

Journal of Hypertension

HOME BLOOD PRESSURE MONITORING: METHODOLOGY, CLINICAL RELEVANCE, AND PRACTICAL APPLICATION. A 2021 Position Paper by the European Society of Hypertension. Working Group on Blood Pressure Monitoring and Cardiovascular Variability

--Manuscript Draft--

Manuscript Number:	
Article Type:	De Novo Submission
Keywords:	home blood pressure monitoring; cardiovascular disease; Hypertension; prevention and control; cardiovascular risk; blood pressure measurement
Corresponding Author:	Gianfranco Parati, MD, FESC Istituto Auxologico Italiano, IRCCS, Department of Cardiovascular Neural and Metabolic Sciences, Milan, Italy. Department of Medicine and Surgery, University of Milano-Bicocca, Milan, Italy Milano, ITALY
First Author:	Gianfranco Parati, MD, FESC
Order of Authors:	Gianfranco Parati, MD, FESC George Stergiou Grzegorz Bilo Anastasios Kollias Martino Pengo Juan Eugenio Ochoa Rajiv Agarwal Kei Asayama Roland Asmar Michel Burnier Alejandro De La Sierra Cristina Giannattasio Philippe Gosse Geoffrey Head Satoshi Hoshide Yutaka Imai Kazuomi Kario Yan Li Efsthios Manios J Mant Richard McManus T Mengden Anastasia S. Mihailidou Paul Muntner Martin Myers Teemu Niiranen

	Angeliki Ntineri
	Eoin O'Brien
	José A. Octavio
	T Ohkubo
	Stefano Omboni
	P Padfield
	Paolo Palatini
	Dario Pellegrini
	N Postel-Vinay
	AJ Ramirez
	james Sharman
	A Shennan
	Egle Silva
	J Topouchian
	Camilla Torlasco
	Ji-Guang Wang
	M Weber
	P Whelton
	William White
	Giuseppe Mancia
Abstract:	The present paper provides an update of previous recommendations on Home Blood Pressure Monitoring from the European Society of Hypertension (ESH) Working Group on Blood Pressure Monitoring and Cardiovascular Variability sequentially published in years 2000, 2008 and 2010. This update has taken into account new evidence in this field, including a recent statement by the American Heart association, as well as technological developments which have occurred over the past twenty years. The present document has been developed by the same ESH Working Group with inputs from an international team of experts, and has been endorsed by the ESH.

Milan May 17, 2021

To Prof. Josep Redon
Associate Editor
Journal of Hypertension

Dear Professor Redon,

Dear Josep,

We wish to thank you and the Editorial Board for having offered us the possibility to proceed with a *de novo* **submission** of our manuscript JH-D-21-00426: ""HOME BLOOD PRESSURE MONITORING: METHODOLOGY, CLINICAL RELEVANCE, AND PRACTICAL APPLICATION. A 2021 Position Paper by the European Society of Hypertension. Working Group on Blood Pressure Monitoring and Cardiovascular Variability"

We have carefully revised our manuscript and addressed all queries raised by the reviewers. In particular, following your advice, we have reduced its size (from 121 pages to 88 pages), by moving part of its content to the online supplemental file, but paying at the same time attention not to alter the main messages provided with this paper.

We hope that, with these changes implemented, you might now find our revised paper suitable to be published in the J. of Hypertension

Best Regards

Gianfranco Parati, also on behalf of all authors

To Prof. Josep Redon

Associate Editor

Journal of Hypertension

Dear Professor Redon,

Dear Josep,

We wish to thank you and the Editorial Board for having offered us the possibility to proceed with a *de novo* **submission** of our manuscript JH-D-21-00426: "HOME BLOOD PRESSURE MONITORING: METHODOLOGY, CLINICAL RELEVANCE, AND PRACTICAL APPLICATION. A 2021 Position Paper by the European Society of Hypertension. Working Group on Blood Pressure Monitoring and Cardiovascular Variability"

We have carefully revised our manuscript and addressed all queries raised by the reviewers. In particular, following your advice, we have reduced its size (from 121 pages to 88 pages), by moving part of its content to the online supplemental file, but paying at the same time attention not to alter the main messages provided with this paper.

We hope that, with these changes implemented, you might now find our revised paper suitable to be published in the J. of Hypertension

Best Regards

Gianfranco Parati, also on behalf of all authors

Response to Reviewers' Comments

Reviewer #1:

Query 1: The manuscript and the supplementary information are huge accumulation of studies, some of them of low quality, and personal opinions evidence-based.

Answer to query 1: In this paper we offer an updated summary of the available evidence on HBPM methodology and clinical application. As the reviewer correctly noticed, not all papers dealing with these issues are of the same quality, and whenever suitable we have provided critical comments on their limitations that might be helpful to the readers. We also acknowledge that there is still need of further well conducted studies in order to better assess many aspects related to HBPM. We have highlighted this important aspect in the section **“Remaining Unresolved Research Questions”**

Query 2: The relevance of the majority of Box are meaningful. The length and structure of the manuscript is too big for the relative low value of the information provided. Concerning bibliography, the presence of Pamela study, one of the best in home BP, is just testimonial. In summary, is a large document useless for the future readings in the already size and structure.

Answer to query 2: Following the reviewer's observation, we have now reduced the length of the main manuscript as well as the number of references. The most relevant and certainly important data on HBPM from the PAMELA study, including very recent evidence, are properly cited, although it has to be acknowledged that the PAMELA study considered a lower number of HBP measures than recommended by available guidelines.

Reviewer #2:

The authors should be congratulated on a very comprehensive, timely and topical update to the increasingly relevant field of home BP monitoring. It is a critical position paper at a time when there is a move for increasing patient engagement in dealing with the complex management of elevated blood pressure. There are only a few minor issues that need consideration.

Response to reviewer 2: we thank the reviewer for having appreciated our work and efforts to provide “a very comprehensive, timely and topical update to the increasingly relevant field of home BP monitoring”. A point by point reply to the reviewer’s queries is reported hereafter:

Query 1: Page 25. In the list of descriptors in relation to validated HBPM devices, there is only one with a reference. It would be useful to add some additional references where possible to make the descriptor more informative, for example, what are the devices that are used for AF. In fact, that descriptor is a little unclear as the first part says that some devices detect AF with high accuracy and the second part says that there are no accurate devices for AF.

Response to query 1: In our manuscript we have provided a link to the STRIDE BP website (www.stridebp.org) where updated information on validated HBPM devices is available . Stride BP is a no profit organization including a panel of international experts which is supported by the ESH, the International Society of Hypertension and the World Hypertension League.

Concerning HBP measurements in atrial fibrillation, in this position paper two different issues are addressed. One is the ability of some HBPM devices to detect the presence of AF, thanks to a dedicated algorithm. Such screening ability does not imply that these devices are accurate in measuring BP in AF patients, however. The other issue is indeed the accuracy of HBP measurements in patients with AF, which remains a pending issue, as reported. We also emphasized that in spite of problematic accuracy, HBP measurements have been reported to predict outcome in AF patients

We have tried to better clarify these different issues in the text.

Query 2: Box 11. For the statement "In subjects with very large arm size the shape of the cuff is also important" include a statement that a tronco-conical cuff shape is recommended.

Answer to Query 2: We thank the reviewer for this suggestion. We have now modified the sentence in box 11 as follows: "In subjects with very large arm size, the shape of the cuff is also important. In these subjects a tronco-conical cuff shape is recommended"

Query 3: Page 63. Section 10-Nocturnal Home Blood Pressure Monitoring. It would be useful to have some explicit explanation of how HBP devices to measure nocturnal BP are distinctly different from the conventional ABPM devices. Presumably, they are brachial cuff devices that inflate and deflate during sleep, similar to ABPM, but with some user-defined time trigger. If so, they would have similar obtrusive and inconvenience features as the ABPM. So, the correlations between nocturnal pressure with HBPM and ABPM would have the same relevance as comparing two ABPM devices. Readers would benefit from some clarification on this issue.

Answer to Query 3:

The reviewer addresses a very important issue. The potential clinical relevance of nocturnal HBP measurements as compared to ambulatory BPM at night is related to the possibility of having a lower number of readings per night with HBPM (thus with less disturbance of sleep), but repeated over several nights, so as to increase the reproducibility of nocturnal HBP levels and of nocturnal BP dipping as compared to ABPM over a single 24 h period. Recently, a further improvement might be represented by the availability of wrist HBPM devices equipped with nocturnal measurement function, following the hypothesis that wrist measurements might interfere less with sleep quality than measurements based on arm cuff inflations. The actual demonstration of this possible advantage still needs to be provided, and a few studies using nocturnal polysomnography with EEG recording are on the way. These issues are now better highlighted in the text

Reviewer #3:

Excellent position paper! Readable despite length comprehensive, yet practical.

On page 44 line 12 section treatment target, the sentence "TASMINH4 showed that BP control was better with self monitoring(73), seems out of context there

Answer to reviewer 3: We thank the Reviewer for having appreciated our work. Following also the suggestion of other reviewers, we have now reduced the length of the manuscript as well as the number of references, by moving part of the text to the online supplemental file. Following the reviewers' appropriate observation we have removed the sentence "TASMINH4 showed (unlike THOP and HOMERUS) that BP control was better with self-monitoring {McManus, 2018 #1226}" at page 44

Condensed Abstract

The present paper provides an update of previous recommendations on Home Blood Pressure Monitoring from the European Society of Hypertension (ESH) Working Group on Blood Pressure Monitoring and Cardiovascular Variability sequentially published in years 2000, 2008 and 2010. This update has taken into account new evidence in this field, including a recent statement by the American Heart association, as well as technological developments which have occurred over the past twenty years. The present document has been developed by the same *ESH Working Group* with inputs from an international team of experts, and has been endorsed by the ESH.

List of Abbreviations

AAMI: Association for the Advancement of Medical Instrumentation

ABP: ambulatory blood pressure

ABPM: Ambulatory blood pressure monitoring

ACC: American College of Cardiology

AF: atrial fibrillation

AHA: American Heart Association

ARV: average real variability

BHS: British Hypertension Society

BP: Blood pressure

BPMCVV: ESH Working Group on BP Monitoring and Cardiovascular Variability

BPV: Blood pressure variability

CE: Conformité Européenne

CHD: coronary hearth disease

CKD: chronic kidney disease

CV: coefficient of variation

CVD: cardiovascular disease

DBP: diastolic blood pressure

ECG: electrocardiogram

EEG: electroencephalogram

ESC: European Society of Cardiology

ESH: European Society of Hypertension

ESKD: End Stage kidney disease

FDA: Food and Drug Administration

GFR: glomerular filtration rate

HBP: Home Blood Pressure

HBPM: Home Blood Pressure Monitoring

HBPT: Home Blood Pressure Telemonitoring

HBPV: home blood pressure variability

HMOD: Hypertension mediated organ damage

HOMED-BP: Hypertension Objective Treatment Based on Measurement by Electrical Devices of Blood Pressure study

HOMERUS: Home versus Office MEasurements, Reduction of Unnecessary treatment Study

HONEST: Home blood pressure measurement with Olmesartan Naive patients to Establish Standard Target blood pressure study

IDHOCO: International Database of HOme blood pressure in relation to Cardiovascular Outcome

ISO: International Organization for Standardization

J-HOP: Japan Morning Surge-Home Blood Pressure Study

LVMI: Left ventricular mass index

CIMT: carotid intima-media thickness

LVH: Left ventricular hypertrophy

MASTER: MASkEd-unconTrolled hypERtension management based on office BP or on ambulatory blood pressure measurement

MH: masked hypertension

mHealth: **mobile health**

MUCH: masked uncontrolled hypertension

NCMH: North Carolina Masked Hypertension Study.

NICE: National Institute for Health and Care Excellence

OBPM: office BP monitoring

OH: Orthostatic Hypotension

PAMELA: Pressioni Arteriose Monitorate e Loro Associazioni study

PWV: pulse wave velocity

RCT: randomized controlled trial

SD: Standard deviation

SPRINT: Systolic Blood Pressure Intervention Trial

TASMINH2: Telemonitoring and Self-Management in Hypertension 2 study

TASMINH4: Efficacy of self-monitored blood pressure, with or without telemonitoring, for titration of antihypertensive medication study

TASMIN-SR: Targets and Self-Management for the Control of Blood Pressure in Stroke and at Risk Groups study

TELEBPMET: home blood pressure telemonitoring vs. conventional management and assessment of psychological determinants of adherence study

THOP: Treatment of Hypertension Based on Home or Office Blood Pressure Trial

UACR: urinary albumin creatinine excretion rate

US: United States

VIM: Variability independent of the mean

VVV: visit-to-visit blood pressure variability

WCH: white coat hypertension

STRIDE BP: international initiative for accurate blood pressure measurement

HOME BLOOD PRESSURE MONITORING: METHODOLOGY, CLINICAL RELEVANCE, AND PRACTICAL APPLICATION.

A 2021 Position Paper by the European Society of Hypertension.

Working Group on Blood Pressure Monitoring and Cardiovascular Variability.

**Parati G,^{1,2} Stergiou G,³ Bilo G,^{1,2} Kollias A,³ Pengo M,¹ Ochoa JE,¹ Agarwal R,⁴ Asayama K,^{5,6,7}
Asmar R,⁸ Burnier M,⁹ De La Sierra A,¹⁰ Giannattasio C,^{2,11} Gosse P,¹² Head G,¹³ Hoshida S,¹⁴
Imai Y,⁷ Kario K,¹⁴ Li Y,¹⁵ Manios E,¹⁶ Mant J,¹⁷ McManus RJ,¹⁸ Mengden T,¹⁹ Mihailidou A,²⁰
Muntner P,²¹ Myers M,²² Niiranen T,^{23,24} Ntineri A,³ O'Brien E,²⁵ Octavio A,²⁶ Ohkubo T,^{5,7}
Omboni S,^{27,28} Padfield P,²⁹ Palatini P,³⁰ Pellegrini D,³¹ Postel-Vinay N,³² Ramirez AJ,³³
Sharman JE,³⁴ Shennan A,³⁵ Silva E,³⁶ Topouchian J,³⁷ Torlasco C,¹ Wang J,¹⁵ Weber M,³⁸
Whelton PK,³⁹ White W,⁴⁰ Mancia G.⁴¹ on Behalf of the Working Group on Blood Pressure
Monitoring and Cardiovascular Variability of the European Society of Hypertension.**

1-Istituto Auxologico Italiano, IRCCS, Department of Cardiovascular Neural and Metabolic Sciences, Milan, Italy

2-Department of Medicine and Surgery, University of Milano-Bicocca, Milan, Italy

3-Hypertension Center STRIDE-7, National and Kapodistrian University of Athens, School of Medicine, Third Department of Medicine, Sotiria Hospital, Athens, Greece

4-Division of Nephrology Department of Medicine, Indiana University School of Medicine and Richard L. Roudebush Veterans Administration Medical Center, Indianapolis, IN, USA.

5-Department of Hygiene and Public Health, Teikyo University School of Medicine, Tokyo, Japan.

6-Research Unit Hypertension and Cardiovascular Epidemiology, KU Leuven Department of Cardiovascular Sciences, University of Leuven, Leuven, Belgium.

7-Tohoku Institute for the Management of Blood Pressure, Sendai, Japan

8-Foundation-Medical Research Institutes, Geneva, Switzerland

9- Service of Nephrology and Hypertension, University Hospital, Lausanne, Switzerland

10-Hypertension Unit, Department of Internal Medicine, Hospital Mútua Terrassa, University of Barcelona, Barcelona, Spain.

11-Cardiology IV, "A.De Gasperis" Department, ASTT GOM Niguarda Ca' Granda

12- Cardiology/Hypertension Unit Saint André Hospital. University hospital of Bordeaux, France

13-Baker Heart and Diabetes Institute, Melbourne Victoria Australia

14-Division of Cardiovascular Medicine, Department of Medicine, Jichi Medical University School of Medicine, Tochigi, Japan

15-Shanghai Institute of Hypertension, Ruijin Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

16-Department of Clinical Therapeutics, National and Kapodistrian University of Athens, School of Medicine, Alexandra Hospital Athens, Greece

17-Primary Care Unit, Department of Public Health & Primary Care, University of Cambridge, Cambridge, UK

- 18-Nuffield Department of Primary Care Health Sciences, University of Oxford, Oxford OX2 6GG.
- 19-Kerckhoff Clinic, Rehabilitation, ESH Excellence Centre, Bad Nauheim, Germany
- 20-Department of Cardiology and Kolling Institute, Royal North Shore Hospital, St Leonards Faculty of Medicine and Health Sciences, Macquarie University, Sydney, Australia 2065.
- 21-Hypertension Research Center, Department of Epidemiology, School of Public Health, University of Alabama at Birmingham, Birmingham, AL, USA.
- 22- Schulich Heart Program, Sunnybrook Health Sciences Centre and Department of Medicine, University of Toronto
- 23- Department of Medicine, Turku University Hospital and University of Turku, Finland
- 24- Finnish Institute for Health and Welfare, Helsinki, Finland
- 25-The Conway Institute, University College Dublin, Dublin 4. Ireland
- 26-Experimental Cardiology, Department of Tropical Medicine Institute, Universidad Central de Venezuela
- 27-Clinical Research Unit, Italian Institute of Telemedicine, Varese, Italy.
- 28-Department of Cardiology, Sechenov First Moscow State Medical University, Moscow, Russian Federation
- 29-Department of Medical Sciences, University of Edinburgh, Edinburgh, United Kingdom
- 30- Studium Patavinum; Department of Medicine. University of Padova, Padua, Italy
- 31-Cardiovascular Department ASST Papa Giovanni XXIII, Bergamo, Italy
- 32-Hypertension Unit. European Georges Pompidou Hospital. Paris, France.
- 33-Arterial Hypertension and Metabolic Unit, University Hospital, Fundacion Favaloro.
- 34-Menzies Institute for Medical Research, College of Health and Medicine, University of Tasmania, Hobart, Australia
- 35-Department of Women and Children's Health, School of Life Course Sciences, FoLSM, Kings College London.
- 36-Research Institute of Cardiovascular Diseases of the University of Zulia, Venezuelan Foundation of Arterial Hypertension. Maracaibo, Venezuela
- 37-Diagnosis and Therapeutic Center, Paris-Descartes University, AP-HP, Hotel Dieu, Paris, France
- 38-Division of Cardiovascular Medicine, Downstate College of Medicine, State University of New York, Brooklyn, New York, USA
- 39-Department of Epidemiology, Tulane University, School of Public Health and Tropical Medicine
- 40-Cardiology Center, University of Connecticut School of Medicine, Farmington, CT, USA
- 41-University Milano-Bicocca, Milano, Italy

KEY WORDS: home blood pressure monitoring, cardiovascular disease, hypertension, prevention and control, cardiovascular risk, blood pressure measurement

Abstract: The present paper provides an update of previous recommendations on Home Blood Pressure Monitoring from the European Society of Hypertension (ESH) Working Group on Blood Pressure Monitoring and Cardiovascular Variability sequentially published in years 2000, 2008 and 2010. This update has taken into account new evidence in this field, including a recent statement by the American Heart association, as well as technological developments which have occurred over the past twenty years. The present document has been developed by the same *ESH Working Group* with inputs from an international team of experts, and has been endorsed by the ESH.

1-Introduction

Arterial hypertension is one of the principal cardiovascular risk factors, and still represents a largely unmet public health challenge given its close association with mortality and morbidity globally due to cardiovascular, cerebrovascular and kidney disease related complications (1), (2). The current sub-optimal management of hypertension might be in part related to the limitations of using only office blood pressure (BP), which has led to increasing use of out-of-office BP. (1, 2) Adoption of home BP monitoring (HBPM), in particular, has had an exponential growth, favoured by technological progress which has led to the availability of small, accurate, user-friendly and relatively inexpensive BP monitoring devices. The present paper provides an update of previous recommendations from the ESH Working Group on BP Monitoring and Cardiovascular Variability (BPMCVV) sequentially published in years 2000 (3), 2008 (4) and 2010 (5) and from AHA (6)

2-Purpose and scope

Hypertension guidelines have to deal with a large number of complex issues, which limits the space for a detailed discussion on practical aspects of BP measurement. This has been the case for HBPM as well, which is recommended in recent hypertension guidelines but without detailed instructions on its practical application. These instructions are provided in the present manuscript, together with an update on the emerging technologies in this field in order to provide healthcare professionals with guidance that details the appropriate use of contemporary HBPM in clinical practice and research (1), (2), (7), (8), (9), (10), (11), (12), (6).

3- What is new in the 2021 Position Paper

Compared with the 2008/2010 documents, the evidence accumulated over the past 12 years has allowed for modification of a number of previous statements or recommendations. This is summarized in **Table 1**.

Table 1. Main changes between 2008/2010 and 2021 HBPM position papers.

Topic	2008/2010	2021
Cuff size	Different cuff sizes are recommended for patients with different arm circumferences	Cuff choice should consider patient’s arm size but should also be based on the instructions by the manufacturer, based on evidence from validation studies. The use of wide-range cuffs with automated devices may be particularly useful.
Clinical validation protocols	Several validation protocols are recommended (BHS, AAMI, ESH International Protocol)	The 2018 Universal Standard AAMI/ESH/ISO is recommended for all new validation studies.
Cuffless devices	(not mentioned)	Now available, they should undergo thorough clinical validation (Appropriate validation protocol by AAMI/ESH/ISO under preparation) before being recommended for performing HBPM
Information on Validated Devices	DABLE, BIHS VDL Hypertension Canada Deutsche Hochdruckliga JSH MEDAVAL	STRIDE BP www.stridebp.org BIHS www.bihsoc.org/bp-monitors US BP VDL www.validatebp.org Hypertension Canada www.hypertension.ca/bpdevices Deutsche Hochdruckliga www.hochdruckliga.de/betroffene/blutdruckmessgeraete-mit-pruefsiegel JSH www.jpnhsh.jp/com_ac_wg1.html .
Preferred devices	(not mentioned)	Preferred HBPM devices (www.stridebp.org) now specified as : upper-arm cuff devices with at least one STRIDE BP approved validation study published in the last 10 years and using a recent protocol (AAMI/ESH/ISO 2018; ANSI/AAMI/ISO 2013 or 2009; ESH-IP 2010); being in use for < 4 years(13);

		and equipped with storage/connectivity facilities for objective reporting of readings
Monitoring schedule and interpretation	3 to 7 days monitoring schedule, with BP values measured on the first monitoring day to be discarded	3 to 7 days monitoring schedule, with 2 measures taken in the morning and evening. Discarding the first day may have an effect on a 3-day schedule, but appears to have minimal impact with more monitoring days
Diagnostic thresholds	Threshold for hypertension $\geq 135/85$ mmHg for systolic/diastolic BP $< 130/80$ mmHg normal HBP	The threshold for ESC/ESH hypertension diagnosis is 135/85 mmHg (corresponding to 140/90 mmHg of clinic BP in the ESC-ESH hypertension guidelines). HBP of 130/80 mmHg may correspond to 130/80 mmHg clinic BP threshold for grade I hypertension used in ACC/AHA Guidelines.
Therapeutic targets	No recommendations	Systolic HBP between 125-135 mmHg for most people. Diastolic HBP between 70-80 mmHg as a reasonable goal. In the frail very elderly slightly higher systolic HBP might be the preferred target (suggested in the 140-150 mmHg range, but more evidence is needed), while avoiding excessive reductions of diastolic HBP.
Children	Few suggestions regarding when and how frequently HBPM should be measured in children	Preliminary evidence supports use of a HBPM schedule similar to that recommended for adults
Pregnancy	HBPM should be performed with the woman seated or lying on her side at a 45° angle	The sitting position appears to be appropriate for HBPM during pregnancy. The same 3 to 7 days monitoring schedule recommended. Concerning BP thresholds: in unselected women HBP = clinic BP (14)
Chronic kidney disease on dialysis (ESKD)	No recommended schedule	HBP should be measured twice daily, at bedtime and on waking up, after the midweek dialysis for 4 days
Arrhythmias	In patients with frequent or persistent arrhythmias, HBPM should not be used as the sole diagnostic tool	With HBPM, automated devices should be preferred to auscultatory devices and used even in the presence of atrial fibrillation (AF) (with controlled ventricular rate). Triplicate measurements could be useful due to increased beat-to-beat variability. In the case of uncontrolled tachyarrhythmias

		automated devices may provide inaccurate readings (a debated issue) (15) AF detecting algorithm during automated HBPM might be useful for early detection of asymptomatic AF in elderly individuals with hypertension
Nocturnal HBPM	Lack of night recordings as a limitation of HBPM	With technological development of devices, nocturnal HBPM is feasible and appears to be a promising alternative to ABPM for the evaluation of sleep BP
Home BP variability	Not mentioned	Home BP variability is an independent outcome predictor but the current evidence is insufficient to support its application in clinical practice

4-Methodology of the position paper

The present recommendations are based on evidence provided by papers published until January 2021, from which a draft prepared by a writing committee (G.P., G.S.S., A.K., E.O.M., G.B. and M.P.) was prepared and circulated among all the authors of this document who reviewed and approved its final version.

5-Definitions and terminology - What is HBPM?

HBPM has become the universally used term to define a procedure by which an individual self-measures BP non-invasively in his/her home. (16)To ensure standardization of HBPM, the conditions summarized in BOX 1 should be fulfilled:

BOX 1. HBPM characteristic features

- Measurements should take place in individuals' home (pharmacy or workplace BP measurements are not home measurements).
- Measurements should be self-performed, with assistance by family member or others in case of physical or cognitive limitations or in children. A measurement taken by healthcare personnel visiting patient's home is not HBPM.
- Individuals should be instructed on the appropriate methodology, as well as on the measurement schedule, best if during a structured hypertension teaching program.
- BP values should be reported as a downloadable electronic log maintained in the monitor memory or in directly connected mobile phone, or tele-transmitted for the physician's review. If this is not possible, then a paper form should be provided for patients to report their readings.
- The next recommended step is discussion between the individual and the healthcare provider to determine an appropriate management plan.

6- HBPM – Advantages and limitations

6.1-Reproducibility (Box 2) (More details in the online supplemental file S6.1)

The reproducibility of any BP measurement method improves by increasing the number of BP readings, and thus one of the advantages of HBPM is the larger number of readings that can be obtained compared to office BP measurement (17), (18). Although head-to-head comparison studies are scarce, a review of the studies on test-retest correlation coefficients and standard deviation of differences between repeated home and ambulatory BP measurements suggests a similar reproducibility of the two methods, and a better reproducibility of both as compared to office BP (OBP) (18) (19), with some studies suggesting a better reproducibility of HBPM than ABPM (20), (21).

Box 2

- HBPM has better reproducibility than office BP.
- HBPM has reproducibility that is comparable to ABPM.
- The better reproducibility of HBPM vs office BP, both in short and long term, is at least in part related to the inclusion of a higher number of readings in its assessment and to a better standardized measurement condition.

6.2- Diagnostic ability (Box 3)

6.2.1-Diagnostic accuracy and identification of masked and white coat hypertension. (More details in the online supplemental file S6.2.1)

(1, 2, 7-9) Studies comparing HBPM with ABPM in detecting masked hypertension report that in about half of the patients diagnosed with masked hypertension, this phenomenon is present with both ABPM and HBPM (dual masked hypertension), whereas in the remainder the diagnosis is only documented with one of the two BP measurement methods (22), (23), (24), (25). In outcome studies, individuals with masked hypertension identified by only HBPM or ABPM have an intermediate level of CVD risk between those identified by both methods as normotensives and those as sustained hypertensives.

Recently, it has been shown that masked hypertension diagnosed by ABPM and not by HBPM, or the reverse, is not uncommon, with age being the most important determinant of isolated ambulatory or home masked hypertension, with the former being more common in younger participants and the latter in older ones (23)

Box 3 - Diagnostic capability of HBPM

- Both HBPM and ABPM have been recommended for wide use by recent US and European Hypertension Guidelines.
- HBPM and ABPM provide similar though not identical information on BP and appear to be complementary diagnostic methods.
- In hypertension diagnosis HBPM has higher specificity and negative predictive value, and lower sensitivity and positive predictive value than ABPM, in particular for the diagnosis of white-coat and masked hypertension.
- In a high proportion of individuals masked or white-coat hypertension are identified only by HBPM or only by ABPM. In outcome studies these individuals have intermediate CVD risk between those identified by both methods as normotensives and those as sustained hypertensives.
- Studies assessing morning BP showed similar results with HBPM or ABPM (see online supplement S.2.1)

6.3-Prognostic value of HBPM

6.3.1- Hypertension mediated organ damage (HMOD) (Box 4) (More details in the online supplemental file S6.3.1)

Cardiac damage

Left ventricular hypertrophy (LVH) is the most widely used marker of cardiac damage in hypertension. In a meta-analysis of 14 studies, echocardiographically measured left ventricular mass index (LVMI) correlated with home systolic/diastolic BP with pooled correlation coefficients of 0.46/0.28, respectively. These correlations were similar to that with ambulatory BP (0.37/0.26, 9 studies) and superior to that with OBP (0.23/0.19, 10 studies). (26) Statistically significant correlations of HBP with LVMI have also been reported in other studies, not included in this meta-analysis (27), (28), (29), (30), (31).

Vascular damage

A meta-analysis of four studies found only weak correlations of home and office systolic/diastolic BP with carotid intima-media thickness (cIMT) with no evident differences between the two BP measuring methods. (26) In contrast, the Ohasama study reported that HBP is more closely associated with carotid atherosclerosis (increased cIMT or presence of plaques) than OBP and ABP. In this study HBP was also a better predictor of silent cerebrovascular disease than OBP (32).

Kidney damage

A systematic review reported similar correlations between urinary protein excretion and HBP and OBP values based on evidence from two studies (26). There was a similar finding in a study by Matsui et al. (28). On the other hand, the ADVANCED-J study in diabetic patients and the J-HOP study showed that HBP was more closely associated with urinary albumin creatinine excretion rate (UACR) than OBP (27), (33). In the latter study HBP appeared to be superior to ABPM in this regard (27). In another study from Indianapolis urine protein excretion was related to office, home and ambulatory BP; OBP was weakly related to urine protein excretion, HBP more strongly, and ABP showed the strongest association (34).

BOX 4 HBPM and Target Organ Damage

- Left ventricular mass index (LVMI) is more closely associated with HBP than with OBP, and this association is as strong as that observed with ABP.
- Some studies suggest that HBP is more closely associated with carotid atherosclerosis than OBP and ABP, while no difference between methods was found for PWV.
- While HBP generally correlates with arterial and kidney hypertension mediated organ damage (HMOD), its superiority over OBP in this regard is not unequivocally supported by available evidence.
- Masked hypertension detected by HBP was characterized by more pronounced organ damage than normotension, similar to findings in sustained hypertension.

6.3.2-Adverse health outcomes (Box 5) (More details in the online supplemental file S6.3.2)

Evidence regarding the relationship between HBP and clinical outcome has been summarized in several papers including the previous ESH HBPM guideline (5), 2 systematic reviews (35), (36) and, in a recent narrative review (37). Overall, solid evidence demonstrates that HBP is associated with CVD risk in community-based cohorts (Ohasama study, Kahoku study, PAMELA study and Didima Study), as well as in clinic-based cohorts (**Table S1**). Moreover, HBP appears to be superior to OBP in predicting outcomes: in the meta-analysis by Ward et al. HBP was associated with higher odds ratios (OR) than OBP for total mortality (ORs per 10 mmHg SBP/DBP increase: 1.14/1.10 vs. 1.07/1.02 for HBP and OBP, respectively), cardiovascular mortality (1.29/1.17 vs. 1.15/1.07) and cardiovascular events (1.14/1.13 vs. 1.10/1.07), with similar findings reported in a second meta-analysis (36). Also when HBP and OBP were mutually adjusted only the former remained a significant predictor of outcomes (35). Similar data have been reported for major cardiovascular events in the IDHOCO database and in the HONEST Study (38),(39),(38). In the former study HBP was a stronger predictor of outcome than OBP in treated individuals while there were no clear differences between the two methods in untreated ones (38). Current evidence does not clearly support either HBP or ABP as the superior method for predicting outcome (40). In the PAMELA study ABP did not add prognostic information when the data from OBP and HBP were combined; however, only 2 HBP readings on a single day were obtained in this study (41). A systematic review summarized studies that assessed both HBP and ABP in terms of outcome prediction. Direct comparisons of hazard ratios did not reveal consistent differences between the two methods and in the few studies where mutual adjustment was performed only one indicated clear superiority of ABP in this regard (42). In a recent paper using data from the PAMELA population, addition of out-of-office systolic or diastolic BP to OBP improved cardiovascular and all-cause mortality prediction. The improvement was more consistent when HBP rather than ABP was added to OBP and, compared with HBP plus OBP, no better

prediction was found when addition was extended to 24h ABP. With all additions, however, the improvement was quantitatively modest (43). A summary of prospective studies linking HBPM to outcome is provided in Table S1, in the online supplement .

Box 5 HBPM and OUTCOME

- HBP is associated with cardiovascular risk in community-based as well as in clinic-based cohorts.
- HBP appears superior to OBP in predicting outcomes.
- HBP is more closely associated with both stroke and end-stage kidney disease than OBP. In case of coronary events this stronger association may be restricted to untreated individuals.
- At present, there is no convincing evidence suggesting superiority of either HBP or ABP in predicting outcome.

6.4-Improving adherence to treatment and blood pressure control (Box 6)

6.4.1-Improving adherence to treatment (More details in the online supplemental file S6.4.1)

Low adherence to antihypertensive medications is the most common cause of treatment resistance (44) and it is associated with an increased risk of cardiovascular events (45). Strategies focused on improving adherence are complex and related to patient's behaviour and education, physician attitude, complexity of drug regimen and other health care supportive measures (46). Since HBPM requires active cooperation by the patient, it may be particularly effective in favourably affecting patients' perceptions of their hypertension, thereby encouraging them to be compliant with lifestyle modifications and antihypertensive therapy. Although HBPM, as an isolated intervention, has been associated with a significant increase in the number of pills taken per week (47) (48), establishing the specific contribution of HBPM to treatment adherence has not been easy since in most studies HBPM has been used in combination with other interventions, such as telemonitoring, patient counselling, additional education, or medication reminders (49). A meta-analysis of 28 trials with more than 7000 participants revealed a significant modest positive effect of HBPM (isolated or associated to other co-interventions) on medication adherence when measured objectively by pill count or electronic monitoring (49), (50) The question on whether improving treatment adherence is more effective when

based on HBPM alone, on HBPM combined with telemonitoring and with feedback to patients by their doctor between visits, or when based exclusively on BP determination during office visits is currently being addressed (51), (52). (53)

6.4.2-Improving BP Control during the long-term follow-up

Some studies (i.e. TASMINH2 and TASMIN-SR studies) have shown that patients can also use HBP to titrate their own antihypertensive medication successfully, which translates into improved BP control rates (54, 55). In a meta-analysis, home BP monitoring was associated with less therapeutic inertia; physicians were more likely to change BP medications when HBP was found to be elevated (56). Recent meta-analyses have shown that self-monitoring alone is not associated with lower BP values or with better BP control rates, but in conjunction with co-interventions (including systematic medication titration by doctors, pharmacists, or patients; education; or lifestyle counselling) it leads to clinically significant BP reduction which persists for at least 12 months (57). In consideration of this evidence, it is recommended that implementation of self-monitoring in hypertension should be accompanied by such co-interventions in all treated hypertensive patients (58, 59). HBPM can also contribute to maintain hypertension control at the time of seasonal BP changes. Although ABPM might be regarded as the most suitable method for the identification of seasonal BP changes (reflecting the effect of indoor and outdoor conditions), a recent meta-analysis showed that HBPM may also identify these changes (60). Thus, HBPM can also be used to identify hypertensive individuals with excessive seasonal BP changes, and effectively titrate antihypertensive treatment. (61). Evidence from studies implementing HBPM has also indicated that the prevalence of masked hypertension is higher in seasons other than summer also showing a significant association between morning home diastolic BP and HMOD in winter (62).

BOX 6 Improving adherence to treatment and blood pressure control with HBPM

- HBPM is recommended as a means to increase long-term treatment adherence and persistence and to stimulate other lifestyle changes.
- More research is needed to establish whether improving treatment adherence is more effective when based on HBPM alone, on HBPM combined with telemonitoring and with feedback to patients by their doctor between visits, or when based exclusively on BP determination during office visits.
- A number of studies have shown that treatment titration based on HBPM is associated with better BP control rates than when based on OBP.
- HBPM is more effective in improving BP control when combined with education and counselling.

6.5- Possible difficulties with HBPM use in clinical practice (Box 7)

Despite its advantages, the clinical application and the accuracy of HBPM may be limited by certain conditions related either to the subject (63),(64),(65), (66), to the procedure itself (67), (4), to the oscillometric technique for BP measurement or to cuff related issues. (65), (68), (4), (69), (70), (71), (72), (73), (74).

Box 7 Difficulties with HBPM use

Difficulties related to HBPM Procedure

- Need of patient training (short-lasting for automated devices)
- Possible use of inaccurate devices
- Limited reliability of BP values reported by patients
- Induction of anxiety, resulting in higher BP levels and excessive number of measurements
- Inappropriate treatment changes made by patients based on of casual home measurements without doctor's guidance.
- Normality thresholds and therapeutic targets still to be defined
- Lack of night-time readings with most available devices

Difficulties related to the oscillometric BP measurement technique

- A number of devices still inaccurate, although the situation is improving
- Oscillometric technique fails in some individuals and such patients should be identified
- New wearable oscillometric devices still need extensive validation

Difficulties related to subjects

- Children
 - Limited research in clinical application
 - Uncertain reference values
 - Arterial compliance and cuff size-related issues
 - Need for specific validation of oscillometric devices
 - Few devices validated (see www.stridebp.org/bp-monitors)

- Home BP monitoring schedule not easily followed
- Uncertain diagnostic role
- Elderly
 - Increased BP variability
 - Limited patient's performance/compliance
- Obese people
 - Need of cuffs with adequate size and shape
- Arrhythmias
 - Issues with BP measurement accuracy
 - Possible inaccuracy of built-in software for arrhythmia detection
 - Need of repeated measurements
- Pregnancy
 - Need for specific validation of oscillometric devices
 - Few devices validated (see www.stridebp.org/bp-monitors)
 - BP underestimation in pre-eclampsia
 - Uncertainty of BP thresholds and treatment targets
 - Uncertainty of efficacy and place in care pathways
- End stage kidney disease and diabetes
 - Reduced accuracy of the oscillometric devices due to arterial stiffness typical of these conditions
 - Presence of arterio-venous fistula may affect measurement accuracy.

7-Technology of HBP monitors

7.1-Cuff-based devices

7.1.1-Types of cuff-based devices for HBPM (More details in the online supplemental file S7.1.1)

Several techniques for measuring BP are used by HBPM devices. The most widely used techniques (auscultatory and oscillometric) are described below, with mention of new perspectives for wearable devices offered by progress in technology.

Auscultatory method

The manual auscultatory method involves the detection of the Korotkoff sounds and is based on the use of aneroid, mercury (where available) or hybrid devices. This approach requires skills, good hearing, substantial patient training and regular calibration in case of aneroid devices (2), (75), (12), (1). Very

few devices incorporate microphones or specific sensors to perform automatic auscultatory (microphonic) measurement of BP with less user interference. Overall, the auscultatory method is not currently recommended for HBPM, due both to its difficult implementation and poor patients' performance.

Oscillometric Method

Most automated or semi-automated electronic devices for BP measurement use the oscillometric method (76). Each device has its own proprietary algorithm to calculate BP from the collected oscillometric signal. Most of these devices acquire data for measurements during cuff deflation whereas some do this during cuff inflation. Since each device has its own specific proprietary algorithm and technical characteristics, the measurement accuracy of one device cannot be extrapolated to another, even if produced by the same manufacturer. Moreover, since the cuff with the oscillometric method is used not only to obtain arterial occlusion but also as a sensor to collect the oscillometric signal, experts agree that each oscillometric device must be used only with its own specific cuff(s) as provided by the manufacturer. Therefore, HBPM devices must be considered as the combination of a device and its accompanying cuff(s), whereas the cuff size and type rules which apply for the auscultatory method may not be applicable to the oscillometric approach. Electronic oscillometric devices require less training and are user-friendly, relatively inexpensive, and generally not affected by observer bias if used correctly. These devices, must meet the requirements of national and international regulatory bodies for safety of medical devices such as the Food and Drug Administration in the United States, and the CE (Conformité Européenne) labeling in Europe, but it is recommended to use only devices that have also undergone independent validation for accuracy and passed the criteria of established validation protocols (See paragraph on Clinical Validation). A list of validated HBPM devices can be found, among others, on the British and Irish Hypertension Society and STRIDE BP websites (www.stridebp.org).

Measurements at different sites. Automatic oscillometric devices have been designed to measure BP at different arterial sites. The most commonly used (and recommended) ones are those measuring BP at the upper-arm (brachial artery) level and to a lesser extent those measuring BP at the wrist (radial artery) level. Devices that measure BP at the finger level are not recommended (77).

Wrist cuff-based devices are popular among patients, because measurement is readily obtained without the need to remove clothing, and can be useful in extreme obesity when even extra large cuff is too small (78). These devices are subject to limitations such as distal measurement site and limb position. Even though several automated wrist devices have successfully passed international validation protocols in a laboratory setting, they are considered more prone to errors than the upper-arm devices in real-life conditions (79). Oscillometric wrist device accuracy can indeed be affected by wrist anatomy and position (with reference to the heart level), as well as by the wrist cuff characteristics (soft or pre-shaped). The pre-shaped cuffs are easier for patients to use but they conform less well than the soft ones to the wrist. Measurement with wrist devices is heavily influenced not only by the level at which the wrist is held but also by its flexion or hyperextension. Furthermore, wrist devices are inherently less accurate because of the difficulties in producing an accurate algorithm to estimate SBP and DBP, as there are two arteries contributing to the oscillometric signal at this site. Wrist devices are therefore not generally recommended, due to their inferior accuracy as compared to upper-arm devices and due to issues with their correct use according to instructions (www.stridebp.org/bp-monitors). However, their use may be considered in certain specific populations, such as obese or elderly individuals, in whom HBPM using the upper arm is more difficult to perform, (80) or in case of novel HBPM devices allowing for nighttime automated BP measurements, given that a wrist cuff inflation is likely to produce less interference with sleep quality than an arm cuff inflation (81).

Arm cuff based devices have been shown to be the most reliable both in clinical practice and research, and therefore their use, coupled with a properly sized cuff, is generally recommended for HBPM.

Wearable devices: new perspective for Home BP Monitoring

The recent technological advances have stimulated the development of wearable systems for health monitoring (82), (83), (84), (85). (86). Before regular adoption of wearable technologies for HBPM, important issues should be addressed, related to system accuracy, efficiency, reliability, legislation, interoperability, services, reimbursement and costs and ethical issues. Preliminary results are promising, but there is a strong need for larger, long-term, and well-designed clinical studies to make these novel solutions really applicable in real-life patients' care (82), (83), (84), (85), (86). The recent introduction of wearable devices measuring BP at wrist level with the oscillometric method also requires further investigations, also aimed at providing reference values for BP self-measured "on the move". (85)

Box 8. Selection of Devices for HBPM.

Selection of devices for HBPM

- Only clinically validated upper arm-cuff devices recommended.
- The devices should be used with appropriate cuff size and according to the manufacturer's instructions.
- Auscultatory devices not recommended except under specific circumstances (e.g. selected cases of arrhythmia).
- Wrist cuff devices not recommended; consider in selected cases when arm-cuff BP measurement is not possible or reliable .
- Finger cuff devices not recommended.
- The clinical usefulness of wearable devices still needs to be established.
- Warn patients that monitors more than 4 years old more likely to be inaccurate. (13)
- Validated upper arm cuff devices with personal computer or internet link connectivity and with software allowing automatic storage and automatic averaging of 7 days with trend analysis should be preferred.

7.1.2-Clinical Validation (Box 9)

As with all BP measurement methods, the use of accurate devices is fundamental for the reliable evaluation of HBP (87). Aiming to standardize the validation procedures of BP monitors and establish minimum accuracy standards, in the last 3 decades the US Association for the Advancement of Medical Instrumentation (AAMI), the British Hypertension Society, the European Society of Hypertension (ESH) Working Group on BP Monitoring, and the International Organization for Standardization (ISO), have developed protocols for clinical validation of BP measuring devices (88). Unfortunately, most of the devices available on the market have not been subjected to independent validation using one of these protocols (87), (88), (89), (69). In 2018, the AAMI, ESH, and ISO developed a single universally acceptable standard (AAMI/ESH/ISO, ISO 81060-2:2018), which is intended to replace all previous protocols(90). Until data on the accuracy of BP monitors using the Universal Standard become plentiful, it is recommended to use only those that have been validated by any of the above-mentioned protocols (89), (69). A device that has been successfully validated in a general population sample might not be accurate in a special population (children, pregnancy, atrial fibrillation, chronic kidney disease, arm circumference >42 cm) and separate validation in each of these populations is recommended (90).(70) Devices suggested by manufacturers to have equivalent BP measurement function need their equivalence to be independently checked. Updated lists of successfully validated BP measuring devices using an established protocol and lists of equivalent devices are provided at www.stridebp.org (91).

Box 9 Validation of HBPM devices

- Before clinical use, any HBPM device should undergo a clinical validation for accuracy, by means of an established validation protocol.
- In 2018, the AAMI, ESH, and ISO developed a single Universal Standard (AAMI/ESH/ISO, ISO 81060-2:2018), which is intended to replace all previous protocols.

- Updated lists of successfully validated BP measuring devices using an established protocol are provided at www.stridebp.org.
- Devices with BP measurement equivalence to be checked as well as identical devices with different model name in different countries.

7.1.3-Assessing individual device accuracy and the need of device calibration, maintenance or replacement (Box 10)

For yet unexplained reasons, validated oscillometric manometers might sometimes not be accurate in some individuals from the general population. However, there is still no agreement on the need to routinely test device accuracy against a mercury sphygmomanometer or an electronic monitor with screen BP countdown in individual patients, when the device is used for the first time. This is an important issue to clarify, given that it is not possible to identify failure of the oscillometric method in individual patients based on clinical features only. (70, 92-95)

Device Calibration and Maintenance

Electronic pressure transducers, which represent the heart of an oscillometric BP measuring device, are characterized by a high stability, and generally maintain their accuracy over the years. Thus, it is unlikely that electronic devices might be affected by errors due to loss of calibration (96). In other words, when a validated automated device yields a BP measurement, the latter should be accurate. Therefore, the finding of persistently abnormal or highly variable readings, without any evident reason (eg. inappropriate measurement conditions, arrhythmias), might be a sign of device malfunction and should indicate the need for device replacement. While for aneroid sphygmomanometers used with the auscultatory technique, device calibration is recommended every 6 months (97), in the case of oscillometric devices regular calibration over time is not generally recommended. However, other BP monitoring device components besides the electronic transducer, such as tubing, connections and cuffs,

may deteriorate (air leaks etc.), and may affect accuracy, which emphasizes the need of regular maintenance. Therefore, users should be advised to follow the manufacturers' recommendations for device maintenance. (4). Finally, given that connected HBPM monitors are becoming more popular and that some of these connected devices allow updates of their software, including the BP measurement algorithm, remotely, special attention should be applied to verify the maintenance of their accuracy.

Box 10. Device calibration, maintenance and replacement

- Electronic pressure transducers are characterized by a very high stability, and generally maintain their accuracy over the course of many years without the need for calibration.
- Device tubing, connections and cuffs may deteriorate over time thus also affecting accuracy, and device maintenance is needed in such cases.
- Persistent finding of systematically inaccurate (e.g. highly variable) readings should indicate need of maintenance or replacement.

7.1.4-Cuffs (Box 11)

The size of a cuff bladder is an important component of a cuff-based BP measuring device, which considerably affects its measurement accuracy. Current recommendations for manual auscultatory devices require a cuff with the length of the inflatable bladder covering 75-100% of the mid-arm circumference of the individual subject and the width covering 37-50% of the length of the mid-arm (90), (98). Using a small bladder (undercuffing) is common in obese adults and leads to overestimation of BP, whereas using a larger cuff (overcuffing) is common in children and leads to BP underestimation (90), (98), (4), (99). However, there is some inconsistency in the recommendations by scientific societies on the issue of miscuffing (90), (98), (4), (99), (1), (100). For automated oscillometric upper arm-cuff devices, the cuff is also the signal sensor and each cuff size should be validated in an adequate number of subjects according to the validation standard used (90), (98). The above-mentioned rules for the dimensions of the inflatable bladder do not necessarily apply for

oscillometric devices, and the accuracy of each oscillometric device should be assessed in association with the recommended cuff size in validation studies (90), (98). The use of wide-range cuffs with oscillometric devices is particularly useful, yet such devices require documentation of their BP measurement accuracy throughout the entire range of arm size of recommended use according to the validation protocol requirements (98). In subjects with very large arm size (arm circumference >42 cm) the shape of the cuff is also important as the large arm shape is tronco-conical (101), (102). Thus, a rectangular (cylindrical) shape cuff is unsuitable as it cannot evenly compress the upper arm and a tronco-conical cuff shape seems to be more appropriate (101), (102). However, there is still uncertainty on how to validate devices in people with a large arm size (i.e. >42 cm), as there are issues with the cuff size and shape of the reference (auscultatory) BP measurement as well (102).

Box 11 Cuffs for HBPM devices

- The cuff is an important component of a cuff-based BP measuring device, which considerably affects its measurement accuracy.
- Oscillometric devices should be used with the appropriate cuff size according to the individuals' arm circumference, as instructed by the device manufacturer.
- Wide-range cuffs with oscillometric devices are particularly useful but need validation.
- In subjects with very large arm size the shape of the cuff is also important. In these subjects a tronco-conical cuff shape is recommended”

7.2-Cuffless devices (Box 12) (More details in the online supplemental file S7.2)

Measurement of arterial BP by the brachial cuff sphygmomanometer is still the cornerstone of modern medicine and this approach has not been yet surpassed by any other non-invasive technology.

However, advances in sensor technology for arterial pulse waveform and speed detection have paved the way for the potential development of devices for cuffless measurement of BP, in the perspective of continuous, beat-by-beat monitoring (103), (104), (105), (106) (See online only Supplemental material S7.2) . It should be mentioned, however, that established validation standards have not yet been developed to specifically assess the accuracy of cuffless devices and a new ISO standard for such

devices is currently under development. Consequently, some of such devices have been validated according to ad hoc draft protocols while others according to standard protocols (107), (108), thus resulting in heterogenous and difficult to interpret evidence on their accuracy. Therefore, although the cuffless devices are very promising, at present their use for HBPM is not recommended.

Box 12 Cuffless Devices

- Measurement of BP by the brachial cuff sphygmomanometer is still the cornerstone of modern medicine.
- Progress in sensor technology for arterial pulse waveform and speed detection has stimulated development of devices for cuffless beat-by-beat measurement of BP.
- Established validation standards have not yet been finalized to specifically assess cuffless devices accuracy, which remains a pending issue for research.

7.3-Telemonitoring of Home Blood Pressure (HBPT) values

Despite the demonstrated benefits of HBPM, critical aspects for a proper application of this approach in clinical practice still include data reporting by patients, as well as their transmission to and interpretation by practicing physicians. In general, BP values obtained by patients at home are reported in handwritten logbooks which are often incomplete and inaccurate (misreporting), and/or illegible, making interpretation of HBPM values difficult. This may discourage physicians from relying on HBPM data for making clinical decisions. A possible solution to this problem is the introduction of HBP measuring devices equipped with automated memory. However, also in this case the problems of reporting may persist since data may be stored over different time periods in different devices, making their availability to physicians difficult. In addition, BP measurements taken from different family members might be stored in the same device memory log, thus further increasing the difficulty of their use for hypertension management. A potentially better solution has been provided more recently by progress in information and communication technologies, which in the last decades have made possible the remote transmission of BP values, measured at home, to the doctor's office or hospital, by means of telehealth applications. The conventional approach to home BP telemonitoring is based on computer-

tailored data collection and interventions through the Internet mediated by professional service providers, while more modern solutions are based on mobile health technologies using smartphones and their dedicated applications.

7.3.1-Clinical value of HBPT

Implementation of HBPT has the potential to induce an increased patients' adherence to treatment through their education and involvement in the management of their own health, and to improve doctor-patients relationship. This may help to avoid unnecessary office visits, (109), (110), (111), and to achieve more satisfactory hypertension control rates (112), (113), (57), (114), (115), thus improving cardiovascular prognosis (116), (52). Preliminary reports also suggest a possible usefulness of HBPT for self-titration of antihypertensive medication by patients (117), and for comparing antihypertensive treatments in clinical trials (118). The potential importance of HBPT has been further emphasized by the difficulties in managing patients, including those with hypertension, at the time of COVID-19 outbreak (119). The main disadvantage of conventional HBPT is the high cost of purchasing and maintaining the system, partly counterbalanced by a reduction in the costs of patients' management compared with usual care. Advantages and current barriers and limitations to adoption of HBPT are summarized in **Box 13**.

Box 13. Advantages and disadvantages of Home Blood Pressure telemonitoring (HBPT). Modified from Omboni et al. (120) by permission

Advantages of HBPT for patients

- Improved patient's adherence to treatment and BP control when combined with education and counselling
- Reduced number of office visits and with possible implications for costs of management
- Optimization of therapy facilitating patient-doctor interaction and individual titration

Advantages of HBPT for doctors

- Teletransmission of BP readings with possible feedback to ensure doctor's quick update on patient's health status and strict patient monitoring
- Centralized automatic analysis (no need of local software or specific computer skills)

- Promotion of counselling between healthcare operators

Current Barriers to adoption of HBPT

- Use of BP telemonitoring out of a clinical research setting in daily practice is difficult to implement, because its costs are not yet reimbursed
- Need of adequate infrastructure (mobile network, Internet, connected homes)
- Need for simple and user-friendly devices, possibly integrated in mobile phones, tablets or home appliances
- Need to ensure data security and privacy
- Need of cost-effective systems (full demonstration lacking)

7.3.2-New approaches to HBPM telemonitoring. Mobile Health: current evidence, future perspectives (More details in the online supplemental file S7.3.2)

In the era of mobile revolution, the widespread use of smartphone technologies, along with the development of smartphones applications for HBPM and remote transmission (T), have opened new perspectives for HBPT (mHealth) (121), (122). Preliminary data from clinical studies and a recent meta-analysis have suggested the value of these technologies in improving patients' adherence to antihypertensive treatment, and in achieving higher BP control rates (123), (124). In a recent prospective pilot study in patients with treated hypertension, using a telemedicine healthcare management system which allowed continuous communication between physician and patient via a smartphone application, improved HBP control was achieved in the patients with poor control at baseline (125). Despite the promising results and future perspectives of mhealth related interventions (126) there are still some issues in the digital health-based approach that should be addressed before recommending it for widespread clinical use (121)

Box 14. Advantages and Limitations of mHealth technologies

Advantages of mHealth technologies

- Cost-effectiveness
- Accessibility (large proportion of the population owns a smartphone)
- Patients empowerment/increased compliance
- Improved achievement of BP control which might reduce cardiovascular risk

- Devices may be linkable to wearable sensors
- Some devices allow multi-parametric recording
- Education and promotion of lifestyle changes
- Possibility of supporting of self-management
- Possibility of recordings during daily activities

Limits of mHealth technologies

- Poorly standardized
- Non-validated/inaccurate devices and/or m-App are frequently employed
- Demonstration of efficacy through RCT needed
- Privacy and data security are critical
- Though mobile devices are relatively cheap, dedicated software or infrastructures may still be expensive.
- Physicians, nurses or technicians may need specific training.
- Social, cultural, and educational barriers with technology (older people may be less comfortable with technology).
- Non-automated recording and transmission of BP values might be prone to bias.
- Cuff based devices are still needed (cuffless devices are still not accurate enough).

8-Clinical application of HBPM in hypertension management

8.1-Optimal monitoring schedule. (More details in the online supplemental file S8.1) The selection of the optimal HBPM schedule is based on cross-sectional data examining the reproducibility of average HBP and on outcome data showing its prognostic ability. Cross-sectional studies have mainly focused on the effect of different numbers of readings and days on (i) average HBP, HBP variability and reproducibility, (ii) cross-classification according to office and home BP (normotension, white-coat, masked and sustained hypertension), (iii) association with ABPM values, and (iv) association with indices of preclinical target-organ damage (*127*), (*18*), (*128*), (*129*) (*130*), (*17*), (*131*), (*132*), (*133*). (*17*, *18*, *127-133*) In the International Database on Home blood pressure in relation to Cardiovascular Outcomes (IDHOCO) database (n=4,802) the consistency in diagnosing hypertension phenotypes between consecutive monitoring days was improved by averaging more HBP measurements with near perfect agreement after the 6th monitoring day for both office and home BP cross-classification (*131*). Furthermore, an increasing number of HBPM days resulted in stronger associations with ABPM, left ventricular mass index and urinary albumin, with most of this

improvement occurring within the first 4 days (16 readings) (132). There was no evidence of an improvement when measurements of the first day were discarded (132). Moreover, there were no differences between morning and evening HBP in their association with indices of target-organ damage (132). A Finnish study showed that HBP was lower on the weekend than on workdays (134) which might be important in calculating average HBP particularly when the minimum requirement of 3 days is obtained.(135). Long-term outcome studies provide the most relevant evidence, as they investigate the effect of different HBPM schedules on the prognostic ability of the method, which is the ultimate clinical criterion. Outcome studies in Japan, Greece and Finland with somewhat different HBPM protocols, as well as of the IDHOCO database indicated that the prognostic value of HBPM for cardiovascular disease is increased within the range of 1-7 days, with most of this benefit achieved in the first 3-4 days (131),(136) (137) (138). The recommended 7-day schedule should be performed before each office visit, in the commencement phase, the treatment-titration phase, the long-term follow-up phase, and whenever there seems to be an unusual change in the BP level (rise or decrease).

Box 15. Optimal home blood pressure monitoring schedule

Timing and duration

- Before each office visit and whenever an unusual BP change is suspected.
- 7-day monitoring (not fewer than 3 days).
- Routine work days preferred, especially if few days.

Blood pressure measurements

- Duplicate morning and evening measurements.
- After a 5-min sitting rest and 1-min between measurements.
- Before drug intake if treated.

Interpretation

- Calculate the average of all measurements (the need of discarding the first day is matter of debate).

Long-term monitoring of treated hypertension

- Once or twice per week or month, according to the individual’s health status and preference. In case of controlled hypertension: 7 days before each clinic visit, at least over one week within 3 months
- Too frequent monitoring (e.g. every day) to be discouraged.
- Self-adjustment of drug dosage based on self-measurements to be avoided, if not under guidance by the physician in charge.

8.2- Diagnostic thresholds (Box 16)

In the 2008 ESH HBPM recommendations a threshold for hypertension diagnosis with systolic/diastolic HBP of 135/85 mmHg was proposed, (4) based on the review of evidence including two meta-analyses (139), (140). Both the analysis of a statistical correspondence to the 140/90 mmHg OBP threshold and the comparison of associated risk of adverse outcomes yielded similar results. Additional evidence regarding the outcome-based thresholds for hypertension diagnosis comes from the IDHOCO database (38). After analysing only the untreated part of the sample the proposed approximate HBP thresholds for prehypertension stages 1 and 2 and hypertension stages 1 and 2 amounted to 120/75, 125/80, 130/85, and 145/90 mmHg, respectively. In the IDHOCO database an OBP value of 140/90 mmHg was a significant predictor of increased risk for all outcomes. The corresponding HBP values were 131.9/82.4 mmHg for cardiovascular events, 132.4/82.8 mmHg for stroke and 131.7/81.2 mmHg for cardiac events (38). These threshold values did not differ significantly between genders or between age groups below or above 60 years (141). Conversely, in untreated individuals aged >80 years a significant increase in cardiovascular risk was observed for systolic HBP ≥ 152.4 mmHg and no risk increase was associated with increased diastolic HBP (the risk level was highest for lowest DBP levels) (142). Notwithstanding these results, the 135/85 mmHg threshold, already accepted in 2013 European hypertension guidelines (143) was maintained also in the 2018 ESC/EH guidelines (1). However, the 2017 US ACC/AHA Guidelines recommended to consider this threshold as equivalent to stage 2 hypertension (ie. $\geq 140/90$ mmHg) (2). The latter document, by lowering the OBP threshold for hypertension diagnosis (grade 1) definition to 130/80 mmHg raised important questions regarding the corresponding HBP levels to be used for diagnosis (2). Several studies found that at lower OBP levels the difference with corresponding HBP values becomes much lower (38), (144). ACC/AHA guidelines proposed that the HBP level to identify grade 1 hypertension is the same as for OBP, i.e. 130/80 mmHg (145), (38), (146), (147) (148) (149). Of note, such lower threshold has a substantial impact on the relative prevalence of sustained, masked and white coat

hypertension (150). While in the Ohasama study changing the thresholds did not have relevant impact on the relationship of these categories with outcome, (150) in another study in primary care setting, when 130/80mm Hg threshold was applied, white coat hypertension cases exhibited some difference in risk compared to normotensive patients (OR 2.0, 95% CI 0.5-7.7) (151).

BOX 16 HBPM Thresholds

- HBP threshold for hypertension diagnosis is $\geq 135/85$ mmHg (systolic/diastolic), which corresponds to OBP threshold $\geq 140/90$ mmHg
- The lower HBP hypertension threshold values ($\geq 130/80$ mmHg) proposed by the ACC/AHA Guidelines, which are related to the lower proposed and still debated OBP thresholds for hypertension ($\geq 130/80$ mmHg), are only partly outcome-based and mostly based on observational surveys.
- The suggestion of using lower HBP thresholds for hypertension diagnosis needs to be confirmed by outcome data.
- In the very elderly, the BP-related risk increase may begin at higher HBP levels but more evidence is needed.

8.3. Therapeutic targets and treatment titration (More details in the online supplemental file S8.3)

Therapeutic targets (Box 17)

BP targets to be achieved with antihypertensive treatment are generally a controversial issue. In recent US and European guidelines new and lower OBP targets were proposed based on the evidence from observational studies, from few specifically designed interventional trials, in particular SPRINT (152), and from recent meta-analyses (153), (154). No direct guidance was provided on the targets for ambulatory or home BP however, because of inadequate evidence (1), (2). In the HOMED-BP study, participants were randomized to more ($<125/<80$ mmHg) or less stringent HBP control (125–134/80–84 mmHg). No differences between the groups in terms of cardiovascular events were observed. It should be noted that the achieved BP was very similar in both groups (155). More recently, the HONEST study provided evidence that achieved systolic HBP above 145 mmHg was associated with significantly higher risk than in a reference group targeting <125 mmHg HBP. The risk of this higher HBP category corresponded to that of OBP >150 mmHg. Spline regression analysis suggested some

further (although minor) benefit down to HBP of 125 mmHg (156). Indirect evidence supporting a HBP target <135/85 mmHg comes from studies on masked uncontrolled hypertension, in which treated individuals with controlled OBP but HBP higher than the above-mentioned target value had clearly elevated risk compared to those with better controlled HBP. In summary, given that the most recent ESC/ESH Hypertension guidelines recommend as a general target for OBP SBP/DBP values $\leq 130/80$ mmHg in treated patients, in absence of specific evidence on corresponding home BP targets, we might provisionally suggest that HBP values $\leq 130/80$ mmHg should also be achieved.

Box 17. HBPM Therapeutic Targets

- Antihypertensive treatment should aim to achieve systolic HBP between 125-130 mmHg for most subjects.
- Diastolic HBP targets are less well defined but values ≤ 80 mmHg might represent a reasonable goal.
- All these suggestions, however, need to be verified in the context of randomized intervention trials with CVD and mortality outcomes.

Treatment titration (Box 18)

Although titration of antihypertensive treatment is a crucial part of the management of patients with high BP,(157) titration on the basis of few OBP measurements in primary care may be suboptimal. HBPM offers the unique possibility to evaluate BP on treatment and titrate BP medications either by professionals or by patients themselves (if educated) based on a higher number of readings. In the past years, several studies have assessed the effectiveness of different titration strategies guided by HBPM. The THOP and the HOMERUS trials were the first to examine the efficacy of antihypertensive titration using HBPM (158), (159), but their results are undermined by major limitations because the same BP target for both randomization arms was considered, and differences in BP titration and blinding were maintained with the prescribing physician unaware of randomisation group. In 2014 a study which randomised patients with untreated hypertension to management based on clinic and ABPM measurement or HBPM alone showed that after 1 year there was no significant difference between groups in LVMI regression. (160) (161) Another study explored whether a telemonitoring-based

intervention (162) provided a better result than usual care. The results showed a significantly better reduction in BP in the tele-HBPM group compared to controls, albeit with relatively short follow-up. Most recently, the TASMINH4 study aimed to assess both the longer term (12 month) effect of titration using HBPM and the influence of telemonitoring over and above HBPM with simple paper-based feedback on hypertension control. After 12 months, both HBPM groups had significantly lower systolic BP than those titrated based on clinic readings and the telemonitoring group also had lower BP at 6 months suggesting quicker titration with telemonitoring. (52) (163). The TASMIN-SR trial (55) developed the concept of self-management guided by primary care physicians based on the results of self-monitoring. The intervention was compared to usual care in higher risk patients with hypertension and after 12 months the mean BP had decreased to 128.2/73.8 mm Hg in the intervention group and to 137.8/76.3 mm Hg in the control group, with a difference of 9.2/3.4 mm Hg after correction for baseline BP. Despite the clear evidence that HBPM is effective in reducing BP, as confirmed by a recent meta-analysis (164), cost effective and well tolerated by patients, there are still some open questions such as how to integrate home self BP monitoring with clinical records and, most of all, how to choose patients for self-titration, an issue currently under investigation (165).

BOX 18 HBPM and Treatment Titration

- Physicians using HBPM to titrate antihypertensive medication can achieve better hypertension control than with OBP alone
- HBP monitoring and guided self-titration lead to significantly lower BP than titration guided by clinic readings.
- There are still some open questions such as how to integrate HBPM with clinical records and which patients to select for self titration.

8.4-HOME vs. ABPM (More details in the online supplemental file S8.4)

When combined with OBP, both HBPM and ABPM can identify white-coat and masked hypertension in untreated and treated individuals. The threshold for BP normality is indicated as similar for HBP and ambulatory daytime BP ($\geq 135/85$ mmHg), while a lower threshold is recommended for 24h ABP

($\geq 130/80$ mmHg) (166), (1), (2), (9). The similar diagnostic ability of HBPM and ABPM is probably due to the fact that both methods provide multiple measurements taken away from the office setting in the usual environment of each individual. However, there are also important methodological differences between them, as HBP is measured only after few minutes rest, in a standardized sitting posture at home and during the day, whereas ABP is measured at different postures (sitting, standing and lying), in different environments (work, home, other) and during routine daytime activities and nighttime sleep. Thus, HBPM and ABPM are similar but are not identical methods and the diagnostic agreement between them is sometimes a challenging clinical issue (20). ABPM has been indicated as the most reliable and accurate measurement of BP for diagnosing hypertension and while assessing the response to therapy (2), because it provides information about specific patterns of BP behavior, such as nocturnal dipping, morning surge and short term variability over 24h (166), (167), (168), (2). At variance from ABPM, HBPM it is widely available, relatively inexpensive and well accepted by patients, particularly for repeated monitoring. Consequently, current guidelines recommend also HBPM as a method for the evaluation of BP in untreated subjects with suspected hypertension and, more so, for monitoring the long-term BP control in treated hypertensive patients (169) (4). An important issue to consider is the reproducibility of BP information provided by HBPM and ABPM, respectively, which was shown to be similar by a direct comparison of HBPM and ABPM data in the same individuals (170) (18), or even higher for HBPM (20). In a recent meta-analysis of 58 studies, diagnostic performance of HBPM was slightly higher than OBP. Indeed, a normal OBP can be accompanied by elevated HBP in case of MH. However, some individuals with normal HBP showed elevated BP from 24-h ABPM, suggesting that ABPM is still necessary for confirming the diagnosis of hypertension (171). A recent study, in agreement with previously published PAMELA study data (172) indicated that individuals showing a diagnostic disagreement between their home and ambulatory BP may have cardiovascular risks that are intermediate between those with sustained home and

ambulatory normotension and hypertension (173). However, no precise indications are given in available guidelines on when and in which particular patients to use ABPM or HBPM and the decision to use ABPM or HBPM often reflects the preference of the individual patient and of the healthcare provider. The health care system in which a patient is managed may also be a factor. Although it remains unclear whether one approach is superior to the other for diagnosing hypertension and monitoring BP control, it has to be acknowledged that HBPM and ABPM are equivalent but they measure different aspects of the BP behaviour, so they represent complementary rather than alternative approaches. **See Box 19.** The 2018 ESC/ESH Hypertension guidelines emphasize the complementary role of HBPM and ABPM and recommend that both methods should be used, whenever possible (1). Unfortunately this is not often possible in low resource settings due to healthcare costs and unavailability of these approaches, in particular ABPM, in daily practice, which might make HBPM the preferred out-of-office BPM method (10), (11).

Box 19. When to use ABPM or HBPM

When to use ABPM or HBPM
<ul style="list-style-type: none"> ● ABPM: for initial diagnosis, best if accompanied by 7-day HBPM ● HBPM: for long-term follow-up unless special situations need to be explored (i.e. nocturnal hypertension in Obstructive Sleep Apnea patients, job strain, increased short term BPV, morning BP surge, etc) ● HBPM should be used whenever ABPM is not available or not tolerated ● Disagreement between ABPM and HBPM may occur. In such a case both HBP and ABP values should be considered, on the background of standardization and reproducibility issues of each method

HBPM vs ABPM: Clinical Relevance (Box 20)

Advantages and disadvantages of HBPM and ABPM

Table 2. Comparison of Advantages and disadvantages of HBPM vs. ABPM

ABPM	HBPM
Advantages <ul style="list-style-type: none"> ● Can identify white-coat and masked hypertension 	Advantages <ul style="list-style-type: none"> ● Can identify white-coat and masked hypertension

<ul style="list-style-type: none"> • Stronger prognostic evidence • Night-time readings • Measurement in real-life settings • Additional prognostic BP phenotypes • Abundant information from a single measurement session, including short-term BP variability <p>Disadvantages</p> <ul style="list-style-type: none"> • Expensive and sometimes limited availability • Can be uncomfortable, particularly at night • Cannot be repeated too frequently 	<ul style="list-style-type: none"> • Cheap and widely available • Patient engagement in BP evaluation, which improves compliance with treatment and BP control • Easily repeated and used over longer periods to assess day-to-day BP variability • Preferred to ABPM by most patients, particularly for repeated use <p>Disadvantages</p> <ul style="list-style-type: none"> • Only BP at home and at rest is evaluated • Potential for measurement and reporting errors • Many HBPM devices on the market have not been validated • No nocturnal readings (with most devices) • HBPM may lead to excessive anxiety about BP levels
---	--

BOX 20 Clinical use of ABPM and HBPM. When and How

<ul style="list-style-type: none"> • Diagnosis of hypertension should be made combining office with out-of-office BP monitoring. • HBPM and 24h ABPM show similar reproducibility and prognostic ability, and can both be considered, depending on availability, preference and tolerability • HBPM does not give the same information on BP behaviour as ABPM does, but it is widely available, relatively inexpensive and well accepted by patients particularly for repeated long-term use, as it causes less discomfort and restriction of daily activities and sleep than ABPM. • HBPM requires reliable recording of self-measured BP. Too frequent HBP measurements should be avoided to prevent anxiety about subject's BP levels • ABPM and HBPM are complementary and not interchangeable techniques, providing complementary information on BP in different conditions and over different time periods. • HBPM, in particular when used with co-interventions, may increase patient's adherence to treatment, awareness and active involvement, leading to improved BP control rates • How to choose HBPM or ABPM: Individualized approach based on patient's characteristics (BP values, cardiovascular risk, target organ damage) and availability of HBPM and ABPM. In case of disagreement between methods, both HBP and ABP data should be considered, keeping in mind that ABPM has larger amount of outcome data available.
--

9-Special conditions

9.1-HBPM in children and adolescents (Box 21)

Considerable emphasis on the methodology of OBP measurements has been put in the recent European and American guidelines for pediatric hypertension, by stressing the importance of standardized

conditions, use of validated monitors with appropriate cuff size, and performing multiple measurements. (174), (175). ABPM is currently regarded as the reference method for hypertension diagnosis in children and adolescents, since white-coat, masked and nocturnal hypertension are as common as in the adults (174), (175), (176), (177), (178). The role of HBPM in the evaluation of pediatric hypertension remains largely unrecognized and inadequately investigated, even though the method is being used in clinical practice in children with hypertension (176), (177). HBPM appears to have several potential advantages over both OBP and ABPM, including user convenience and acceptance, and the ability to obtain multiple measurements in the usual environment over several days, weeks or months (174), (175), (176), (177), (178), (179). Preliminary evidence for HBPM in children shows that, as in the adults: (a) its reproducibility is superior to that of OBP measurements and close to that of ambulatory monitoring (176), (177), (178), (21), (b) there is close agreement between home and ambulatory BP monitoring in diagnosing hypertension phenotypes within the range of 80-85% (176), (177), (178), (179), (c) the association of HBPM with several indices of preclinical target-organ damage, mainly left ventricular mass index, appears to be superior to OBP measurements and similar to ABPM (176), (177), (178), (180), (181). An automated oscillometric device which has been successfully validated in adults may not be accurate in children (90) (182) (91). Thus, HBPM in children must only be performed using automated upper-arm devices that have been validated specifically in this population. Unfortunately, very few oscillometric home BP monitors have been tested in children (182), (91). Lists of electronic BP monitors successfully validated in children are available at www.stridebp.org (91). The normalcy range of HBP has been investigated in a single cross-sectional school-based study in 778 children and adolescents, which provided percentile tables according to gender and height (**Table 3**) (183). Home BP at the 50th centile for gender and height represents the 'usual' HBP level, whereas HBP equal or higher than the 95th percentile represents the threshold for home hypertension (183). A recent study investigating the HBP normalcy in adolescents

in Brazil showed no clear differences in distribution patterns of the 95th percentiles for HBP in European and non-European adolescents (184). It should be mentioned that, in contrast to the adults in whom home and daytime ambulatory BP have similar levels, in children and adolescents HBP is considerably lower than daytime ABP, which is attributed to the higher level of physical activity of the young individuals during the day (176),(185). Preliminary evidence on the optimal HBP monitoring schedule in children showed that 6-day monitoring (no less than 3 days) with duplicate morning and evening measurements taken after few minutes rest in the sitting position is adequate, which is in line with the evidence in the adults (186). In young children measurements should be taken by parents, whereas in the adolescents self-measurement is usually appropriate. Practical recommendations for HBPM in children are shown in Box 21.

Table 3. Normalcy table for home blood pressure in children and adolescents by gender and height (systolic/diastolic, mmHg; from (183) with permission)

Height (cm)	N	Percentiles for boys (n=347)		N	Percentiles for girls (n=420)	
		50 th	95 th		50 th	95 th
120–129	23	105/64	119/76	36	101/64	119/74
130–139	51	108/64	121/77	51	103/64	120/76
140–149	39	110/65	125/77	61	105/65	122/77
150–159	41	112/65	126/78	71	108/66	123/77
160–169	45	115/65	128/78	148	110/66	124/78

170–179	91	117/66	132/78	46	112/66	125/79
180–189	57	121/67	134/79	7	114/67	128/80

Box 21. Instructions for home blood pressure monitoring in children and adolescents. Modified from (177) with permission.

Devices

- Automated electronic (oscillometric) upper-arm specifically validated in children.
- Appropriate cuff size to fit the individual’s arm circumference.
- Automated storage and averaging of readings, or mobile Bluetooth connection, or PC link, or tele-monitoring for unbiased reporting.

Conditions

- Measurements in a quiet room after 5 min sitting rest.
- Back supported, arm resting at heart level, feet flat on floor.
- Avoid talking during and between measurements.
- Measurements by parents in young children, or self-measurements in adolescents.

Schedule

- Home monitoring for 7 routine school days (no less than 3 days).
- Duplicate morning and evening measurements on each day with 1 min intervals.

Interpretation

- Calculate the average of all measurements after discarding the first day.
- Evaluate the average value using the normalcy data for HBP in children.
- Average HBP \geq 95th percentile for gender and height indicates home hypertension.

9.2-HBPM in pregnancy (Box 22)

Hypertensive disorders of pregnancy, including pre-eclampsia, complicate up to 10% of pregnancies worldwide, being one of the major causes of maternal and perinatal morbidity and mortality worldwide (187), (188), (189). BP in pregnant women should be measured at every antenatal visit. However, even antenatal schedules may not be sufficiently frequent to identify fulminant pre-eclampsia where onset and progress can be rapid and often asymptomatic (189). In addition, white-coat hypertension is common in pregnancy, especially towards its end (15-35%) (188), (14). Both home and ambulatory BP monitoring have been shown to more accurately characterize BP in pregnancy as in non-pregnant

individuals (189). HBPM is well accepted by pregnant women, and results in fewer antenatal visits overall, while improving surveillance (190). Two large trials are currently exploring the place of self-monitoring in pregnancy. (191) Analysis of individual patient data from self-home monitored and clinic BP readings from 8 studies (N=758) did not reveal any systematic difference between these 2 methods, suggesting that appropriate treatment and diagnostic thresholds for self-home BP monitoring during pregnancy would be equivalent to standard clinic thresholds (14). However, average BP values in this analysis were in the range 117-125 mmHg, which does not represent pregnant women with hypertension. More research is needed to define the threshold of hypertension based on HBP measurements during pregnancy. An automated oscillometric device which has been successfully validated in adults may not be accurate in pregnancy or preeclampsia (90), (192). Thus, these devices should be specifically validated in normotensive and hypertensive pregnant women and also in preeclampsia (90), (192). Lists of BP monitors which have been successfully validated in pregnancy including pre-eclampsia are available at www.stridebp.org (91). The sitting position appears to be appropriate for HBPM during pregnancy (189).

BOX 22 HBPM in Pregnancy

- HBPM is well accepted by pregnant women, and results in fewer antenatal visits overall, while improving surveillance and allowing diagnosis of white coat hypertension.
- More research is needed to define the threshold of hypertension based on HBP measurements during pregnancy
- HBPM devices should be specifically validated in normotensive and hypertensive pregnant women and also in preeclampsia

9.4-People with large arm circumference (Box 23)

Large arm circumference is typical, but not exclusive, of the obese patient, an issue to consider when performing HBPM in these subjects. This observation is relevant given that high BP variability and, most of all, elevated prevalence of white coat hypertension and masked hypertension among obese patients make HBPM a fundamental tool to appropriately define the BP profile in such patients (193), (194). One of the main issues in the management of patients with large arm circumference is the

limited availability of properly sized cuffs, which can end up in an overestimation of BP whilst using a standard size cuff (195), (196). Other issues which may affect accuracy of HBPM include the conical shape of large arms and the combination of large arm circumference with short humerus length (197) (see also session on cuff size and shape). The use of wrist devices may help avoiding these difficulties and may represent a potential alternative for HBPM in obese individuals whenever upper arm cuff devices cannot measure BP, but further investigation to prove this possibility and technological improvement is needed.

BOX 23 (HBPM in individuals with large arms)

- Difficulty in performing HBPM in subjects with large arms is due to a number of factors (lack of properly sized cuffs, conical shaped arms, short humerus length)
- Studies are needed to explore the possible usefulness of wrist devices.

9.5-Patients with Chronic Kidney Disease (Box 24) (More details in the online supplemental file S9.5)

Patients with chronic kidney disease (CKD) often exhibit abnormal 24h BP profiles, including increased short term BP variability, reduced nocturnal BP dipping and, not infrequently, reverse dipping (198), (199), (200). Thus, defining hypertension control in such patients is challenging, and HBPM has been shown to be superior to OBP in identifying lack of hypertension control (201). Given that in patients with CKD adequate BP control reduces not only the decline in kidney function, but also cardiovascular morbidity and mortality, an accurate assessment of BP status is a key to the optimal management of patient with reduced kidney function (202), (203). A meta-analysis shows that among patients with CKD, both white coat hypertension and masked hypertension is common; about 40% of patients thought to have normotension (or adequately treated hypertension) in fact had hypertension at home whereas about 30% of patients thought to have hypertension had normotension at home (204). Home BP monitoring can better define the progression to kidney failure, including end-stage kidney

disease (ESKD), and cardiovascular risk among patients with CKD (203). Therefore, HBPM in CKD patients is important (203). Patients with CKD on haemodialysis are profoundly different from patients with CKD who are not on dialysis; this is so because of varying states of volume excess among patients and volume accumulation in the interdialytic period (205). (206, 207) In fact, compared with peridialysis BP, HBP has a stronger association with left ventricular hypertrophy in patients on haemodialysis (208). Furthermore, considering ABPM as a reference standard, HBP and not predialysis or postdialysis BP, offers the best combination of high sensitivity and high specificity for the diagnosis of hypertension (209). In contrast to peridialytic BP recordings, high home systolic BP relates to an increased mortality in dialysis patients (210), (211). It also carries greater prognostic information. Lastly, it should be mentioned that in ESKD patients, the accuracy of the oscillometric devices is reduced due to increased arterial stiffness and presence of an arteriovenous fistula, but only a few of them have been successfully validated in these patients (212).

BOX 24. HBPM in CKD patients

- HBPM has been shown to be superior to OBP in identifying lack of hypertension control
- Masked hypertension is frequent in patients with CKD
- In CKD HBPM better predicts cardiovascular events, progression to end stage kidney disease (ESKD) or death than OBP
- HBP is better associated with left ventricular hypertrophy in patients on haemodialysis compared with peridialysis BP
- HBPM twice daily, after the midweek dialysis for 4 days, shows satisfactory agreement with interdialytic 44-h ABPM.
- Separate validation of oscillometric HBPM devices might be considered in ESKD patients
- Given the high prevalence of elevated nocturnal BP levels in CKD, usefulness of HBPM devices with nocturnal BP function should be tested

9.6-HBPM in patients with arrhythmia (atrial fibrillation) (Box 25)

HBPM in patients with arrhythmias, especially AF, raises special concerns (213), (214). Particularly in the elderly, hypertension and AF often coexist as their prevalence is rising considerably with increasing age, as clearly demonstrated in recent outcome trials of novel oral anticoagulants where 50-90% of the AF participants

were hypertensives (215). In the presence of AF, both the manual auscultatory and the automated oscillometric measurement of BP are difficult and uncertain due to variations in ventricular filling time, stroke volume and contractility, all of which increase beat-to-beat BP variability (213). Thus, issues with the accuracy of automated BP measurement and its clinical relevance in AF are of high importance. To account for the increased BP variability in AF, it is recommended that several measurements should be averaged using the auscultatory method, and that the automated oscillometric devices should be avoided as most of them have not been validated for accuracy in such patients (1). However, self-measurement using the auscultatory method at home is not feasible in the elderly hypertensives with AF. The current evidence from published validation studies of automated oscillometric BP monitors in AF is rather limited and methodologically heterogeneous (213), (15), (216). However, it appears that there is reasonable accuracy of these devices in measuring systolic BP in the presence of AF, but with a small yet consistent overestimation of diastolic BP (pooled automated minus auscultatory systolic BP difference 1 mmHg, 95% CI -0.1, 2.1, and diastolic BP 2.1 mmHg, 95% CI 0.1, 4.0) (213). In such a context triplicate rather than duplicate measurements should be considered, due to increased beat-to-beat variability (213). An invasive study in AF patients with high ventricular rate showed that there is larger underestimation of oscillometric systolic BP compared to intra-aortic measurement (217). The clinical relevance of BP measurement in AF has been demonstrated in a recent meta-analysis, which showed that both manual auscultatory and automated oscillometric OBP measurements predict stroke or systemic embolism in AF patients, and follow-up BP control has superior predictive ability than baseline BP (218). Thus, despite their inherent instability, BP measurements in AF are clinically relevant as in subjects with sinus rhythm. These findings, together with the fact that in the elderly systolic hypertension is far more common and important for prognosis, suggest that automated devices should be used for HBPM even in the presence of AF (213) in particular when ventricular rate is controlled by treatment. HBPM with specific devices has also been suggested as a means to screen for presence of AF. In fact, novel oscillometric HBPM devices have been developed which are equipped with an algorithm specific for AF detection during routine automated BP measurement. Accumulating evidence suggests that screening for AF in the elderly using an AF-specific algorithm during routine automated office, home or ambulatory BP measurement has high diagnostic accuracy (213), (219), (220).

Two studies have shown that HBPM with automated AF detector might be useful for early detection of asymptomatic AF in elderly individuals with hypertension (220), (221).

BOX 25 HBPM in patients with arrhythmias

- Particularly in the elderly, hypertension and AF often coexist
- In the presence of AF, both the manual auscultatory and the automated oscillometric measurement of BP are difficult and uncertain due to increased beat-to-beat BP variability
- There are few and methodologically heterogeneous validation studies of automated oscillometric BP monitors in AF. It appears that with AF there is reasonable accuracy of these devices in measuring SBP, but with a small yet consistent overestimation of DBP
- Despite their inherent instability, BP measurements in AF predict outcome as in subjects with sinus rhythm
- Oscillometric HBPM devices equipped with an algorithm specific for AF detection during BP measurement can be useful

10-Nocturnal Home Blood Pressure Monitoring (Box 26) (More details in the online supplemental file S10)

There is evidence that nocturnal BP assessed by ABPM has superior prognostic ability compared to OBP and daytime ambulatory or home BP measurements (222), (223). Recent technological development of electronic home monitors has enabled automated measurement of home BP during night-time sleep (81), (224). These novel HBPM devices are programmed to be initiated by a trigger pre-asleep measurement by the patient and later take few automated pre-scheduled measurements during nighttime sleep (81), (224). These devices can be used for consecutive nights to obtain a sufficient number of asleep BP readings, thus possibly increasing the reproducibility of nighttime BP. A meta-analysis of 6 studies including 1,404 subjects compared nocturnal HBPM with night time BP by ABPM and showed pooled correlation coefficients between them of 0.70/0.72 and pooled differences of 1.4/-0.2 mmHg (systolic/diastolic) (170). In the same meta-analysis, 2 studies including 212 subjects investigated the agreement between nocturnal HBPM and ABPM in detecting non-dippers and showed weighted agreement of 77%, which is close to the reproducibility of each of the two methods (170). Moreover, similar pooled correlation coefficients of nocturnal systolic HBP and ABP

were reported with left ventricular mass index, urinary albumin excretion and carotid intima-media thickness (170). The Japan Morning Surge-Home Blood Pressure (J-HOP) Nocturnal BP Study in 2,545 participants showed nighttime systolic HBP to predict incident cardiovascular events, independent of office and morning home BP (225). (226, 227) Regarding the optimal schedule of nighttime HBPM, a single study showed that a 2-night HBPM schedule with 3 automated measurements scheduled per night (total of 6 asleep BP readings) appears to be the minimum requirement for a reliable assessment of nighttime HBPM, providing reasonable agreement with nocturnal ABPM and association with indices of preclinical organ damage (228). These findings are in line with the current recommendations for assessing nighttime ambulatory BP with a minimum requirement of 7 readings (229). Furthermore, in a crossover study the reliability of nocturnal HBPM appeared to be similar between a schedule of measurements at 2, 3 and 4 hours after the chosen bedtime and that with measurements at fixed time points (at 2:00, 3:00 and 4:00 am) (230). Obstructive sleep apnea is known to be associated with nocturnal hypertension and non-dipping profile, which are associated with adverse prognosis. Preliminary evidence suggests that nocturnal HBPM can be used as an alternative to ABPM in the investigation of nocturnal BP in patients with sleep apnea (231), (232). A novel home BP monitor developed specifically for the evaluation of patients with obstructive sleep apnea, is able to trigger asleep BP measurement during episodes of hypoxia (reduced oxygen saturation) (232). In conclusion, there is accumulating evidence that nocturnal HBPM is feasible and appears to be a reliable alternative to ABPM for the evaluation of asleep BP. A recent consensus statement presents a systematic review of the current evidence on nocturnal HBP, and highlights the potential of the method, the remaining research questions and preliminary recommendations for its clinical application (81). Whether wrist devices may perform better at night than arm cuff devices, because of less pronounced interference with sleep patterns, this is an issue which deserves to be further explored.

BOX 26 Nocturnal HBPM

- Technological development of HBPM devices has enabled automated measurement of HBP during night-time sleep
- Available data suggest reasonable correlation and similarity between asleep BP values obtained by HBPM and ABPM
- A 2-night HBPM schedule with 3 automated measurements scheduled per night (total of 6 asleep BP readings) appears to be the minimum requirement for a reliable assessment of nighttime HBPM
- Nocturnal HBPM seems to be feasible also as a reliable alternative to ABPM in the detection of nocturnal hypertension and non-dippers and the investigation of patients with sleep apnea, but more research is needed.
- Whether wrist devices may perform better at night than arm cuff devices, because of less pronounced interference with sleep patterns, this is an issue which deserves to be further explored

11-Orthostatic Hypotension (Box 27)

Orthostatic hypotension (OH) is a common condition associated with adverse cardiovascular prognosis. (233), (234) Screening for OH consists of BP measurements in supine (or sitting) and standing position during clinical consultations (235). However, OH is poorly reproducible; thus assessments carried out at the doctors' office are likely to underestimate its true prevalence (236). HBPM can improve OH diagnosis without compromising the quality of the postural BP assessment, as shown by Cremer and co-authors (237) who demonstrated that in 505 mostly hypertensive patients OH prevalence defined as the presence of one episode of OH detected by HBPM was 37.5%, much higher than OH prevalence measured in the same cohort in a clinic setting (15%). OH is a common finding in elderly patients due to their impaired baroreceptor sensitivity, (238) and is often associated with hypertension, dementia, other neurodegenerative diseases (e.g. Parkinson's disease), atrial fibrillation, diabetes, and heart failure (239), (240), (241), (242). However, in the elderly individuals, it may be difficult to use HBPM because of physical and/or cognitive dysfunction of the users (243). The diagnostic accuracy of HBPM in detecting OH as compared to ABPM needs to be explored. The potential usefulness of wearable devices for self BPM in detecting orthostatic hypotension requires to be investigated.

BOX 27 HBPM in orthostatic hypotension

- Orthostatic hypotension is common in the elderly but is poorly reproducible. Thus, assessments carried out during consultations may underestimate the true prevalence
- HBPM can improve orthostatic hypotension diagnosis, by allowing for repeated measurements in daily life, also in association with the peak drug effect and associated symptoms
- The diagnostic accuracy of HBPM in detecting orthostatic hypotension as compared to ABPM needs to be explored

12-Home blood pressure variability (Box 28) . (More details in the online supplemental file S12)

Blood pressure variability (BPV) has been assessed for many years by mostly focusing on 24h ABPM recordings. More recently, evidence has been provided also on the clinical relevance of BPV assessed over longer periods, ie. based on OBP measured in different visits (visit-to-visit BPV, VVV) or on HBP measurements obtained over a week or even longer time intervals (home BPV, HBPV) (244). Since HBPV is easier to obtain than VVV in a standardized manner, it has even been suggested that it might be the ideal approach to assess BPV (245). Increased day-by-day HBPV has been associated with advanced age, female gender, increased arterial stiffness, elevated mean BP values, low body mass index, low heart rate, excessive alcohol intake, cigarette smoking, cardiovascular disease, diabetes, diabetic nephropathy and sedentary lifestyle (246). Studies focusing on treated hypertensive patients have found a higher day-by-day BPV among these individuals compared to untreated subjects (38), (140), also reporting higher values of HBPV in case of treatment with beta-blockers, short duration of treatment (247), and increasing number of antihypertensive drugs (248). Regarding the optimal methodology of HBPV assessment, two principal elements should be considered: 1) how HBP data are collected; 2) what estimates of HBPV should be considered . Studies addressing the predictive value of HBPV for HMOD are characterized by heterogeneous methodology and by discrepant results (246). Conversely, the evidence supporting the relationship of HBPV with clinical outcome is more consistent. In the IDHOCO database all indices of systolic/diastolic HBPV (SD, CV, ARV, VIM) were independently associated with all-cause and cardiovascular mortality (249) although did not significantly improve risk stratification. A meta-analysis of observational cohorts and of clinical trials

reported a significantly increased risk of cardiovascular events, cardiovascular and all-cause mortality in relation to an increased HBPV after accounting for confounders (250). HBPV was superior to OBP variability in the Didima study (251). Morning day-by-day home BPV may have superior prognostic value as compared to morning-evening or evening home BPV (137), (252). Regarding potential threshold values for mid-term day-by-day BPV, the results of the IDHOCO study indicate that the risk of cardiovascular morbidity and mortality steeply increased in the highest decile of systolic/diastolic home BPV distribution ($CV \geq 11/12.8\%$, respectively)(253). These data need however to be validated by other studies. Also, there is no unequivocal evidence that HBPV reduction may provide benefits in terms of HMOD or risk of events independently of average BP reduction, due to lack of ad hoc intervention trials (254), (255). In conclusion, HBPV is an independent outcome predictor and might be particularly useful for long-term monitoring, but the available evidence does not support its application in clinical practice.

BOX 28 Home BPV

- Home BPV can be measured by considering readings obtained day-by-day over one week of HBPM
- HBPV is related to several possible determinants and has been reported to predict outcome after accounting for confounders. Available evidence however comes from heterogeneous studies
- There is no clear evidence that any treatment modality might be superior in reducing HBPV
- HBPV is an independent outcome predictor but the available evidence does not support its application in clinical practice.

13-Barriers for clinical use, cost-effectiveness and patients' preference (Box 29)

13.1-Barriers for clinical use of HBPM (More details in the online supplemental file S13.1)

Adoption of HBPM is still challenging due to barriers that involve three general domains: cultural, structural and financial (256), (257), (258), (259). From a cultural standpoint, poor education on the need for regular BP monitoring still exists among doctors and patients with the former being unable to implement properly local guidelines and the latter being often unaware of the importance of

cardiovascular risk factors detection and control. Such cultural barriers are relevant and are often enhanced by the need of more robust evidence on the benefit of HBPM, including additional studies focusing on HBPM impact on prognosis, advantageous cost/benefit ratio and HBP thresholds/targets for treatment. Some more structural barriers limit the availability of HBPM and include the lack of adequate infrastructures for HBPM implementation at a population level and for data transfer to the physician in charge but also the need for simpler and more user-friendly devices, with simple functioning and readable displays capable to ensure data security and privacy. Lastly, financial issues represent still a major problem for patients highlighting the need of cost-effective systems made by cheap and integrated devices with the aim of being reimbursed by health care services or insurances. In this context, we should consider that diffusion of HBPM in developing countries may be importantly limited by income levels of the population well below what occurs in more developed areas of the world.

13.2-Cost-Effectiveness of HBPM

Published data on the cost-effectiveness of HBPM have been conflicting (260). Without other co-interventions, HBPM has been found to provide only a small BP lowering benefit that is not sustained over time (261), (262). However, HBPM by itself may not improve BP control but can improve therapeutic inertia and thereby provide a substantial benefit (56). In fact, the BP-lowering benefit of HBPM has been greater when used with co-interventions (e.g., telemonitoring, pharmacist visits) (261). Therefore, the cost-effectiveness of HBPM needs to be considered within the context of these co-interventions, and in relation to the associated costs. It is important to distinguish HBPM from the broader category of self-measured BP, which may also include the use of kiosks or measurements obtained by a patient using an automated device at their healthcare provider's office (258). A recent systematic review showed that although the accuracy of both office and home BP for the diagnosis of hypertension has increased, ambulatory BP remains the most cost-effective option to confirm a

diagnosis of hypertension, an issue currently under debate (263). Individual trials of self BP monitoring at home have also shown cost-effectiveness. In primary care, the TASMINH4 study showed that titration of antihypertensives using self-monitored BP was cost-effective, with similar probabilities of cost-effectiveness from manual and telemonitored transmission of readings (163). A recent study showed that HBP telemonitoring accompanied with pharmacist management effectively lowered BP levels, with an estimation for a significant reduction in costs for the health system by avoiding cardiovascular events over 5 years (264).

13.3-Patients' preference and healthcare provider concerns

HBPM is preferred to ABPM by the majority of patients, because it is less intrusive in their daily life. ABPM has been reported to cause discomfort in 55% of patients and the need of severe restrictions of daily activities was reported by 30% of patients. However, although there is limited data for direct comparison with HBPM (265) (266). This is perhaps more so in minority ethnic populations (267). Concerning health care providers there is a need of specific education and update on use of contemporary HBPM devices and on the criteria for their selection and use. Pharmacists, who are often in charge of selling the devices, should be informed and constantly updated on the devices that have been successfully validated according to internationally acknowledged validation protocols, as well as on their specific features, including the availability of cuffs of different size, wide-range cuffs, or specific algorithms for arrhythmia detection. They should also be informed on which devices have been validated for special populations, such as pregnant women or children and adolescents. Regarding physicians, they should also be educated on how to instruct patients to make proper use of HBPM devices. In particular, indications should be provided on how to prescribe a HBPM and what explanation should be given to patients, also regarding where to buy and how to choose a reliable HBPM device. Finally, physicians concerned about the possible “neurotic” performance of an

excessive number of BP measurements by anxious patients should be trained on how to educate and instruct such patients.

BOX 29 HBPM: Barriers, cost-effectiveness and patients' preference

- Adoption of HBPM is still challenging due to cultural, structural and financial barriers
- Taken together, preference of patients and providers and cost-effectiveness data support the use of HBPM.

14-Home Blood Pressure Monitoring in Clinical Research (Box 30) (More details in the online supplemental file S6.1 and S14)

During the last two decades HBPM has been used increasingly in clinical hypertension research (155), (17), (268), (269), (270), (271), (272), (273), (274). Its multiple advantages lead to superior diagnostic reliability and measurement reproducibility, ensuring improved accuracy of clinical trials as compared to use of OBP measurements, and thereby leading to smaller study sample size and lower research costs, together with better patients' acceptance, particularly for longer-term trials (17).

HBPM use may improve selection of study participants, because it offers more accurate definition of hypertension phenotypes and allows identification of individuals with white-coat and masked hypertension.

HBPM improves evaluation of the duration of action of antihypertensive drugs, because it allows to obtain measurements before drug intake and post-dose, thus providing information on the “trough” and “plateau” (not peak) effect calculating the morning-to-evening (M/E) home BP ratio. Moreover, as already mentioned, HBP has no regression to the mean phenomenon during both pretreatment drug-free period and antihypertensive drug monotherapy period (275).

HBPM also allows for evaluation of drug-induced effects on BPV

HBPM allows tracking specific BP changes during usual activities or interventions (i.e. Postprandial hypotension).

Box 30 HBPM in a Research Setting. Usefulness in clinical trials

- General Advantages:** availability of multiple readings over time, high reproducibility and diagnostic accuracy, correlation with early HMOD and cardiovascular events, easily acceptable to patients.
- **Improved selection of study participants**
- Improved Study Power and reduced Sample Size**
- Improved evaluation of the duration of action of antihypertensive drugs**
- Better support to chronotherapy studies**
- **Evaluation of Drug-Induced Effects on Blood Pressure Variability**

15-Remaining Unresolved Research Questions

- Diagnostic agreement between ABPM and HBPM needs further evaluation
- More longitudinal studies are needed to confirm the association between HBP and HMOD (kidney in particular).
- The respective role of morning vs evening HBP with regards to outcomes is still unclear
- There is no convincing evidence on superiority of either HBP or ABP in predicting outcome, due to the lack of head-to-head comparisons.
- There is still uncertainty on how to validate devices in large arms, sized greater than 42 cm, as there are issues with the cuff size and shape of the reference (auscultatory) BP measurement as well.
- Lack of availability of properly sized cuffs, which can end up in an over estimation of BP whilst using a standard size cuff on large arms.
- Established validation standards have not yet been developed to assess cuffless devices (ISO standard)
- The use of HBP telemonitoring deserves further research to clearly demonstrate its clinical efficacy and economic benefits.
- How to integrate self monitoring with clinical records and, most of all, how to choose patients for self-titration.

- Home BP variability – what are the threshold values for risk stratification? Are there any independent prognostic benefits from reducing BPV? What treatments are effective in treating increased BPV?
- Can HBPM reimbursement improve BP control in the populations?
- More home BP devices should be validated in special populations (children, pregnant women, CKD, etc)
- Evidence supported thresholds for hypertension in children and during pregnancy based on home BP measurements is needed.
- Outcome data on the use of self-monitoring of blood pressure for guiding management in children and in pregnancy is needed.
- Nocturnal HBPM: clinical and prognostic value of HBPM devices for the detection of non-dippers and of sleep apnea patients, and usefulness/reliability of wrist-worn nocturnal BP monitors is to be established.
- Randomized controlled intervention trials exploring whether hypertension management based on HBPM leads to a better outcome than a management based on OBP are needed. The ongoing MASTER trial (276) is exploring this important issue with regard to ABPM, but also includes data on HBPM and might provide some evidence in this regard.

16-Conclusions

Compared to the last 2008-2010 Position Papers (4), the number of articles published in the field of HBPM in the last decade has been on considerable rise and convincing evidence has now further clarified several aspects about the use of HBPM in clinical practice and research. Some of these new indications are summarized in Boxes 31 and 32. Additional evidence is still needed from population

studies and randomized trials on hypertension management, to clarify whether hypertension management based on out of office BP, in particular on HBPM, leads to a better outcome than hypertension management guided by OBP.

BOX 31 New Indications on Methodology of HBPM

- The use of wide-range cuffs with oscillometric devices is useful for HBPM, (but cuff choice should be based on the instruction by the manufacturer).
- A new Universal Standard for validation of BP monitors has been published in 2018 (90)
- The main international website providing a reference list of validated devices is now www.stridebp.org.
- Cuffless devices may offer information on BP in a less intrusive manner, but to date, none of them has been properly validated.
- Main characteristics of a preferred HBPM device include: (i) upper-arm cuff; (ii) successful validation within the last 10 years and (iii) storage/connectivity for objective reporting of readings.
- Use of such devices is recommended both for clinical and research purposes.

Box 32. New indications on clinical application of HBPM

- Re-definition of diagnostic thresholds for hypertension: HBP $\geq 135/85$ mmHg corresponds to $\geq 140/90$ mmHg clinic BP in ESC-ESH guidelines), while HBP $\geq 130/80$ mmHg may correspond to $\geq 130/80$ mmHg clinic BP threshold for grade I hypertension in ACC/AHA Guidelines. (2)
- Therapeutic targets: systolic HBP between 125-130 mmHg and diastolic HBP < 80 mmHg are now considered reasonable goals. Such targets do not apply in the very elderly where higher systolic HBP values might be considered for SBP
- Recent technologies have now made nocturnal HBPM feasible. Studies are needed to explore whereas nocturnal HBPM can improve the prognostic stratification of patients with hypertension.

Conflicts of interest related to the present position paper

RA has received honoraria from Akebia, AstraZeneca, Bayer, Boehringer Ingelheim, Chinook, Diamedica, Merck, Reata, Relypsa, and Sanofi and has received royalties from UpToDate. R.A. is supported by National Heart Lung and Blood Institute grant R01 HL126903 and U.S. Veterans Administration grant I01CX001753.

KA has received Research support from Omron Healthcare

PG has received Research grants from Recor Medical

KK has received Research grants from Omron Healthcare Fukuda Denshi, and A&D, Otsuka Medical.

YL has received research grants from A&D, Bayer, Omron and lecture fees from A&D, Daiichi Sankyo, Omron, and Takeda

JM is part of the Scientific Advisory Board for BMS/Pfizer

RJM Grant income from NIH. Telemonitoring development and evaluation with Omron (all fees to his institution). Speaker expenses ESH 2019 and ASN 2019. Honoraria paid to his institution/College.

ASM has received Research funding from Novartis & honorarium from Merck, Servier, Hillrom

TO has received Research grant from Omron Healthcare Co.Ltd.

SO is a Scientific consultant of Biotechmed Ltd. provider of telemedicine services

GP Has received honoraria for lectures by OMRON Healthcare, SERVIER, Sanofi, FIDIA.

PP has received Honoraria for validation Studies from Microlife, AND, and Hingmed

GS has conducted validation studies for various manufacturers of blood pressure measurement technologies and advised manufacturers on device and software development

J-GW has received Grants from Omron

MAW is a consultant for Medtronic; ReCor; Ablative Solutions; Urovant; Regeneron; Bayer

WBW is a cardiovascular safety consultant (DSMB, CV endpoints committees) for Astra-Zeneca, Bristol-Myers Squibb, Takeda-Millennium; and editor for UptoDate (Wolters Kluwer)

Acknowledgments

All authors thank OMRON Healthcare and SERVIER for the generous and unrestricted support to the organization of the ESH Satellite Symposium held in Milan on June 2019, from which the present work was generated.

References

1. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, et al. 2018 Practice Guidelines for the management of arterial hypertension of the European Society of Hypertension and the European Society of Cardiology: ESH/ESC Task Force for the Management of Arterial Hypertension. *Journal of hypertension*. 2018;36(12):2284-309.
2. Whelton PK, Carey RM, Aronow WS, Casey DE, Jr., Collins KJ, Dennison Himmelfarb C, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for

the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Hypertension*. 2017.

3. Asmar R, Zanchetti A. Guidelines for the use of self-blood pressure monitoring: a summary report of the First International Consensus Conference. Groupe Evaluation & Measure of the French Society of Hypertension. *Journal of hypertension*. 2000;18(5):493-508.
4. Parati G, Stergiou GS, Asmar R, Bilo G, de Leeuw P, Imai Y, et al. European Society of Hypertension guidelines for blood pressure monitoring at home: a summary report of the Second International Consensus Conference on Home Blood Pressure Monitoring. *Journal of hypertension*. 2008;26(8):1505-26.
5. Parati G, Stergiou GS, Asmar R, Bilo G, de Leeuw P, Imai Y, et al. European Society of Hypertension practice guidelines for home blood pressure monitoring. *Journal of human hypertension*. 2010;24(12):779-85.
6. Shimbo D, Artinian NT, Basile JN, Krakoff LR, Margolis KL, Rakotz MK, et al. Self-Measured Blood Pressure Monitoring at Home: A Joint Policy Statement From the American Heart Association and American Medical Association. *Circulation*. 2020;142(4):e42-e63.
7. Hypertension in adults: diagnosis and management. NICE guideline [NG136] [Available from: <https://www.nice.org.uk/guidance/ng136/chapter/recommendations>].
8. Lovibond K, Jowett S, Barton P, Caulfield M, Heneghan C, Hobbs FD, et al. Cost-effectiveness of options for the diagnosis of high blood pressure in primary care: a modelling study. *Lancet*. 2011;378(9798):1219-30.
9. Kario K, Imai Y, Kollias A, Niiranen TJ, Ohkubo T, McManus RJ, et al. Diagnostic value of home blood pressure: Springer 2019.

10. Sanchez RA, Boggia J, Penaherrera E, Barroso WS, Barbosa E, Villar R, et al. Ambulatory blood pressure monitoring over 24 h: A Latin American Society of Hypertension position paper-accessibility, clinical use and cost effectiveness of ABPM in Latin America in year 2020. *J Clin Hypertens (Greenwich)*. 2020;22(4):527-43.
11. Villar R, Sanchez RA, Boggia J, Penaherrera E, Lopez J, Barroso WS, et al. Recommendations for home blood pressure monitoring in Latin American countries: A Latin American Society of Hypertension position paper. *J Clin Hypertens (Greenwich)*. 2020;22(4):544-54.
12. Nerenberg KA, Zarnke KB, Leung AA, Dasgupta K, Butalia S, McBrien K, et al. Hypertension Canada's 2018 Guidelines for Diagnosis, Risk Assessment, Prevention, and Treatment of Hypertension in Adults and Children. *Can J Cardiol*. 2018;34(5):506-25.
13. Hodgkinson JA, Lee MM, Milner S, Bradburn P, Stevens R, Hobbs FR, et al. Accuracy of blood-pressure monitors owned by patients with hypertension (ACCU-RATE study): a cross-sectional, observational study in central England. *Br J Gen Pract*. 2020;70(697):e548-e54.
14. Tucker KL, Bankhead C, Hodgkinson J, Roberts N, Stevens R, Heneghan C, et al. How Do Home and Clinic Blood Pressure Readings Compare in Pregnancy? *Hypertension*. 2018;72(3):686-94.
15. Clark CE, McDonagh STJ, McManus RJ. Accuracy of automated blood pressure measurements in the presence of atrial fibrillation: systematic review and meta-analysis. *Journal of human hypertension*. 2019;33(5):352-64.
16. Stergiou G, Efstathiou S, Alamara C, Mastorantonakis S, Roussias L. Home or self blood pressure measurement? What is the correct term? *Journal of Hypertension*. 2003;21(12):2259-64.
17. Stergiou GS, Baibas NM, Gantzourou AP, Skeva, II, Kalkana CB, Roussias LG, et al. Reproducibility of home, ambulatory, and clinic blood pressure: implications for the design of

- trials for the assessment of antihypertensive drug efficacy. *American journal of hypertension*. 2002;15(2 Pt 1):101-4.
18. Stergiou GS, Ntineri A. The optimal schedule for self-home blood pressure monitoring. *Journal of hypertension*. 2015;33(4):693-7.
 19. Guo QH, Cheng YB, Zhang DY, Wang Y, Huang QF, Sheng CS, et al. Comparison Between Home and Ambulatory Morning Blood Pressure and Morning Hypertension in Their Reproducibility and Associations With Vascular Injury. *Hypertension*. 2019;74(1):137-44.
 20. Schwartz JE, Muntner P, Kronish IM, Burg MM, Pickering TG, Bigger JT, et al. Reliability of Office, Home, and Ambulatory Blood Pressure Measurements and Correlation With Left Ventricular Mass. *J Am Coll Cardiol*. 2020;76(25):2911-22.
 21. Stergiou GS, Bountzona I, Alamara C, Vazeou A, Kollias A, Ntineri A. Reproducibility of Office and Out-of-Office Blood Pressure Measurements in Children: Implications for Clinical Practice and Research. *Hypertension*. 2021.
 22. Stergiou GS, Salgami EV, Tzamouranis DG, Roussias LG. Masked hypertension assessed by ambulatory blood pressure versus home blood pressure monitoring: is it the same phenomenon? *American journal of hypertension*. 2005;18(6):772-8.
 23. Stergiou GS, Kyriakoulis KG, McManus RJ, Andreadis EA, Jula A, Kollias A, et al. Phenotypes of masked hypertension: Isolated ambulatory, isolated home and dual masked hypertension. *Journal of hypertension*. 2020;38(2):218-23.
 24. Anstey DE, Muntner P, Bello NA, Pugliese DN, Yano Y, Kronish IM, et al. Diagnosing Masked Hypertension Using Ambulatory Blood Pressure Monitoring, Home Blood Pressure Monitoring, or Both? *Hypertension*. 2018;72(5):1200-7.

25. Mancia G, Sega R, Grassi G, Cesana G, Zanchetti A. Defining ambulatory and home blood pressure normality: further considerations based on data from the PAMELA study. *Journal of hypertension*. 2001;19(6):995-9.
26. Bliziotis IA, Destounis A, Stergiou GS. Home versus ambulatory and office blood pressure in predicting target organ damage in hypertension: a systematic review and meta-analysis. *Journal of hypertension*. 2012;30(7):1289-99.
27. Ishikawa J, Hoshida S, Eguchi K, Ishikawa S, Shimada K, Kario K, et al. Nighttime home blood pressure and the risk of hypertensive target organ damage. *Hypertension*. 2012;60(4):921-8.
28. Matsui Y, Ishikawa J, Eguchi K, Shibasaki S, Shimada K, Kario K. Maximum value of home blood pressure: a novel indicator of target organ damage in hypertension. *Hypertension*. 2011;57(6):1087-93.
29. Her AY, Kim YH, Rim SJ, Kim JY, Choi EY, Min PK, et al. Home blood pressure is the predictor of subclinical target organ damage like ambulatory blood pressure monitoring in untreated hypertensive patients. *Anadolu Kardiyol Derg*. 2014;14(8):711-8.
30. Tsunoda S, Kawano Y, Horio T, Okuda N, Takishita S. Relationship between home blood pressure and longitudinal changes in target organ damage in treated hypertensive patients. *Hypertens Res*. 2002;25(2):167-73.
31. Mancia G, Zanchetti A, Agabiti-Rosei E, Benemio G, De Cesaris R, Fogari R, et al. Ambulatory blood pressure is superior to clinic blood pressure in predicting treatment-induced regression of left ventricular hypertrophy. SAMPLE Study Group. Study on Ambulatory Monitoring of Blood Pressure and Lisinopril Evaluation. *Circulation*. 1997;95(6):1464-70.

32. Hara A, Tanaka K, Ohkubo T, Kondo T, Kikuya M, Metoki H, et al. Ambulatory versus home versus clinic blood pressure: the association with subclinical cerebrovascular diseases: the Ohasama Study. *Hypertension*. 2012;59(1):22-8.
33. Tanaka Y, Daida H, Imai Y, Miyauchi K, Sato Y, Hiwatari M, et al. Morning home blood pressure may be a significant marker of nephropathy in Japanese patients with type 2 diabetes: ADVANCED-J study 1. *Hypertens Res*. 2009;32(9):770-4.
34. Agarwal R, Andersen MJ. Correlates of systolic hypertension in patients with chronic kidney disease. *Hypertension*. 2005;46(3):514-20.
35. Ward AM, Takahashi O, Stevens R, Heneghan C. Home measurement of blood pressure and cardiovascular disease: systematic review and meta-analysis of prospective studies. *Journal of hypertension*. 2012;30(3):449-56.
36. Stergiou GS, Siontis KC, Ioannidis JP. Home blood pressure as a cardiovascular outcome predictor: it's time to take this method seriously. *Hypertension*. 2010;55(6):1301-3.
37. Kario K, Shimbo D, Hoshide S, Wang JG, Asayama K, Ohkubo T, et al. Emergence of Home Blood Pressure-Guided Management of Hypertension Based on Global Evidence. *Hypertension*. 2019:HYPERTENSIONAHA11912630.
38. Niiranen TJ, Asayama K, Thijs L, Johansson JK, Ohkubo T, Kikuya M, et al. Outcome-driven thresholds for home blood pressure measurement: international database of home blood pressure in relation to cardiovascular outcome. *Hypertension*. 2013;61(1):27-34.
39. Shimada K, Kario K, Kushiro T, Teramukai S, Zenimura N, Ishikawa Y, et al. Prognostic significance of on-treatment home and clinic blood pressure for predicting cardiovascular events in hypertensive patients in the HONEST study. *Journal of hypertension*. 2016;34(8):1520-7.

40. Niiranen TJ, Maki J, Puukka P, Karanko H, Jula AM. Office, home, and ambulatory blood pressures as predictors of cardiovascular risk. *Hypertension*. 2014;64(2):281-6.
41. Sega R, Facchetti R, Bombelli M, Cesana G, Corrao G, Grassi G, et al. Prognostic value of ambulatory and home blood pressures compared with office blood pressure in the general population: follow-up results from the Pressioni Arteriose Monitorate e Loro Associazioni (PAMELA) study. *Circulation*. 2005;111(14):1777-83.
42. Shimbo D, Abdalla M, Falzon L, Townsend RR, Muntner P. Studies comparing ambulatory blood pressure and home blood pressure on cardiovascular disease and mortality outcomes: a systematic review. *Journal of the American Society of Hypertension : JASH*. 2016;10(3):224-34 e17.
43. Mancia G, Facchetti R, Seravalle G, Cuspidi C, Corrao G, Grassi G. Adding Home and/or Ambulatory Blood Pressure to Office Blood Pressure for Cardiovascular Risk Prediction. *Hypertension*. 2021;77:640–9.
44. Jung O, Gechter JL, Wunder C, Paulke A, Bartel C, Geiger H, et al. Resistant hypertension? Assessment of adherence by toxicological urine analysis. *Journal of hypertension*. 2013;31(4):766-74.
45. Corrao G, Parodi A, Nicotra F, Zambon A, Merlino L, Cesana G, et al. Better compliance to antihypertensive medications reduces cardiovascular risk. *Journal of hypertension*. 2011;29(3):610-8.
46. Vrijens B, Antoniou S, Burnier M, de la Sierra A, Volpe M. Current Situation of Medication Adherence in Hypertension. *Front Pharmacol*. 2017;8:100.
47. Ogedegbe G, Schoenthaler A. A systematic review of the effects of home blood pressure monitoring on medication adherence. *J Clin Hypertens (Greenwich)*. 2006;8(3):174-80.

48. Vrijens B, Goetghebeur E. Comparing compliance patterns between randomized treatments. *Control Clin Trials*. 1997;18(3):187-203.
49. Fletcher BR, Hartmann-Boyce J, Hinton L, McManus RJ. The Effect of Self-Monitoring of Blood Pressure on Medication Adherence and Lifestyle Factors: A Systematic Review and Meta-Analysis. *American journal of hypertension*. 2015;28(10):1209-21.
50. Tang O, Foti K, Miller ER, Appel LJ, Juraschek SP. Factors Associated With Physician Recommendation of Home Blood Pressure Monitoring and Blood Pressure in the US Population. *American journal of hypertension*. 2020;33(9):852-9.
51. Parati G, Omboni S, Compare A, Grossi E, Callus E, Venco A, et al. Blood pressure control and treatment adherence in hypertensive patients with metabolic syndrome: protocol of a randomized controlled study based on home blood pressure telemonitoring vs. conventional management and assessment of psychological determinants of adherence (TELEBPMET Study). *Trials*. 2013;14:22.
52. McManus RJ, Mant J, Franssen M, Nickless A, Schwartz C, Hodgkinson J, et al. Efficacy of self-monitored blood pressure, with or without telemonitoring, for titration of antihypertensive medication (TASMINH4): an unmasked randomised controlled trial. *Lancet*. 2018;391(10124):949-59.
53. Mengden T, Binswanger B, Spuhler T, Weisser B, Vetter W. The use of self-measured blood pressure determinations in assessing dynamics of drug compliance in a study with amlodipine once a day, morning versus evening. *Journal of hypertension*. 1993;11(12):1403-11.
54. McManus RJ, Mant J, Bray EP, Holder R, Jones MI, Greenfield S, et al. Telemonitoring and self-management in the control of hypertension (TASMINH2): a randomised controlled trial. *Lancet*. 2010;376(9736):163-72.

55. McManus RJ, Mant J, Haque MS, Bray EP, Bryan S, Greenfield SM, et al. Effect of self-monitoring and medication self-titration on systolic blood pressure in hypertensive patients at high risk of cardiovascular disease: the TASMIN-SR randomized clinical trial. *JAMA*. 2014;312(8):799-808.
56. Agarwal R, Bills JE, Hecht TJ, Light RP. Role of home blood pressure monitoring in overcoming therapeutic inertia and improving hypertension control: a systematic review and meta-analysis. *Hypertension*. 2011;57(1):29-38.
57. Tucker KL, Sheppard JP, Stevens R, Bosworth HB, Bove A, Bray EP, et al. Self-monitoring of blood pressure in hypertension: A systematic review and individual patient data meta-analysis. *PLoS Med*. 2017;14(9):e1002389.
58. de la Sierra A, Mihailidou A, Wang JG, Shimbo D, McManus RJ. Home Blood Pressure Monitoring, Treatment Adherence and Hypertension Control In: Springer, editor. *Updates in Hypertension and Cardiovascular Protection*2019. p. 73-8.
59. McManus RJ, Little P, Stuart B, Morton K, Raftery J, Kelly J, et al. Home and Online Management and Evaluation of Blood Pressure (HOME BP) using a digital intervention in poorly controlled hypertension: randomised controlled trial. *BMJ*. 2021;372:m4858.
60. Kollias A, Kyriakoulis KG, Stambolliu E, Ntineri A, Anagnostopoulos I, Stergiou GS. Seasonal blood pressure variation assessed by different measurement methods: systematic review and meta-analysis. *Journal of hypertension*. 2020;38(5):791-8.
61. Stergiou GS, Palatini P, Modesti PA, Asayama K, Asmar R, Bilo G, et al. Seasonal variation in blood pressure: Evidence, consensus and recommendations for clinical practice. Consensus statement by the European Society of Hypertension Working Group on Blood Pressure Monitoring and Cardiovascular Variability. *Journal of hypertension*. 2020;38(7):1235-43.

62. Narita K, Hoshide S, Fujiwara T, Kanegae H, Kario K. Seasonal Variation of Home Blood Pressure and Its Association With Target Organ Damage: The J-HOP Study (Japan Morning Surge-Home Blood Pressure). *American journal of hypertension*. 2020;33(7):620-8.
63. Padwal RS, Majumdar SR. Comparability of two commonly used automated office blood pressure devices in the severely obese. *Blood pressure monitoring*. 2016;21(5):313-5.
64. Azaki A, Diab R, Harb A, Asmar R, Chahine MN. Questionable accuracy of home blood pressure measurements in the obese population - Validation of the Microlife WatchBP O3((R)) and Omron RS6((R)) devices according to the European Society of Hypertension-International Protocol. *Vasc Health Risk Manag*. 2017;13:61-9.
65. Stergiou GS, Kollias A, Destounis A, Tzamouranis D. Automated blood pressure measurement in atrial fibrillation: a systematic review and meta-analysis. *Journal of hypertension*. 2012;30(11):2074-82.
66. Stergiou GS, Dolan E, Kollias A, Poulter NR, Shennan A, Staessen JA, et al. Blood pressure measurement in special populations and circumstances. *J Clin Hypertens (Greenwich)*. 2018;20(7):1122-7.
67. Edmondson D, Arndt J, Alcantara C, Chaplin W, Schwartz JE. Self-Esteem and the Acute Effect of Anxiety on Ambulatory Blood Pressure. *Psychosomatic medicine*. 2015;77(7):833-41.
68. Parati G, Mendis S, Abegunde D, Asmar R, Mieke S, Murray A, et al. Recommendations for blood pressure measuring devices for office/clinic use in low resource settings. *Blood pressure monitoring*. 2005;10(1):3-10.
69. Stergiou GS, O'Brien E, Myers M, Palatini P, Parati G, Kollias A, et al. STRIDE BP international initiative for accurate blood pressure measurement: Systematic review of published validation studies of blood pressure measuring devices. *J Clin Hypertens (Greenwich)*. 2019;21(11):1616-22.

70. Stergiou GS, Palatini P, Asmar R, Ioannidis JP, Kollias A, Lacy P, et al. Recommendations and Practical Guidance for performing and reporting validation studies according to the Universal Standard for the validation of blood pressure measuring devices by the Association for the Advancement of Medical Instrumentation/European Society of Hypertension/International Organization for Standardization (AAMI/ESH/ISO). *Journal of hypertension*. 2019;37(3):459-66.
71. Palatini P, Frick GN. Cuff and bladder: overlooked components of BP measurement devices in the modern era? *American journal of hypertension*. 2012;25(2):136-8.
72. Bilo G, Sala O, Perego C, Faini A, Gao L, Gluszcwska A, et al. Impact of cuff positioning on blood pressure measurement accuracy: may a specially designed cuff make a difference? *Hypertens Res*. 2017;40(6):573-80.
73. Nathan HL, Vousden N, Lawley E, de Greeff A, Hezelgrave NL, Sloan N, et al. Development and evaluation of a novel Vital Signs Alert device for use in pregnancy in low-resource settings. *BMJ Innov*. 2018;4(4):192-8.
74. Cohen JB, Wong TC, Alpert BS, Townsend RR. Assessing the accuracy of the OMRON HEM-907XL oscillometric blood pressure measurement device in patients with nondialytic chronic kidney disease. *J Clin Hypertens (Greenwich)*. 2017;19(3):296-302.
75. (NICE). NIfHaCE. Hypertension. The clinical management of primary hypertension in adults. Clinical Guideline 127; 2011 www.nice.org.uk/guidance/CG127. 2011.
76. Alpert BS, Quinn D, Gallick D. Oscillometric blood pressure: a review for clinicians. *Journal of the American Society of Hypertension : JASH*. 2014;8(12):930-8.
77. O'Brien E, Waeber B, Parati G, Staessen J, Myers MG. Blood pressure measuring devices: recommendations of the European Society of Hypertension. *BMJ*. 2001;322(7285):531-6.

78. Irving G, Holden J, Stevens R, McManus RJ. Which cuff should I use? Indirect blood pressure measurement for the diagnosis of hypertension in patients with obesity: a diagnostic accuracy review. *BMJ Open*. 2016;6(11):e012429.
79. Casiglia E, Tikhonoff V, Albertini F, Palatini P. Poor Reliability of Wrist Blood Pressure Self-Measurement at Home: A Population-Based Study. *Hypertension*. 2016;68(4):896-903.
80. Parati G, Asmar R, Stergiou GS. Self blood pressure monitoring at home by wrist devices: a reliable approach? *Journal of hypertension*. 2002;20(4):573-8.
81. Asayama K, Fujiwara T, Hoshida S, Ohkubo T, Kario K, Stergiou GS, et al. Nocturnal blood pressure measured by home devices: evidence and perspective for clinical application. *Journal of hypertension*. 2019;37(5):905-16.
82. Postel-Vinay N, Bobrie G, Savard S, Persu A, Amar L, Azizi M, et al. Home blood pressure measurement and digital health: communication technologies create a new context. *Journal of hypertension*. 2018;36(11):2125-31.
83. Frederix I, Caiani EG, Dendale P, Anker S, Bax J, Bohm A, et al. ESC e-Cardiology Working Group Position Paper: Overcoming challenges in digital health implementation in cardiovascular medicine. *Eur J Prev Cardiol*. 2019;26(11):1166-77.
84. Parati G, Pellegrini D, Torlasco C. How Digital Health Can Be Applied for Preventing and Managing Hypertension. *Current hypertension reports*. 2019;21(5):40.
85. Kuwabara M, Harada K, Hishiki Y, Kario K. Validation of two watch-type wearable blood pressure monitors according to the ANSI/AAMI/ISO81060-2:2013 guidelines: Omron HEM-6410T-ZM and HEM-6410T-ZL. *J Clin Hypertens (Greenwich)*. 2019;21(6):853-8.
86. Chan M, Esteve D, Fourniols JY, Escriba C, Campo E. Smart wearable systems: current status and future challenges. *Artif Intell Med*. 2012;56(3):137-56.

87. O'Brien E, Stergiou GS. The pursuit of accurate blood pressure measurement: A 35-year travail. *J Clin Hypertens (Greenwich)*. 2017;19(8):746-52.
88. Stergiou GS, Alpert BS, Mieke S, Wang J, O'Brien E. Validation protocols for blood pressure measuring devices in the 21st century. *J Clin Hypertens (Greenwich)*. 2018;20(7):1096-9.
89. O'Brien E, Stergiou G, Palatini P, Asmar R, Ioannidis JP, Kollias A, et al. Validation protocols for blood pressure measuring devices: the impact of the European Society of Hypertension International Protocol and the development of a Universal Standard. *Blood pressure monitoring*. 2019;24(4):163-6.
90. Stergiou GS, Alpert B, Mieke S, Asmar R, Atkins N, Eckert S, et al. A universal standard for the validation of blood pressure measuring devices: Association for the Advancement of Medical Instrumentation/European Society of Hypertension/International Organization for Standardization (AAMI/ESH/ISO) Collaboration Statement. *Journal of hypertension*. 2018;36(3):472-8.
91. Stergiou GS, O'Brien E, Myers M, Palatini P, Parati G, Board SBSA. STRIDE BP: an international initiative for accurate blood pressure measurement. *Journal of hypertension*. 2020;38(3):395-9.
92. Coleman A, Freeman P, Steel S, Shennan A. Validation of the Omron 705IT (HEM-759-E) oscillometric blood pressure monitoring device according to the British Hypertension Society protocol. *Blood pressure monitoring*. 2006;11(1):27-32.
93. Gupta M, Shennan AH, Halligan A, Taylor DJ, de Swiet M. Accuracy of oscillometric blood pressure monitoring in pregnancy and pre-eclampsia. *Br J Obstet Gynaecol*. 1997;104(3):350-5.
94. van Ittersum FJ, Wijering RM, Lambert J, Donker AJ, Stehouwer CD. Determinants of the limits of agreement between the sphygmomanometer and the SpaceLabs 90207 device for blood

- pressure measurement in health volunteers and insulin-dependent diabetic patients. *Journal of hypertension*. 1998;16(8):1125-30.
95. van Popele NM, Bos WJ, de Beer NA, van Der Kuip DA, Hofman A, Grobbee DE, et al. Arterial stiffness as underlying mechanism of disagreement between an oscillometric blood pressure monitor and a sphygmomanometer. *Hypertension*. 2000;36(4):484-8.
 96. Coleman AJ, Steel SD, Ashworth M, Vowler SL, Shennan A. Accuracy of the pressure scale of sphygmomanometers in clinical use within primary care. *Blood pressure monitoring*. 2005;10(4):181-8.
 97. O'Brien E, Asmar R, Beilin L, Imai Y, Mallion JM, Mancia G, et al. European Society of Hypertension recommendations for conventional, ambulatory and home blood pressure measurement. *Journal of hypertension*. 2003;21(5):821-48.
 98. 81060-2:2018. IOfSI. Noninvasive sphygmomanometers: part 2: clinical investigation of intermittent automated measurement type [updated 2020. Available from: <https://www.iso.org/standard/73339.html>.
 99. Palatini P, Asmar R, Bilo G, Parati G. Cuff design for home blood pressure monitors. . In: Springer, editor. *Updates in Hypertension and Cardiovascular Protection; Home Blood Pressure Monitoring 2019*. p. 13-22.
 100. O'Brien E, Petrie J, Littler WA, De Swiet M, Padfield PD, Dillon MJ. *Blood pressure measurement: recommendations of the British hypertension society 3rd edn*. London: BMJ Publishing Group; 1997.
 101. Palatini P, Benetti E, Fania C, Saladini F. Only troncoconical cuffs can provide accurate blood pressure measurements in people with severe obesity. *Journal of hypertension*. 2019;37(1):37-41.

102. Palatini P, Benetti E, Fania C, Ermolao A, Spinella P, Battista F, et al. Effect of the shape of the cuff on blood pressure measurement in people with large arms. *Blood Press.* 2020:1-6.
103. Sharma M, Barbosa K, Ho V, Griggs D, Ghirmai T, Krishnan S, et al. Cuff-Less and Continuous Blood Pressure Monitoring: A Methodological Review. *Technologies* 2017;5(2):21.
104. Parati G, Casadei R, Gropelli A, Di Rienzo M, Mancia G. Comparison of finger and intra-arterial blood pressure monitoring at rest and during laboratory testing. *Hypertension.* 1989;13(6 Pt 1):647-55.
105. Cho J. Current Status and Prospects of Health-Related Sensing Technology in Wearable Devices. *J Healthc Eng.* 2019;2019:3924508.
106. Kachuee M, Kiani MM, Mohammadzade H, Shabany M. Cuffless Blood Pressure Estimation Algorithms for Continuous Health-Care Monitoring. *IEEE Trans Biomed Eng.* 2017;64(4):859-69.
107. Bilo G, Zorzi C, Ochoa Munera JE, Torlasco C, Giuli V, Parati G. Validation of the Somnotouch-NIBP noninvasive continuous blood pressure monitor according to the European Society of Hypertension International Protocol revision 2010. *Blood pressure monitoring.* 2015;20(5):291-4.
108. Loukogeorgakis S, Dawson R, Phillips N, Martyn CN, Greenwald SE. Validation of a device to measure arterial pulse wave velocity by a photoplethysmographic method. *Physiol Meas.* 2002;23(3):581-96.
109. De Luca N, Izzo R, Iaccarino G, Malini PL, Morisco C, Rozza F, et al. The use of a telematic connection for the follow-up of hypertensive patients improves the cardiovascular prognosis. *Journal of hypertension.* 2005;23(7):1417-23.

110. Mengden T, Ewald S, Kaufmann S, vor dem Esche J, Uen S, Vetter H. Telemonitoring of blood pressure self measurement in the OLMETEL study. *Blood pressure monitoring*. 2004;9(6):321-5.
111. Parati G, Dolan E, McManus RJ, Omboni S. Home blood pressure telemonitoring in the 21st century. *J Clin Hypertens (Greenwich)*. 2018;20(7):1128-32.
112. Omboni S, Gazzola T, Carabelli G, Parati G. Clinical usefulness and cost effectiveness of home blood pressure telemonitoring: meta-analysis of randomized controlled studies. *Journal of hypertension*. 2013;31(3):455-67; discussion 67-8.
113. Duan Y, Xie Z, Dong F, Wu Z, Lin Z, Sun N, et al. Effectiveness of home blood pressure telemonitoring: a systematic review and meta-analysis of randomised controlled studies. *Journal of human hypertension*. 2017;31(7):427-37.
114. Margolis KL, Asche SE, Bergdall AR, Dehmer SP, Groen SE, Kadrmas HM, et al. Effect of home blood pressure telemonitoring and pharmacist management on blood pressure control: a cluster randomized clinical trial. *JAMA*. 2013;310(1):46-56.
115. Margolis KL, Asche SE, Dehmer SP, Bergdall AR, Green BB, Sperl-Hillen JM, et al. Long-term Outcomes of the Effects of Home Blood Pressure Telemonitoring and Pharmacist Management on Blood Pressure Among Adults With Uncontrolled Hypertension: Follow-up of a Cluster Randomized Clinical Trial. *JAMA Netw Open*. 2018;1(5):e181617.
116. Parati G, Omboni S, Albin F, Piantoni L, Giuliano A, Revera M, et al. Home blood pressure telemonitoring improves hypertension control in general practice. The TeleBPCare study. *Journal of hypertension*. 2009;27(1):198-203.
117. Bobrie G, Postel-Vinay N, Delonca J, Corvol P, Investigators S. Self-measurement and self-titration in hypertension: a pilot telemedicine study. *American journal of hypertension*. 2007;20(12):1314-20.

118. Bobrie G, Delonca J, Moulin C, Giacomino A, Postel-Vinay N, Asmar R, et al. A home blood pressure monitoring study comparing the antihypertensive efficacy of two angiotensin II receptor antagonist fixed combinations. *American journal of hypertension*. 2005;18(11):1482-8.
119. Omboni S, McManus RJ, Bosworth HB, Chappell LC, Green BB, Kario K, et al. Evidence and Recommendations on the Use of Telemedicine for the Management of Arterial Hypertension: An International Expert Position Paper. *Hypertension*. 2020;76(5):1368-83.
120. Omboni S, Ferrari R. The role of telemedicine in hypertension management: focus on blood pressure telemonitoring. *Current hypertension reports*. 2015;17(4):535.
121. Parati G, Torlasco C, Omboni S, Pellegrini D. Smartphone Applications for Hypertension Management: a Potential Game-Changer That Needs More Control. *Current hypertension reports*. 2017;19(6):48.
122. Kumar N, Khunger M, Gupta A, Garg N. A content analysis of smartphone-based applications for hypertension management. *Journal of the American Society of Hypertension : JASH*. 2015;9(2):130-6.
123. Albini F, Liu X, Torlasco C, Soranna D, Faini A, Ciminaghi R, et al. An ICT and mobile Health integrated approach to optimize patients' education on hypertension and its management by physicians: the Patients Optimal Strategy of Treatment(POST) pilot study. 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC). 2016:517 - 20.
124. Lu X, Yang H, Xia X, Lu X, Lin J, Liu F, et al. Interactive Mobile Health Intervention and Blood Pressure Management in Adults. *Hypertension*. 2019;74(3):697-704.
125. Wijkman M, Carlsson M, Darwiche G, Nystrom FH. A pilot study of hypertension management using a telemedicine treatment approach. *Blood pressure monitoring*. 2020;25(1):18-21.

126. de Jongh T, Gurol-Urganci I, Vodopivec-Jamsek V, Car J, Atun R. Mobile phone messaging for facilitating self-management of long-term illnesses. The Cochrane database of systematic reviews. 2012;12:CD007459.
127. Niiranen TJ, McManus RJ, Ohkubo T, Stergiou GS. Home blood pressure monitoring schedule. Updates in Hypertension and Cardiovascular Protection; Home Blood Pressure Monitoring: Springer 2019. p. 55-62.
128. Chatellier G, Day M, Bobrie G, Menard J. Feasibility study of N-of-1 trials with blood pressure self-monitoring in hypertension. Hypertension. 1995;25(2):294-301.
129. Chatellier G, Dutrey-Dupagne C, Vaur L, Zannad F, Genes N, Elkik F, et al. Home self blood pressure measurement in general practice. The SMART study. Self-measurement for the Assessment of the Response to Trandolapril. American journal of hypertension. 1996;9(7):644-52.
130. Stergiou GS, Skeva, II, Zourbaki AS, Mountokalakis TD. Self-monitoring of blood pressure at home: how many measurements are needed? Journal of hypertension. 1998;16(6):725-31.
131. Niiranen TJ, Asayama K, Thijs L, Johansson JK, Hara A, Hozawa A, et al. Optimal number of days for home blood pressure measurement. American journal of hypertension. 2015;28(5):595-603.
132. Johansson JK, Niiranen TJ, Puukka PJ, Jula AM. Optimal schedule for home blood pressure monitoring based on a clinical approach. Journal of hypertension. 2010;28(2):259-64.
133. Bello NA, Schwartz JE, Kronish IM, Oparil S, Anstey DE, Wei Y, et al. Number of Measurements Needed to Obtain a Reliable Estimate of Home Blood Pressure: Results From the Improving the Detection of Hypertension Study. J Am Heart Assoc. 2018;7(20):e008658.

134. Juhanoja EP, Puukka PJ, Johansson JK, Niiranen TJ, Jula AM. The impact of the day of the week on home blood pressure: the Finn-Home study. *Blood pressure monitoring*. 2016;21(2):63-8.
135. Eguchi K, Kuruvilla S, Ogedegbe G, Gerin W, Schwartz JE, Pickering TG. What is the optimal interval between successive home blood pressure readings using an automated oscillometric device? *Journal of hypertension*. 2009;27(6):1172-7.
136. Niiranen TJ, Johansson JK, Reunanen A, Jula AM. Optimal schedule for home blood pressure measurement based on prognostic data: the Finn-Home Study. *Hypertension*. 2011;57(6):1081-6.
137. Ohkubo T, Asayama K, Kikuya M, Metoki H, Hoshi H, Hashimoto J, et al. How many times should blood pressure be measured at home for better prediction of stroke risk? Ten-year follow-up results from the Ohasama study. *Journal of hypertension*. 2004;22(6):1099-104.
138. Stergiou GS, Nasothimiou EG, Kalogeropoulos PG, Pantazis N, Baibas NM. The optimal home blood pressure monitoring schedule based on the Didima outcome study. *Journal of human hypertension*. 2010;24(3):158-64.
139. Thijs L, Staessen JA, Celis H, de Gaudemaris R, Imai Y, Julius S, et al. Reference values for self-recorded blood pressure: a meta-analysis of summary data. *Archives of internal medicine*. 1998;158(5):481-8.
140. Thijs L, Staessen JA, Celis H, Fagard R, De Cort P, de Gaudemaris R, et al. The international database of self-recorded blood pressures in normotensive and untreated hypertensive subjects. *Blood pressure monitoring*. 1999;4(2):77-86.
141. Nomura K, Asayama K, Thijs L, Niiranen TJ, Lujambio I, Boggia J, et al. Thresholds for conventional and home blood pressure by sex and age in 5018 participants from 5 populations. *Hypertension*. 2014;64(4):695-701.

142. Aparicio LS, Thijs L, Boggia J, Jacobs L, Barochiner J, Odili AN, et al. Defining thresholds for home blood pressure monitoring in octogenarians. *Hypertension*. 2015;66(4):865-73.
143. Mancia G, Fagard R, Narkiewicz K, Redon J, Zanchetti A, Bohm M, et al. 2013 ESH/ESC Guidelines for the management of arterial hypertension: The Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *Journal of hypertension*. 2013;31(7):1281-357.
144. Kario K. Global Impact of 2017 American Heart Association/American College of Cardiology Hypertension Guidelines: A Perspective From Japan. *Circulation*. 2018;137(6):543-5.
145. Staessen JA, Thijs L, Ohkubo T, Kikuya M, Richart T, Boggia J, et al. Thirty years of research on diagnostic and therapeutic thresholds for the self-measured blood pressure at home. *Blood pressure monitoring*. 2008;13(6):352-65.
146. Kikuya M, Hansen TW, Thijs L, Bjorklund-Bodegard K, Kuznetsova T, Ohkubo T, et al. Diagnostic thresholds for ambulatory blood pressure monitoring based on 10-year cardiovascular risk. *Circulation*. 2007;115(16):2145-52.
147. Pickering TG, Miller NH, Ogedegbe G, Krakoff LR, Artinian NT, Goff D, et al. Call to action on use and reimbursement for home blood pressure monitoring: executive summary: a joint scientific statement from the American Heart Association, American Society Of Hypertension, and Preventive Cardiovascular Nurses Association. *Hypertension*. 2008;52(1):1-9.
148. Muntner P, Carey RM, Jamerson K, Wright JT, Jr., Whelton PK. Rationale for Ambulatory and Home Blood Pressure Monitoring Thresholds in the 2017 American College of Cardiology/American Heart Association Guideline. *Hypertension*. 2019;73(1):33-8.
149. Vongpatanasin W, Ayers C, Lodhi H, Das SR, Berry JD, Khera A, et al. Diagnostic Thresholds for Blood Pressure Measured at Home in the Context of the 2017 Hypertension Guideline. *Hypertension*. 2018;72(6):1312-9.

150. Satoh M, Asayama K, Murakami T, Kikuya M, Metoki H, Imai Y, et al. Stroke risk due to partial white-coat or masked hypertension based on the ACC/AHA guideline's blood pressure threshold: the Ohasama study. *Hypertens Res.* 2019;42(1):120-2.
151. Coll-de-Tuero G, Saez M, Rodriguez-Poncelas A, Bayo-Llibre J, Beltran-Vilella M, Reyes-Negre C, et al. What is the optimal cut-off threshold in self-home blood pressure measurement?: A cohort study according to STROBE statement. *Medicine (Baltimore).* 2019;98(10):e14817.
152. Drawz PE, Pajewski NM, Bates JT, Bello NA, Cushman WC, Dwyer JP, et al. Effect of Intensive Versus Standard Clinic-Based Hypertension Management on Ambulatory Blood Pressure: Results From the SPRINT (Systolic Blood Pressure Intervention Trial) Ambulatory Blood Pressure Study. *Hypertension.* 2017;69(1):42-50.
153. Thomopoulos C, Parati G, Zanchetti A. Effects of blood pressure lowering on outcome incidence in hypertension: 2. Effects at different baseline and achieved blood pressure levels--overview and meta-analyses of randomized trials. *Journal of hypertension.* 2014;32(12):2296-304.
154. Thomopoulos C, Parati G, Zanchetti A. Effects of blood pressure lowering on outcome incidence in hypertension: 7. Effects of more vs. less intensive blood pressure lowering and different achieved blood pressure levels - updated overview and meta-analyses of randomized trials. *Journal of hypertension.* 2016;34(4):613-22.
155. Asayama K, Ohkubo T, Metoki H, Obara T, Inoue R, Kikuya M, et al. Cardiovascular outcomes in the first trial of antihypertensive therapy guided by self-measured home blood pressure. *Hypertens Res.* 2012;35(11):1102-10.
156. Kario K, Saito I, Kushiro T, Teramukai S, Ishikawa Y, Mori Y, et al. Home blood pressure and cardiovascular outcomes in patients during antihypertensive therapy: primary results of

- HONEST, a large-scale prospective, real-world observational study. *Hypertension*. 2014;64(5):989-96.
157. Five-year findings of the hypertension detection and follow-up program. I. Reduction in mortality of persons with high blood pressure, including mild hypertension. Hypertension Detection and Follow-up Program Cooperative Group. *JAMA*. 1979;242(23):2562-71.
 158. Staessen JA, Den Hond E, Celis H, Fagard R, Keary L, Vandenhoven G, et al. Antihypertensive treatment based on blood pressure measurement at home or in the physician's office: a randomized controlled trial. *JAMA*. 2004;291(8):955-64.
 159. Verberk WJ, Kroon AA, Kessels AG, Dirksen C, Nelemans PJ, Lenders JW, et al. Home versus Office blood pressure MEasurements: Reduction of Unnecessary treatment Study: rationale and study design of the HOMERUS trial. *Blood Press*. 2003;12(5-6):326-33.
 160. Stergiou GS, Karpettas N, Destounis A, Tzamouranis D, Nasothimiou E, Kollias A, et al. Home blood pressure monitoring alone vs. combined clinic and ambulatory measurements in following treatment-induced changes in blood pressure and organ damage. *American journal of hypertension*. 2014;27(2):184-92.
 161. Niiranen TJ, Kantola IM, Vesalainen R, Johansson J, Ruuska MJ. A comparison of home measurement and ambulatory monitoring of blood pressure in the adjustment of antihypertensive treatment. *American journal of hypertension*. 2006;19(5):468-74.
 162. McKinstry B, Hanley J, Wild S, Pagliari C, Paterson M, Lewis S, et al. Telemonitoring based service redesign for the management of uncontrolled hypertension: multicentre randomised controlled trial. *BMJ*. 2013;346:f3030.
 163. Monahan M, Jowett S, Nickless A, Franssen M, Grant S, Greenfield S, et al. Cost-Effectiveness of Telemonitoring and Self-Monitoring of Blood Pressure for Antihypertensive Titration in Primary Care (TASMINH4). *Hypertension*. 2019;73(6):1231-9.

164. Chen TY, Kao CW, Cheng SM, Chang YC. Effect of Home Medication Titration on Blood Pressure Control in Patients With Hypertension: A Meta-Analysis of Randomized Controlled Trials. *Med Care*. 2019;57(3):230-6.
165. Hammersley V, Parker R, Paterson M, Hanley J, Pinnock H, Padfield P, et al. Telemonitoring at scale for hypertension in primary care: An implementation study. *PLoS Med*. 2020;17(6):e1003124.
166. Parati G, Stergiou G, O'Brien E, Asmar R, Beilin L, Bilo G, et al. European Society of Hypertension practice guidelines for ambulatory blood pressure monitoring. *Journal of hypertension*. 2014;32(7):1359-66.
167. O'Brien E, White WB, Parati G, Dolan E. Ambulatory blood pressure monitoring in the 21st century. *J Clin Hypertens (Greenwich)*. 2018;20(7):1108-11.
168. O'Brien E, Kario K, Staessen JA, de la Sierra A, Ohkubo T. Patterns of ambulatory blood pressure: clinical relevance and application. *J Clin Hypertens (Greenwich)*. 2018;20(7):1112-5.
169. O'Brien E, Stergiou GS, Turner MJ. The quest for accuracy of blood pressure measuring devices. *J Clin Hypertens (Greenwich)*. 2018;20(7):1092-5.
170. Kollias A, Ntineri A, Stergiou GS. Association of night-time home blood pressure with night-time ambulatory blood pressure and target-organ damage: a systematic review and meta-analysis. *Journal of hypertension*. 2017;35(3):442-52.
171. Karnjanapiboonwong A, Anothaisintawee T, Chaikledkaew U, Dejthevaporn C, Attia J, Thakkinstian A. Diagnostic performance of clinic and home blood pressure measurements compared with ambulatory blood pressure: a systematic review and meta-analysis. *BMC Cardiovasc Disord*. 2020;20(1):491.

172. Mancia G, Facchetti R, Bombelli M, Grassi G, Sega R. Long-term risk of mortality associated with selective and combined elevation in office, home, and ambulatory blood pressure. *Hypertension*. 2006;47(5):846-53.
173. Kim CH, Kim JS, Rhee MY. Characteristics of Individuals with Disagreement between Home and Ambulatory Blood Pressure Measurements for the Diagnosis of Hypertension. *Healthcare (Basel)*. 2020;8(4).
174. Lurbe E, Agabiti-Rosei E, Cruickshank JK, Dominiczak A, Erdine S, Hirth A, et al. 2016 European Society of Hypertension guidelines for the management of high blood pressure in children and adolescents. *Journal of hypertension*. 2016;34(10):1887-920.
175. Flynn JT, Kaelber DC, Baker-Smith CM, Blowey D, Carroll AE, Daniels SR, et al. Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents. *Pediatrics*. 2017;140(3).
176. Stergiou G, Stambolliu E, Bountzona I, Ntineri A, Kollias A, Vazeou A, et al. Home Blood Pressure Monitoring in Children and Adolescents: Systematic Review of Evidence on Clinical Utility. *Current hypertension reports*. 2019;21(8):64.
177. Stergiou GS, Ntineri A. Methodology and applicability of home blood pressure monitoring in children and adolescents. In: Flynn J IJ, Redwine K., editor. *Pediatric Hypertension Cham: Springer*; 2018. p. 305–21.
178. Kollias A, Shennan A, Agarwal R, Ntineri A, Stergiou GS. Home blood pressure monitoring in children, pregnancy, and chronic kidney disease. . *Updates in Hypertension and Cardiovascular Protection; Home Blood Pressure Monitoring: Springer* 2019; 2019. p. 131-42.
179. Stergiou GS, Nasothimiou E, Giovas P, Kapoyiannis A, Vazeou A. Diagnosis of hypertension in children and adolescents based on home versus ambulatory blood pressure monitoring. *Journal of hypertension*. 2008;26(8):1556-62.

180. Kollias A, Dafni M, Poulidakis E, Ntineri A, Stergiou GS. Out-of-office blood pressure and target organ damage in children and adolescents: a systematic review and meta-analysis. *Journal of hypertension*. 2014;32(12):2315-31; discussion 31.
181. Zeniodi ME, Ntineri A, Kollias A, Servos G, Moyssakis I, Destounis A, et al. Home and ambulatory blood pressure monitoring in children, adolescents and young adults: comparison, diagnostic agreement and association with preclinical organ damage. *Journal of hypertension*. 2020;38(6):1047-55.
182. Stergiou GS, Boubouchairopoulou N, Kollias A. Accuracy of Automated Blood Pressure Measurement in Children: Evidence, Issues, and Perspectives. *Hypertension*. 2017;69(6):1000-6.
183. Stergiou GS, Yiannes NG, Rarra VC, Panagiotakos DB. Home blood pressure normalcy in children and adolescents: the Arsakeion School study. *Journal of hypertension*. 2007;25(7):1375-9.
184. Jardim TV, de Souza Carneiro C, Morais P, Mendonca KL, Povoas TIR, Nascente FM, et al. Home blood pressure normalcy in non-European adolescents. *Journal of hypertension*. 2018;36(1):61-8.
185. Stergiou GS, Karpettas N, Panagiotakos DB, Vazeou A. Comparison of office, ambulatory and home blood pressure in children and adolescents on the basis of normalcy tables. *Journal of human hypertension*. 2011;25(4):218-23.
186. Stergiou GS, Christodoulakis G, Giovas P, Lourida P, Alamara C, Roussias LG. Home blood pressure monitoring in children: how many measurements are needed? *American journal of hypertension*. 2008;21(6):633-8.

187. Gillon TE, Pels A, von Dadelszen P, MacDonell K, Magee LA. Hypertensive disorders of pregnancy: a systematic review of international clinical practice guidelines. *PLoS One*. 2014;9(12):e113715.
188. Rodrigues A, Barata C, Marques I, Almeida MC. Diagnosis of White Coat Hypertension and pregnancy outcomes. *Pregnancy Hypertens*. 2018;14:121-4.
189. Kollias A, Shennan A, Agarwal R, Ntineri A, Stergiou GS. Home blood pressure monitoring in children, pregnancy, and chronic kidney disease.
. In: Springer, editor. *Updates in Hypertension and Cardiovascular Protection; Home Blood Pressure Monitoring*; Springer 2019. p. 131-42.
190. Ross-McGill H, Hewison J, Hirst J, Dowswell T, Holt A, Brunskill P, et al. Antenatal home blood pressure monitoring: a pilot randomised controlled trial. *BJOG*. 2000;107(2):217-21.
191. Dougall G, Franssen M, Tucker KL, Yu LM, Hinton L, Rivero-Arias O, et al. Blood pressure monitoring in high-risk pregnancy to improve the detection and monitoring of hypertension (the BUMP 1 and 2 trials): protocol for two linked randomised controlled trials. *BMJ Open*. 2020;10(1):e034593.
192. Nathan HL, Duhig K, Hezelgrave NL, Chappell LC, Shennan AH. Blood pressure measurement in pregnancy. . *The Obstetrician & Gynaecologist*. 2015;17:91-8.
193. Obara T, Ohkubo T, Funahashi J, Kikuya M, Asayama K, Metoki H, et al. Isolated uncontrolled hypertension at home and in the office among treated hypertensive patients from the J-HOME study. *Journal of hypertension*. 2005;23(9):1653-60.
194. Lurbe E, Invitti C, Torro I, Maronati A, Aguilar F, Sartorio A, et al. The impact of the degree of obesity on the discrepancies between office and ambulatory blood pressure values in youth. *Journal of hypertension*. 2006;24(8):1557-64.

195. Siddiqui M, Calhoun DA. Blood Pressure Measurement Challenges in Severely Obese Patients. *American journal of hypertension*. 2019;32(2):139-40.
196. Halm MA. Arm circumference, shape, and length: how interplaying variables affect blood pressure measurement in obese persons. *Am J Crit Care*. 2014;23(2):166-70.
197. Palatini P, Asmar R. Cuff challenges in blood pressure measurement. *J Clin Hypertens (Greenwich)*. 2018;20(7):1100-3.
198. Parati G, Ochoa JE, Bilo G, Agarwal R, Covic A, Dekker FW, et al. Hypertension in Chronic Kidney Disease Part 1: Out-of-Office Blood Pressure Monitoring: Methods, Thresholds, and Patterns. *Hypertension*. 2016;67(6):1093-101.
199. Parati G, Ochoa JE, Bilo G, Agarwal R, Covic A, Dekker FW, et al. Hypertension in Chronic Kidney Disease Part 2: Role of Ambulatory and Home Blood Pressure Monitoring for Assessing Alterations in Blood Pressure Variability and Blood Pressure Profiles. *Hypertension*. 2016;67(6):1102-10.
200. Timio M, Venanzi S, Lolli S, Lippi G, Verdura C, Monarca C, et al. "Non-dipper" hypertensive patients and progressive renal insufficiency: a 3-year longitudinal study. *Clinical nephrology*. 1995;43(6):382-7.
201. Andersen MJ, Khawandi W, Agarwal R. Home blood pressure monitoring in CKD. *American journal of kidney diseases : the official journal of the National Kidney Foundation*. 2005;45(6):994-1001.
202. Rave K, Bender R, Heise T, Sawicki PT. Value of blood pressure self-monitoring as a predictor of progression of diabetic nephropathy. *Journal of hypertension*. 1999;17(5):597-601.
203. Agarwal R, Andersen MJ. Prognostic importance of clinic and home blood pressure recordings in patients with chronic kidney disease. *Kidney international*. 2006;69(2):406-11.

204. Bangash F, Agarwal R. Masked hypertension and white-coat hypertension in chronic kidney disease: a meta-analysis. *Clinical journal of the American Society of Nephrology : CJASN*. 2009;4(3):656-64.
205. Agarwal R. Volume overload in dialysis: the elephant in the room, no one can see. *American journal of nephrology*. 2013;38(1):75-7.
206. Agarwal R, Light RP. Chronobiology of arterial hypertension in hemodialysis patients: implications for home blood pressure monitoring. *American journal of kidney diseases : the official journal of the National Kidney Foundation*. 2009;54(4):693-701.
207. Agarwal R, Peixoto AJ, Santos SF, Zoccali C. Pre- and postdialysis blood pressures are imprecise estimates of interdialytic ambulatory blood pressure. *Clinical journal of the American Society of Nephrology : CJASN*. 2006;1(3):389-98.
208. Agarwal R, Brim NJ, Mahenthiran J, Andersen MJ, Saha C. Out-of-hemodialysis-unit blood pressure is a superior determinant of left ventricular hypertrophy. *Hypertension*. 2006;47(1):62-8.
209. Agarwal R, Andersen MJ, Bishu K, Saha C. Home blood pressure monitoring improves the diagnosis of hypertension in hemodialysis patients. *Kidney international*. 2006;69(5):900-6.
210. Alborzi P, Patel N, Agarwal R. Home blood pressures are of greater prognostic value than hemodialysis unit recordings. *Clinical journal of the American Society of Nephrology : CJASN*. 2007;2(6):1228-34.
211. Agarwal R. Blood pressure and mortality among hemodialysis patients. *Hypertension*. 2010;55(3):762-8.
212. Akpolat T, Erdem E, Aydogdu T. Validation of the Omron M3 Intellisense (HEM-7051-E) upper arm blood pressure monitor, for self-measurement, according to the European Society of

- Hypertension International Protocol revision 2010 in a stage 3-5 chronic kidney disease population. *Kidney Blood Press Res.* 2012;35(2):82-8.
213. Stergiou GS, Kyriakoulis KG, Stambolliu E, Destounis A, Karpettas N, Kalogeropoulos P, et al. Blood pressure measurement in atrial fibrillation: review and meta-analysis of evidence on accuracy and clinical relevance. *Journal of hypertension.* 2019;37(12):2430-41.
214. Clark CE, McDonagh STJ, McManus RJ, Blood Pressure Measurement Working Party of the B, Irish Hypertension S. Measurement of blood pressure in people with atrial fibrillation. *Journal of human hypertension.* 2019;33(11):763-5.
215. Manolis AJ, Rosei EA, Coca A, Cifkova R, Erdine SE, Kjeldsen S, et al. Hypertension and atrial fibrillation: diagnostic approach, prevention and treatment. Position paper of the Working Group 'Hypertension Arrhythmias and Thrombosis' of the European Society of Hypertension. *Journal of hypertension.* 2012;30(2):239-52.
216. Park SH, Choi YK. Measurement reliability of automated oscillometric blood pressure monitor in the elderly with atrial fibrillation: a systematic review and meta-analysis. *Blood pressure monitoring.* 2020;25(1):2-12.
217. Xie F, Xu J, Xia LL, Luo X, Jiang Z, Wu Y, et al. The impact of atrial fibrillation on accuracy of oscillometric blood pressure measurement: effect of ventricular rate. *Hypertens Res.* 2020.
218. Kollias A, Kyriakoulis KG, Stambolliu E, Stergiou GS. Prognostic value of office blood pressure measurement in patients with atrial fibrillation on anticoagulation therapy: systematic review and meta-analysis. *Journal of hypertension.* 2020;38(1):13-20.
219. Park SH, June KJ, Choi YK. Predictive validity of automated oscillometric blood pressure monitors for screening atrial fibrillation: a systematic review and meta-analysis. *Expert Rev Med Devices.* 2019;16(6):503-14.

220. Wiesel J, Abraham S, Messineo FC. Screening for asymptomatic atrial fibrillation while monitoring the blood pressure at home: trial of regular versus irregular pulse for prevention of stroke (TRIPPS 2.0). *The American journal of cardiology*. 2013;111(11):1598-601.
221. Savvari P, Triantafyllidi H, Skiadas J, Kalogeropoulos P, Menegas D, Manolis A, et al. Increased detection of suspected atrial fibrillation in elderly and female hypertensive patients through home blood pressure monitoring: the HOME-AF study. *Journal of hypertension*. 2020;38(3):441-7.
222. Boggia J, Li Y, Thijs L, Hansen TW, Kikuya M, Bjorklund-Bodegard K, et al. Prognostic accuracy of day versus night ambulatory blood pressure: a cohort study. *Lancet*. 2007;370(9594):1219-29.
223. Investigators A-H, Roush GC, Fagard RH, Salles GF, Pierdomenico SD, Reboldi G, et al. Prognostic impact from clinic, daytime, and night-time systolic blood pressure in nine cohorts of 13,844 patients with hypertension. *Journal of hypertension*. 2014;32(12):2332-40; discussion 40.
224. Stergiou GS, Andreadis E, Asayama K, Kario K, Kollias A, Ohkubo T. Nocturnal Home Blood Pressure Monitoring. . In: Springer, editor. *Updates in Hypertension and Cardiovascular Protection; Home Blood Pressure Monitoring*2019. p. 121-30.
225. Kario K, Kanegae H, Tomitani N, Okawara Y, Fujiwara T, Yano Y, et al. Nighttime Blood Pressure Measured by Home Blood Pressure Monitoring as an Independent Predictor of Cardiovascular Events in General Practice. *Hypertension*. 2019;73(6):1240-8.
226. Mokwatsi GG, Hoshida S, Kanegae H, Fujiwara T, Negishi K, Schutte AE, et al. Direct Comparison of Home Versus Ambulatory Defined Nocturnal Hypertension for Predicting Cardiovascular Events: The Japan Morning Surge-Home Blood Pressure (J-HOP) Study. *Hypertension*. 2020;76(2):554-61.

227. Fujiwara T, Hoshide S, Kanegae H, Kario K. Cardiovascular Event Risks Associated With Masked Nocturnal Hypertension Defined by Home Blood Pressure Monitoring in the J-HOP Nocturnal Blood Pressure Study. *Hypertension*. 2020;76(1):259-66.
228. Kollias A, Andreadis E, Agaliotis G, Kolyvas GN, Achimastos A, Stergiou GS. The optimal night-time home blood pressure monitoring schedule: agreement with ambulatory blood pressure and association with organ damage. *Journal of hypertension*. 2018;36(2):243-9.
229. O'Brien E, Parati G, Stergiou G, Asmar R, Beilin L, Bilo G, et al. European Society of Hypertension position paper on ambulatory blood pressure monitoring. *Journal of hypertension*. 2013;31(9):1731-68.
230. Fujiwara T, Nishizawa M, Hoshide S, Kanegae H, Kario K. Comparison of different schedules of nocturnal home blood pressure measurement using an information/communication technology-based device in hypertensive patients. *J Clin Hypertens (Greenwich)*. 2018;20(11):1633-41.
231. Stergiou GS, Triantafyllidou E, Cholidou K, Kollias A, Destounis A, Nasothimiou EG, et al. Asleep home blood pressure monitoring in obstructive sleep apnea: a pilot study. *Blood pressure monitoring*. 2013;18(1):21-6.
232. Kario K. Nocturnal Hypertension: New Technology and Evidence. *Hypertension*. 2018;71(6):997-1009.
233. Ricci F, Fedorowski A, Radico F, Romanello M, Tatasciore A, Di Nicola M, et al. Cardiovascular morbidity and mortality related to orthostatic hypotension: a meta-analysis of prospective observational studies. *European heart journal*. 2015;36(25):1609-17.
234. Xin W, Lin Z, Mi S. Orthostatic hypotension and mortality risk: a meta-analysis of cohort studies. *Heart*. 2014;100(5):406-13.

235. Gupta V, Lipsitz LA. Orthostatic hypotension in the elderly: diagnosis and treatment. *Am J Med.* 2007;120(10):841-7.
236. Vara-Gonzalez L, Arauzo Alonso S, Gonzalez Fernandez RM, Marin-Gil Vecilla M, Virseda Marin N, Munoz Cacho P. Reproducibility of postural changes of blood pressure in hypertensive elderly patients in primary care. *Blood pressure monitoring.* 2006;11(1):17-20.
237. Cremer A, Rousseau AL, Boulestreau R, Kuntz S, Tzourio C, Gosse P. Screening for orthostatic hypotension using home blood pressure measurements. *Journal of hypertension.* 2019;37(5):923-7.
238. Cohen A, Vidal JS, Roca F, Rananja H, Hernandorena I, Coude du Foresto L, et al. Feasibility and Determinants of Orthostatic Hypotension Self-measurement at Home in an Elderly Community-Dwelling Population. *American journal of hypertension.* 2019;32(9):824-32.
239. Weiss A, Beloosesky Y, Kornowski R, Yalov A, Grinblat J, Grossman E. Influence of orthostatic hypotension on mortality among patients discharged from an acute geriatric ward. *J Gen Intern Med.* 2006;21(6):602-6.
240. Finucane C, O'Connell MD, Fan CW, Savva GM, Soraghan CJ, Nolan H, et al. Age-related normative changes in phasic orthostatic blood pressure in a large population study: findings from The Irish Longitudinal Study on Ageing (TILDA). *Circulation.* 2014;130(20):1780-9.
241. Xin W, Mi S, Lin Z, Wang H, Wei W. Orthostatic hypotension and the risk of incidental cardiovascular diseases: A meta-analysis of prospective cohort studies. *Prev Med.* 2016;85:90-7.
242. Verwoert GC, Mattace-Raso FU, Hofman A, Heeringa J, Stricker BH, Breteler MM, et al. Orthostatic hypotension and risk of cardiovascular disease in elderly people: the Rotterdam study. *Journal of the American Geriatrics Society.* 2008;56(10):1816-20.

243. Cacciolati C, Tzourio C, Dufouil C, Alperovitch A, Hanon O. Feasibility of home blood pressure measurement in elderly individuals: cross-sectional analysis of a population-based sample. *American journal of hypertension*. 2012;25(12):1279-85.
244. Parati G, Ochoa JE, Lombardi C, Bilo G. Assessment and management of blood-pressure variability. *Nature reviews Cardiology*. 2013;10(3):143-55.
245. Stergiou GS, Nasothimiou EG. Home monitoring is the optimal method for assessing blood pressure variability. *Hypertens Res*. 2011;34(12):1246-8.
246. Stergiou GS, Ntineri A, Kollias A, Ohkubo T, Imai Y, Parati G. Blood pressure variability assessed by home measurements: a systematic review. *Hypertens Res*. 2014;37(6):565-72.
247. Ishikura K, Obara T, Kato T, Kikuya M, Shibamiya T, Shinki T, et al. Associations between day-by-day variability in blood pressure measured at home and antihypertensive drugs: the J-HOME-Morning study. *Clin Exp Hypertens*. 2012;34(4):297-304.
248. Okada T, Nakao T, Matsumoto H, Nagaoka Y, Tomaru R, Iwasawa H, et al. [Day-by-day variability of home blood pressure in patients with chronic kidney disease]. *Nihon Jinzo Gakkai shi*. 2008;50(5):588-96.
249. Juhanoja EP, Niiranen TJ, Johansson JK, Puukka PJ, Thijs L, Asayama K, et al. Outcome-Driven Thresholds for Increased Home Blood Pressure Variability. *Hypertension*. 2017;69(4):599-607.
250. Stevens SL, Wood S, Koshiaris C, Law K, Glasziou P, Stevens RJ, et al. Blood pressure variability and cardiovascular disease: systematic review and meta-analysis. *BMJ*. 2016;354:i4098.
251. Ntineri A, Kalogeropoulos PG, Kyriakoulis KG, Aissopou EK, Thomopoulou G, Kollias A, et al. Prognostic value of average home blood pressure and variability: 19-year follow-up of the Didima study. *Journal of hypertension*. 2018;36(1):69-76.

252. Johansson JK, Niiranen TJ, Puukka PJ, Jula AM. Prognostic value of the variability in home-measured blood pressure and heart rate: the Finn-Home Study. *Hypertension*. 2012;59(2):212-8.
253. Juhanoja EP, Johansson JK, Puukka PJ, Jula AM, Niiranen TJ. Optimal Schedule for Assessing Home BP Variability: The Finn-Home Study. *American journal of hypertension*. 2018;31(6):715-25.
254. Matsui Y, O'Rourke MF, Hoshida S, Ishikawa J, Shimada K, Kario K. Combined effect of angiotensin II receptor blocker and either a calcium channel blocker or diuretic on day-by-day variability of home blood pressure: the Japan Combined Treatment With Olmesartan and a Calcium-Channel Blocker Versus Olmesartan and Diuretics Randomized Efficacy Study. *Hypertension*. 2012;59(6):1132-8.
255. Hoshida S, Yano Y, Shimizu M, Eguchi K, Ishikawa J, Kario K. Is home blood pressure variability itself an interventional target beyond lowering mean home blood pressure during anti-hypertensive treatment? *Hypertens Res*. 2012;35(8):862-6.
256. Kronish IM, Kent S, Moise N, Shimbo D, Safford MM, Kynerd RE, et al. Barriers to conducting ambulatory and home blood pressure monitoring during hypertension screening in the United States. *Journal of the American Society of Hypertension : JASH*. 2017;11(9):573-80.
257. Logan AG, Dunai A, McIsaac WJ, Irvine MJ, Tisler A. Attitudes of primary care physicians and their patients about home blood pressure monitoring in Ontario. *Journal of hypertension*. 2008;26(3):446-52.
258. Fletcher BR, Hinton L, Hartmann-Boyce J, Roberts NW, Bobrovitz N, McManus RJ. Self-monitoring blood pressure in hypertension, patient and provider perspectives: A systematic review and thematic synthesis. *Patient Educ Couns*. 2016;99(2):210-9.
259. Claridge A. What is the educational value of ward rounds? A learner and teacher perspective. *Clin Med (Lond)*. 2011;11(6):558-62.

260. Beyhaghi H, Viera AJ. Comparative Cost-Effectiveness of Clinic, Home, or Ambulatory Blood Pressure Measurement for Hypertension Diagnosis in US Adults. *Hypertension*. 2019;73(1):121-31.
261. Uhlig K, Patel K, Ip S, Kitsios GD, Balk EM. Self-measured blood pressure monitoring in the management of hypertension: a systematic review and meta-analysis. *Annals of internal medicine*. 2013;159(3):185-94.
262. Reboussin DM, Allen NB, Griswold ME, Guallar E, Hong Y, Lackland DT, et al. Systematic Review for the 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Hypertension*. 2018;71(6):e116-e35.
263. Constanti M, Boffa R, Floyd CN, Wierzbicki AS, McManus RJ, Glover M. Options for the diagnosis of high blood pressure in primary care: a systematic review and economic model. *Journal of human hypertension*. 2020.
264. Margolis KL, Dehmer SP, Sperl-Hillen J, O'Connor PJ, Asche SE, Bergdall AR, et al. Cardiovascular Events and Costs With Home Blood Pressure Telemonitoring and Pharmacist Management for Uncontrolled Hypertension. *Hypertension*. 2020;76(4):1097-103.
265. Nasothimiou EG, Karpettas N, Dafni MG, Stergiou GS. Patients' preference for ambulatory versus home blood pressure monitoring. *Journal of human hypertension*. 2014;28(4):224-9.
266. McGowan N, Padfield PL. Self blood pressure monitoring: a worthy substitute for ambulatory blood pressure? *Journal of human hypertension*. 2010;24(12):801-6.
267. Wood S, Greenfield SM, Sayeed Haque M, Martin U, Gill PS, Mant J, et al. Influence of ethnicity on acceptability of method of blood pressure monitoring: a cross-sectional study in primary care. *Br J Gen Pract*. 2016;66(649):e577-86.

268. Bhatt DL, Kandzari DE, O'Neill WW, D'Agostino R, Flack JM, Katzen BT, et al. A controlled trial of renal denervation for resistant hypertension. *The New England journal of medicine*. 2014;370(15):1393-401.
269. Mengden T, Binswanger B, Weisser B, Vetter W. An evaluation of self-measured blood pressure in a study with a calcium-channel antagonist versus a beta-blocker. *American journal of hypertension*. 1992;5(3):154-60.
270. Stergiou GS, Efstathiou SP, Skeva, II, Baibas NM, Kalkana CB, Mountokalakis TD. Assessment of drug effects on blood pressure and pulse pressure using clinic, home and ambulatory measurements. *Journal of human hypertension*. 2002;16(10):729-35.
271. Vaur L, Dubroca II, Dutrey-Dupagne C, Genes N, Chatellier G, Bouvier-d'Yvoire M, et al. Superiority of home blood pressure measurements over office measurements for testing antihypertensive drugs. *Blood pressure monitoring*. 1998;3(2):107-14.
272. Stergiou G, Ntineri A. Home (self) monitoring of blood pressure in clinical trials. In: White WB, editor. *Blood pressure monitoring in cardiovascular medicine and therapeutics* Third edition New York: ed: Springer; 2016.
273. Agarwal R, Sinha AD, Pappas MK, Abraham TN, Tegegne GG. Hypertension in hemodialysis patients treated with atenolol or lisinopril: a randomized controlled trial. *Nephrology, dialysis, transplantation : official publication of the European Dialysis and Transplant Association - European Renal Association*. 2014;29(3):672-81.
274. Agarwal R, Alborzi P, Satyan S, Light RP. Dry-weight reduction in hypertensive hemodialysis patients (DRIP): a randomized, controlled trial. *Hypertension*. 2009;53(3):500-7.
275. Sano H, Hara A, Asayama K, Miyazaki S, Kikuya M, Imai Y, et al. Antihypertensive drug effects according to the pretreatment self-measured home blood pressure: the HOMED-BP study. *BMJ Open*. 2020;10(12):e040524.

276. Parati G, Agabiti-Rosei E, Bakris GL, Bilo G, Branzi G, Cecchi F, et al. MASked-unconTrolled hypERTension management based on office BP or on ambulatory blood pressure measurement (MASTER) Study: a randomised controlled trial protocol. *BMJ Open*. 2018;8(12):e021038.



[Click here to access/download](#)

Supplemental Data File (.doc, .tif, pdf, etc.)
Online Only Supplement-17-05-2021.docx

