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Review Article

Mobile phones and applications in the management of patients with arterial hypertension

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Abstract: The use of mobile health (mHealth) in the field of medicine is constantly evolving and advancing. Arterial hypertension, a major modifiable cardiovascular risk factor with a high prevalence in the general population, frequently remains underdiagnosed and thus untreated. Furthermore, the majority of hypertensive patients fail to achieve blood pressure target levels. The purpose of this review is to identify and evaluate current use of mHealth strategies, with focus on mobile phones, smartphones and applications, in the management of patients with arterial hypertension. Current mobile technology has the capacity to inform and motivate the general public for timely diagnosis of hypertension, to facilitate communication between physicians and patients, to aid in the monitoring of blood pressure levels and the optimization of treatment and to promote, in general, a healthy lifestyle and assist in the management of other cardiovascular risk factors. There is potential for positive impact of mHealth technology in the management of arterial hypertension, as well as probable detrimental effects that warrant caution. The research in this field is ongoing and future well-conducted studies are needed in order to establish the use of mobile technology in arterial hypertension management.

Keywords: Arterial hypertension, mobile phones, smartphones, smartphone apps, mHealth

Introduction

The rapid technologic advancements at the end of the previous century and at the beginning of the 21st century have brought changes in everyday life, with older persons being constantly acquainted with new technologies, while younger generations consider many novel advances as basic commodities at a professional and recreational level. Electronic Health (eHealth) is based on the use of information and communication technologies to support health and health-related activities. Mobile Health (mHealth) is a component of eHealth that uses mobile devices extending from basic functions (voice messages, SMS) to more complex functionalities and applications including general packet radio service (GPRS), third and fourth generation mobile telecommunications (3G and 4G systems), global positioning system (GPS), and Bluetooth technology [1].

Approximately 85% of the world's population has mobile phone coverage. Importantly, a mobile phone device is readily accessible by patients in contrast to personal computers or laptops, providing thus with the opportunity of immediate access to mHealth services all the time. Furthermore, the technology in this field has demonstrated a rapid advancement with the development of user-friendly smartphone applications (apps) available at low or no cost. A recent position statement from the European Society of Cardiology on eHealth sites the use of mobile apps as an integral part of mHealth [2].

Arterial hypertension (AH), one of the major modifiable cardiovascular disease (CVD) risk factors, is a highly prevalent condition in the general population affecting approximately one billion patients worldwide [3]. Adequate control of blood pressure (BP) levels with appropriate

treatment is effective in reducing the risk of cardiovascular and cerebrovascular events, therefore, timely diagnosis and proper management of patients is recommended [4, 5]. However, at least half of hypertensive patients fail to achieve target goals for BP despite prescription of antihypertensive medications [6], a fact that, at least partially, is attributed to poor adherence to treatment [7, 8].

Mobile health strategies have been used to assist in the screening process of arterial hypertension in the general population and in the management of hypertensive patients considering lifestyle modification, adherence to medical treatment and global risk factor management. In this review we focus on the role of mobile phones and applications in the diagnosis, evaluation and management of patients with arterial hypertension.

Search strategy

We conducted a search of pubmed using the keywords 'arterial hypertension', 'mobile phones', 'cell phones', 'mHealth', 'eHealth' in order to find scientific studies evaluating the use of mHealth technologies in arterial hypertension. We included randomized control trials, open-label trials, reviews and meta-analyses regarding the use of mHealth strategies in the management of arterial hypertension (**Table 1**).

We also performed a research of the internet via Google for smartphone applications (apps) for Android and iPhone related to arterial hypertension. The number of available apps is expanding and their versions are constantly being upgraded based on the user's needs. Our study is meant to demonstrate the rationale of apps regarding hypertension management rather than present an exhaustive list of all relevant available apps. Therefore, we selected an indicative number of smartphone apps presented in **Table 2** based on their characteristics.

Screening

Since their discovery, cell phones have been subject to evaluation considering possible detrimental effects on human health. Cell phones use electromagnetic fields and exert both thermal and non-thermal influences on the user with possible adverse effects including the promotion of cardiovascular disease [9]. An older study had demonstrated an increase in resting BP of cell phone users [10]. However, recent reports have not confirmed an adverse association between the incidence of arterial hypertension and mobile phone use [11]. On the contrary, an analysis from 21,135 adults in the US has demonstrated a protective effect of cell phone usage on self-reported hypertension, which, according to the authors, could be attributed to improvement of autonomic nervous system function or to parameters associated with social networking and more feasible connection with the community [12].

Concern has been expressed lately regarding smartphone applications that claim to obtain BP measurement without the use of a standardized BP cuff devices [13]. These applications hypothetically obtain BP measurements (within a range of 83-178 mmHg for SBP and 58-107 mmHg for DBP) by placing the bottom of the mobile phone at the patient's chest and the right index finger over the rear camera lens and flash [14]. A recent analysis by Plante et al. demonstrated a significant inaccuracy in BP measurements with the use of the Instant Blood Pressure app in comparison to calibrated, validated automated sphygmomanometers. The authors concluded that the use of similar non-validated mobile phone apps for BP measurement could lead to a 77.5% of individuals with hypertensive BP levels to be falsely reassured that their BP is in the non-hypertensive range [15]. These findings highlight the need for validation of evolving technology in order to optimize accuracy of blood pressure measurements.

Management of hypertension

Text messaging

Optimal management of hypertension often requires constant communication between patients and health care providers. A 2012 study tested the clinical efficacy of using short message services (SMS) and mobile phone technology in patients with arterial hypertension. Patient population consisted of 97 hypertensive patients under active ambulatory care management and 102 patients under traditional ambulatory care. After 1 year of follow-up, 77% of patients from the active care management group had achieved the goal BP level, a percentage that was more than 5 times higher

Table 1. Summary of the literature

Authors	Publication Type	Material	Endpoint	Technology used	Results/Conclusions	Ref.
Suresh S, et al. *Int J Hypertens.* 2011	Survey	21,135 participants of the 2008 National Health Interview Survey	Self-reported physician-diagnosed hypertension	Cell-phone, landline phone	Cell-phone use was inversely associated with hypertension	[12]
Kumar N, et al. *J Am Soc Hypertens.* 2015	Cross-sectional Study	107 apps	Content analysis	Smartphone–based medical applications (apps)	A large and growing number of m-health technologies are currently available for patients with AH. Most applications currently focus on monitoring BP, heart rate, and lifestyle changes, with smaller numbers focused on medication adherence	[13]
Kiselev AR, et al. *J Am Soc Hypertens.* 2012	Open-label study	199 hypertensive patients	Blood pressure level goal achievement	SMS, mobile phone technology	77% of patients from the active care management group had achieved the goal blood pressure level. That percentage was more than 5 times higher than that in the traditional ambulatory care management group	[16]
Piette JD, et al. *Telemed J E Health.* 2012	Randomized Trial	200 hypertensive patients in two low/middle-income countries	Improving systolic BP	Automated self-management calls plus home blood pressure monitoring	Automated telephone care management plus home BP monitors can improve outcomes for hypertensive patients in low/middle-income countries	[17]
Tobe S, et al. *J Clin Hypertens.* 2019	Randomized Controlled	243 hypertensive patients	Efficacy of active (with hypertension specific management) versus passive (health behaviors) SMS on blood pressure reduction	SMS, mobile phone technology	There was no difference in the blood pressure change between groups from baseline to final for systolic or diastolic blood pressure	[19]
Varleta P, et al. *J Clin Hypertens.* 2017	Randomized Controlled	314 hypertensive patients	Efficacy of SMS in antihypertensive medication adherence	SMS, mobile phone technology	Text messaging intervention improved adherence to antihypertensive medication	[21]
Liew SM, et al. *Br J Gen Pract.* 2009	Randomized Controlled Trial	931 patients on long-term follow-up	Non-attendance rates	SMS text messaging reminder, telephone reminder	Text messaging was found to be as effective as telephone reminder in reducing non-attendance in patients who required long-term follow-up for their chronic illnesses	[22]
Patel S, et al. *J Diabetes Sci Technol.* 2013	Open-Label Trial	50 high-risk patients with hypertension	Medication adherence	Mobile phone medication reminder software	A mobile-phone-based automated medication reminder system shows promise in improving medication adherence and blood pressure	[23]
Senecal C, et al. *J Am Soc Hypertens.* 2018	Retrospective Observational Study	3,330 hypertensive participants	Changes in blood pressure, weight, and body mass index (BMI)	Desktop and mobile digital health intervention (DHI) as an adjunct to a workplace health program	DHI as an adjunct to a workplace health program is associated with greater improvement in blood pressure and BMI at 1 year	[24]

McManus RJ, et al. *Lancet.* 2010	Randomized Controlled Trial	527 participants with blood pressure > 140/90 mmHg	Change in mean systolic blood pressure between baseline and follow-up	Self-monitoring of blood pressure and self-titration of antihypertensive drugscombined with telemonitoring of home blood pressure measurements	Systolic blood pressure decreased more in the self-management group in comparison to the control group	[27]
Milani RV, et al. *Am J Med.* 2017	Open-Label Trial	156 patients with uncontrolled hypertension	Blood pressure control	Home-based digital-medicine blood pressure program	At 90 days, 71% of digital-medicine vs 31% of usual-care patients had achieved target blood pressure control	[29]
AbuDagga A, et al. *Telemed J E Health.* 2010	Review	15 Articles	Blood pressure control	Blood pressure (BP) telemonitoring	BP telemonitoring resulted in reduction of BP in all but two studies	[30]
McManus RJ, et al. *The Lancet* 2018	Randomized Controlled	1182 participants with arterial hypertension	Efficacy of blood pressure telemonitoring in antihypertensive titration in primary care	Blood pressure telemonitoring	Self-monitoring, with or without telemonitoring, when used by general practitioners to titrate antihypertensive medication, leads to significantly lower blood pressure than titration guided by clinic readings	[32]
Duan Y, et al. *J Hum Hypertens.* 2017	Meta-analysis of Randomized Control Trials (RCTs)	49 RCTs with a total of 13,875 participants	Blood pressure control	Home Blood Pressure Telemonitoring (HBPT)	Compared with usual care, HBPT improved office SBP and DBP by 3.99 mmHg and 1.99 mmHg respectively. A larger proportion of patients achieved BP normalization in the intervention group (relative risk: 1.16)	[34]
Stephani V, et al. *BMC Public Health.* 2016;16:572	Review of Randomized Control Trials (RCTs)	8 RCTs with a total of 4,375 participants	Outcome measures of non-communicable diseases (diabetes, asthma, hypertension)	mHealth interventions	Positive results, however a firm conclusion s is not yet possible because of the limited number of studies, the heterogeneity of evaluated mHealth interventions and the wide variety of reported outcome measures	[40]
Prabhakaran D, et al. *Circulation.* 2018	Open-label, cluster-randomized controlled trial	3,324 patients with hypertension and diabetes mellitus	Systolic blood pressure and glycated hemoglobin	mWellcare: a mHealth system for the integrated management of 5 chronic conditions	There was no evidence of difference between the mWellcare arm versus the enhanced usual care arm for systolic blood pressure and glycated hemoglobin even after adjustment for several key variables	[41]
Liu S, et al. *Can J Cardiol.* 2013	Meta-analysis	13 Trials	Efficacy of e-counselling in reducing blood pressure	Internet-based iynterventions (e-counselling)	Preliminary evidence of blood pressure reduction with Internet-based interventions	[45]

Table 2. Indicative list of smartphone applications (apps) regarding arterial hypertension management grouped by their offered features

Feature	Apps
Awareness Tools (Information about Hypertension with images, videos etc)	● Manage your Hypertension five
	● Hypertension Management
	● Know Hypertension
	● Hypertension - Dr. in Pocket
Claiming to attain Blood Pressure measurements	● Fingerprint Blood Pressure Scanner Check BP Prank
	● Finger Blood pressure pro
	● Instant Blood Pressure
Claiming to offer antihypertensive effects through relaxation	● Vital Tones Hypertension
Aid in risk factor management (Lifestyle modification, diet, exercise etc)	● DASH Diet Plan
	● Diet Plan For Hypertension
	● Exercise Hypertension
	● Pedometer
	● Quit Tracker: Stop Smoking
Storage, monitoring and processing of blood pressure measurements	● BP Tracker
	● BloodPressureDB
	● bpresso PRO
	● Cardio Journal-Blood Pressure Log
Cardiovascular Disease Risk Calculation	● ASCVD Risk Estimator Plus
	● Know Your Cholesterol
	● BMI Calculator

than that in the traditional ambulatory care management group (12% of patients, $P < 0.001$) [16]. Another study in patients with lower education or high informative needs in Honduras and Mexico demonstrated that providing personalized advice via telephone calls based on self-reported BP levels was effective in further reducing BP compared to standard care [17].

In a recent randomized trial comparing 104 hypertensive patients to either text messaging intervention or standard care. participants in the intervention group received healthy behavior text messages, weekly reminders for BP measurements and targeted text messages regarding hypertensive medication, finally demonstrating a significant reduction in systolic BP with a mean drop of 9.1 mmHg [18].

The DREAM-GLOBAL trial (Diagnosing hypertension-Engaging Action and Management in Getting Lower Blood Pressure in Indigenous and low- and middle-income countries) investigated the efficacy of an active hypertension specific management SMS and a passive health behaviors SMS alone text messaging-based system in hypertension management in Canadian Aboriginal and Tanzanian communities. There was an overall reduction in BP over the study, although no superiority of the active compared to the passive SMS system was demonstrated [19]. Nevertheless, the study improved the connection between patients and community workers, helping the latter to provide BP management service [20].

Varleta et al. investigated adherence to antihypertensive treatment by randomizing a total of 314 hypertensive patients to either receive or not receive SMS related to adherence and healthy lifestyle. After 6 months of follow-up, text messaging intervention resulted in an increase in antihypertensive treatment adherence from 49% to 62.3% ($P = 0.01$) compared to a decrease from 59.3% to 51.4% ($P = 0.1$) in the non-SMS group [21].

However, the limited number of randomized control studies, the heterogeneity of evaluated mHealth interventions and the wide variety of reported outcome measures make it difficult to draw firm conclusions.

Attendance of patients to follow-up visits is a key element of optimal management of chronic illnesses. Several interventions, including telephone reminders, orientation statements and postal reminders, have been used to reduce non-attendance, with varying degree of success. Among 931 patients suffering from chronic disease in two primary care clinics in Malaysia, text messaging was found to be at least as effective as telephone reminder in

reducing non-attendancecompared to no-notification where non-attendance rates reached 23% of the participants [22].

Novel technology allows for various uses of mobile phones, including built-in calendars and reminders. An open-label trial in 48 high risk patients evaluating a medication reminder software on a mobile phone demonstrated positive results in improving medication adherence and BP control [23]. A recently published observational study evaluated the usefulness of digital health tools in addition to traditional intervention as a part of a workplace health program in 3,330 hypertensive individuals. After the one-year follow-up period it was shown that participants that logged on to the digital health intervention application demonstrated greater improvements in SBP, DBP and body mass index, and that the positive results correlated with the frequency of use [24].

Blood pressure telemonitoring

Home blood pressure measurement (HBPM) has been shown to aid adherence to medication and produce lower BP levels in comparison to traditional office BP measurements [25]. Telemonitoring of HBPM with transmission of recorded home values promotes a more effective link between patients and physicians fighting both physicians' inertia and patients' poor adherence to treatment [26]. In a randomized control trial with 527 participants, self-management of hypertension in combination with telemonitoring of BP measurements was shown to further reduce SBP by a mean 5.4 mmHg during the first year of intervention, with only slight difference in the occurrence of adverse effects from antihypertensive medications, mainly leg swelling [27]. The result was even more pronounced in patients at high risk (history of stroke, coronary heart disease, diabetes, or chronic kidney disease) in whom a difference of 8.8 mmHg for systolic and 3.1 mmHg for diastolic BP between groups was recorded when an individualized self-titration algorithm was applied [28].

Milani, et al. compared the efficacy of HPBM versus usual care in improving patient engagement and hypertension control. Mean patient activation (a measure of patient engagement) improved from 41.9 to 44.1 ($P = 0.008$), and the percentage of patients with low adherence to treatment decreased from 15% to 6% ($P = 0.03$) in the telemonitored BP group. Mean decrease in SBP/DBP was 14/5 mmHg with the digital medicine intervention, versus 4/2 mmHg in usual care ($P < 0.001$) [29]. In most relevant studies, BP telemonitoring resulted in reduction of BP levels [30]. The favorable effect of telemonitoring is usually more pronounced in younger patients with diastolic hypertension who take less than 3 antihypertensive pills per day [31].

The TASMINH4 was a randomized controlled clinical trial aimed to assess the efficacy of self-monitored blood pressure, with or without telemonitoring, compared to usual care for antihypertensive titration in primary care, enrolling a total of 1182 hypertensive patients. After a 12-month follow-up period, systolic blood pressure was significantly lower in both intervention groups compared with usual care (self-monitoring (137.0 [SD 16.7] mmHg and telemonitoring 136.0 [SD 16.1] mmHg vs usual care 140.4 [SD 16.5] mmHg. Nevertheless, no difference between the self-monitoring and telemonitoring groups was observed [32]. The message of this study was that, although telemonitoring provides additional benefits in BP management in terms of easier communication and convenience, a paper-based self-monitoring constitutes an easier and similarly effective strategy for hypertension management in primary care [33].

A meta-analysis of 46 randomized control trials with 13,875 cases has demonstrated that home BP telemonitoring improved office SBP and DBP compared with usual care, leading to a 16% larger proportion of patients achieving target BP value [34]. Use of smartphone applications for HBPM may be of further advantage [35]. FDA has approved a number of cuff devices for home BP measurements that have the ability to connect to a mobile phone for data transfer, even though, caution has been expressed regarding the reproducibility of BP measurement [36].

Home BP telemonitoring can report a sufficient number of proper BP measurements and provide automatic calculation of mean values, ensuring unbiased documentation of home BP in order to evaluate treatment results. However, there are barriers in the implementation of home BP telemonitoring that may impede its

widespread use. In an article by Wood et al. the authors have identified certain structural and financial barriers in Canada. Availability of commercial telemonitoring systems that are user-friendly and compliant with data protection policy and legislation is paramount. Home BP monitors should be clinically validated according to international standards and ensure secure transmission of BP readings through a protected network. Systems for data transfer should include alert features in order to allow timely communication with the patients in case of very high or very low BP readings. Companies will need to provide assistance with installation and ongoing customer support. Telemonitoring systems must be priced competitively, their use must be cost-effective, payers must be identified and appropriate provider reimbursement ensured. Once these barriers are overcome telemonitoring could alter patient management, providing clinical benefit in high risk hypertensive patients and fewer in-person follow-up visits in adequately controlled patients [37].

Non-communicable chronic diseases (CVD, diabetes mellitus, chronic respiratory diseases and cancer) are the leading cause of morbidity and mortality in modern western societies and are slowly becoming a source of threat for public health in developing countries as well [38]. Cardiovascular diseases and diabetes affect many people and risk factor management with the aid of mHealth is gaining attention in the recent years [39]. Moreover, mHealth interventions have been utilized for the optimization of treatment of non-communicable disease in low income countries, and studies have in general demonstrated positive effects of mHealth interventions on reported outcome measures for diabetes, asthma and hypertension [40].

On the other hand, a relatively recent study failed to demonstrate incremental benefit with the use of a mHealth-based electronic decision support system for integrated management of chronic conditions in primary care in India. In the mWellcare trial there was no statistically significant difference in the pre-specified primary outcomes of reduction in SBP and glycated hemoglobin between the active intervention and the enhanced usual care arm after one year of follow-up [41]. Previous trials that have demonstrated better blood pressure control in similar patient groups did not utilize nurse support [42]. The authors attributed the lack of incremental efficacy of the electronic decision support system mainly to the high standard of care provided to the control group, due to the engagement of centrally trained non-communicable disease specialized nurses and physicians and the use of standardized treatment algorithms. Nevertheless, these findings highlight the importance of optimal organization of health care systems regarding the management of non-communicable diseases in a primary prevention setting, implementing mHealth interventions alongside proper nurse support and periodic training of healthcare professionals.

Smartphone applications

There exist numerous smartphone applications regarding cardiovascular health in general and hypertension in particular. These apps often take into account feedback from users and provide updated versions with appropriate modifications. Therefore, there exists a bidirectional relationship between app developers and users, leading to a constant improvement of services based on the consumer's needs. There are various apps that could be of use to patients with hypertension; apps may act as awareness tools, offer education about hypertension, monitor blood pressure (BP) levels, monitor and aid adherence to treatment, promote healthy lifestyle, estimate CVD risk and aid in the optimal management of other CVD risk factors. Even though not all applications comply with the requirements of best medical practice and constant audit is warranted, smartphone apps comprise a part of contemporary life and every effort to utilize them for the benefit of the patients should be made.

Arterial hypertension is an asymptomatic condition that may remain undetected and untreated for years before clinical manifestations occur. Therefore, raising public awareness for the detection and subsequent management of CVD risk factors is of utmost importance. Unmasking the presence of CVD risk factors requires simple and widely available measurements; the main issue is to motivate a person that feels otherwise well and healthy to undergo physical examination and blood tests. Mobile phones offer information to the general

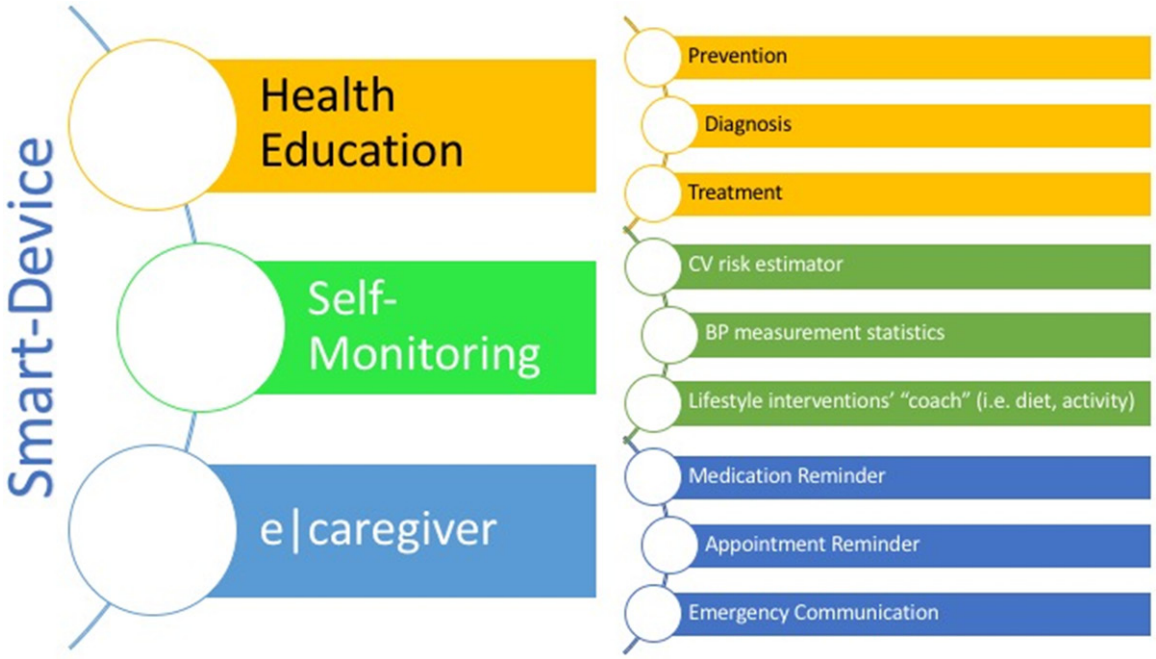

Figure 1. mHealth in Arterial Hypertension.

public regarding CVD risk factors and thus play a critical role in the screening process of the population. In aid of this concept a number of apps urge users to examine their risk profile concerning various medical conditions. It should be noted, however, that detection and management of CVD risk factors is the responsibility of properly trained physicians and no smartphone app should substitute clinical examination.

For the time being cuffless BP measurements with mobile phone apps are not recommended due to inaccuracies. On the other hand, there exist a number of mobile apps claiming to measure BP levels, stating, however, that the measurement is not genuine and that they may be used as a prank. These apps could prove useful as awareness tools since they could probe smartphone owners and their environment to measure their BP levels using a valid method, and thus help in the timely diagnosis of AH. Maybe future advancement of technology will allow for valid cuffless BP measurement utilizing mobile phone functions, however, for the time being, caution should be exercised and diagnosis of AH and modifications of treatment should be based solely on valid BP measurement with standardized cuff devices.

The majority of hypertensive patients fail to achieve blood pressure target levels despite the availability of efficient and safe medication. mHealth strategies aim to address issues that impede optimal management of patients with hypertension, including implementation of lifestyle interventions, adherence to medical treatment, monitoring and analysis of blood pressure measurements, contact with health providers, reminders of follow-up visits to the treating physician and optimal management of other CVD risk factors (**Figure 1**). Fixed daily reminders on the mobile phone for ingestion of antihypertensive pills could aid the adherence to medication. Furthermore, contemporary mobile phones allow other users, with the permission of the owner, to alter information on their calendars through internet connection. This technology is already being utilized for remote secretary services, such as handling professional appointments (tele-secretary). A similar approach could be of use in keeping up with follow-up visits and drug adherence in patients. To our knowledge, however, that approach for the organization of out-patient clinics has not been tested for the time being.

When dealing with the management of hypertension it is essential to manage all CVD risk factors. Therefore, patients should be screened

for the presence of dyslipidemia, diabetes mellitus and other diseases that promote atherosclerosis and receive counseling regarding smoking cessation, regular physical activity and reduction of body weight when appropriate. Management of hypertension is a part of a global CVD risk reduction strategy and mHealth tools that target all CVD risk factors could be of use in this context. Apps that estimate CVD risk, promote a healthy lifestyle and aid in the management of dyslipidemia, diabetes and other CVD risk factors could prove useful for the optimization of therapeutic interventions in order to obtain maximal benefit.

The guidelines of the European Society of Hypertension/European Society of Cardiology for the management of arterial hypertension published in 2018 dedicate a paragraph on the role of communication and information technologies [43]. Mobile phones support self-monitoring of BP values, adherence to medication and lifestyle modification and feedback to healthcare professionals. Even though such practices have not been studied extensively and their efficacy has not been proven in large randomized control trials, their use in the management and follow-up of hypertensive patients is not discouraged. In the more recent guidelines by the American College of Cardiology/American Heart Association telehealth strategies are graded with a class of recommendation IIa (level of evidence A) as useful adjuncts to interventions shown to reduce BP for adults with hypertension [44]. This recommendation has been updated since 2013, given the fact that there is in general a positive effect of telehealth interventions in BP lowering even though results are not always consistent [45, 46].

A recent randomized clinical trial including 480 hypertensive patients investigated the efficacy of the "Yan Fu" application in the management of hypertension and adherence to antihypertensive treatment. At the end of the study, patients assigned to the application group demonstrated a significantly greater systolic blood pressure and diastolic blood pressure reduction along with a higher medication adherence compared to the control group ($P < 0.05$) [47].

Even though many trials have shown favorable effects of mHealth strategies on BP levels, there remains a need to clearly demonstrate that electronic interventions can exert meaningful improvements on the risk of adverse events. In order for this to be proven, there is a need of collaboration between mHealth researchers and clinicians for the optimal utilization of mHealth technology focusing on improvement of patient health and care delivery and prevention of adverse cardiovascular outcomes. A step forward is represented by apps developed and supported by scientific societies, such as the ESH CARE app proposed jointly by the Italian and the European Society of Hypertension, that offers validated educational material and represents a reliable tool for patient doctor interactions and remote patient monitoring. A pilot study utilizing this application in north Italy has demonstrated positive results in blood pressure control after 6 months [48]. There is still a need, however, for prospective randomized clinical trials focusing on hard outcomes over long follow-up periods to demonstrate the actual clinical impact of these eHealth approaches.

Discussion

Hypertension constitutes one of the most common medical conditions in adults, representing one of the main risk factors for cardiovascular disorders, namely heart disease, strokes and chronic kidney disease. Despite the significant health risks associated with uncontrolled hypertension and a great number of available pharmacologic options, arterial hypertension remains yet inadequately detected and treated in the majority of patients. Thus, improvement of hypertension management is of crucial importance.

In this direction, novel mHealth technologies may contribute in better hypertension management, in terms of enhanced individuals' awareness of the disease, improved blood pressure monitoring, increased adherence to medical treatment, adoption of healthy lifestyles, and positive behavior change. Especially in the current conditions due to Covid-19 pandemic, developing mHealth technologies constitute a valuable tool for healthcare providers, minimizing the need for constant visits without diminishing the doctor-patient relationship. Nevertheless, there is still lack of robust evidence in several areas regarding the effectiveness of mHealth technologies in primary and second-

ary care. The most urgent need the assessment and clinical validation of these technologies before their widespread implementation in the general population. The fact that only a very small amount has been developed by established organizations, such as universities or companies working on the field of hypertension, raises concerns about the scientific accuracy of the content of these technological products. Moreover, the reliability of the provided information as well as the level of data privacy and security remains questionable.

Because of all the previous issues, well-organized, large-scale studies are needed to assess the effectiveness of mHealth technologies and mobile phone applications, focusing on functionalities for self-management of hypertension, including self-monitoring, reminders and alerts with either automatic feedback and educational information, while it is also important to assess the users' interaction with these technologies.

Conclusions

The rapid technological evolution affects many aspects of everyday life including medicine and patient-physician relationships. Mobile phones have long been a part of daily routine in developed countries, and are slowly infiltrating developing countries as well. Optimal management of hypertension constitutes one of the cornerstones of cardiovascular disease prevention. In this context, all available means that could prove useful in achieving target BP values at a population and individual level should be utilized, including mobile phones, smartphones and their various applications. Research and development in the field of mHealth is ongoing and constantly evolving based on patient and doctors' needs. Mobile phones and smartphone applications facilitate communication between physicians and patients, offer information to the general public and have the potential to motivate healthy persons to undergo diagnostic evaluation, as well as aid in blood pressure control in hypertensive patients. Caution, however, should be taken in order for this new and readily available technology to be used in a proper way, without undermining patient-physician relationship and good clinical practice. Today's opportunities are overwhelming and in the near future they could prove to advance further. There remains the need for well conducted future studies that will demonstrate the efficacy of mHealth practices in optimizing the management of arterial hypertension.

Disclosure of conflict of interest

None.

Abbreviations

AH, Arterial Hypertension; App, Application; BP, Blood Pressure; CVD, Cardiovascular Disease; DBP, Diastolic Blood Pressure; eHealth, Electronic Health; HBPM, Home Blood Pressure Monitoring; mHealth, Mobile Health; SBP, Systolic Blood Pressure.

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