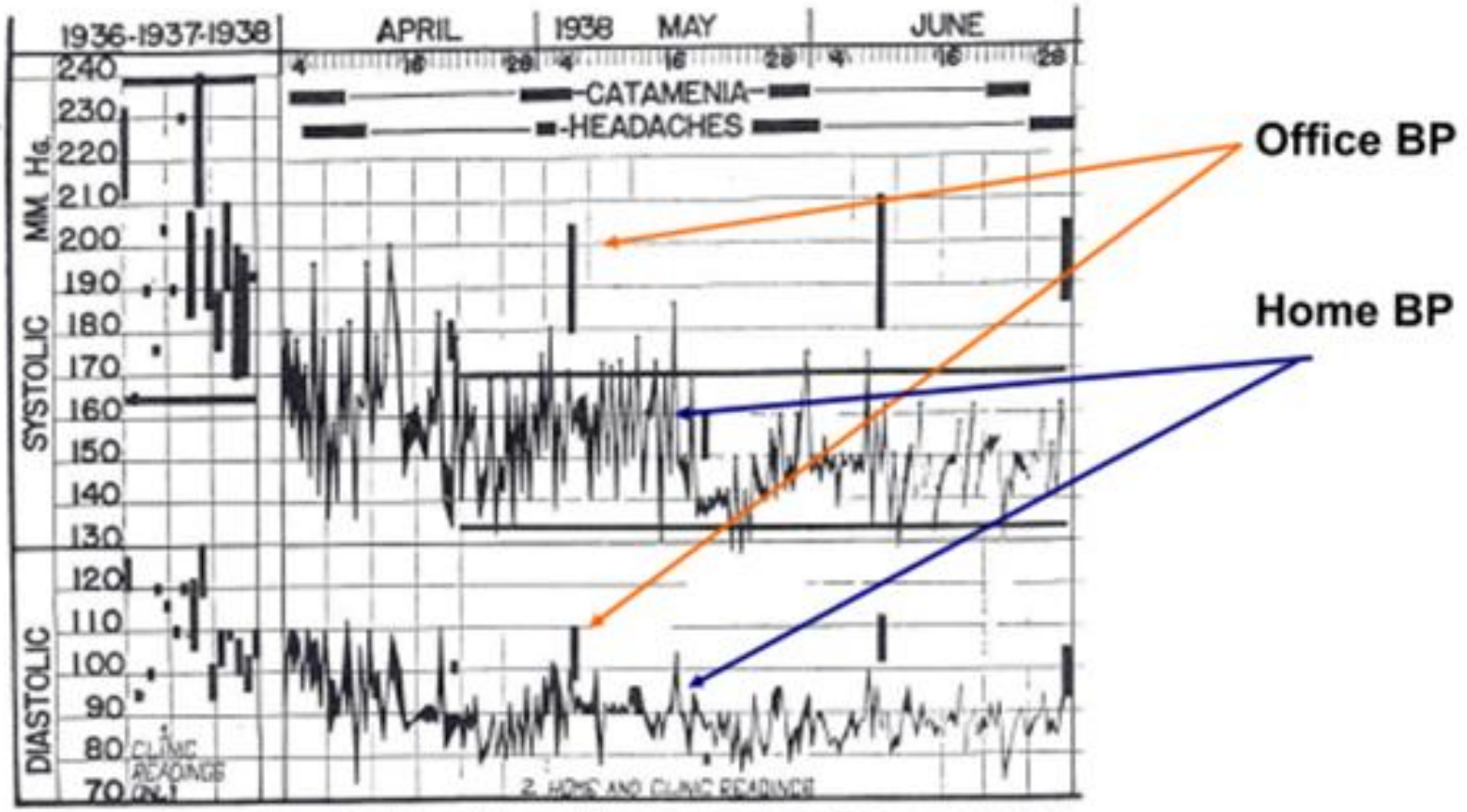
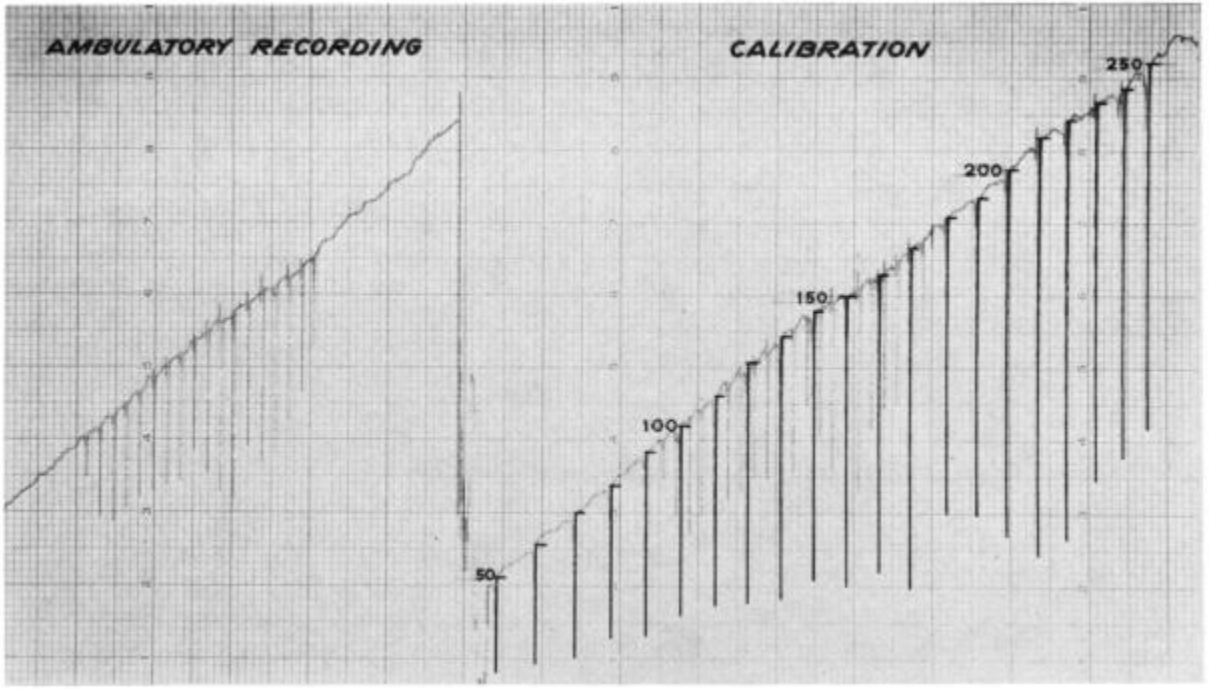


FIG. 1.—Comparison of clinic and home blood pressure readings in a patient with essential hypertension.

Am J Med Sci 1940;200:465.

ABPM ; more than 40 yrs ago



Circulation 1964;30:882-92.

Factors affect the BP measurement result

Aspect	Different approaches affecting the BP assessment
Setting	Office, work, ambulatory, home
Time	Daytime, nighttime, nocturnal dip, morning, evening, morning surge, postprandial
Observer	Doctor, nurse, technician, relative, self-measurement, automated
Device	Mercury, aneroid, hybrid, oscillometric
Posture	Basal, lying, seated, standing, exercise
Reading	First reading, first day, first visit, several measurements
Calculation	Average, variability, reactivity, maximum

Hypertension 2011;57:1041-2.

Definitions

Usual blood pressure

The theoretical true underlying level of blood pressure, which cannot be measured with total precision, but which is widely considered to be the most important component of blood pressure, determining its adverse effects and accounting for the benefits of antihypertensive drugs. Risk relations between measurements of blood pressure and risk of vascular events can be corrected for inaccuracy in estimation of usual blood pressure by adjustment for regression-dilution bias.[5,6]

Mean blood pressure

The average of several readings of either systolic or diastolic blood pressure (as opposed to mean arterial pressure). Readings can be derived from several clinic vists, home measurement, or ambulatory monitoring, although all these techniques will result in different values. Modelling studies show that at least seven to ten measurements of blood pressure on different clinic visits (and ideally many more) are needed for mean blood pressure to be an accurate estimate of usual blood pressure.[7]

Blood-pressure variability

The variation in blood pressure with time, either the overall variability during a period of time (SD or coefficient of variation), with or without adjustment for time trends in underlying mean blood pressure (residual SD), or the average absolute difference between adjacent readings (successive variation).[7,8] Variability has mainly been studied during periods of hours on ambulatory monitoring, but can also be measured over minutes during a clinic visit, or over days, weeks, and months with home measurements or repeated clinic visits (webappendix pp 5–9). These approaches yield different estimates of variabilty, which are only partly correlated,[7] and which might have different primary determinants. Extent of variability is usually positively associated with mean blood pressure, but independent transformations can be generated.[7] Measurements of variability in blood pressure are generally less precise than are estimates of usual blood pressure, and risk relations could in theory be adjusted for error in estimation of usual variability.

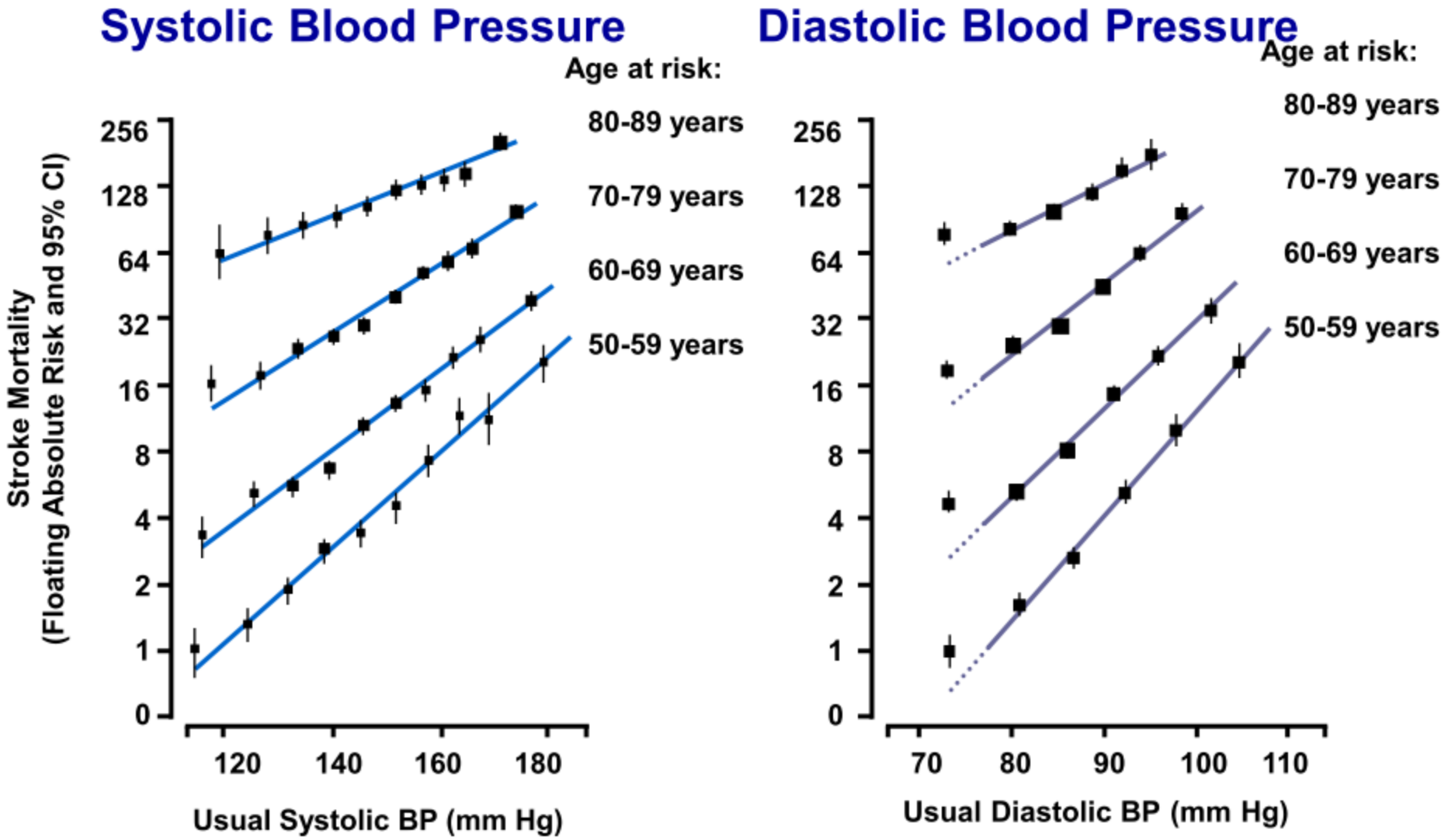
Blood-pressure instability

Describes transient fluctuations in blood pressure, usually in response to a specific stimulus, such as change in posture, emotional stress, or pain. Instability contributes to overall variability and will often have similar clinical associations, such as arterial stiffness and baroreceptor dysfunction. However, instability differs from variability in that it refers specifically to sudden changes in blood pressure, the consequences of which might differ from more gradual fluctuations.

Lancet 2010;375:938-48.

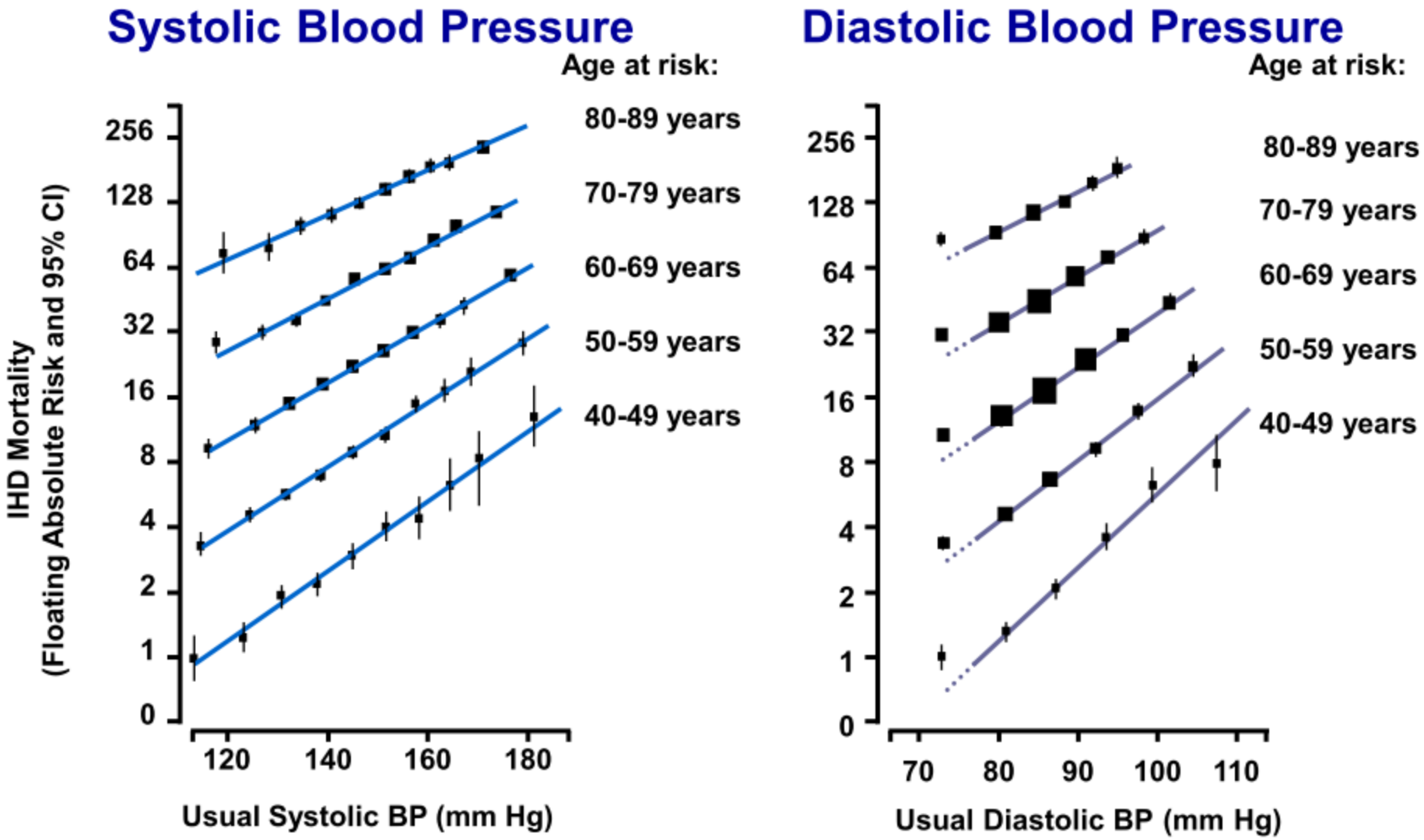
HIGH BP MEASURED IN THE DOCTOR'S OFFICE

Stroke mortality linked to BP levels : meta-analysis of 61 prospective studies



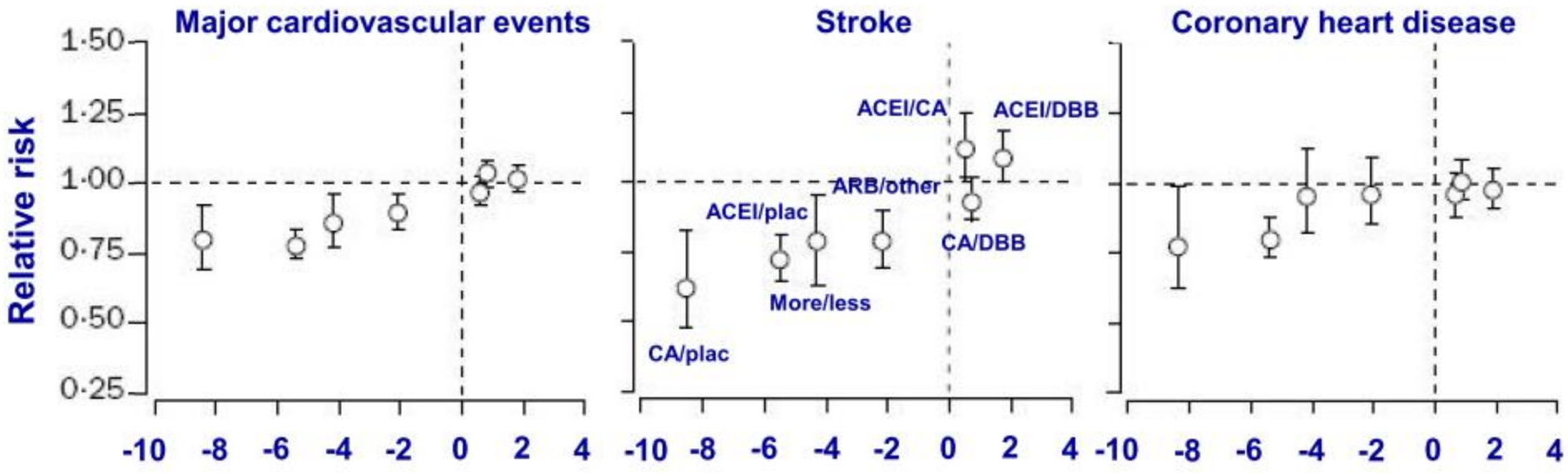
Prospective Studies Collaboration. Lancet 2002;360:1903-13.

IHD mortality linked to BP levels : meta-analysis of 61 prospective studies



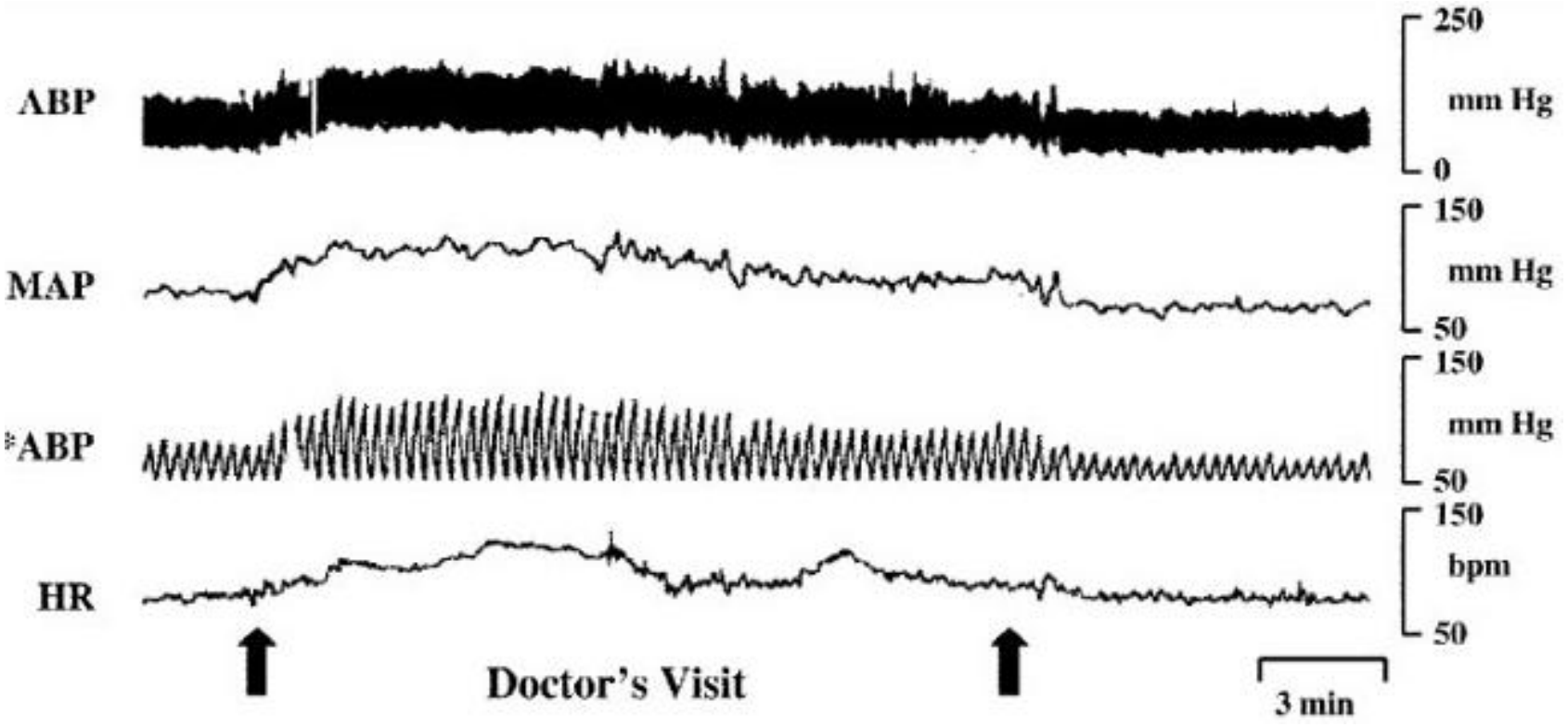
Prospective Studies Collaboration. Lancet 2002;360:1903-13.

Clear benefit with more BP lowering
Prospective meta-analysis of 15 trials



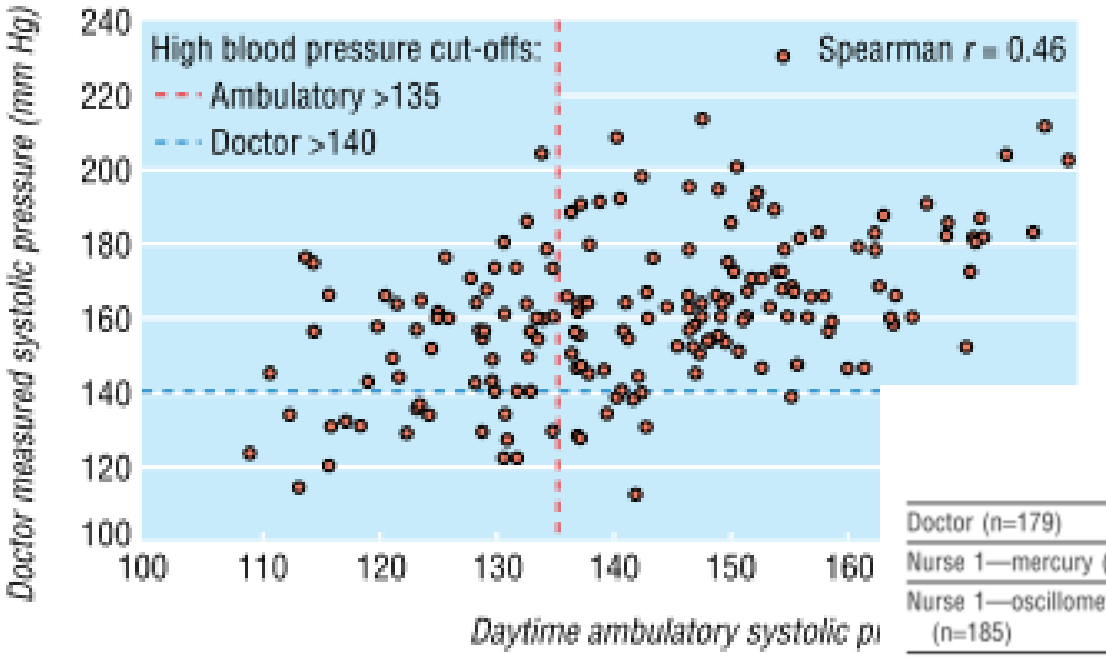
Blood Pressure Lowering Treatment Trialists' Collaboration. Lancet 2000;356:1955-1964.

Major problems associated with conventional clinic BP measurement



Lancet 1983;2:695-8.

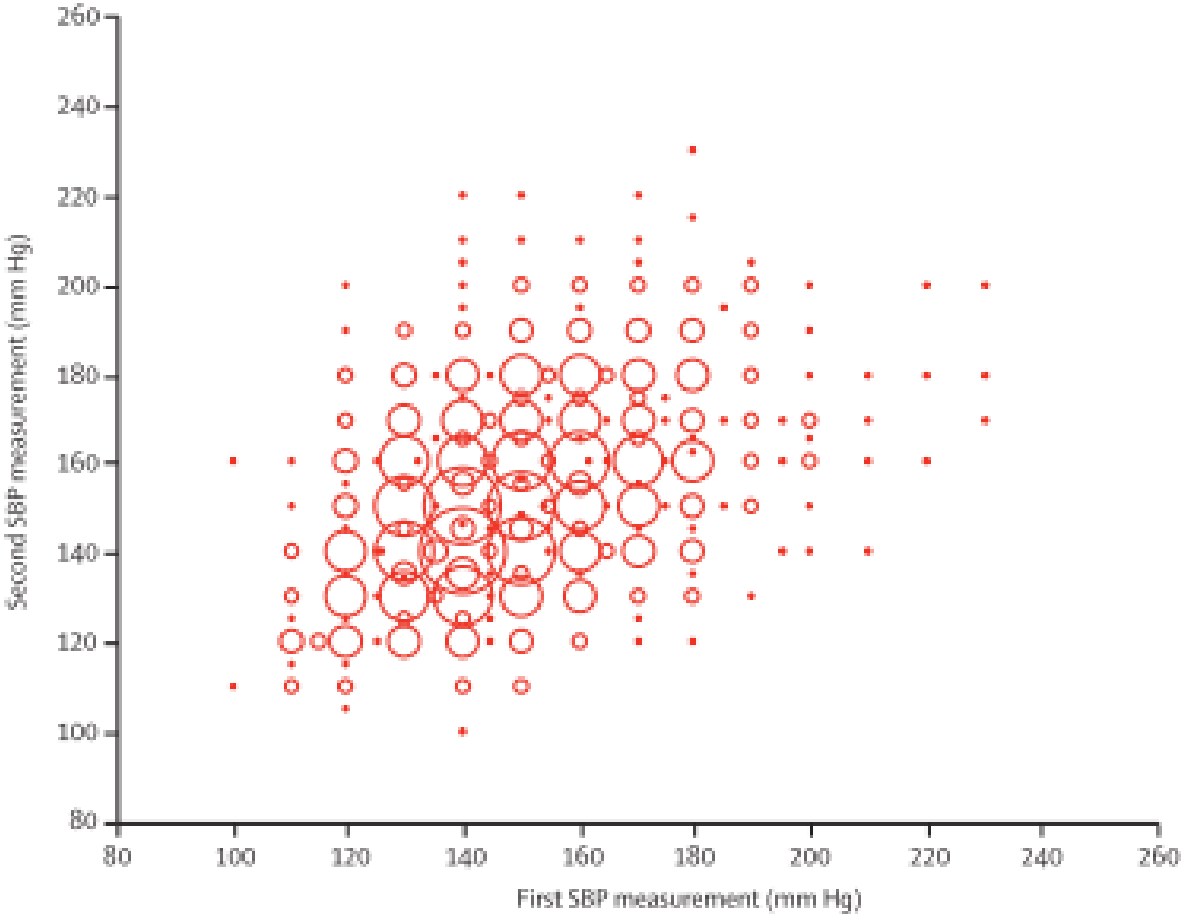
OBP vs. ABP and HBP



	Systolic pressure		
	Mean difference (95% CI)	Standard deviation	Scatter plot *r*
Doctor (n=179)	18.9 (16.1 to 21.7)	19.0	0.46
Nurse 1—mercury (n=194)	9.0 (6.8 to 11.3)	16.1	0.48
Nurse 1—oscillometric (n=185)	7.6 (5.3 to 9.8)	15.6	0.52
Nurse 2—mercury (n=193)	5.2 (2.9 to 7.5)	16.2	0.60
Nurse 2—oscillometric (n=190)	3.9 (1.8 to 6.1)	15.2	0.63
Self measurement in surgery 1 (n=59)	9.8 (5.9 to 13.0)	15.0	0.63
Self measurement in surgery 2 (n=52)	7.4 (3.9 to 10.9)	12.5	0.73
Home measurement (n=190)	4.6 (2.7 to 6.4)	12.8	0.75
Last three clinic measurements (n=182)	19.9 (17.6 to 22.1)	15.5	0.47

BMJ 2002;325:254-8.

SBP at one clinic visit versus the next visit



Stroke 2006;37:2776-83.

AVERAGE(MEAN) BP

Mean BP and usual BP

Modeling studies show that at least seven to ten measurements of blood pressure on different clinic visits(and ideally many more) are needed for mean blood pressure to be an accurate estimate of usual blood pressure.

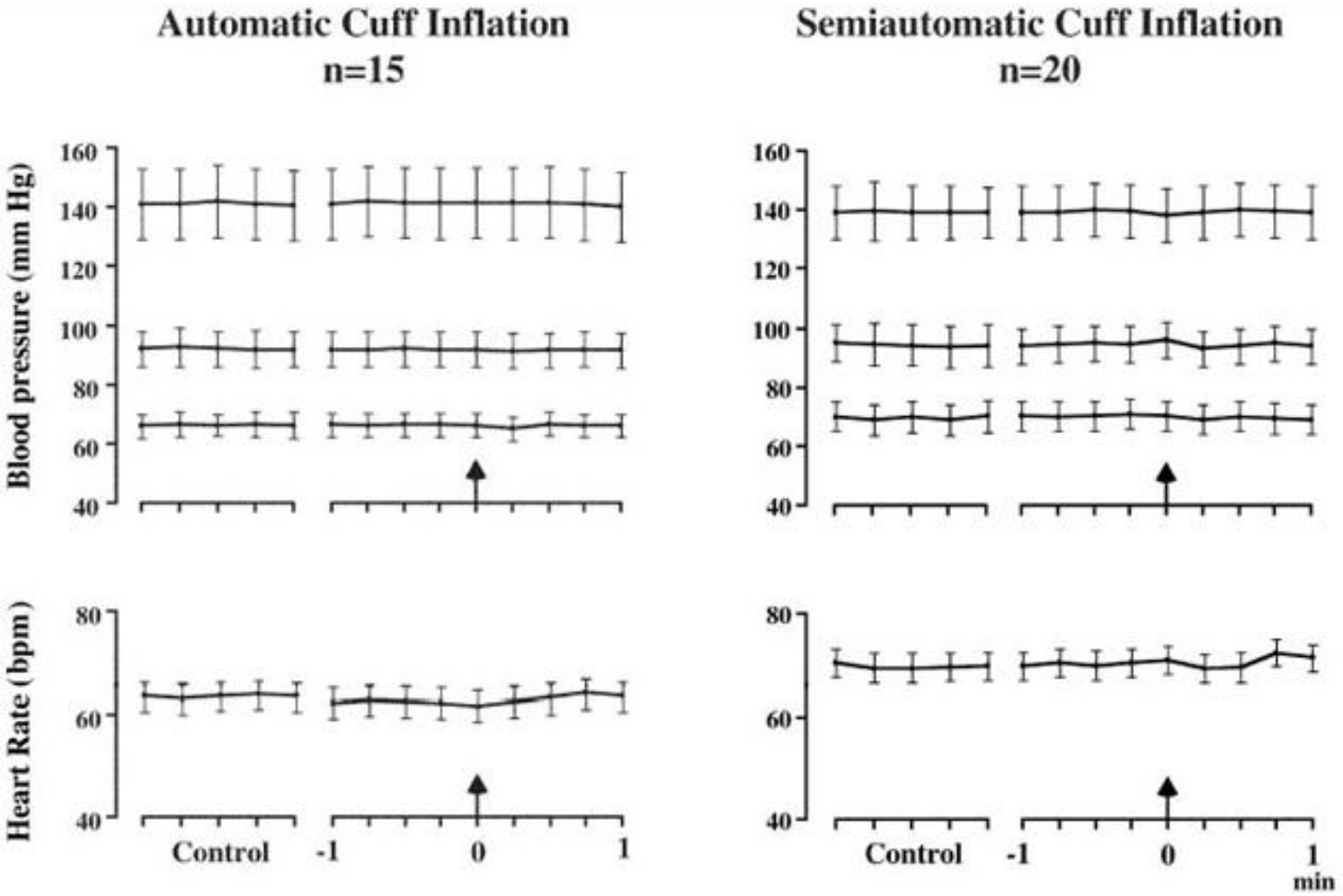
	HR for mean SBP		HR for variability in SBP	
	HR (95% CI)	p value	HR (95% CI)	p value
SD SBP				
Two readings	2·44 (1·53–3·89)	<0·0001	1·15 (0·73–1·81)	0·55
Four readings	2·44 (1·39–4·29)	0·002	1·51 (0·86–2·66)	0·16
Six readings	2·49 (1·24–4·97)	0·01	2·02 (0·97–4·22)	0·061
Eight readings	1·85 (0·84–4·10)	0·13	6·01 (1·72–20·96)	0·005
Ten readings	1·44 (0·58–3·57)	0·43	13·04 (1·66–102·6)	0·015
CV SBP				
Two readings	2·67 (1·74–4·11)	<0·0001	1·09 (0·73–1·62)	0·67
Four readings	2·82 (1·67–4·76)	<0·0001	1·50 (0·90–2·48)	0·12
Six readings	3·07 (1·62–5·83)	0·001	1·98 (1·05–3·77)	0·036
Eight readings	2·68 (1·29–5·56)	0·008	5·00 (1·75–14·30)	0·003
Ten readings	2·26 (0·98–5·17)	0·055	13·05 (1·74–97·66)	0·012
VIM SBP				
Two readings	2·86 (1·88–4·36)	<0·0001	1·25 (0·86–1·82)	0·25
Four readings	3·18 (1·90–5·33)	<0·0001	1·59 (1·00–2·54)	0·053
Six readings	3·70 (1·97–6·94)	<0·0001	2·31 (1·26–4·23)	0·007
Eight readings	3·70 (1·81–7·56)	<0·0001	6·04 (2·14–17·03)	0·001
Ten readings	3·31 (1·46–7·47)	0·004	15·35 (2·08–113·1)	0·007

Every row shows the estimates from a Cox model applied to data from patients who survived for at least n follow-up visits, where n ranges from 2 (3 months) to 10 (3 years). Quintiles were used rather than deciles to provide sufficient group sizes to extend the analysis to ten blood-pressure readings. SBP=systolic blood pressure. HR=hazard ratio. CV=coefficient of variation. VIM=variation independent of mean.

Table 1: **Hazard ratios (top *vs* bottom quintile) for risk of subsequent stroke (ie, after the measurement period) in the UK-TIA trial from a model combining mean SBP and visit-to-visit variability in SBP (SD or CV or VIM), repeated with increasingly precise estimates of both variables**

Lancet 2010;375:895-905.

WCE is not due to arm cuff inflation per se, but to the presence of a physician performing the measurement



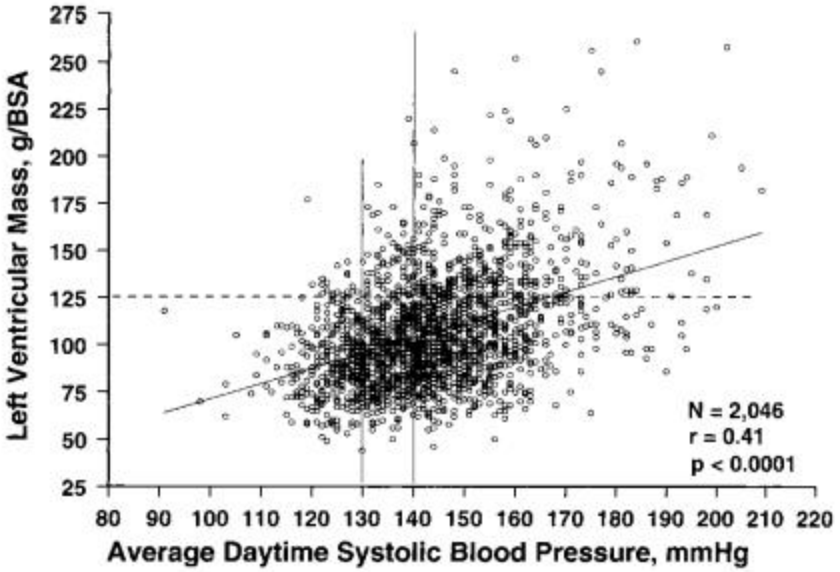
Hypertension 1985;7:597-601.

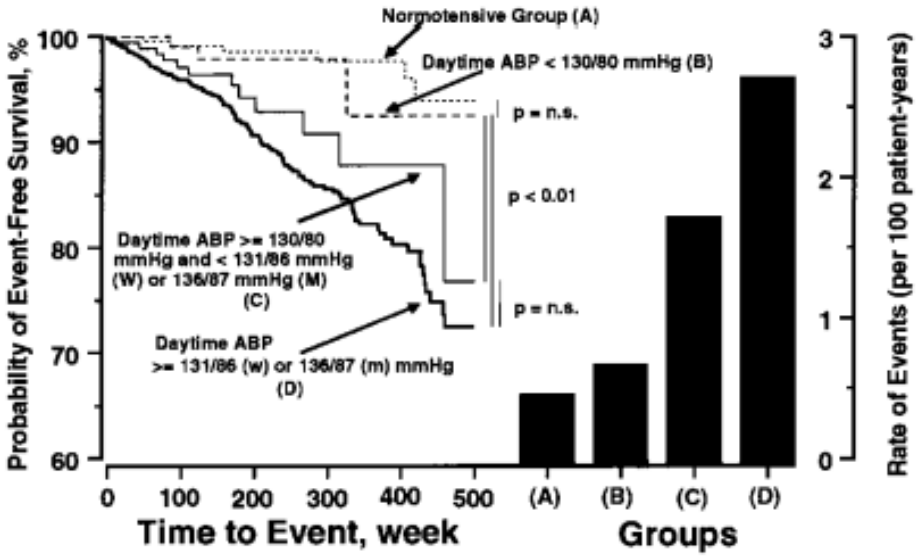
ABP is lower than OBP

	Classification of patients						P-value (by χ2 test)
	Normotension	Masked hypertension		White coat hypertension		Sustained hypertension	
	n=2901	n=1172		n=5522		n=8791	
Age	49±15	52±14	***	53±15	***††	53±13	***††
Male, %	46.5	59.5		47.4		60.9	<0.001
Body mass index, kg/m²	27.3±4.7	27.4±4.2		28.1±4.6	***†††	28.0±4.3	***†††
Smoking, %	19.7	22.3		17.1		22.4	<0.001
Diabetes mellitus, %	13.2	10.4		10.7		10.4	<0.001
Dislipidemia, %	26.4	27.3		30.5		29.3	<0.001
Renal insufficiency, %	0.6	0.3		0.3		0.4	0.237
Cardiovascular disease, %	2.8	2.9		1.9		2.1	0.021
Clinic SBP	125±10	129±7.9	***	150±12	***†††	154±15	***†††‡‡‡
Clinic DBP	78±7.8	80±7/2	***	90±12	***†††	94±13	***†††‡‡‡
Clinic PR	75±12	75±12		77±13	***†††	77±13	***†††
24hr SBP	116±7.4	132±10	***	120±6.6	***†††	137±11	***†††‡‡‡
24hr DBP	71±5.8	82±6.9	***	72±5.7	***†††	84±8.4	***†††‡‡‡
24hr PR	72±9/0	74±9.5	***	71±9.5	*†††	74±9.7	***‡‡‡
Daytime SBP	121±8.6	137±11	***	125±7.9	***†††	142±11	***†††‡‡‡
Daytime DBP	75±6.9	86±8.1	***	77±7.0	***†††	88±9.4	***†††‡‡‡
Daytime PR	77±10	78±11	***	76±11	*†††	78±11	***‡‡‡
Nighttime SBP	108±9.3	123±13	***	110±.1	***†††	126±14	***†††‡‡‡
Nighttime DBP	62±6.7	73±8.1	***	63±6.5	†††	74±9.3	***†††‡‡‡
Nighttime PR	64±9.1	67±9.9	***	64±9.4	†††	66±9.7	***‡‡‡

J Hypertens 2010;28:e78.

Prognostic value of ABP
; 9 event-based cohort studies



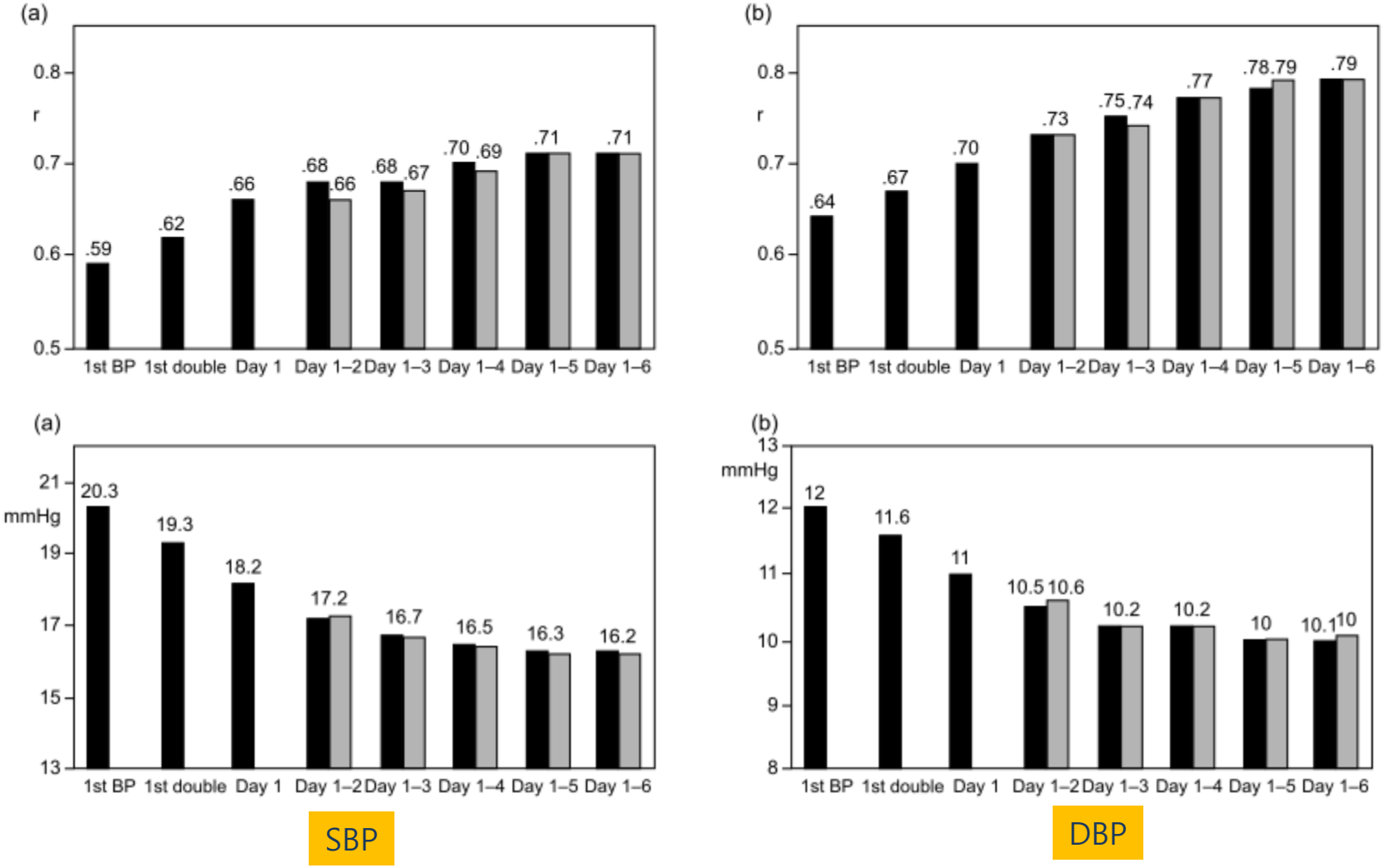


Hazard ratio per 10 mmHg increase of 24-h SBP was 1.27.
Hazard ratio per 10 mmHg increase of daytime SBP was 1.17.
Several studies did not provide effect estimates for DBP.

Hypertension 2000;35:844-51.
J Hypertens 2008;26:1290-9.

Number of HBPM needed to ensure a reliable estimate of true BP

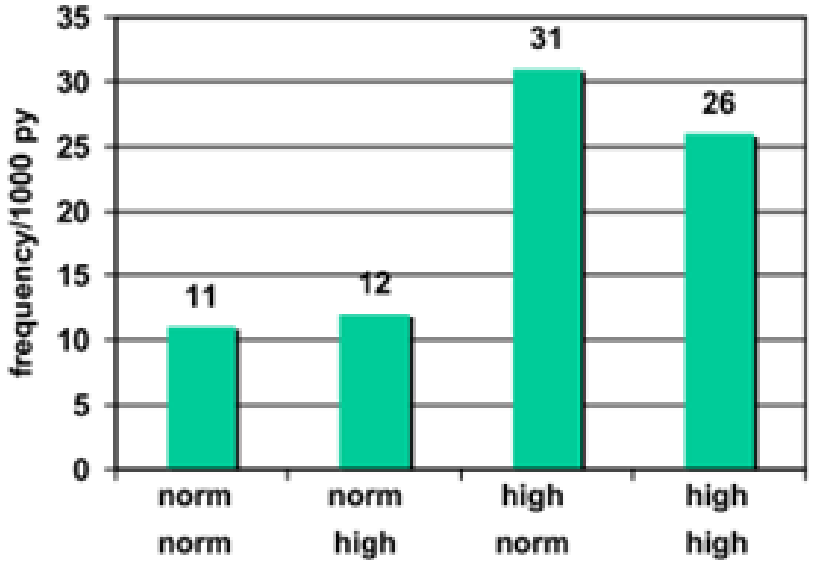
The relationship of HBP with daytime ABP (correlation coefficient *r*)



J Hypertens 1998;16:725-31.

Frequency of CV events according to OBP and HBP levels

Normal home BP <135/85 mmHg, normal office BP <140/90 mmHg



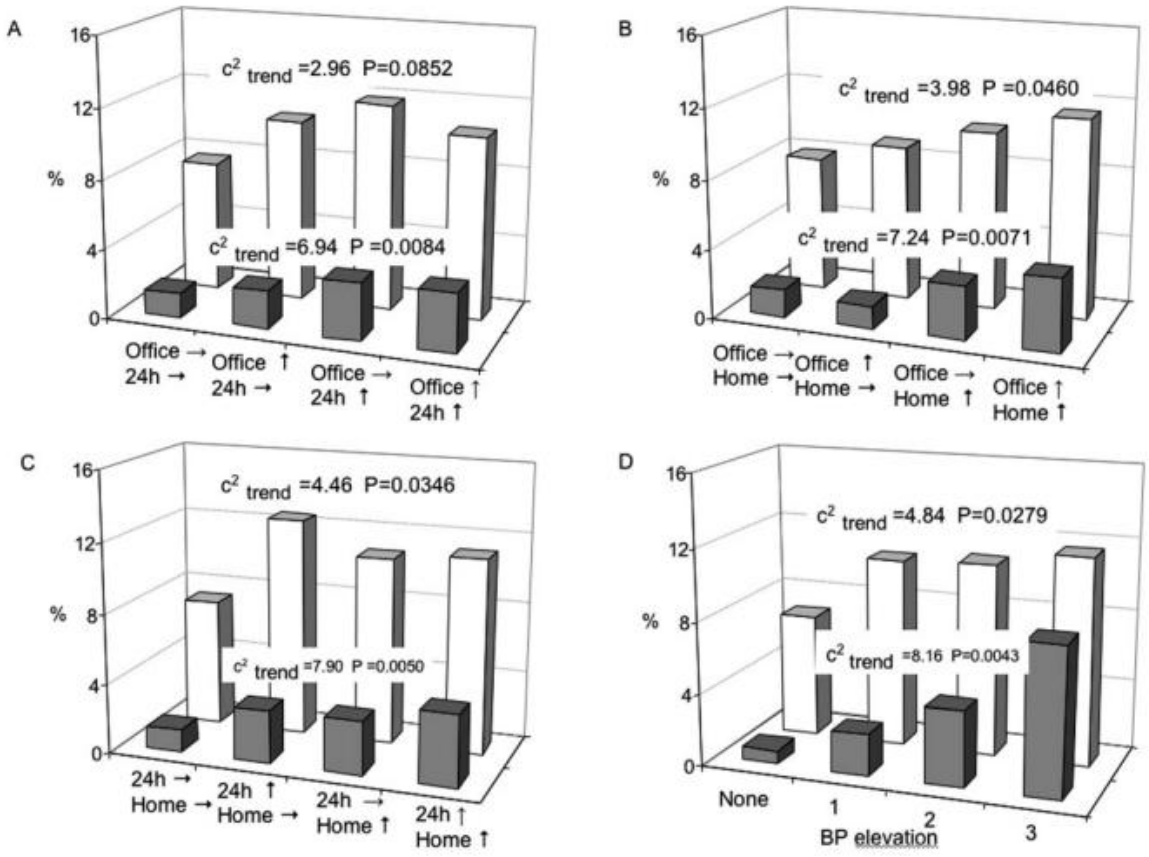
Study	Population Studied	No. of Subjects	Days	AM	PM	Total	Outcome
Ohasama[81]	Population	1789	28	1	0	28	Strokes and mortality predicted better by HBPM
SHEAF[99]	Treated hypertensive patients	4939	4	3	3	24	CV morbidity and mortality predicted better by HBPM
PAMELA[82]	Population	2051	1	1	1	2	CV and total mortality predicted better by HBPM
Belgian[100]	Referred	391	1	3	0	3	Combined CV events predicted better by HBPM
Didima[98]	Population	662	3	2	2	12	CV events predicted by both HBPM and office BP

CV indicates cardiovascular.

SHEAF study. JAMA 2004;291:11342.

2008 AHA/ASH guideline. Hypertension 2008;52:10-29.

PAMELA study

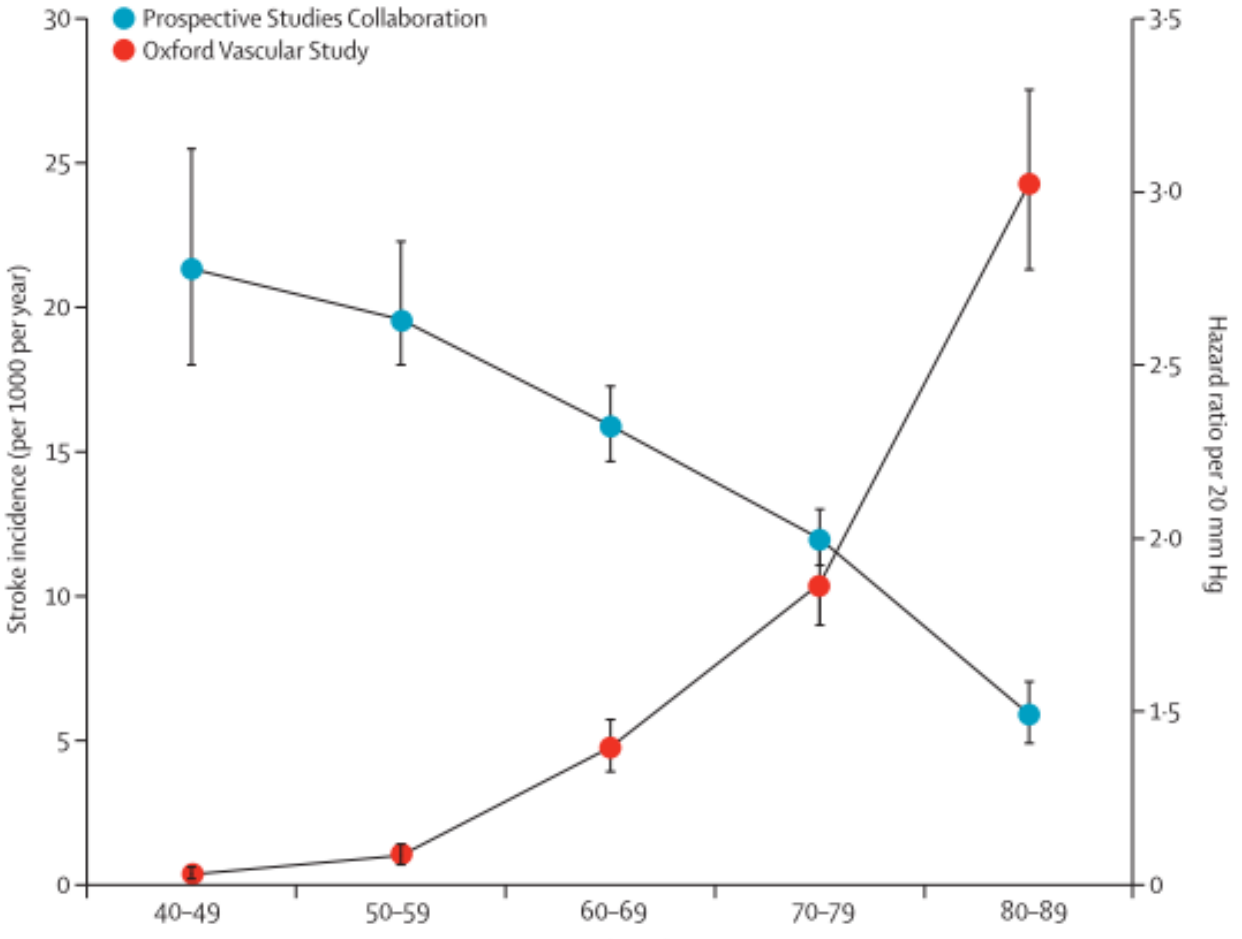


SBP level of a CV death risk over 11 yrs of 10%

- 179 mmHg for OBP
- 163 mmHg for HBP
- 157 mmHg for ABP(daytime)

Hypertension 2006;47:846-53.

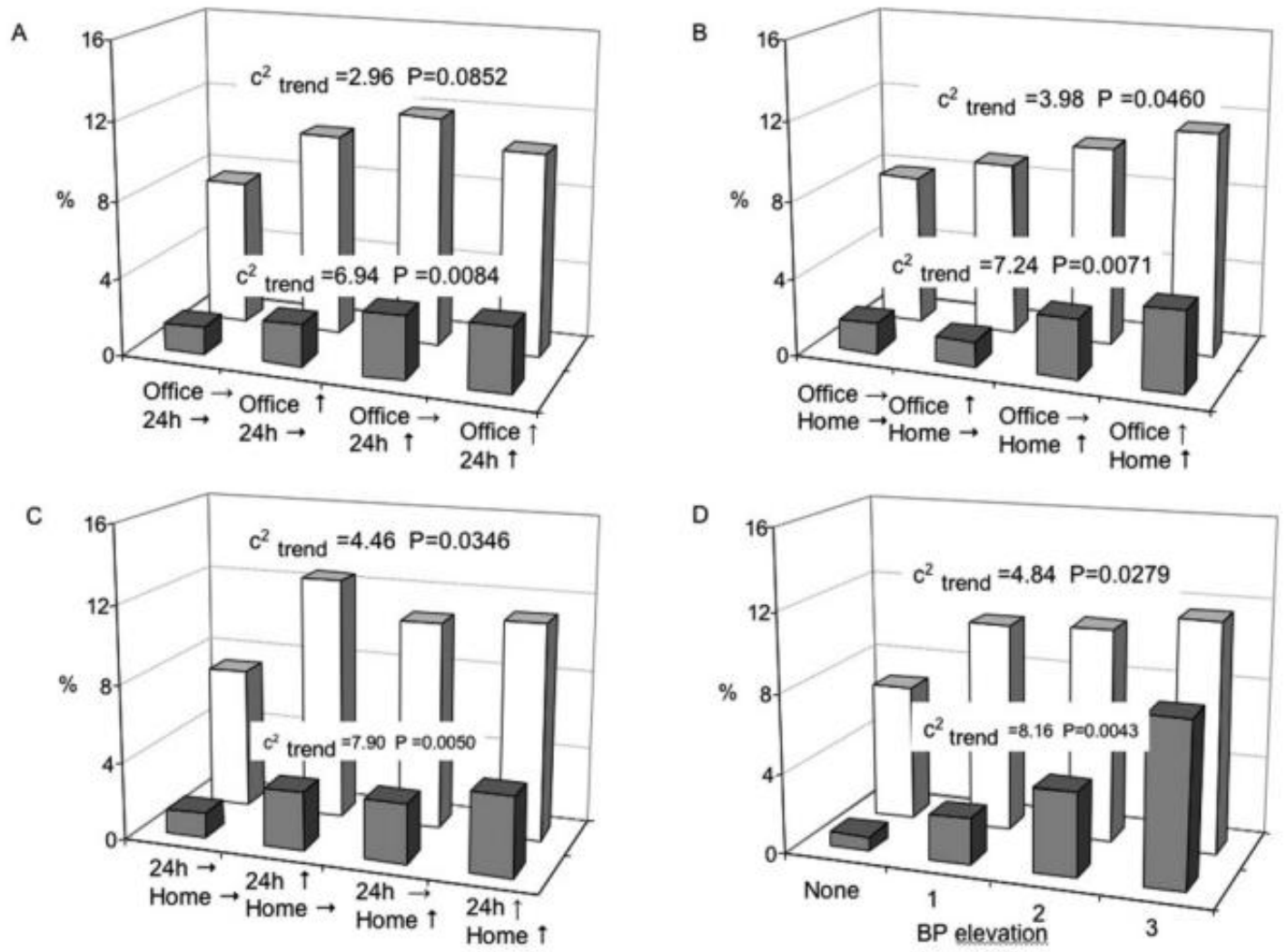
Predictive value of estimated usual BP falls with age ; Prospective Studies Collaboration



Mean BP is a very powerful risk factor for vascular events, but…

Hypertension 2006;47:846-53.

WCH and MH are not prognostic innocent
; PAMELA study



Hypertension 2006;47:846-53.

High BPV and mean BP

	UK trial	Dutch trial	Pooled*
Patients with low visit-to-visit variability†			
Unadjusted baseline SBP	1·58 (1·25–2·00)	1·35 (0·99–1·85)	1·50 (1·24–1·80)
Estimated usual SBP‡	1·93 (1·38–2·70)	1·60 (0·98–2·61)	1·82 (1·38–2·40)
Actual mean SBP§	1·72 (1·25–2·35)	1·68 (1·18–2·39)	1·70 (1·35–2·15)
Patients with high visit-to-visit variability‡			
Unadjusted baseline SBP	1·30 (1·11–1·52)	1·15 (0·95–1·40)	1·24 (1·09–1·40)
Estimated usual SBP‡	2·83 (1·51–5·30)	4·06 (0·57–28·8)	2·93 (1·61–5·32)¶
Actual mean SBP§	1·27 (1·00–1·61)	1·08 (0·76–1·54)	1·21 (1·00–1·47)¶

Data are hazard ratio (95% CI). Stroke risk calculation included all strokes after the measurement period (ie, after seventh follow-up visit); however, results were very similar when analysis also included events during and after the measurement period. SBP=systolic blood pressure. TIA=transient ischaemic attack. *Based on fixed-effect meta-analysis of the two trials. †Low variability includes patients with median variability or lower, and high those greater than the median; within-individual visit-to-visit variability is expressed as a transformation of the SD of measurements made at seven consecutive visits, which is uncorrelated with mean SBP.[7] ‡Calculated by adjustment of baseline SBP for regression-dilution bias, with regression-dilution ratios of 0·42 (all patients), 0·70 (low variability), and 0·25 (high variability) in the UK trial and 0·38, 0·64, and 0·10, respectively, in the Dutch trial; ratios were calculated from the baseline measurement and the visit 7 (2-year) measurement. §Based on measurements of SBP made at the first seven consecutive follow-up visits. ¶ p value for comparison of difference between hazard ratios was 0·006.

Lancet 2010;375:895-905.

BLOOD PRESSURE VARIABILITY

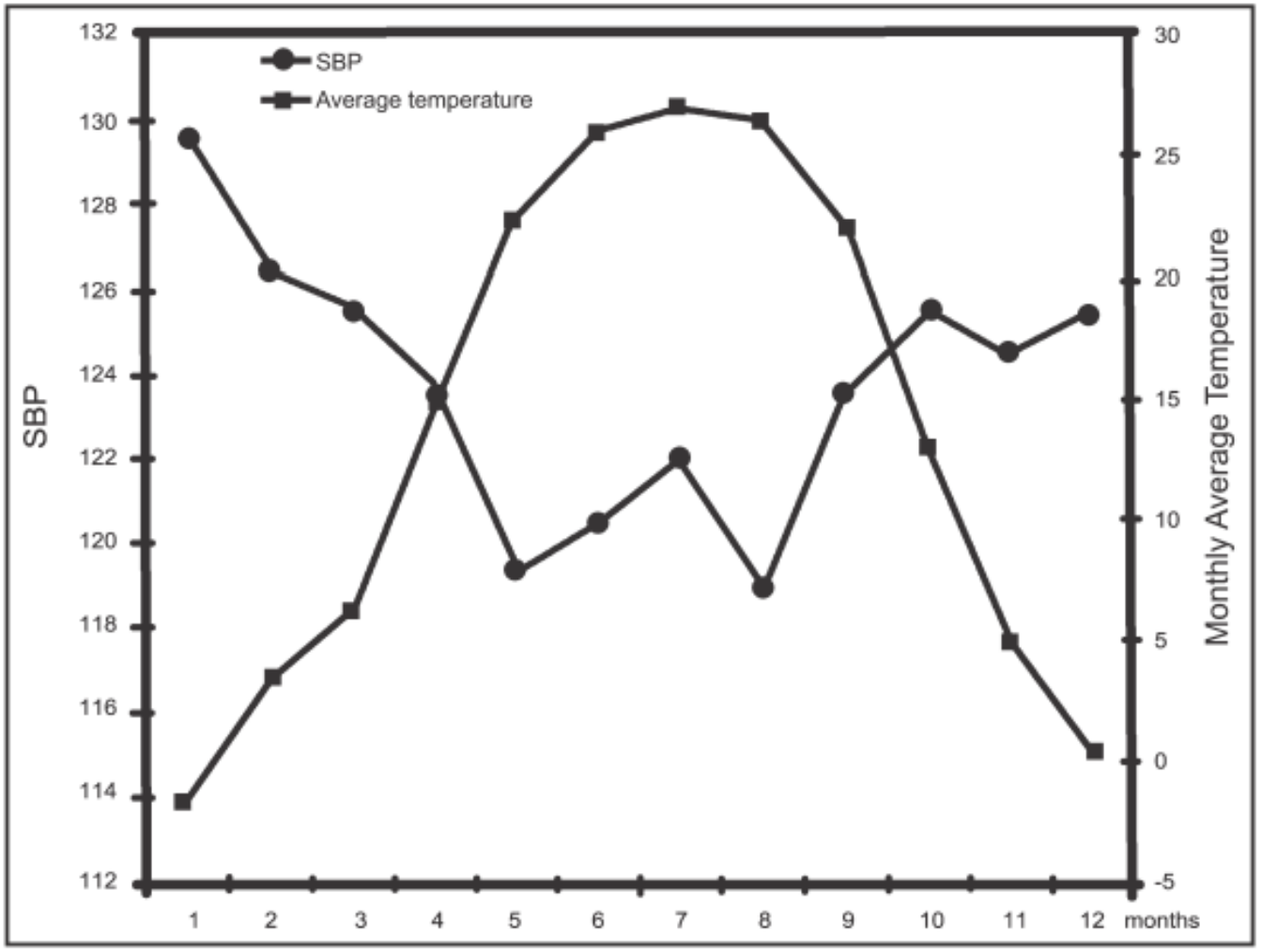
Measures of BP Variability, Instability, and Reativity

Variability	Short term: reading-to-reading (ambulatory monitoring)* Medium term: day-to-day (home monitoring)* Long term: visit-to-visit (office measurements)*
Instability	Maximum BP: office, home, ambulatory monitoring* Morning BP surge: ambulatory monitoring*
Reactivity	Physical tests: isometric or isotonic exercise testing,* cold pressor test, tec Mental tests: arithmetic task, reaction time task, psychologic and emotional challenges, mental stressor test, etc

may carry different clinical implications still poorly understood…

Hypertension 2011;57:1041-2.

Seasonal BPV



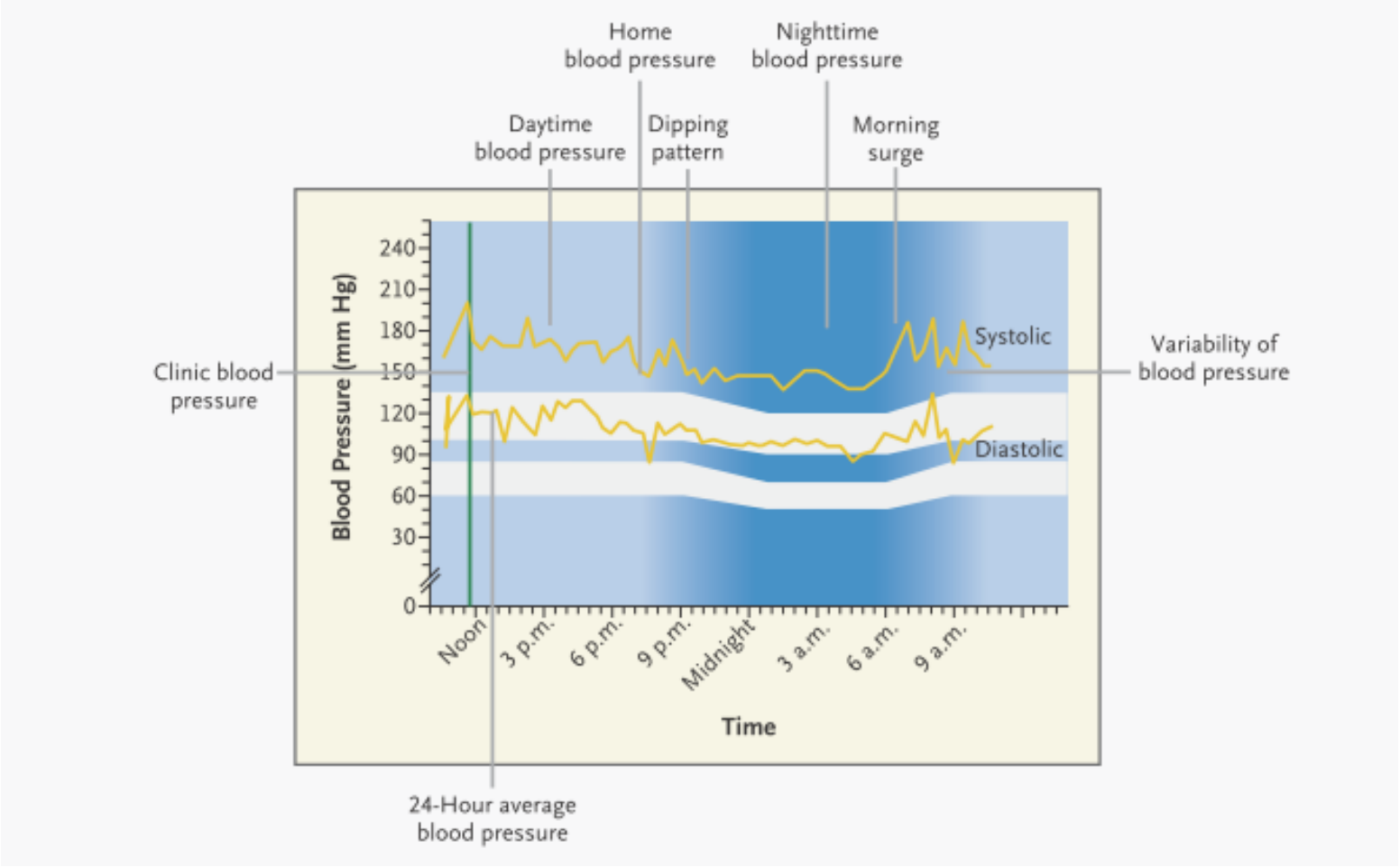
Clin Nephrol 2010;73:216-20.

Factors associated with BPV

- Average BP levels
- Heart rate
- Temperature
- Diabetes
- Smoking
- Increasing age
- Presence of vascular diseases (stiffness)
- Poor compliance with antihypertensives
  - Subclinical cerebral ischemia
  - Increased arterial stiffness
  - Impaired baroreceptor

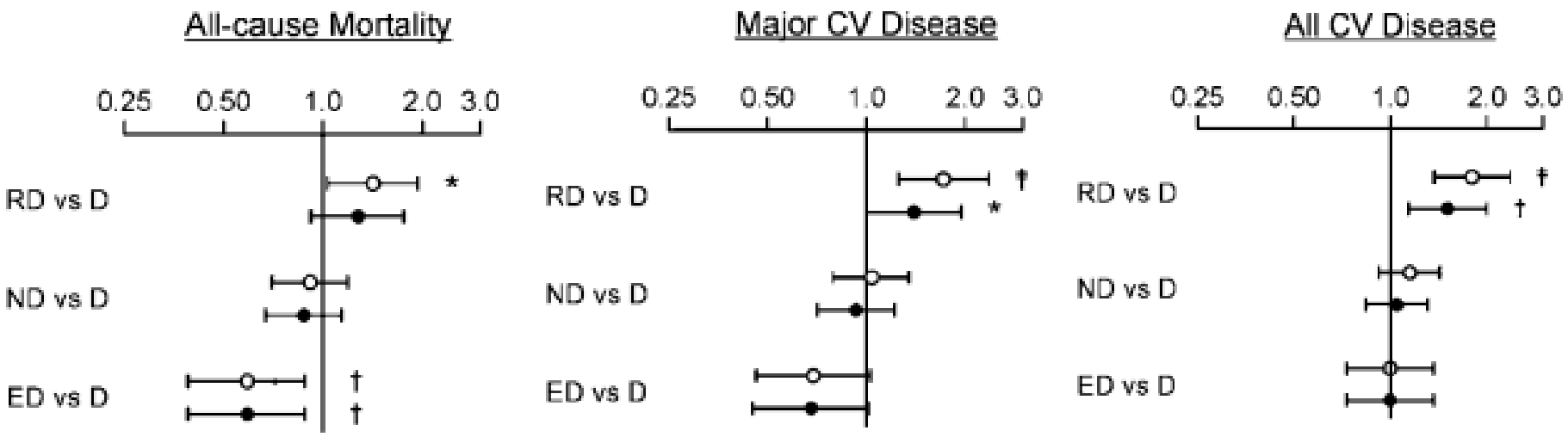
Circ Res 1971;29:424.
Cerebrovasc Dis 1997;7:214-19.
Lancet 2010;375:906-15.

BPV by ABPM
; short-term variability



NEJM 2006;354:2368-74.

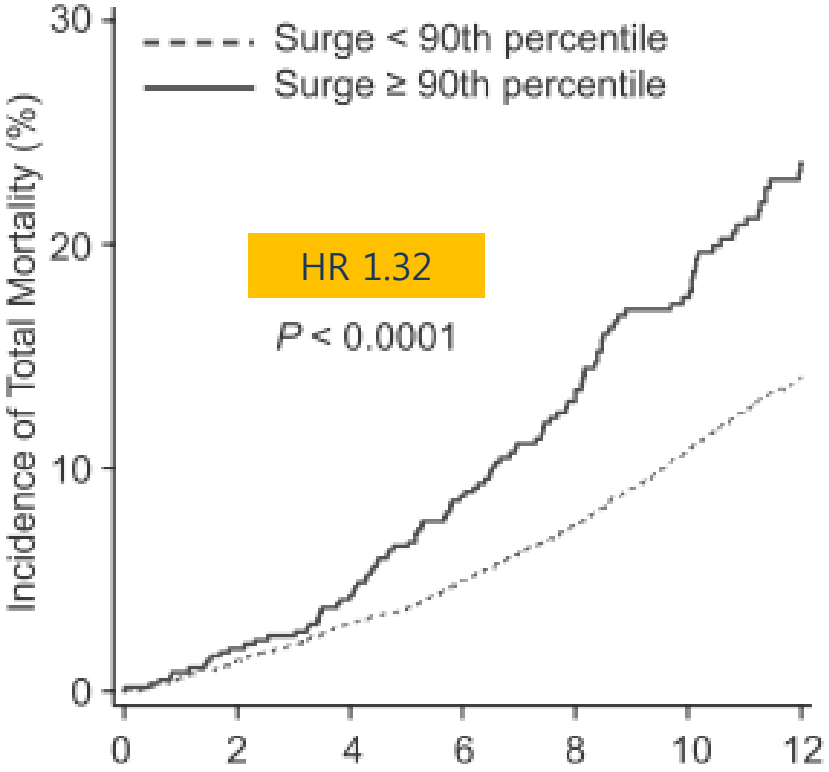
Dipping pattern and CV outcomes
; meta-analysis from 4 prospective studies

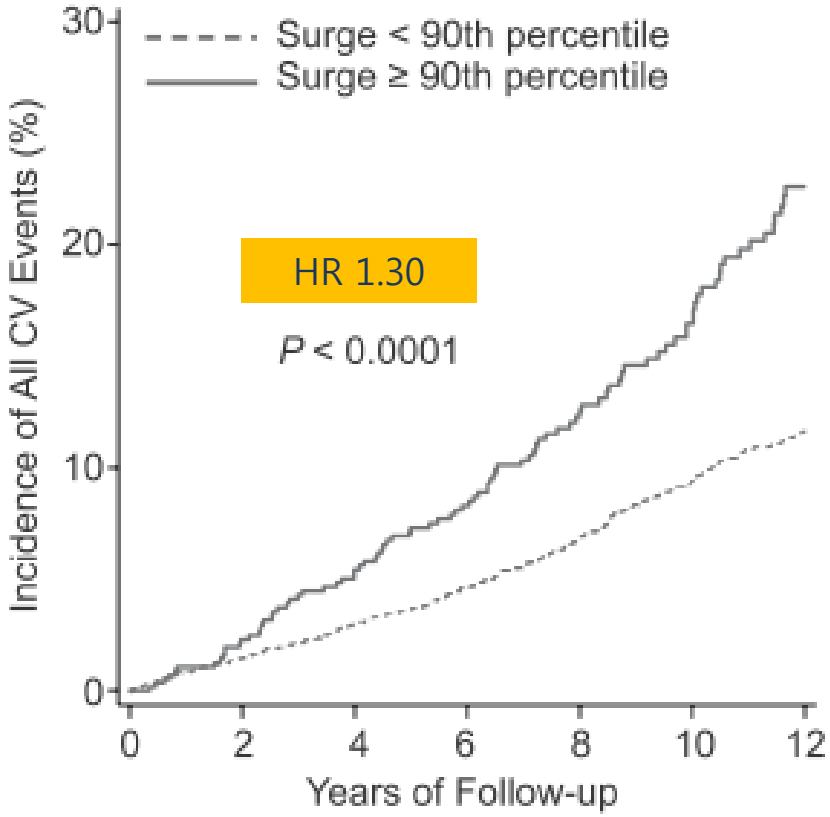


Physiologic variation of BP(nocturnal dipping)

J Hum Hypertens 2009;23:645-53.

Morning surge and CV events
; 5645 subjects from 8 populations (ABP)





Pathologic variation of BP(EMBPS)

Hypertension 2010;55:1040-8.

BPV in NT, WCH, MHT and SHT ; Spanish ABPM registry

Figure 3. Standard deviation of nighttime SBP for four groups

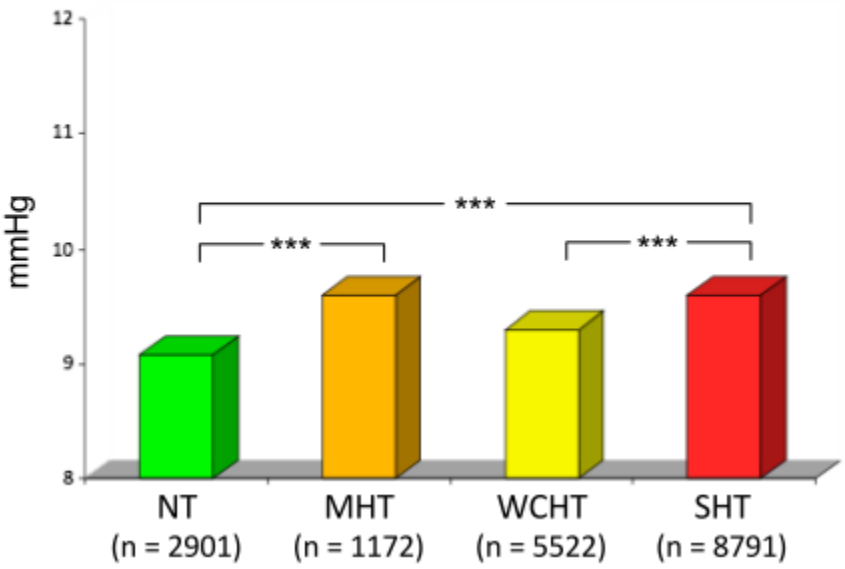
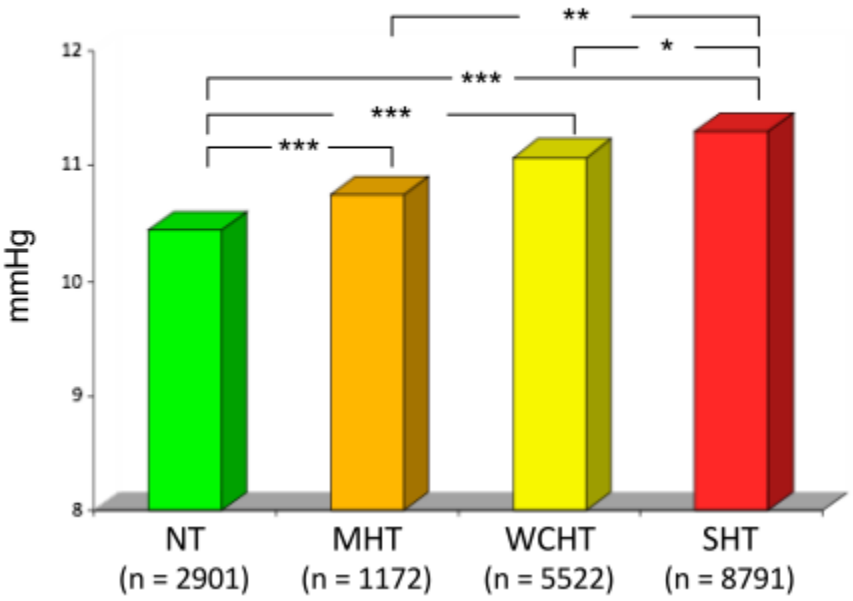


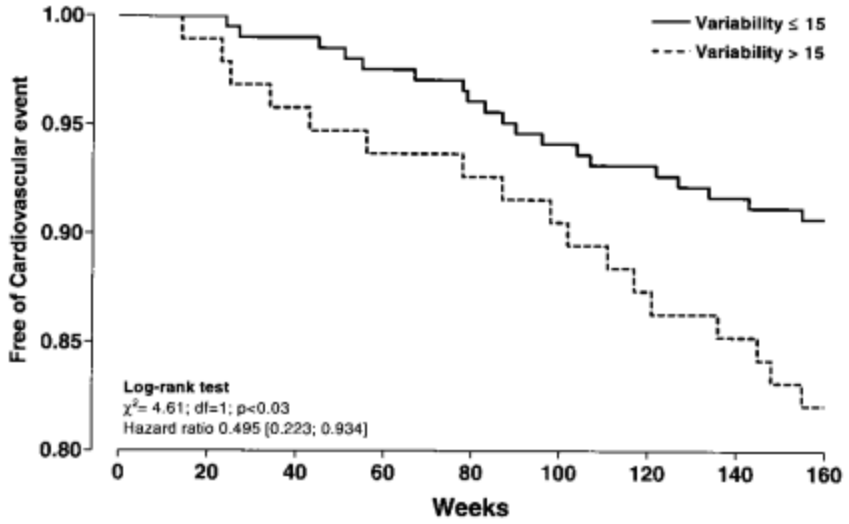
Figure 4. Standard deviation of daytime SBP for four groups



J Hypertens 2010;28:e78.

BPV(SBP;ABP) and carotid atherosclerosis
; independent of average BP

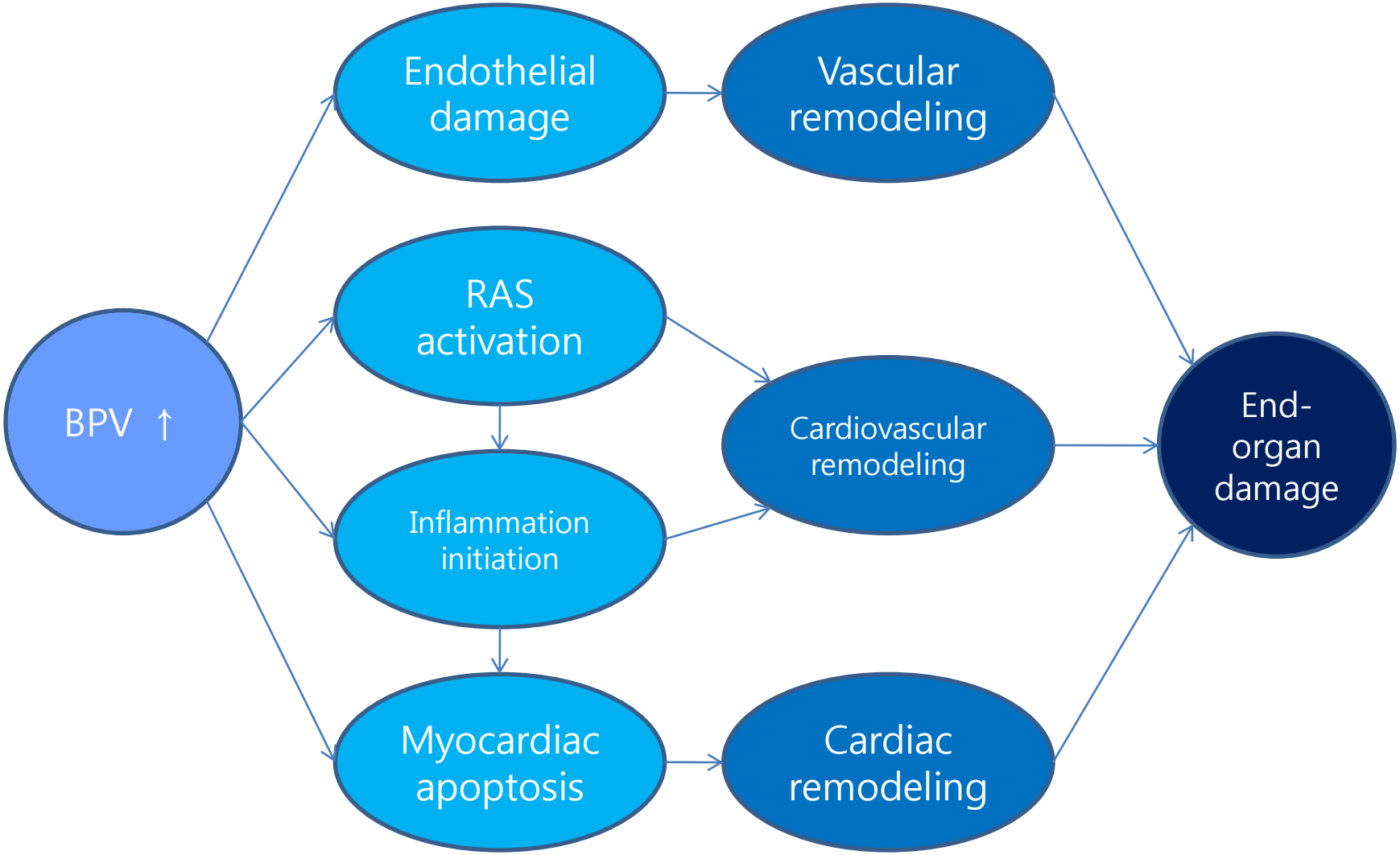
	Odds Ratio (95% CI)	*P*
Variability (>15 vs ≤15 mm Hg)	3.9 (1.4–11.1)	<0.01
Variation (nighttime blood pressure increase vs decrease)	1.27 (0.38–4.3)	NS
Blood pressure (hypertensive vs normotensive)	1.17 (0.55–2.07)	NS



Short-term BPV predict organ damage and CV events.

Circulation 2000;102:1536-41.

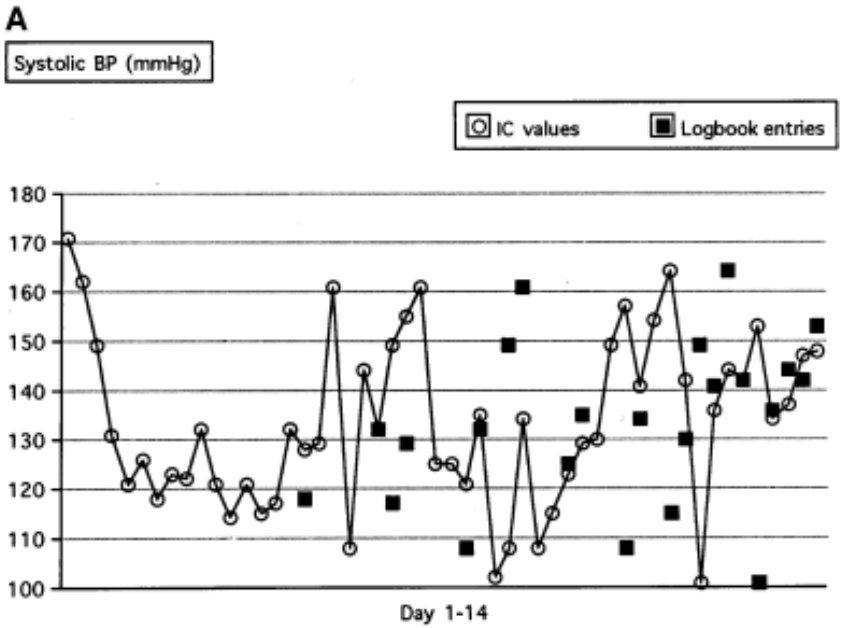
Possible mechanisms involved in high BPV-induced organ damage



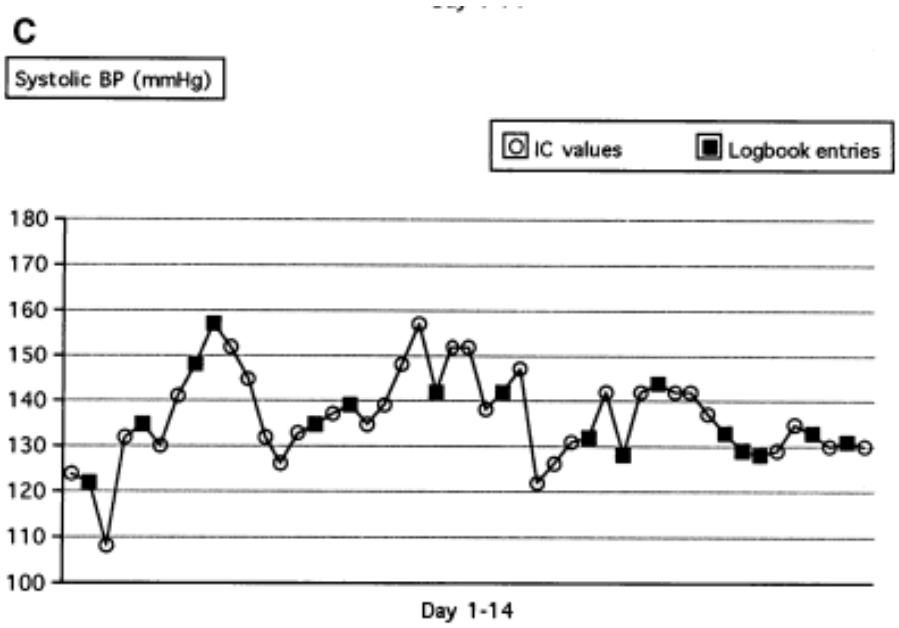
Curr Opin Cardiol 2006;21:486-91.

BPV by HBPM

; medium-term variability



Precision index of 0%
Under-reporting of 26%
Over-reporting of 5%



Precision index of 100%
Under-reporting of 65%

Am J Hypertens 1998;11:1413-7.

Reproducibility

Blood Pressure Measurement	Reproducibility Criteria	
	Test–Retest Correlation Coefficient (Systolic/Diastolic)	SD of Differences (Systolic/ Diastolic)
Clinic		
1 visit	0.77/0.76	11.0/6.6
Ambulatory		
24-H	0.80/0.84	8.3/5.6
Awake	0.74/0.80	10.0/6.6
Asleep	0.81/0.79	9.2/7.0
Home		
2 days	0.91/0.86	6.9/4.7

Am J Hypertens 2002;15:101-4.

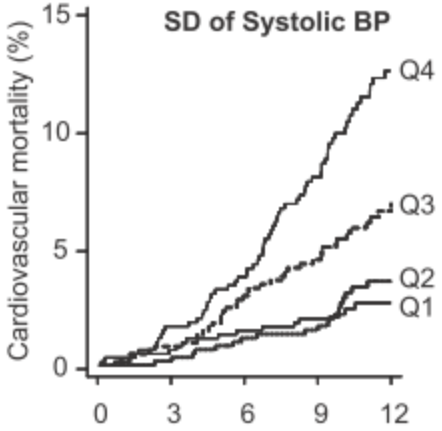
Maximum value of HBP

; a novel indicator of TOD beyond average HBP

	LVMI		Carotid IMT		Log UACR	
Variable	*r*	*P*	*r*	*P*	*r*	*P*
Mean office SBP, mm Hg	0.41	<0.001	0.24	<0.001	0.29	<0.001
Mean office DBP, mm Hg	0.05	0.34	0.03	0.56	0.05	0.34
Mean home SBP, mm Hg	0.46	<0.001	0.31	<0.001	0.30	<0.001
Mean home DBP, mm Hg	0.13	0.02	0.09	0.10	0.08	0.15
Maximum home SBP, mm Hg	0.51	<0.001	0.40	<0.001	0.29	<0.001
Maximum home DBP, mm Hg	0.23	<0.001	0.13	0.012	0.08	0.16
Day-by-day home SBP variability, mm Hg	0.31	<0.001	0.23	<0.001	0.20	<0.001
Day-by-day home DBP variability, mm Hg	0.22	<0.001	0.10	0.07	0.06	0.29

Hypertension 2011;57:1087-93.

BPV and mortality
; the Ohasama study (HBP)



Mortality	Total*	Cardiovascular*	Stroke*
Deaths, n	462	168	83
Base model			
Systolic BP, mm Hg	1.18 (1.07 to 1.31)‖	1.33 (1.13 to 1.57)‖	1.43 (1.13 to 1.80)§
Heart rate, bpm	1.21 (1.11 to 1.31)‖	1.24 (1.08 to 1.42)§	1.27 (1.06 to 1.53)§
Adjusted			
SD of systolic BP, mm Hg	1.21 (1.10 to 1.32)‖	1.27 (1.09 to 1.47)§	1.41 (1.15 to 1.73)‖
SD of heart rate, bpm	1.11 (1.02 to 1.21)‡	1.24 (1.09 to 1.41)§	1.17 (0.96 to 1.43)
Fully adjusted			
Systolic BP, mm Hg	1.13 (1.01 to 1.25)‡	1.26 (1.06 to 1.49)§	1.29 (1.01 to 1.64)‡
Heart rate, bpm	1.19 (1.09 to 1.30)‖	1.16 (1.01 to 1.34)‡	1.25 (1.02 to 1.52)‡
SD of systolic BP, mm Hg	1.18 (1.07 to 1.31)‖	1.20 (1.02 to 1.40)‡	1.38 (1.12 to 1.72)§
SD of heart rate, bpm	1.05 (0.96 to 1.16)	1.18 (1.02 to 1.36)‡	1.06 (0.84 to 1.33)

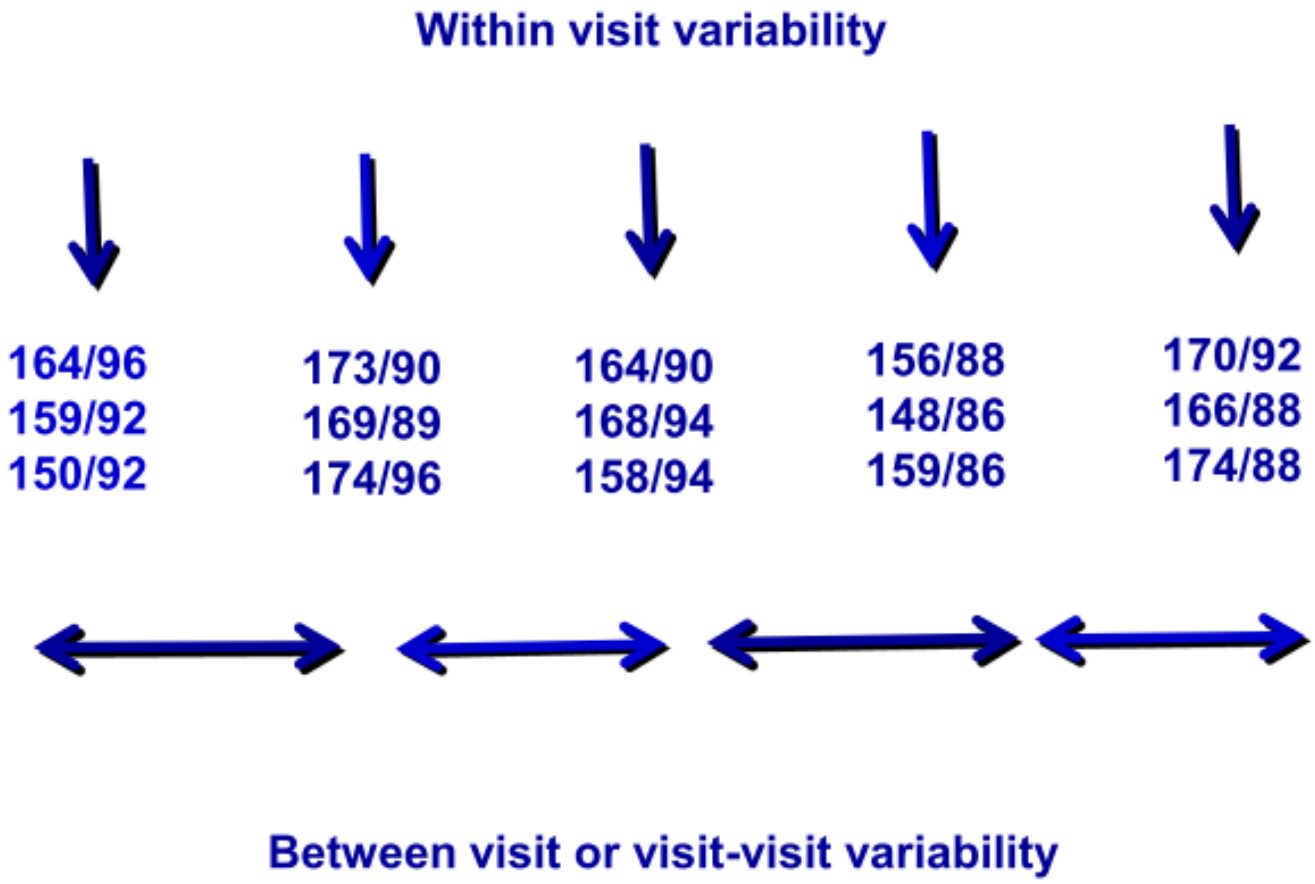
Hypertension 2008;52:1045-50.

BPV in treated and untreated patients ; Ohasama population

	ABP			HBP	
	SD of daytime (mmHg)	SD of nighttime (mmHg)	SD of 24-h (mmHg)	SD of morning (mmHg)	SD of evening (mmHg)
All subjects (n=1,207)					
SBP	15.1 ± 4.4	11.0±3.9**	16.5±4.3**,††	8.8±3.1**,††,‖‖	9.0±2.3**,††,‖‖
DBP	9.6 ± 2.8	6.9±2.4**	10.8±2.5**,††	6.6±2.3**,††,‖	6.8±2.2*,‖,§
Untreated subjects (n=881)					
SBP	14.3 ± 4.3	10.6±3.8**	16.0±4.2**,††	8.3±2.9**,††	8.5±3.0**,††,‖‖
DBP	9.2 ± 2.6	6.6±2.3**	10.5±2.4**,††	6.5±2.4**,‖‖	6.7±2.2**,‖‖
Treated subjects (n=326)					
SBP	17.2 ± 4.3##	12.2±4.1**,##	18.1±4.2**,††,##	10.1±3.2**,††,‖‖,##	10.3±3.3**,††,‖‖,##
DBP	10.7 ± 2.8##	7.4±2.5**,##	11.6±2.6**,††,##	6.9±2.3**,†,‖‖,#	7.1±2.2**,‖‖,#

Hypertens Res 1999;22:261-72.

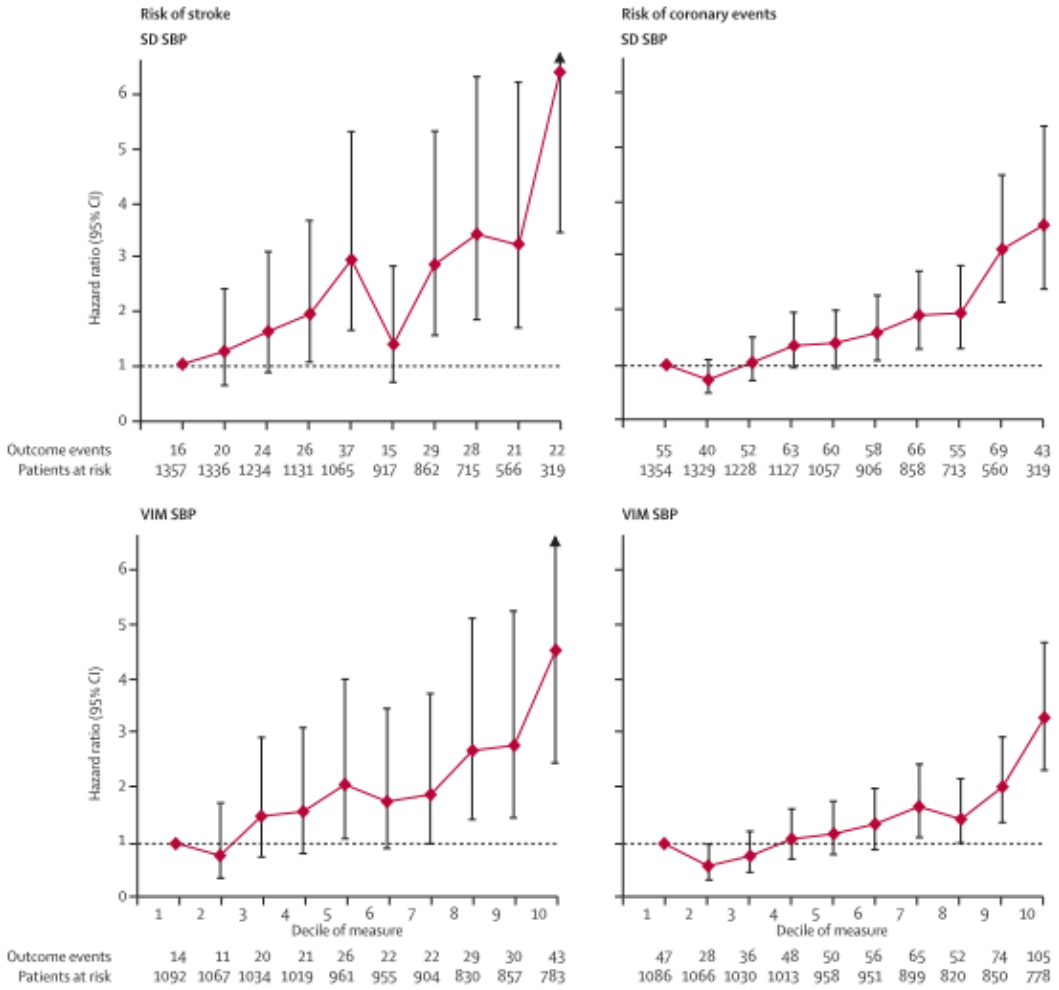
BPV by OBPM
; long-term variability



Peter Sever. BHS Primary Care Meeting 2011

Maximum BP assessed by OBP

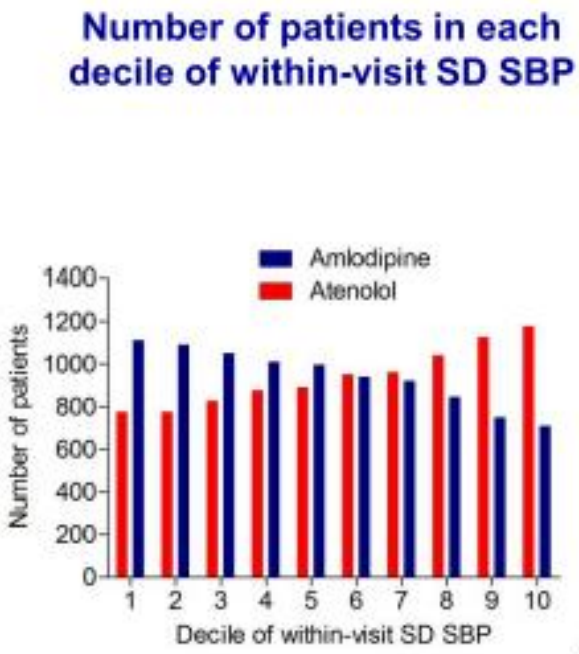
; a strong predictor of stroke and coronary events independent of mean BP (visit-to-visit variability)

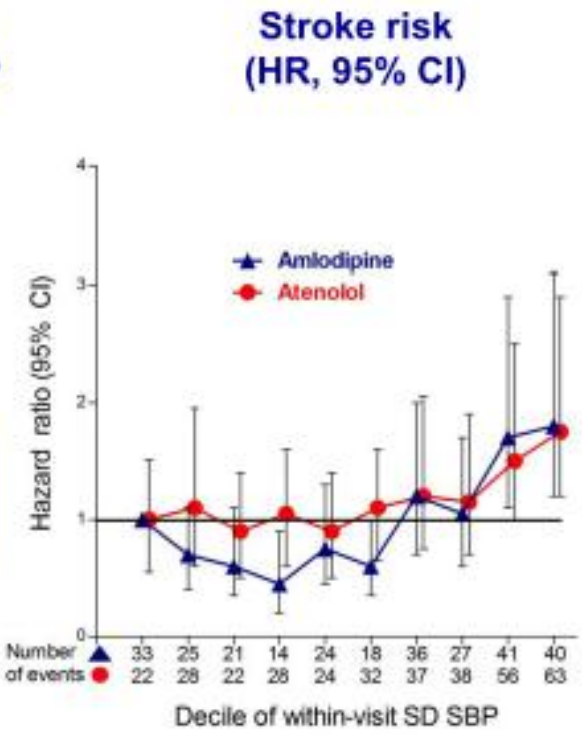


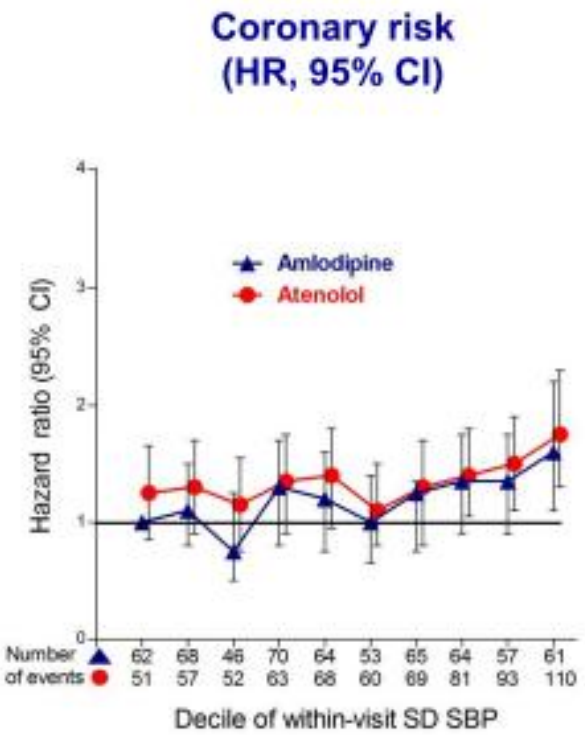
WCE was not predictive of stroke or coronary events (data not shown), and was not correlated with visit-to-visit variability (r=0·01 for visit-to-visit SD, coefficient of variation, and variation independent of mean).

Lancet 2010;375:895-905.

Within-visit SBP variability
; ASCOT-BPLA

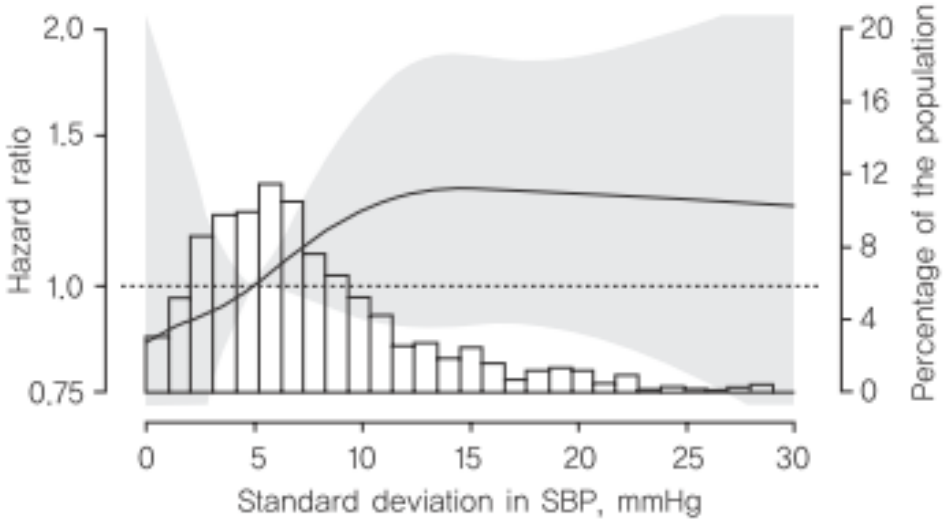


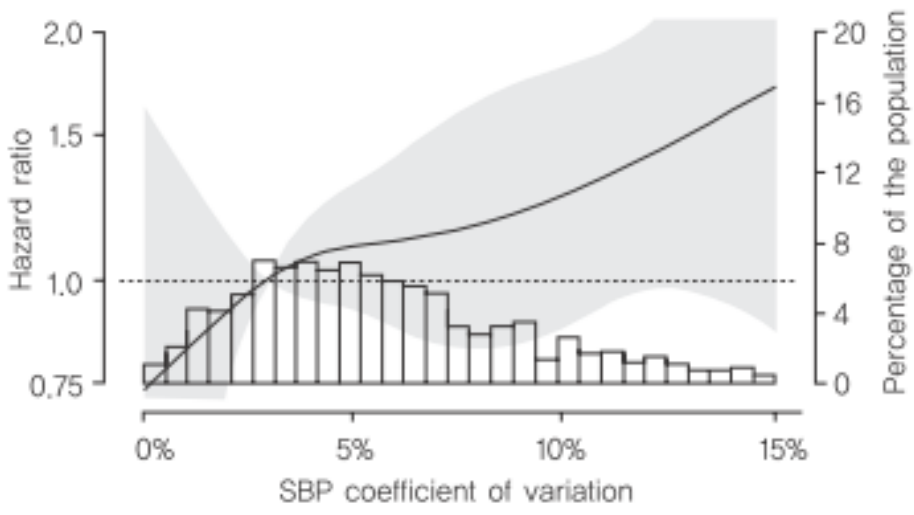




Lancet 2010;375:895-905.

Visit-to-visit variability in the general population ; from NHANES III (OBP)





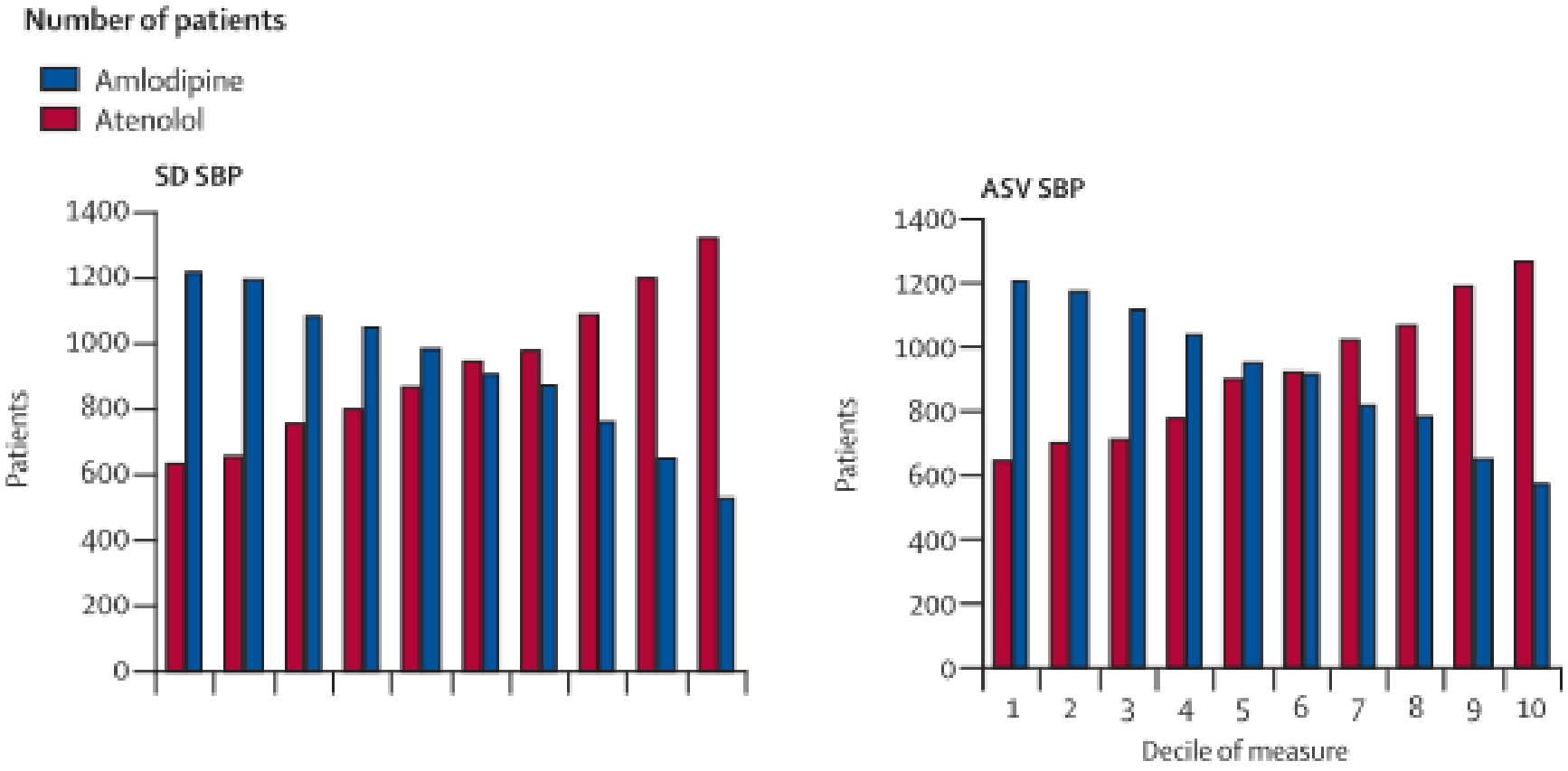
Visit-to-visit variability for DBP was not associated with mortality.

Visit-to-visit variability has only a weak relation(r=0.29 to 0.38) with the SD of daytime BP on ambulatory monitoring.

Hypertension 2011;57:160-6.

Different antihypertensives might differently affect BPV

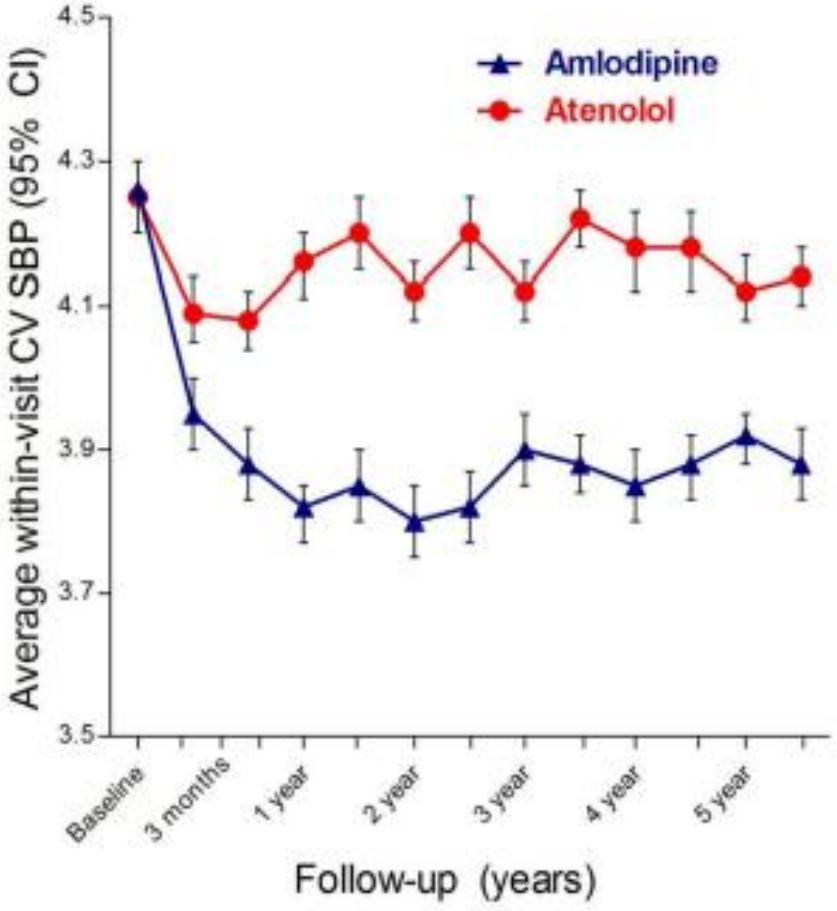
; ASCOT-BPLA (visit-to-visit variablity; interindividual)

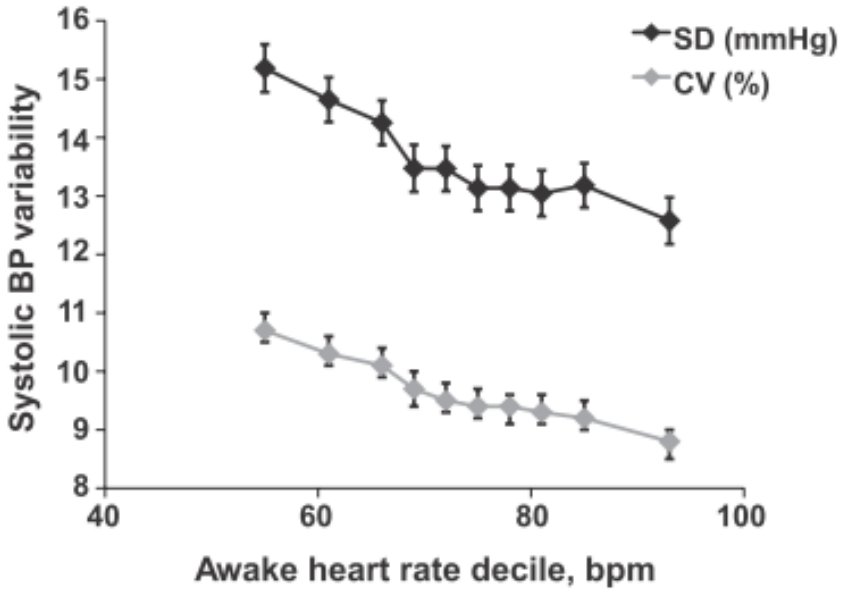


Lancet 2010;375:895-905.

Different antihypertensives might differently affect BPV

; ASCOT-BPLA (within-visit variablity)





Lancet 2010;375:895-905.
Hypertens Res 2009;32:488-95.

Small differences in mean SBP but large in SD ; ALLHAT

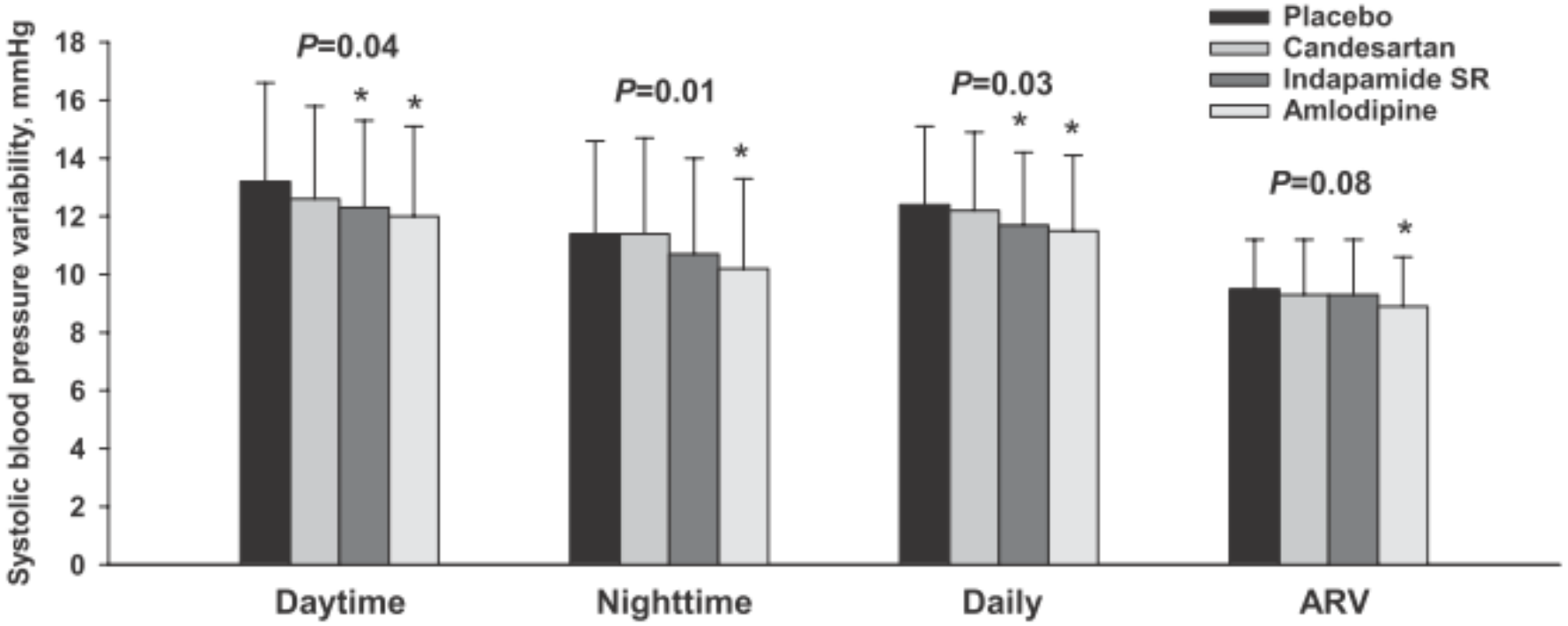
	Treatment group			p value for difference in SD SBP	
	Amlodipine	Chlorthalidone	Lisinopril	Amlodipine vs lisinopril	Chlorthalidone vs lisinopril
Baseline	146·2 (15·7)	146·2 (15·7)	146·4 (15·7)	0·5	0·5
1-year follow up	138·5 (14·9)	136·9 (15·8)	140·0 (18·5)	9×10^{-79}	7×10^{-55}
2-year follow up	137·1 (15·0)	135·9 (15·9)	138·4 (17·9)	3×10^{-48}	1×10^{-28}
3-year follow up	135·6 (15·2)	134·8 (15·4)	136·7 (17·3)	9×10^{-35}	2×10^{-25}
4-year follow up	134·8 (15·0)	133·9 (15·7)	135·5 (17·2)	1×10^{-24}	2×10^{-14}
5-year follow up	134·7 (14·9)	133·9 (15·2)	135·9 (17·9)	1×10^{-24}	8×10^{-25}

Data are mean (SD). p values for differences between treatment groups in inter-individual variation in systolic blood pressure (SBP; ie, SD SBP) are shown for every follow-up visit.

***Table 2*: Mean (SD) SBP at baseline and during follow-up in the ALLHAT trial,[74] stratified by randomised treatment group**

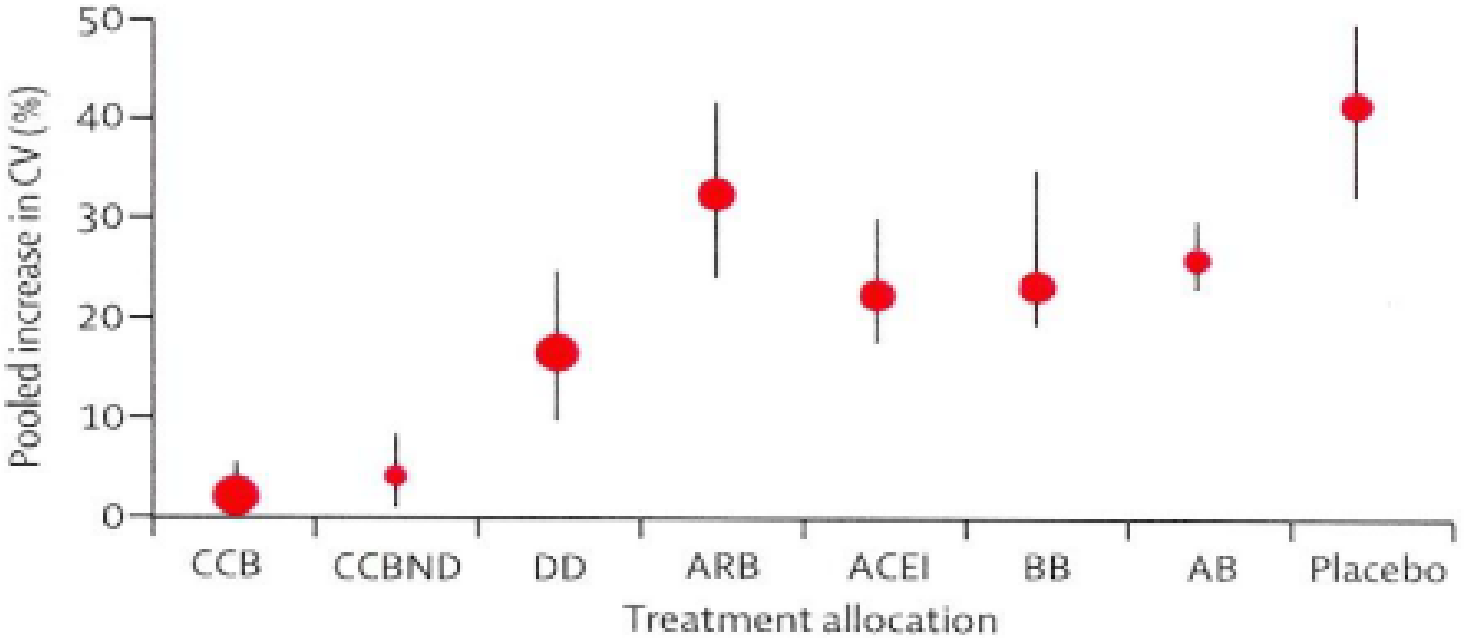
JAMA 2002;288:2981-97.

CCB, diuretics and ARB on BPV ; X-CELLENT study



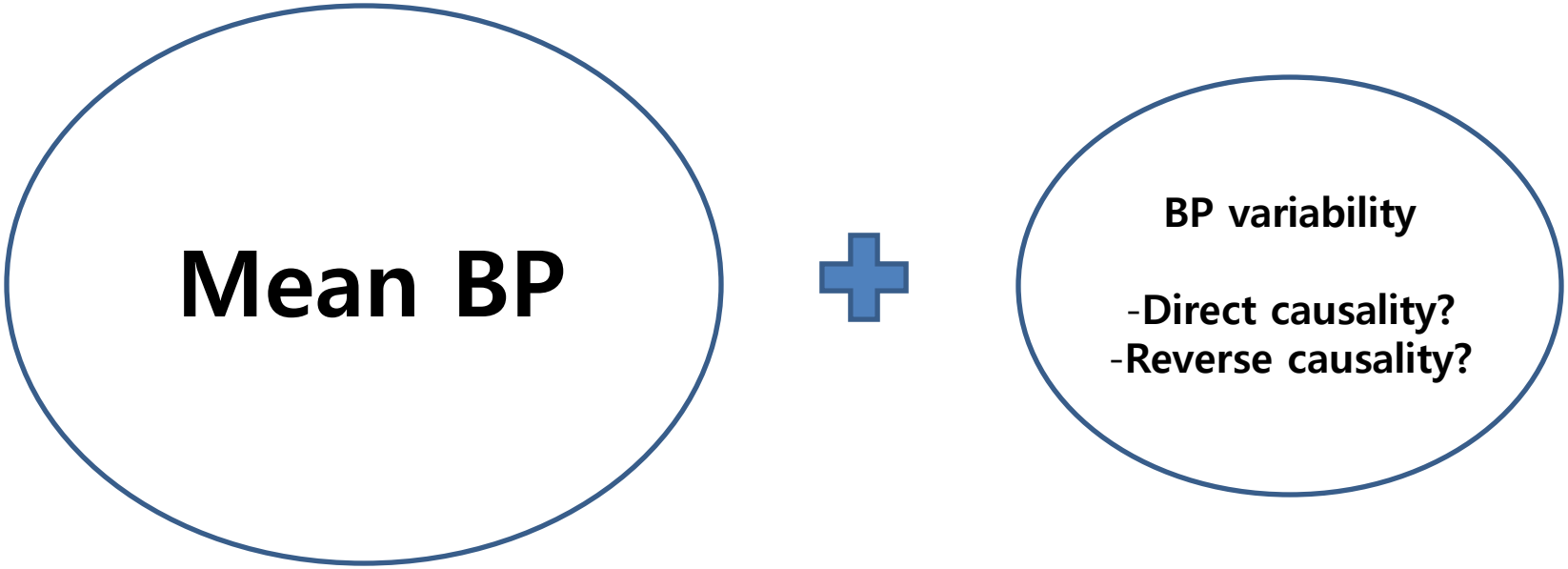
Hypertension 2011;58:155-60.

SBP variability btw antihypertensives



Peter Sever. BHS Primary Care Meeting 2011
Lancet 2010;375:895-905.

More precise risk prediction



Physicians are frequently concerned by the possibility that BP fluctuations occurring in daily life, which often rise well above the average BP level, might cause additional hemo-dynamic stress on the heart and vasculature, increasing the risk of organ damage.

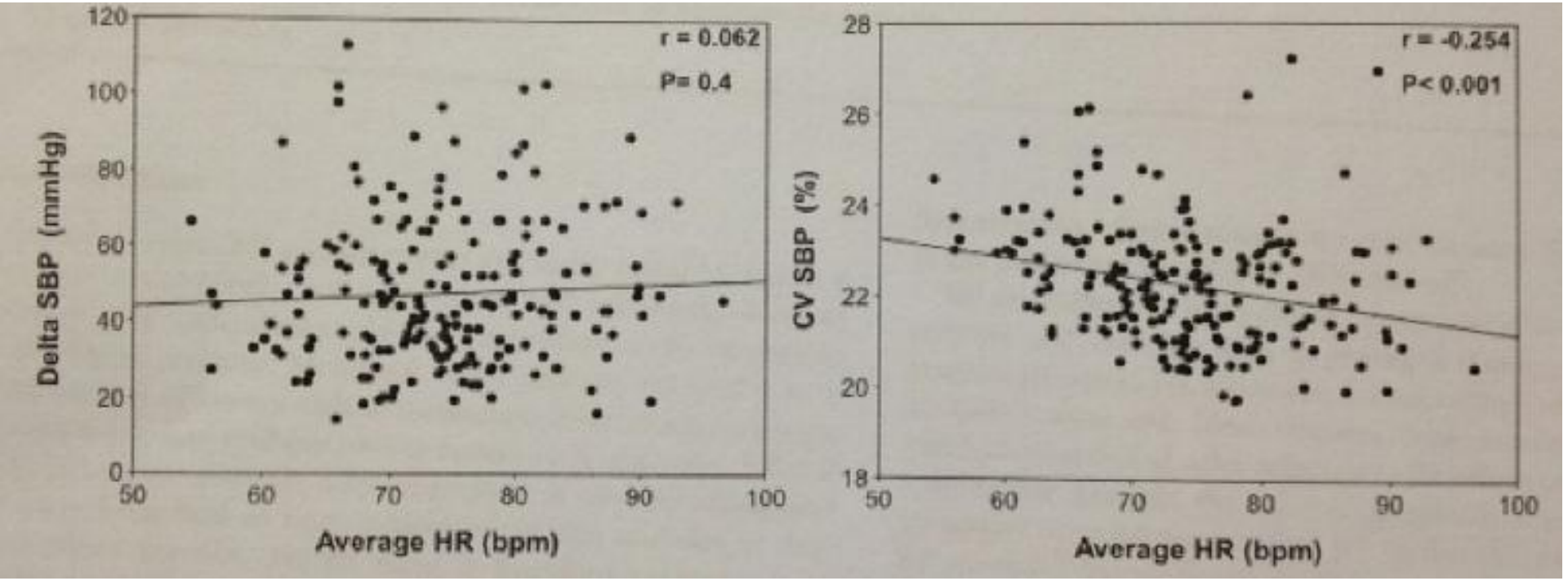
Hypertension 2011;57:1041–42.

Summary

- Mean BP is a very powerful risk factor for vascular events, but much other epidemiological evidence suggests that variability in BP are also important.
- BPV have important roles in the progression of organ damage and in triggering of vascular events.
- But, recent study results come from post-hoc analysis and not from analysis planned at the time of setting up the protocols for the studies.
- There is currently no proof that BPV reduction improves cardiovascular risk in human subjects.
- BPV reduction as an additional goal for antihypertensive treatment, along with the reduction in average BP values?
- Clinician needs to record as many BP values as possible, to allow for the determination of all “intra” and “inter” visit BP values and their variations.

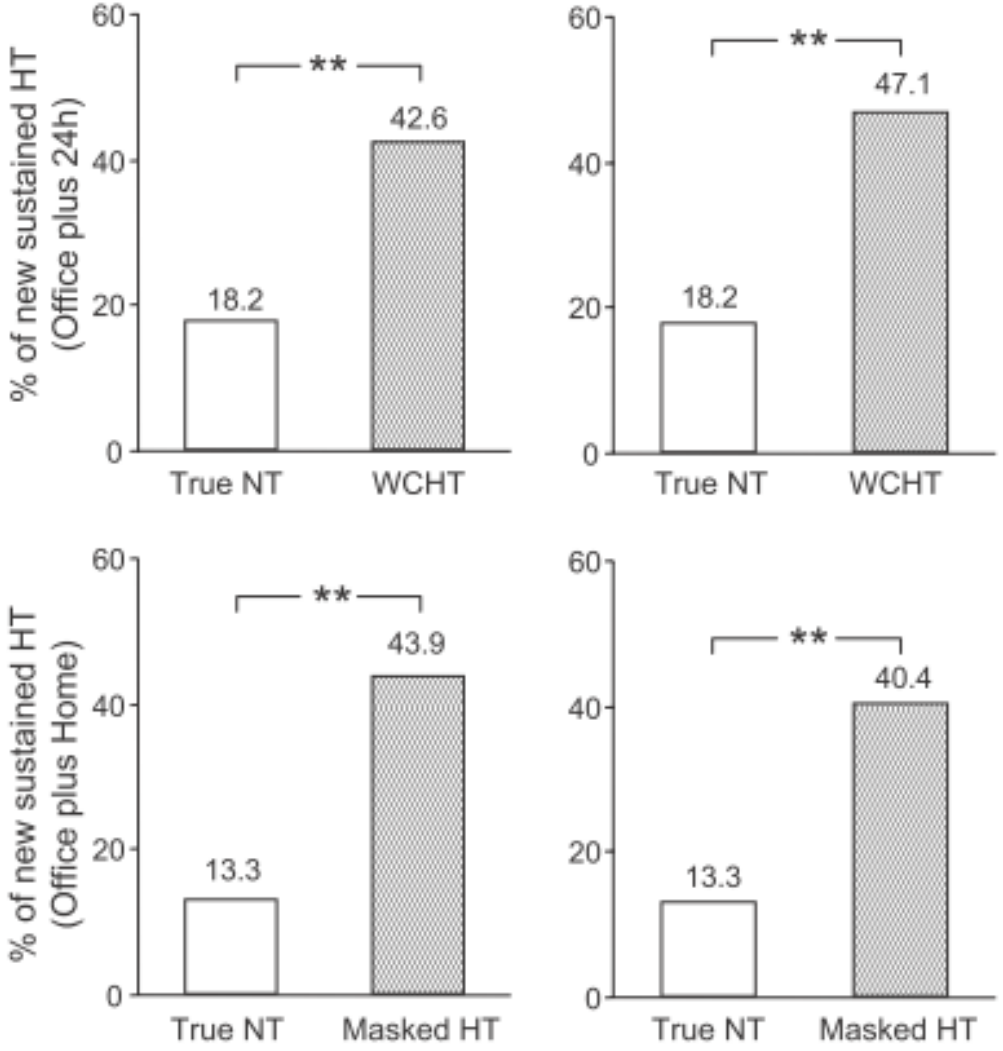
경청해 주셔서 감사합니다.

BPV and HR



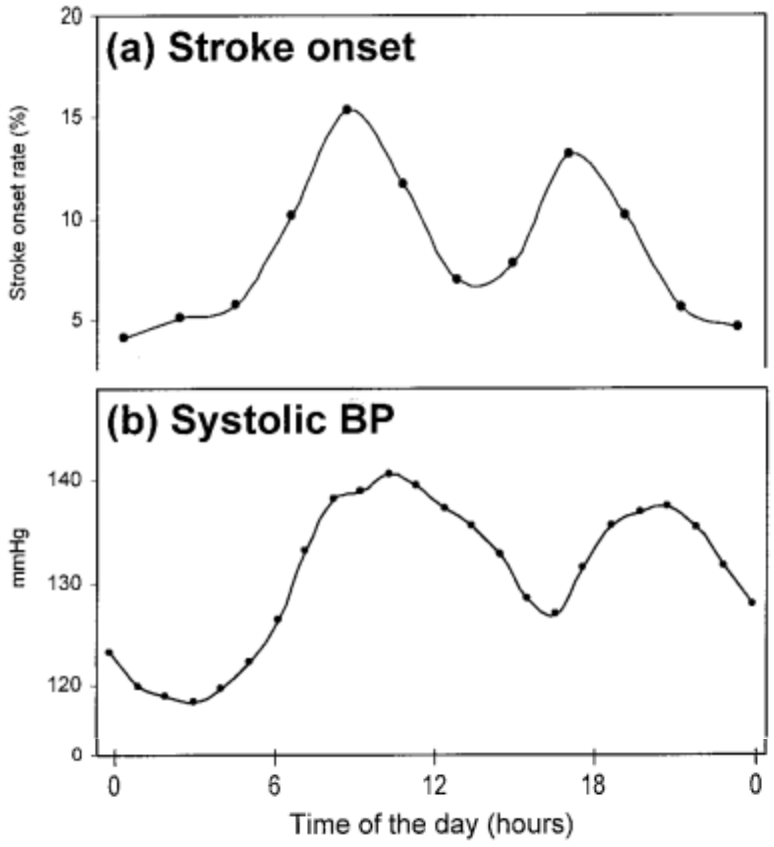
J Am Soc Hypertens 2011;5:184–92.

Long-term risk of sustained hypertension



Hypertension 2009;54:226-32.

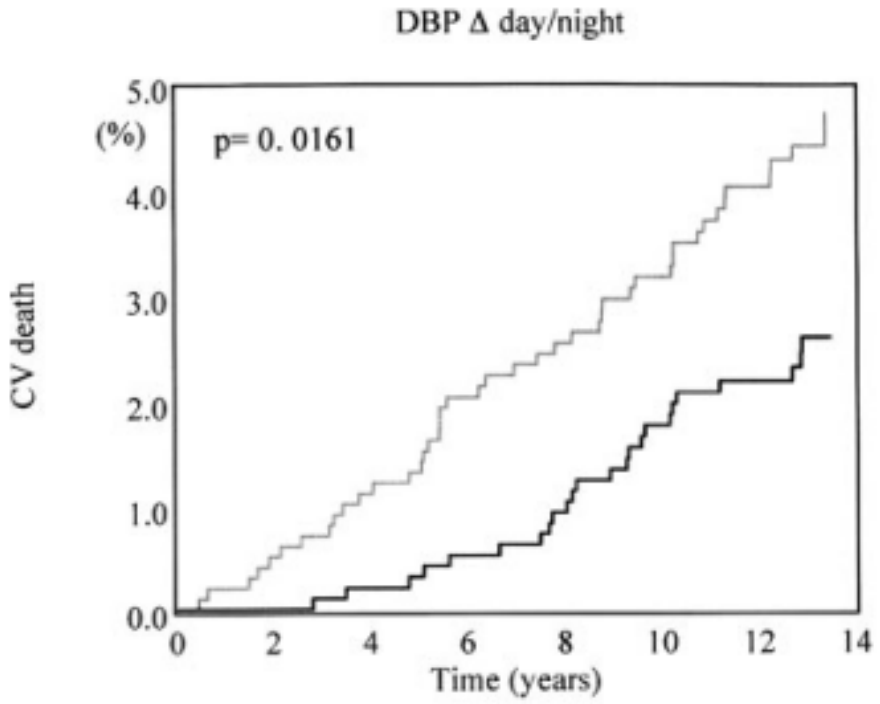
Whatever the time of the day when a BP surge occurs…(ABP)

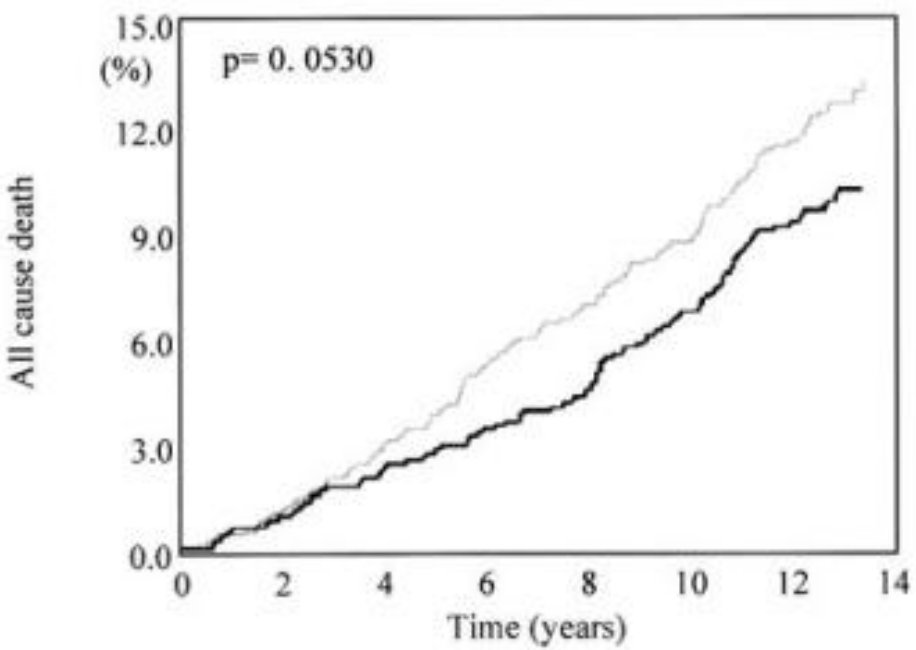


		Stroke Onset Rate			
		Hypertensives (n=633)		Normotensives (n=178)	
Period	Time Interval	Strokes per Hour, n	Stroke Percent per Hour	Strokes per Hour, n	Stroke Percent per Hour
Morning	6 to noon	39.2	6.2	12.7	7.1
Afternoon	Noon to 4	23.3	3.7	6.5	3.7
Evening	4 to 8	36.8	5.8	8.0	4.5
Night	8 to 6	15.8	2.5	4.4	2.5
Expected rate		26.4	4.2	7.4	4.2
P for χ^2		<0.001		<0.001	

Stroke 2002;33:1480-6.

BPV(DBP;ABP) and mortality
; PAMELA study

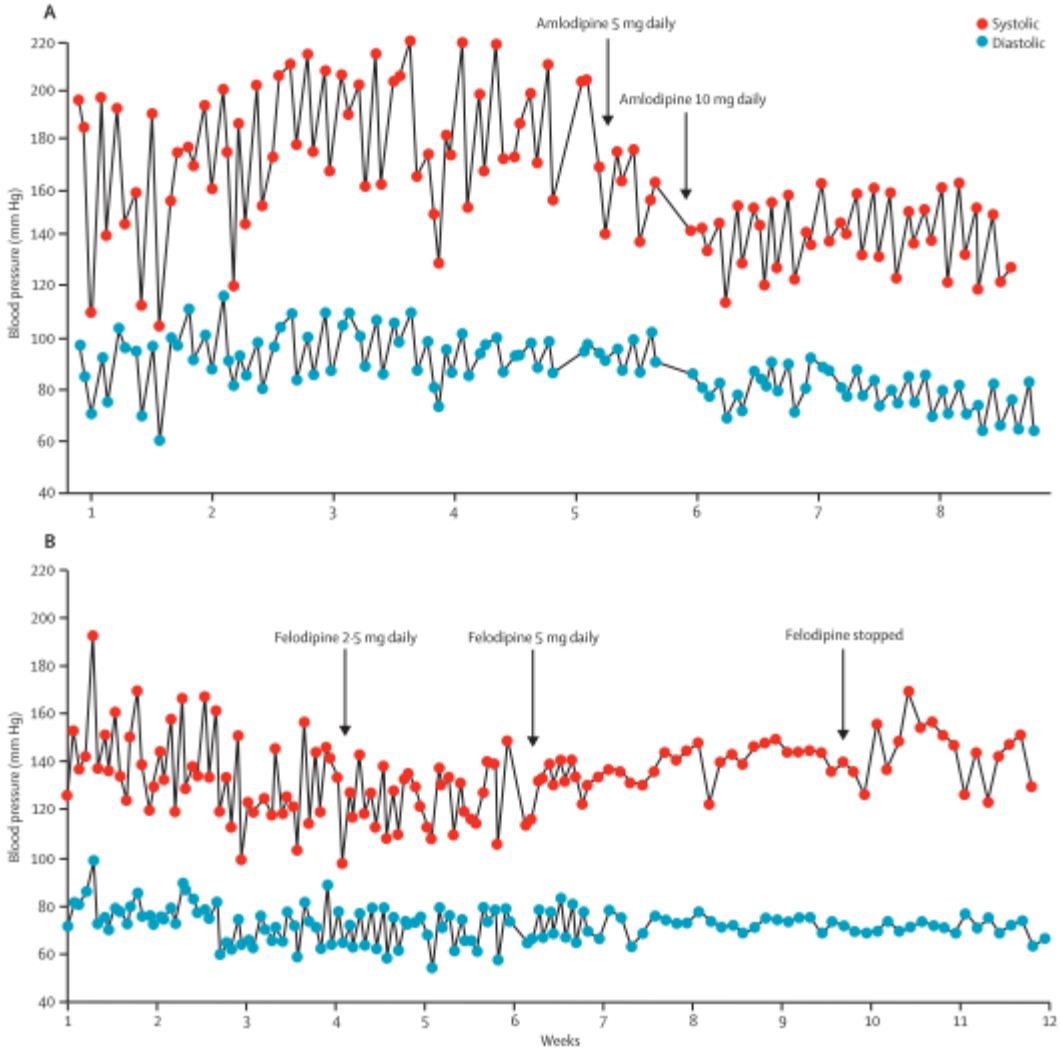




Independent of 24 hour mean BP values

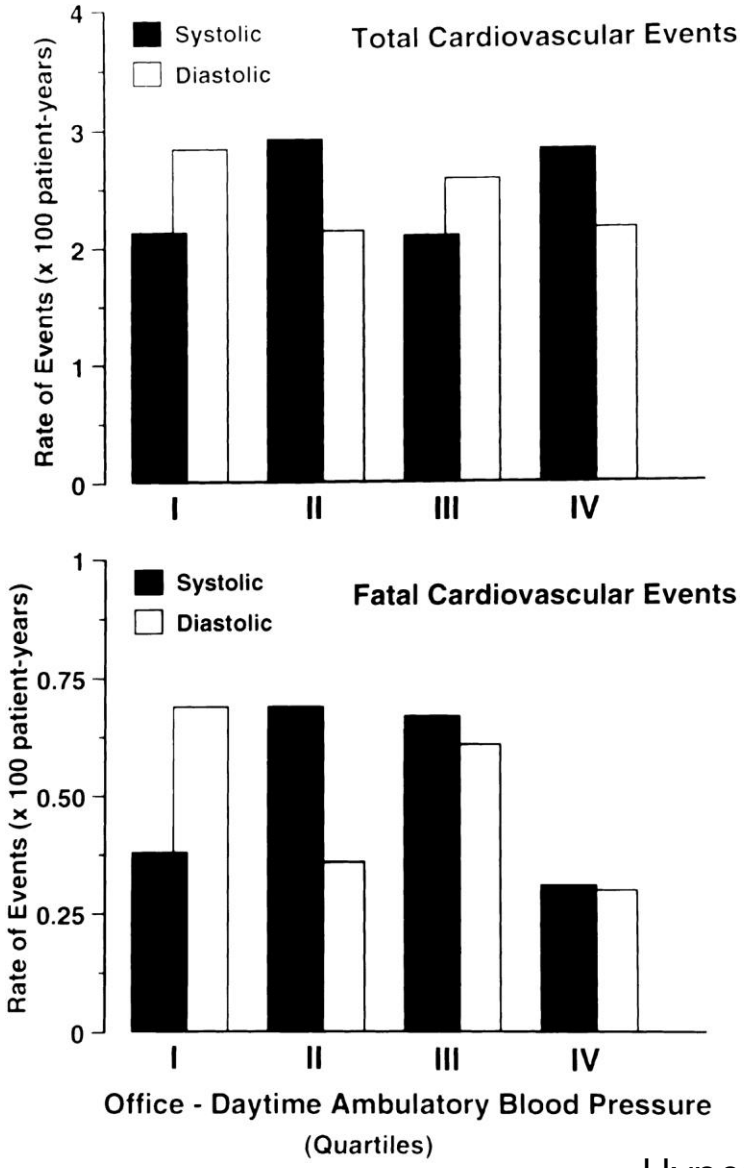
Hypertension 2007;49:1265-70.

CCB on within-individual BPV



Lancet 2010;375:895-905.

WCE does not predict cardiovascular morbidity and mortality in subjects with essential hypertension



Hypertension 1997;29:1218-24.

Blood pressure thresholds

NICE 2011

Measurement	Normal	Stage 1	Stage 2	Target <80	Target ≥ 80
Office or clinic	< 120/80	≥ 140/90	≥ 160/100	< 140/90	< 150/90
Home		≥ 135/85	≥ 150/95	< 135/85	< 145/85
Ambulatory (daytime)		≥ 135/85	≥ 150/95	< 135/85	< 145/85

ESH 2010

Measurement	Normal	Systolic BP	Diastolic BP
Office or clinic		140	90
Home	< 130/80	135	85
Ambulatory		125	80

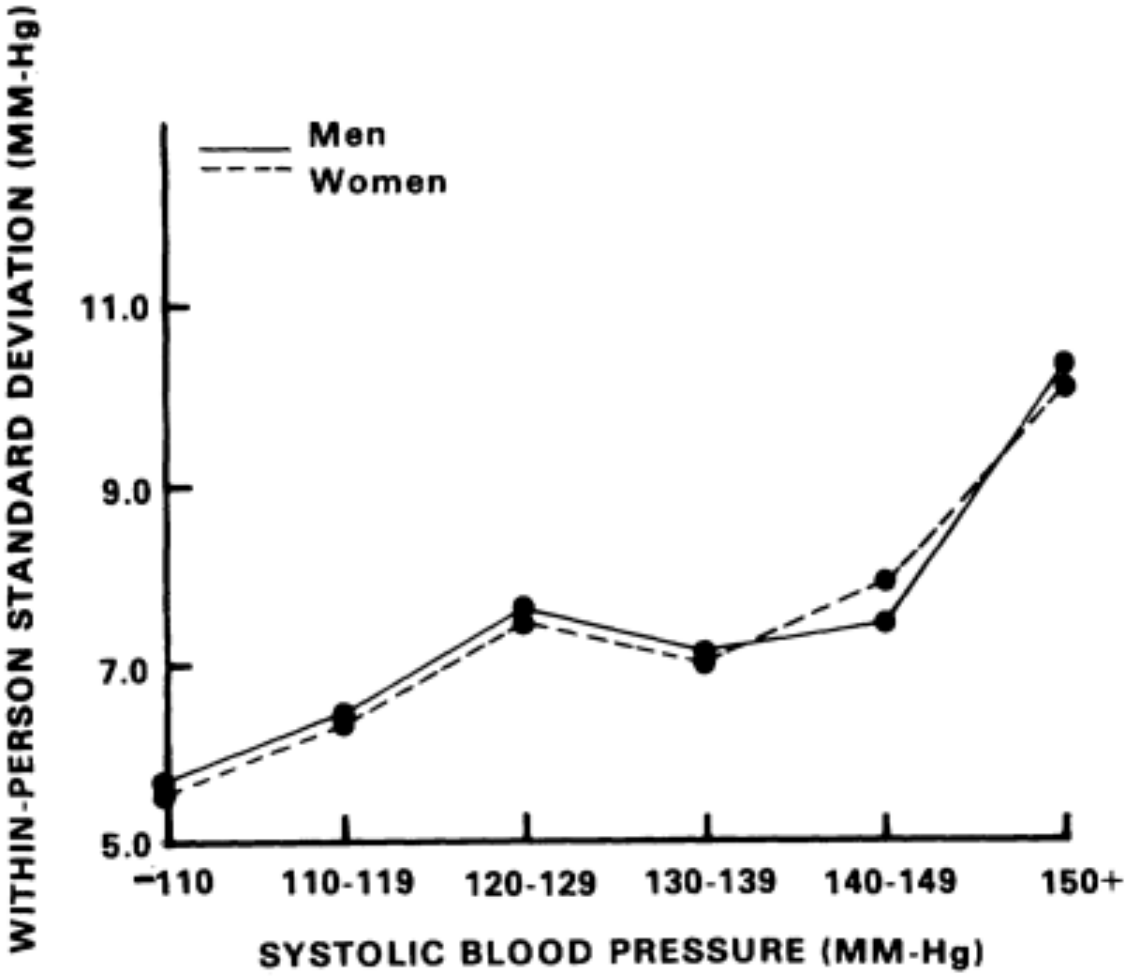
ESH hypertension guideline, J Hum Hypertens 2010;24:779-785.

JSH 2009

Measurement	Normal	Systolic BP	Diastolic BP
Office or clinic		140	90
Home	< 125/75	135	85
Ambulatory		130	80

JSH hypertension guideline, Hypertension Research 2009;32:11-23.

BPV and average BP levels
; from Framingham study



Circulation 1980;61:1183-7.