Consensus Document

# Virtual management of hypertension: lessons from the COVID-19 pandemic: International Society of Hypertension position paper endorsed by the World Hypertension League and European Society of Hypertension

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The coronavirus disease 2019 pandemic caused an unprecedented shift from in person care to delivering healthcare remotely. To limit infectious spread, patients and providers rapidly adopted distant evaluation with online or telephone-based diagnosis and management of hypertension.
It is likely that virtual care of chronic diseases including hypertension will continue in some form into the future. The purpose of the International Society of Hypertension's (ISH) position paper is to provide practical guidance on the virtual management of hypertension to improve its diagnosis and blood pressure control based on the currently available evidence and international experts' opinion for nonpregnant adults. Virtual care represents the provision of healthcare services at a distance with communication conducted between healthcare providers, healthcare users and their circle of care. This statement provides consensus guidance on: selecting blood pressure monitoring devices, accurate home blood pressure assessments, delivering patient education virtually, health behavior modification, medication adjustment and long-term virtual monitoring. We further provide recommendations on modalities for the virtual assessment and management of hypertension across the spectrum of resource availability and patient ability.

**Keywords:** blood pressure, digital health, guidelines, hypertension, online, telehealth, telemonitoring, virtual

**Abbreviations:** ABPM, ambulatory blood pressure monitoring; Apps, applications; BP, blood pressure; CVD, cardiovascular disease; ECG, electrocardiogram; e-health, electronic health; EMR, electronic medical record; HIC, high income countries; ISH, International Society of Hypertension; LMIC, low- and middle-income countries; m-health, mobile health; Na, sodium (in figure); SMS, short message service (text message)

## INTRODUCTION AND RATIONALE

Despite available, low cost and highly effective treatments, hypertension control remains suboptimal, ranging from 7% to 65% in most countries worldwide [1]. Since the coronavirus disease 2019 (COVID-19) pandemic, many patients with hypertension throughout the world were rapidly shifted to online or telephone based assessment and management [2,3]. This forced shift to virtual management may represent an untapped opportunity to improve care and control of hypertension.

Journal of Hypertension 2020, 38:000–000

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**Received** 15 April 2022 **Accepted** 4 May 2022



DOI:10.1097/HJH.0000000000003205

The rapid transition to virtual care brought both challenges and advantages to diagnosing and managing hypertension. Patients had reduced access to in-person care providers [4], office blood pressure (BP) devices for diagnosis and monitoring of treatment, and uncertainty about validity of the myriad of home BP devices. Further, there was variability in protocols for monitoring BP out of office, patient self-management and assessments of medication adherence. There are concerns that the introduction of virtual health further exacerbated health inequities with the digital divide [5], including unequal access to providers and monitoring from limited internet access, insufficient broadband speeds, lack of technology or digital literacy. Despite these challenges, evidence to date indicates several advantages to virtual or telehealthcare, including improved patient satisfaction, convenience (especially for those in rural or remote areas), improved engagement and adherence with augmented home monitoring and enhanced self-management, and similar or improved BP control relative to 'traditional' in person office hypertension management [6–8]. In a study of 1051 patients, asynchronous structured online hypertension visits were associated with similar BP control and reduced in-office primary care utilization, without increased utilization of specialists, emergency department visits, or inpatient admissions [7]. These data suggest that virtual care of chronic conditions such as hypertension will likely outlast the pandemic becoming a normative component of hypertension management with the potential of improved patient care and reduced costs.

There are several modalities for the virtual assessment and management of hypertension (audio-video conferencing through the internet, web-based exchange through mobile apps, electronic medical records (EMRs) portals or web platforms, text or electronic mail exchange or telephone consultations); their selection and utilization will depend upon availability of resources, infrastructure and abilities, skills and preferences of patients and providers. Telephone-based consultations were the most commonly used type of virtual communication and care during the pandemic. A key objective for this International Society of Hypertension's (ISH) position paper is to provide practical guidance on the virtual management of hypertension to improve its diagnosis and BP control based on the currently available evidence and consensus expert opinion for non-pregnant adults. We provide guidance on selecting BP monitoring devices, virtual patient education, home BP assessments, and long-term monitoring virtually. We further provide recommendations on modalities for the virtual assessment and management of hypertension across the spectrum of resource availability and patient ability. Although there are many terms in use, including telemedicine, telehealth, virtual care and digital medicine, in this report, we will use these terms interchangeably to refer to the provision of healthcare services at a distance with communication conducted between healthcare providers, healthcare users and their circle of care. For recommendations for other aspects of hypertension, please refer to the International Society of Hypertension Global Practice guidelines [9].

## PROCESS OF WRITING

This position paper summarizes the priorities and recommendations put forward by an international panel of experts. The ISH College of Experts convened these experts from 11 countries. Separate groups of experts were then assigned specific topics based on their area of expertise and developed draft recommendations by consensus. Revisions were made by all authors and then submitted for further review internationally to the World Hypertension League and the European Society of Hypertension, aiming at developing consensus recommendations for clinical practice. Given the various degrees of technology penetration between patients and locations, summary recommendations were then categorized by resource and patient capacity.

## HOME BLOOD PRESSURE MONITORING DEVICE SELECTION

During the pandemic, there has been a dramatic increase in home BP measurement for the diagnosis of hypertension and monitoring. In several study populations in the United States, France and China, 45–50% of patients monitored their BP at home [10–12]. Home BP measurement carries advantages over office measurements including superior cardiovascular disease (CVD) risk prediction, avoidance of white-coat and masked hypertension, convenience, enhanced adherence to BP treatments, and an increased ability to detect circadian and seasonal variations [13–16]. These advantages, however, are only realized when using accurate devices with proper technique under medical supervision. However, studies indicate that almost 80% of home BP monitoring devices used by the public are not validated to international standards [17–19]. A Canadian study demonstrated that nonvalidated devices were associated with clinically meaningful discrepancies in measured BP: a >5 mmHg discrepancy in 69% of patients and >10 mmHg discrepancy in 36% of patients relative to accurately measured BP [18]. A 5-mmHg error in BP measurement globally would be associated with misclassification of 84 million individuals. Given these significant discrepancies [20,21], patients should use devices that are validated using international protocols (see Table 1 for websites with lists of internationally validated upper arm and wrist cuff BP devices). To further reduce over- or underestimation of BP, patients should be advised on proper cuff sizing, especially those with large or conical upper arm circumferences, and accurate measurement technique [22] (see Table 1 for websites with patient videos on accurate measurement technique).

Other barriers to accurate home measurement include an insufficient number of BP measurements obtained to estimate average home BP, selective under-reporting of elevated readings, or failure to relay BP readings to their healthcare provider [14,15,23]. To mitigate these barriers, devices capable of telemonitoring, where all BP measurements are automatically recorded on the patient's home device (e.g. smartphone) and transmitted wirelessly to care providers through a secured patient portal or electronic medical record are preferred. In a systematic review of 46 studies, home BP telemonitoring alone was associated with a 16% relative increase in achieving BP targets (95%

**TABLE 1. Hypertension resources for patient and providers (see: https://ish-world.com/resources)**

| Topic | Organization | Type of resource | Languages | Link |
|---|---|---|---|---|
| BP device accuracy and selection | | | | |
| How to check if a BP monitor is properly assessed for accuracy | World Hypertension League developed by Menzies Institute for Medical Research | Online (printable) PDF | English, Afrikaans, Arabic, Chinese, Danish, Dutch, French, German, Italian, Korean, Portuguese, Setswana, Spanish, Urdu, Vietnamese | https://www.whleague.org/images/Validated_Blood_Pressure_Monitor.pdf |
| Listing of validated devices | STRIDE BP (supported by the International Society of Hypertension, the European Society of Hypertension, and the World Hypertension League) | Online lists of validated devices for adults, children pregnancy (printable) PDF | English, Spanish, Chinese | https://www.stridebp.org/bp-monitors |
| | US Blood Pressure Validated Device Listing (VDL) | Online lists of validated devices for adults (printable) PDF | English | https://www.validatebp.org/ |
| | Hypertension Canada | Online lists of validated devices for adults | English | https://hypertension.ca/bpdevices |
| Patient education materials: how to measure BP at home and general information on hypertension | | | | |
| What is high BP<br>Monitoring BP at home<br>BP diary<br>How to manage high BP<br>Guide for talking to health professionals<br>BP toolkit for patients | American Heart Association | Video Online (printable) PDF Jpeg<br>Online (printable) brochures | English, Spanish, Chinese | https://www.heart.org/en/health-topics/high-blood-pressure |
| Monitoring BP at home<br>How to use a BP monitor<br>Patient experiences of BP monitoring | Million Hearts | Video Online (printable) PDF | English | https://millionhearts.hhs.gov/tools-protocols/smbp.html |
| Monitoring BP at home<br>Patient information leaflet<br>BP diary | British and Irish Hypertension Society | Online (printable) PDF Excel | English | https://bihsoc.org/resources/bp-measurement/hbpm/ |
| What is high BP<br>BP diary<br>BP action plan | Hypertension Canada | Online (printable) PDF | English | https://guidelines.hypertension.ca/patient-resources/ |
| Mobile health applications for BP logging | | | | |
| ESH care app | European Society of Hypertension | Mobile app available for smartphone and tablet | English, Italian, Spanish, French, Portuguese, Dutch, German, Turkish (available in Europe only) | https://www.eshonline.org/guidelines/blood-pressure-monitoring/ |
| Multidisciplinary healthcare team members hypertension training: E-learning with hypertension certification | | | | |
| Hypertension diagnosis and management | Global Hypertension at Hopkins | Online | English, Chinese, French and Spanish | https://globalhypertensionathopkins.org/M |
| All practical aspects of applying office, home, and ambulatory BP<br>Assessment test and certification | STRIDE BP (supported by the International Society of Hypertension, the European Society of Hypertension, and the World Hypertension League) | Downloadable PDF with practical instructions for each method; Forms for clinical use | English | https://www.stridebp.org/training |
| Strategies to optimize the virtual consultation for care providers | | | | |
| Telehealth Best Practices, Telehealth Etiquette checklist | Western States Regional Genetics Network (WSRGN) | Video PDF | English | https://www.youtube.com/watch?v=lQx0SDh9Jc0<br>https://3f9znz109u3oybcpa3vow591-wpengine.netdna-ssl.com/wp-content/uploads/2020/11/Telehealth-Etiquette-Checklist.pdf |
| Antihypertensive patient self-adjustment algorithms | | | | |
| Example scenarios with patient medication self adjustment plans | Home BP study (28) | PDF | English | https://ish-world.com/resources |
| Team care antihypertensive adjustment algorithms | | | | |
| Million Hearts featured evidence-based protocols | Center for Disease Control and Prevention (CDC) and Centers for Medicare and Medicaid Services (CMS) | Downloadable PDF | English | https://millionhearts.hhs.gov/tools-protocols/protocols.html |

confidence interval [CI]: 1.08–1.25; $P < 0.001$) [6], particularly in high-risk hypertensive patients [24–28]. BP telemonitoring is also effective in high-risk natural disaster situations analogous to the pandemic for the prompt initiation of hypertension treatment [29].

The measurement of BP in patients with atrial fibrillation is challenging given the increased beat-to-beat BP variability, regardless of the method used (intra-arterial, manual, auscultatory, or automated oscillometric). Automated oscillometric devices validated in people with sinus rhythm appear to be relatively accurate for measuring systolic BP in stable patients with atrial fibrillation, but may underestimate diastolic BP. More importantly, office BP measurements taken with oscillometric devices in patients with atrial fibrillation have been shown to predict future CV risk [30]. Thus, until specific device validation protocols for atrial fibrillation are developed and devices validated [31], it is practical to continue to use home BP monitoring similarly to people with sinus rhythm.

Recent progress in technology offers additional features to expand duration of home monitoring. Several home BP monitoring devices are now equipped with nocturnal BP monitoring capabilities. Nocturnal BP assessed using home BP monitors was shown to have similar accuracy in detecting nondippers as with 24-h ambulatory monitoring [32,33] and similar associations with preclinical target organ damage [33]. Given evidence that nocturnal hypertension increases the risk of stroke, coronary artery disease and heart failure, even when office and home BP (morning and evening) are well controlled [34], availability of these validated devices may represent an important step forward towards better 24 h hypertension control and CVD risk reduction especially among high-risk patients and whenever ambulatory BP monitoring (ABPM) is not easily available [35,36]. Additionally, a recently developed, wrist-cuff watch-type device that allows for oscillometric BP monitoring was compared with 24 h ABPM providing promising early results [35]. The difference between the wearable oscillometric and ABPM device was acceptable both in and out of the office [37]. More evidence is needed, however, before also recommending this technology for routine clinical use as a complement to the guideline-recommended home BP measurements.

### Cuffless blood pressure measuring devices

Unlike the currently used upper arm or wrist cuff oscillometric BP devices intended for intermittent BP monitoring, *wearable* BP monitoring devices could provide the unique opportunity to obtain longer term, dynamic information on BP behavior, even beat to beat, in a noninvasive and easy to obtain manner. Cuffless BP monitors constitute a wide and heterogeneous group of novel technologies and devices, which provide intermittent or continuous measurements and have different intended uses. Some technologies are embedded in wearable devices, others in smartphones or other devices, some require user calibration, and others, still in early research stages, do not [38–40]. While in principle, cuffless BP devices could enable long-term monitoring to support enhanced BP management, there are issues with their accuracy, performance and clinical implementation, and there is no agreed standard for their validation [14,38–40]. Thus, at the present time they are not recommended for clinical evaluation and management of hypertension [14].

**Recommendations**

- Patients should use upper arm cuff oscillometric BP measurement devices validated using established protocols, with appropriate cuff size and technique. Validated wrist oscillometric devices are appropriate for patients with arms too large for standard or conic shaped cuffs (see Table 1 resource section)
- For patients using home BP devices that are not validated using an established protocol, care providers should recommend replacement with a validated device.
- BP devices with automated storage, capacity to average multiple readings, and if available, automated asynchronous data transfer to care providers with mobile phone, personal computer or internet link or cloud-based connectivity are preferred.
- For patients with atrial fibrillation, until specific device validation protocols for atrial fibrillation are developed, and devices validated, it is practical to continue to use home BP monitoring similarly to people with sinus rhythm.
- There are insufficient data to recommend cuffless BP devices for clinical practice.

## BLOOD PRESSURE MEASUREMENT

Guidelines including those issued by ISH [9] recommend home or 24-h ABPM for hypertension diagnosis [9,14,15]. Because of the pandemic, an increasing number of care providers are relying on home measurements for monitoring and follow up of hypertension in addition to diagnosis [39,40]. Studies identified significant associations between home BP measurements and risk of cardiovascular events [40–42]. The optimal measurement schedule includes duplicate readings taken in the morning and the evening over a 7-day period (minimum 3 days) [43–45]. A minimum of 12 readings taken over 3 days (12 readings with duplicate morning and evening readings) results in over 80% of the prognostic information, rising to over 90% with 28 readings taken over 7 days [43–46]. The first day readings are generally higher and unstable, and should be discarded, particularly when the minimum 3-day monitoring schedule is obtained. Further, home BP measurements taken during follow up are associated with major adverse cardiovascular events [47], indicating that a similar BP measurement schedule for diagnosis can be applied for hypertension monitoring. Therefore, for the diagnosis and monitoring of hypertension, home or 24-h ABPM can be used with validated devices and standardized measurement technique and protocol [9,14,15].

**Recommendations**

- BP monitoring for 7 days is recommended (minimum is 3 days with at least 12 readings).
- Duplicate morning and evening BP measurements each day (taken 1 min apart after few minutes sitting at rest).
- Before antihypertensive agent intake if treated and before meals.
- The first day readings should preferably be discarded, particularly if the 3-day schedule is obtained, and the remaining readings are averaged (separately for systolic and diastolic readings).
- Monitor during consecutive or nonconsecutive routine workdays.
- An average home BP of 135/85 mmHg or higher indicates a diagnosis of hypertension.
- Fewer readings than the minimum of 3 days with at least 12 readings are insufficient for diagnosis.

## HOW TO EVALUATE A NEW PATIENT FOR HYPERTENSION VIRTUALLY

A new patient evaluation for hypertension includes clinical assessment and also allows care providers to establish rapport, educate and guide patient self-management. Patients receiving virtual care report high satisfaction, but patients and providers also raise concern over the lack of or limited physical examination, the engagement of the care provider, patient's apprehension in voicing a concern, and the ability to establish a meaningful relationship [48]. Given these limitations, it is preferable to carry out an initial evaluation in person to physically examine for hypertension mediated organ damage, other coexisting conditions, and secondary causes. If not possible, then a video based medical consultation is preferable to telephone (see Table 1 for strategies to optimize video based consultation – 'webside' manner). Prior to, or during the virtual visit a physician, assistant or nurse can guide patients through appropriate BP self-measurement technique [49].

**Recommendations**
- The initial evaluation should be conducted in person.
- If not possible or preferred, then video based medical consultation is preferred to telephone (see Table 1 resource section for strategies to optimize the virtual healthcare visit)

## PATIENT EDUCATION

Although a vital component of hypertension self-management and achieving BP control, patient education is often suboptimal. Surveys prior to the pandemic indicate that although the majority of physicians encourage home monitoring, only 8–30% of patients recall receiving training on BP measurement technique and 18% measure their BP correctly [50–52]. Further, the public is frequently exposed to misleading online information on hypertension [53].

Virtual management of hypertension, therefore, provides an opportunity to provide accurate and effective education for patients. Home-BP monitoring is more effective for BP management than usual care only when combined with patient education or ongoing support [25,54]. Systematic reviews evaluated a variety of e-learning and patient education programs to improve CVD self-management and disease outcomes [25,55,56]. Although the significant heterogeneity of these interventions and patient settings precludes a single strategy or program to be recommended globally, several important principles of health education should be applied. Patient education is more effective when tailored to a patient's individual needs, including two-way feedback between patient and care provider and using a variety of delivery approaches including printed materials [57], telephone based brief interactive sessions, group online education sessions, interactive digital tools and creating opportunities for peer-support [58–61]. These interventions can be effectively delivered by physicians, nurses, pharmacists or community health workers and in multidisciplinary teams [62,63]. For patients with low health literacy levels, strategies that use visual aids such as video or infographics; deliver self-management curriculum in small, more achievable instructional units; repeat intervention training; confirm learning or mastery; and provide corrective or tailored instruction until mastery is attained, improve achievement of CVD self-management behaviors [64].

Publicly available education resources to support virtual management of hypertension delivered in multiple languages including remote BP measurement, logs to record BP readings, and BP management information are outlined in the Table 1 resource section.

**Recommendations**
- Patients require educational support to purchase a suitable BP device, be trained in using it, obtain reliable BP measurements and log them (see resource section for patient education weblinks).
- Strategies to improve patient education include:
  - Use of printed materials, online education sessions, audio and visual resources and telephone peer support.
  - Education delivery via multidisciplinary teams including physicians, pharmacists, nurses or community health workers.
  - Education responsive to patient needs, with two-way feedback between patient and care provider.
- For patients with lower health literacy, incorporate visual aids, repetition of instruction, delivering smaller instructional units, confirm learning, and provide ongoing support.

## VIRTUAL APPROACHES TO HEALTH BEHAVIOR CHANGE

Telehealth is feasible and practical for BP monitoring, lifestyle counseling and supporting those with mental health problems [65,66]. During the pandemic with various lockdowns, isolation and social distancing, there was a trend for increased snacking, food consumption with reduced level of exercise, resulting in weight gain [67–69]. Anxiety, stress, depression, alterations in sleep patterns, smoking, substance abuse and alcohol consumption also increased during the pandemic [70], further increasing the risk of uncontrolled hypertension.

Many software applications allow patients to monitor their daily weight, dietary intake and mental health [71]. Applications that provide functions such as self-monitoring of behavior, information-sharing, goal-setting, action planning and reminder alarms, enhance patients' engagement for digital health behavior change [71]. Digital therapeutics is a new personalized interactive approach to facilitate nonpharmacological treatment of hypertension using software algorithms or applications (apps). A randomized trial of an interactive and personalized smart phone program of lifestyle education and behavior change, showed superiority compared with standard lifestyle modification alone to reduce 24-h ambulatory, home, and office BPs in the absence of antihypertensive medications [72]. In China, online psychological counseling services including online cognitive behavioral therapy, or artificial intelligence programs were effective for those suffering from depression, anxiety, and stress secondary to COVID-19 [73]. Studies reported mental health services could be delivered effectively through videoconferencing, online forums, smartphone apps, text-messaging, and e-mails [73]. Psychological stress can be tackled by teaching patients stress reduction techniques, for instance, sleep adequacy, deep breathing exercises, meditation, yoga, limiting social media usage, and immersive activities such as crafting, gardening, or cooking [74]. Virtual care should be tailored to individual needs, and contextualized to the patient's environment, culture, and personal preferences to complement the management of hypertension [75]. Optimally, patients would receive health behavior and psychosocial support from multidisciplinary teams that include a nutritionist, lifestyle or exercise coach, and community peer support with a case manager and under the supervision of the physician [76] (see Fig. 1).

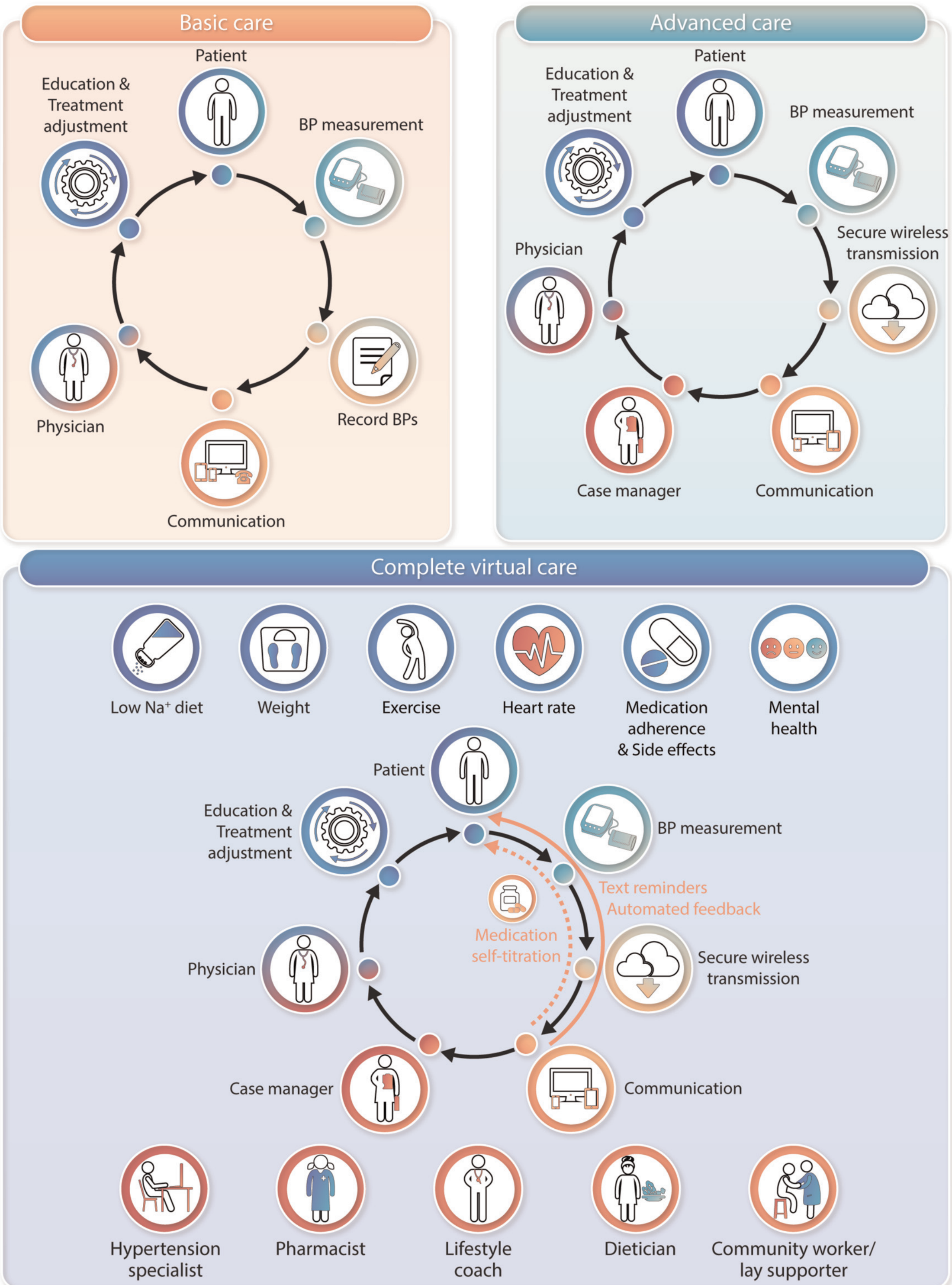


**FIGURE 1** Virtual hypertension basic, advanced and complete virtual care.

**Recommendations**

- Telecounseling and telemonitoring are feasible and effective for lifestyle counseling when incorporating self-monitoring of behavior, BP tracking, information-sharing, goal setting, action planning and reminders.
- Software applications can aid in lifestyle interventions.
- Mental health services can be delivered effectively through videoconferencing, online forums, smartphone apps, text-messaging, and e-mail.

## LONG-TERM TELEMONITORING AND FOLLOW-UP VISITS

Long-term monitoring of hypertensive patients may be accomplished through different levels of intervention (see Fig. 1). The simplest one is home BP monitoring without remote data exchange with a case manager [15,16]. A more complex level of intervention is based on telehealth, particularly on BP telemonitoring [76]. In this case, all the BP readings obtained at home and stored in the device's memory are asynchronously sent to a central monitoring facility, using a built-in modem, an access point with a modem-router, or a mobile app. Synchronous transmission is not typically employed unless critically ill or frail patients require tighter monitoring and careful surveillance. The advantages of a telehealth-based approach are the possibility of adding functions for tracking medication adherence, the occurrence of adverse events, and additional vital and nonvital signs (e.g., ECG, blood glucose, body weight, body temperature, blood oxygen saturation, etc.); providing automated summaries and analyses of monitoring metrics; bi-directional data exchange (e.g., time reminders for pill intake or BP measurement; educational tools to ensure proper technique and support monitoring); and interaction with a case manager to obtain feedback on the individual health status and adjust treatment dosage and schedule.

The co-intervention or additional support, if available, may be provided at different levels. The basic form is represented by data exchange with a case manager (usually a nurse or a pharmacist under the supervision of a clinician) through the web, e-mails, or text messaging. More complex interventions, generally relying on mobile health, foresee a more direct involvement of the patient through self-management, under the supervision of a multidisciplinary clinical team, integrated with education on lifestyle, risk factors, and proper use of antihypertensive medications, eventually including video consultation [24,65,77,78]. The best option for a multidisciplinary telehealth-based approach includes a nurse as the primary patient's manager, supported by a trained nonhealthcare professional with technical skills under the physician's supervision, with a pharmacist and a nutritionist or lifestyle coach as potential co-managers [65,76]. A physician, typically a primary care provider, would supervise the team who may confirm treatment adjustments and need for an in-person visit. A specialist may be contacted in critical cases and through remote consultation involving the managing physician and, eventually, the patient.

The recommended 7-day (or 3 day minimum) schedule for home BP monitoring (see BP measurement section) should be performed before each communication with the healthcare professional, in the commencement and treatment-adjustment phases until control is achieved (i.e., 4–6 weeks after increasing or starting a new antihypertensive agent) [79], and whenever an unusual BP change is suspected (rise or low BP).

There are little data on the optimal long-term home BP schedule for treated patients once BP control is achieved. A pragmatic approach includes 1–2 duplicate measurements per week or month. Weekly or monthly (minimum) monitoring should be selected based on patient preference, BP and CVD risk level [14,15]. For patients with anxiety surrounding self-monitoring, daily monitoring of home BP should be discouraged and it is advisable to limit the number of measurements to a minimum. Patients should be informed of their target BP, normal BP variability and an action plan if BP is too high or too low. If there are excessive changes in these BP readings (either high or low), a 7-day (3-day minimum) measurement should be obtained.

Provider-patient remote interaction should also occur periodically to reinforce adherence, even in patients with reasonable BP control but the optimal frequency of these interactions are not clear. Weekly automatic reminders to take BP readings and medications, and automatic notifications with a summary of the patients' status can be used, particularly in patients who are high risk, nonadherent or uncontrolled. A monthly contact through text, video chat or e-mail is preferred for most patients, if feasible. If BP is not improving or controlled despite automatic notifications and remote care provider contact, an in-person visit may be required. In the case where the patient's BP level is uncertain or labile, 24 h ABPM, including 24 h ABPM telemonitoring, is recommended for confirming the level of BP control [80]. In high-risk patients who are likely to develop heart failure, nocturnal BP assessments using 24 h ABPM or nocturnal home BP monitoring can be performed [81].

**Recommendations**

**Type of Remote Telemonitoring and Feedback**

- Monitor BP and additional vital and nonvital signs (e.g., weight)
- Track medication adherence
- Monitor health behaviors and risk factors
- Provide automated or mixed asynchronous reminders (e.g., reminders to take BP measurements, pill reminders, medication titration) and summary feedback on BP control for patients if available
- Provide patient education and feedback on target BP, normal BP variability, actions to take if BP too high or too low

**Home BP Monitoring Schedule and Frequency**

Short Term Monitoring When Acute Assessments or Treatment Adjustment Decisions Required

- 7-day home BP measurement (3-day minimum) and discard first day (particularly in minimum 3-day schedule)
  - Prior to each healthcare visit
  - Every 4-6 weeks minimum after initiating or titrating medication dose
  - When excessive BP change is suspected (rise or drop)

**Long Term Monitoring of Treated and Controlled Patients**

- 1–2 duplicate measurements per week or monthly depending on patient preference and risk. Weekly monitoring for patients with:
  - Elevated BP level or requiring multiple medications
  - Risk of nonadherence
  - High CVD risk
- For patients with anxiety or BP monitoring phobia, discourage frequent measurement
- If long-term measurements are consistently above target or too low, then patients should perform a 7-day (3-day minimum) home BP measurement and schedule a healthcare visit.

## MEDICATION ADJUSTMENT THROUGH VIRTUAL CARE

Appropriate medication adjustment is a key aspect of hypertension care in general and for telemedicine/remote management this is no different [82]. Delays in antihypertensive medication adjustment due to clinical inertia or the COVID-19 pandemic are likely to lead to increases in CVD events, even for quite modest differences (6 weeks or more) [83,84]. This has been an important consideration during the recent COVID-19 pandemic and has been an important rationale for the urgent implementation of effective remote management.

Self-monitoring of BP for people with hypertension leads to lower BP compared to usual clinic based measurement, leading to approximately a 5 mmHg additional systolic BP reduction [25,78]. The benefits of self-monitoring appear to be driven by optimized prescription of antihypertensive medications to people with truly elevated BP, and improved medication adherence [78,85].

A key issue for remote management of hypertension is that out-of-office BP is generally lower than clinic measurement hence the targets for medication adjustment in international guidelines need to account for this [82,86,87]. At 140/90 mmHg clinic BP, home/daytime ambulatory is around 5–10/5 mmHg lower and this difference increases at higher BP levels, and reduces at lower BP so that there are no appreciable differences at 130/80 mmHg or lower [88]. Failure to use such adjustments may be one reason why the original trials testing titration of antihypertensive medication using home BP monitoring did not show benefit [89].

Medication adjustment using out-of-office BP is effective when operationalized by primary care physicians [78]. Importantly, titration does not need to be undertaken solely by medical personnel. There is now a significant literature showing the efficacy of clinical pharmacists in this role [90,91]. Similarly with selected patients, when provided with simple medication adjustment plans, patients can achieve better BP control than physicians and this is true both in uncomplicated and higher risk hypertension [24,28,92]. (see Table 1 for weblink for examples of simple patient medication self-adjustment plans [28]). As with other self-monitoring interventions, a reduction in clinical inertia appears to underlie the benefits from patient and pharmacist titration with evidence of significantly increased adherence in following titration algorithms [93].

The shift in guidelines towards more pragmatic and simplified treatment algorithms facilitated the development of simple titration schemes that allow maximum benefit and may include single pill combinations or even ‘polypill’ type interventions, to reduce the need for monitoring [82,94]. Observational data suggest that maximum benefit from timely medication up-titration is likely to accrue from those with higher BP or who have not been titrated recently [84]. Clinicians faced with long backlogs of patients requiring review are best advised to start with those with the highest pressures and work down. Similarly, those at the highest CVD risk are likely to have the most to be gained from timely medication adjustments [95].

**Recommendations**

- Antihypertensive medication adjustment should be started promptly with adjustments implemented in maximum 6-week intervals (earlier in people with very high BP or CVD risk).
- Using home BP for medication adjustment, clinicians should take into account that home BP is generally 5–10/5 mmHg lower than in the clinic and the optimal treatment target is lower than the clinic equivalent with a home BP target of generally <135/85 mmHg. The lower the BP, the lower the difference between office and home BP (no appreciable differences at 130/80 mmHg or lower); the higher the BP, the greater the BP difference.
- Effective medication titrations can also be achieved using clinical pharmacists or by the patients themselves, by following a self-management treatment plan.

## ASSESSING AND MAINTAINING ADHERENCE VIRTUALLY

The COVID-19 pandemic may have introduced new barriers to patients’ adherence to antihypertensive treatment and exacerbated existing ones. Firstly, lockdowns or other restrictions in response to the pandemic in many countries resulted in cancellations/delays of many elective non-COVID-19 appointments in cardiovascular clinics where adherence is discussed and monitored as a part of standard care [96,97]. Those most vulnerable may have also avoided pharmacies for picking up antihypertensive medications, leading to discontinuation of treatment. Thirdly, the suspicions that certain antihypertensive medications (i.e., ACE-inhibitors and angiotensin receptor blockers) may increase susceptibility to infection, may have led to a drop in adherence to these medications amongst patients with hypertension [98]. The effects of the pandemic on unemployment and subsequent drop in income (even in the developed economies) are likely to have augmented already high rates of cost-related medication nonadherence [99]. Finally, COVID-19 was reported to disrupt supply chains of commonly prescribed medications (including antihypertensive agents) [100] and reduced affordability in some parts of the world [99].

Monitoring medication adherence remains a challenge virtually and effective measures such as pharmacy databases, medication event monitoring devices, or direct measurement of drug levels are not widely available [101]. Newer technologies such as smart pills (drug-device combinations) whereby an ingestible sensor is embedded in the pill that records medication ingestion onto smart phones are available but there are limited data on the feasibility and associated adherence with these devices [102].

Telehealth interventions, (e.g., calls, text messaging, short online videos) and electronic health-based interventions (e-health) but not mobile health interventions (e.g., based on mobile applications) appear to improve adherence to treatment (measured as medication possession ratio or proportion of days covered) in patients with chronic conditions, including hypertension [8]. Overall, when compared to the standard care, telemedicine-based approaches appear to increase adherence but the overall level of evidence for their effectiveness is low [65]. The efficacy of mobile health (m-health) to improve adherence to antihypertensive treatment is currently insufficient to recommend this strategy [103]. There is an increasing emphasis on including pharmacists [9,104] and other nonphysician healthcare professionals [105] in multidisciplinary teams responsible for management of nonadherence to BP-lowering treatment. Several telemedicine services are further integrated into the pharmacy-led care; e.g. phone outreach, dispensing of medications, educational efforts, digital pill counts to track adherence, and telemonitoring [106]. The strongest evidence of the efficacy of telepharmacy services is for collaborative interventions engaging physicians and pharmacists, home BP telemonitoring, education on lifestyle, drug therapy, and cardiovascular risk factor control [104]. There is an increasing body of evidence that an approach integrating nonphysician health workers with multifaceted educational efforts and e-health is effective in improving adherence and BP control through reduced clinical inertia [105].

**Recommendations**

- Evaluating adherence to antihypertensive treatment should be a part of each virtual appointment with a hypertensive patient (with a particular emphasis on known pandemic-related barriers to adherence).
- Wherever possible, objective methods of confirming adherence and detecting of nonadherence to antihypertensive treatment are preferred (e.g., pharmacy refill data) but their practicability in the setting of virtual appointments remains to be determined.
- Telehealth-supported interventions (in particular those based on collaborative health teams including include nonphysician health workers) are likely to improve adherence to antihypertensive treatment.

## GLOBAL APPLICABILITY OF VIRTUAL HEALTH

Recently, a number of papers and calls to action highlighted the need to use modern digital technologies to fight against hypertension globally [107,108]. Indeed, these solutions are likely to be more effective in low- and middle-income countries (LMICs) than in high-income countries (HIC), mainly because of the limited healthcare workforce capacity in the former.

The applicability of these approaches, in particular of m-health in LMICS is further enhanced by the widespread use of mobile phones to access the internet in LMICs. As reported by Schutte *et al.* of the total 3.5 billion people connected to mobile internet, 2.6 billion live in LMICs representing just over 40% of the total LMIC population [109,110]. Many projects aimed at improving detection and management of hypertension in LMICs have used m-health technology to identify, track, and follow-up patients with hypertension; address medication adherence; and educate patients and community health workers [111].

A systematic review published in 2020 evaluated the impact of m-health interventions in countries with different economic levels [112]. The interventions considered were text messages, calls, mobile phone applications, and wearable or portable monitoring devices [113]. m-Health interventions may help reduce systolic BP on average by 3 mmHg. When the analysis was focussed on systolic BP data obtained in LMIC countries, the reduction was small and not statistically significant (0.25 mmHg). However, most of the studies in LMICs did not include clinical care management.

A recent systematic review of 14 studies in LMIC's used telemedicine interventions (7 studies with telephone communications, 4 with video chat, 3 with SMS) for behavioral counselling, medication management, and provider to provider consultations [113]. While telephone was the most common mode of communication, three of the four studies incorporated video-chat and all electronic messaging studies that focused on medical management demonstrated significant improvements in BP.

Thus, there is preliminary evidence supporting the possibility that adoption of m-Health strategies might improve the quality of healthcare, and specifically hypertension control in LMICs. However, there are also important limitations and a number of difficult challenges to face when considering the implementation of digital health solutions in LMICs and in some settings in high-income countries. These include limited resources, lack of broadband internet and cellular connectivity (particularly in rural areas), legal barriers related to payment, privacy, and data protection, potentially low acceptance by healthcare professionals, and telehealth inequities (e.g., low digital literacy, affordability of access to BP monitors and cell phones). They also include the cost of these interventions in absence of their reimbursement by the healthcare system, which calls for political interventions aimed at sharing of resources and at keeping costs very low for devices and apps, and capitalizing on lessons learned from COVID-19 in making telehealthcare more accessible to individuals and countries worldwide. Future developments in this field are thus needed to be promoted by international organizations and implemented by local health authorities.

## FUTURE PERSPECTIVES

The diffusion of the internet and smartphone, and the recent pandemic that forced hypertensive patients to stay at home with intermittent or limited medical support, increased the awareness among healthcare professionals and the public of the potential, the importance, and the advantages of telehealth for BP control (See Table 2 for a summary of recommendations). The increasing use of virtual based interventions has the potential to improve hypertension management globally by expanding access to screening, diagnosis and management across the population of patients from remote locations or where care providers are limited, favoring early detection of high BP, improving patient training, enhancing BP control, and ultimately improving the quality of care. To fully actualize these benefits, further investigation is urgently needed in the following areas:

1. Increased access, evaluation of accuracy, acceptability and effectiveness of home BP monitoring, telemonitoring for reliable diagnosis and monitoring, and use of self-management medication titration plans in LMICs. This has potential to greatly enhance diagnosis and management given the limited number of healthcare workers, hospitals/clinics insufficient transportation system, and the large proportion of the populations with hypertension.
2. Optimal strategies for interacting using a virtual interface to establish rapport and engagement; adaptations needed for delivering telehealthcare in special

TABLE 2. At a glance: virtual hypertension detection and management according to available resources and patient selection

| Resource or patient capacity and engagement | Home BP device | Diagnosis | Education | Health behavior support | Telemonitoring | Medication adjustment | Adherence |
|---|---|---|---|---|---|---|---|
| Basic care: less resources or limited patient capacity or engagement | Validated upper arm BP device with automatic memory | 7 days duplicate readings (minimum 3 days) with patient relaying results | Telephone based education by care provider or trained team member; provision of print or online tools | Telephone based support by care provider or team member using goal setting, encouraging stress reduction techniques | 7 day (minimum 3-day) home BP monitoring with patient transmitting results via E-mail, or text to care provider prior to each visit and for medication adjustments<br>Long term monitoring 1–2 duplicate BP readings monthly | Antihypertensive agents adjusted based on BP every 4–6 weeks by care provider until BP control achieved | Monitor for nonadherence at each visit<br>Examine prescription refills |
| Advanced care: moderate resources or sufficient patient capacity or engagement | Validated BP device with asynchronous home BP telemonitoring capacity with care provider team | 7 days duplicate readings (minimum 3 days) with home BP results automatically teletransmitted to care provider | Telephone based or online education by care provider or trained team member; provision of print or online tools | Telephone or video based support by care provider or team member using goal setting, encouraging stress reduction techniques | Monitor as above with BP data teletransmitted prior to each visit and for medication adjustments<br>Long term monitoring 1–2 duplicate BP readings monthly | Antihypertensive agents adjusted based on BP every 4–6 weeks by care provider until BP control achieved | Monitor for nonadherence at each visit<br>Examine prescription refills |
| Complete virtual care: high resource or patient capacity and engagement appropriate | Validated BP device with asynchronous home BP telemonitoring capacity with care provider team | 7 days duplicate readings (minimum 3 days) with home BP results automatically teletransmitted to care provider team | Multidisciplinary team based education including pharmacists, nursing and community workers<br>Use of interactive digital tools | Online psychological counseling<br>Software apps for health behavior monitoring and change<br>Multidisciplinary team based health behavior coaching with nursing case manager, nutrition or lifestyle coach | Monitor BP as above & health behavior changes, other physiologic metrics with data asynchronously and automatically transmitted to a multidisciplinary team case manager to provide assessment and feedback under the supervision of physician<br>Weekly automatic notification reminders and summary feedback on BP control<br>Monthly contact with care team through text, video chat or e-mail to indicated BP control | Adjustments with pharmacist including use of digital programs under supervision of care provider prior to each visit and every 4–6 weeks until BP control achieved<br>*For selected patients, medication self-titration using simple self-management algorithm* | Monitor for nonadherence at each visit using pharmacy prescription fill data |

populations including the elderly, people with cognitive impairment, people with poor health, or limited digital literacy. Novel interventions to improve engagement need to be examined further.

3. Wearable cuffless BP technologies are promising for enabling regular long-term measurement and monitoring, and may help in improving hypertension awareness, diagnosis, and control. However, proper validation of these novel technologies and investigation of their clinical utility in real-life settings, are needed before recommending clinical use.

## ACKNOWLEDGEMENTS

We thank the European Society of Hypertension, the World Hypertension League and Professor Raj Padwal, University of Alberta, Canada for review of the manuscript.

### Conflicts of interest

Conflicts of Interest & Funding Support: SO is a scientific consultant of Biotechmed Ltd, provider of telemedicine services. R.J.M. has received BP monitors for research from Omron and is working with them to develop and test a BP telemonitoring system. His employer, Oxford University have licenced telemonitoring software for hypertensive pregnancy to Sensyne. B.W. has an investigator-led grant from Omron, Japan.

S. Islam is supported by the National Heart Foundation of Australia (102112) and a National Health and Medical Research Council (NHMRC) Emerging Leadership Fellowship (APP1195406). B. Williams is supported by the NIHR UCL Hospitals Biomedical Research Centre. The remaining authors have no conflicts of interest to declare. This position paper received funding supported through the International Society of Hypertension.

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