New aspects in the management of hypertension in the digital era

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Purpose of review
Hypertension (HTN) is the most common chronic disease impacting over half the US adult population. Our current office-based model of care is failing in its ability to control blood pressure (BP) as only 44% of adult US hypertensives are achieving minimal levels of BP control (< 140/90 mmHg), leading to high rates of preventable cardiovascular events and death.

Recent findings
Reengineering care delivery using a fully digital platform combined with a dedicated team-based approach to HTN management has demonstrated superior BP control rates, very high levels patient acceptance, and the ability to better diagnose and treat masked and white coat HTN.

Summary
A digital medicine program in the clinical care setting can be an effective and convenient mechanism of delivering HTN management, outperforming traditional office-based care, and is well accepted by patients.

Keywords
connected devices, digital medicine, hypertension

INTRODUCTION

Hypertension (HTN) affects nearly one in two US adults and is a major modifiable risk factor for cardiovascular (CV) disease (CVD) [1▪,2]. In fact, more CVD events in the USA have been attributed to HTN than any other modifiable risk factor [3▪▪]. Controlling blood pressure (BP) levels via medication and/or lifestyle change reduces the risk for CVD and all-cause mortality among adults with HTN, yet only 44% of US hypertensive adults are currently controlled to a BP $<$ 140/90 mmHg and just 24% achieve a BP $\leq$ 130/80 mmHg [3▪▪,4,5]. What is equally concerning is that these trends are have deteriorated since 2013–2014 when BP control rates peaked at 54% (Fig. 1), leading the US Surgeon General to declare HTN control an urgent national priority [2,3▪▪].

In addition to the worsening trends recognized in HTN control rates, similar failures are also being observed with other chronic diseases such as diabetes mellitus, where outcomes such as emergency department visits, lower-extremity amputations, hospitalizations for hyperglycemic crisis, and deaths due to diabetes have worsened over the past decade [6,7]. The National Academy of Medicine concluded in 2001 that our office-based model of care delivery is inadequate to meet the current needs of the population when managing chronic diseases such as HTN, and recommended that our health delivery system be reengineered to better adapt to the demands of the 21st century [8]. This review will highlight the major issues identified in our current delivery model and will introduce a new paradigm of care delivery for individuals with HTN encompassing digital medicine.

HOME-MEASURED BP

The diagnosis and management of HTN have been effectively based on the measurement of BP in the office, however, BP may differ considerably when measured in the office versus outside of the office setting [9,10▪]. White-coat HTN is defined as having elevated office BP measurements and having normal

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KEY POINTS

- BP control rates continue to decline in the US with only 44% of hypertensive adults achieving minimal BP control (<140/90 mmHg).
- A digital platform that enables home-based BP measurements provides a large sample that can better diagnose and treat masked and white coat hypertension as well as react to abnormal BP readings in real-time.
- Reengineering our care delivery model to encompass dedicated team-based care utilizing a fully digital platform results in higher levels of patient engagement, improved medication adherence, and superior BP control compared to a standard office-based approach.

out-of-office BP measurements, whereas masked HTN is defined as having normal office BP measurements and having elevated out-of-office BP measurements. These diagnoses are prevalent in the population, and without the ability to consistently measure home BP, they will be frequently missed leading to an unnecessary increase in CV events [11,12]. Additionally, the small number of BP measurements in the office does not adequately capture the known fluctuations in BP that take place day to day and month to month [13,14]. Several guidelines and scientific statements have now been published including a scientific statement from the American Heart Association, American Society of Hypertension, and Preventive Cardiovascular Nurses Association on self-measured BP monitoring, all of which conclude that self-measured BP monitoring at home is an essential component in HTN management [10▪,15]. Home measurements better predict CV risk than do office measurements, are more reproducible and better correlate with measures of target organ damage [15].

Current consumer BP technology is accurate, reliable, easy to use, and relatively inexpensive. Moreover, home BP readings taken from a Bluetooth-connected BP device can directly populate the patient's electronic medical record (EMR) in real-time, and no longer necessitate each patient generating a hand-written diary of readings to bring to their provider. Data can be safely transmitted through a Health Insurance Portability and Accountability Act (HIPAA)-secure enterprise portal, such as Apple's HealthKit. Additionally, home BP measurements can be visually displayed over time in various consumer-facing smartphone apps and have been shown to independently enhance patient engagement and medication adherence [15,16].

Finally, the current management of chronic diseases such as HTN is crippled because of the paucity of BP data to work from. Patients with

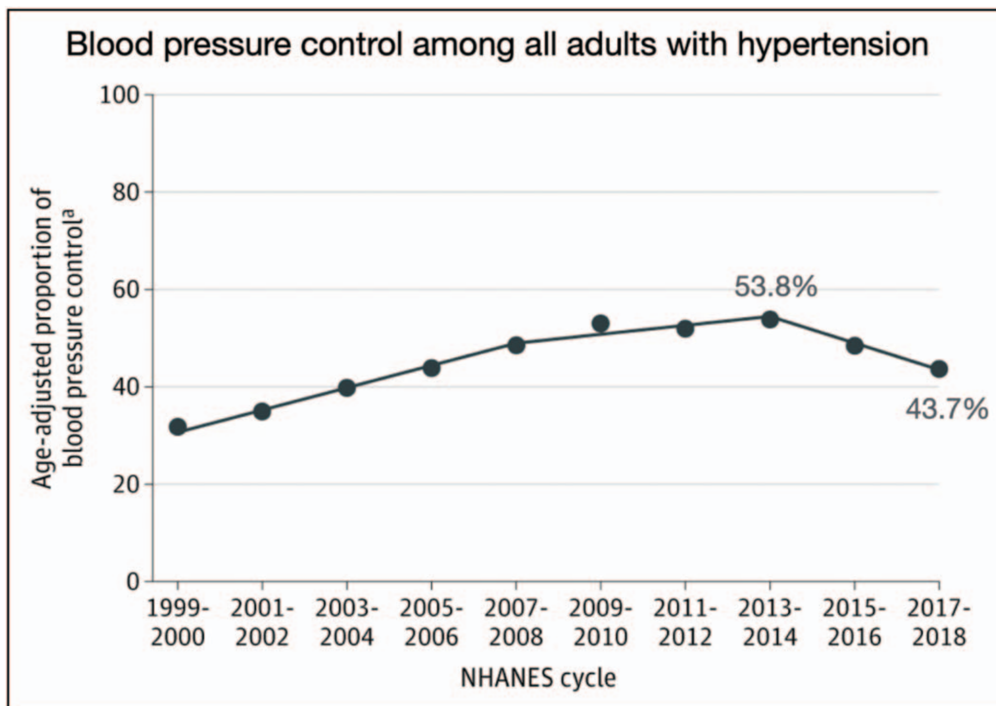

FIGURE 1. Trends in blood pressure control among adults with hypertension, 1999–2000 to 2017–2018. Adapted from Muntner *et al.* [3▪▪].

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uncontrolled HTN on average have four BPs documented in the medical record per year and fewer recorded values are noted in those with controlled BP [17]. Compared to the relatively small sample of in-office BP values, the higher sampling frequency afforded by home monitoring has been shown to improve the likelihood of BP control and is more likely to detect natural variabilities in BP that would otherwise be missed by in-office values [18,19▪]. Capturing and reducing BP variability is an important component in BP management as several studies have now demonstrated that systolic BP variability better predicts all-cause and CVD, mortality, stroke, and total CVD, compared to average systolic BP [14,20]. Optimal BP management today should include a large sample of home BP readings in order to characterize BP variability, as well as diagnose and treat both masked and white coat HTN [4].

TEAM-BASED CARE DELIVERY

The current model of episodic office-based care has several shortcomings when managing chronic diseases such as HTN. Physician adherence to the current evidence base is suboptimal as patients with chronic conditions typically receive guideline-based therapy less than half the time [21,22,23]. In the case of the two most common chronic diseases, fewer than one in three patients with HTN and hypercholesterolemia attain control of both disorders [24,25]. In diabetes, approximately half of individuals do not meet individualized targets for glycated hemoglobin, and less than 15% meet all three targets of glycemic control, BP, and low-density lipoprotein cholesterol [26,27,6]. These failures are not trivial and have been shown to result in worse clinical outcomes and higher costs of care [28,29,30,31].

Multiple studies covering a variety of medical conditions consistently show that providing the physician with a team-based complement of specialized, nonphysician caregivers improves adherence to quality measures and yields superior clinical outcomes, cost and patient satisfaction [32]. Moreover, nonphysician caregivers more closely adhere to evidence-based guidelines and are less likely to be impeded by therapeutic inertia during pharmacologic management [33,34,35]. As a result, team-based care of many chronic conditions including HTN is being promoted by multiple guidelines and policy statements [1▪,36,37,38,39]. Office-based care delivery, therefore, can be reengineered through the use of guideline-based protocols executed by nonphysician providers working in a 'focused-factory' model of disease management [22,40]. This care model utilizes specialized integrated practice units (IPU), often composed of pharmacists, advanced practice clinicians, social workers, and health coaches, and has demonstrated clinical efficacy in HTN management and in other chronic diseases [41]. The IPU model is generally dedicated to a specific disease for the full cycle of care and is organized around a patient's specific needs [40,42]. In this model, patients can be more frequently and effectively connected to the health delivery system and communication can be relatively constant and at regular intervals [22]. Patients can achieve a higher level of engagement in the care process via enhanced education, real-time feedback, and enriched communication. Finally, and importantly, the IPU can assess and address many of the social determinants that directly impede successful HTN control [43].

MANAGING HYPERTENSION IN REAL-TIME: THE HYPERTENSION DIGITAL MEDICINE PROGRAM

With over half of individuals with HTN uncontrolled, patients should not have to wait until the next in-office visit to have therapy intensified, since population studies suggest that clinical CV events including death can take place as early as 6 weeks following the loss of BP control [44]. With the advent of Bluetooth-connected BP devices and smartphones (and tablets), home BP readings can now be directly transmitted automatically into the EMR upon assessment [45]. Once captured in the EMR, the data can be triaged into hierarchical groups based on levels of severity, and managed daily by a dedicated HTN IPU made up of pharmacists, advanced practiced clinicians, and health coaches (Fig. 2). Therapy can be adjusted, medication adherence reinforced, and lifestyle recommendations bolstered in real-time. Patients in our program each receive a monthly report that highlights their progress along with additional lifestyle tips aimed at reducing BP as well as overall CV risk. A particular focus of the IPU is 'activating' patients, by arming them with knowledge, self-awareness, skills, and confidence in order to partner with them in managing their HTN [46]. Improving measures of activation have been shown to increase medication adherence and reduce overall healthcare costs [47].

We now have over 12,000 patients enrolled in the Hypertension Digital Medicine program at Ochsner Health, a program that began in 2015. Patients range in age from 20 to 100 years and up to 6% lack basic technology skills such as E-Mail, texting, or shopping online. Each individual is equipped with a connected BP device that directly

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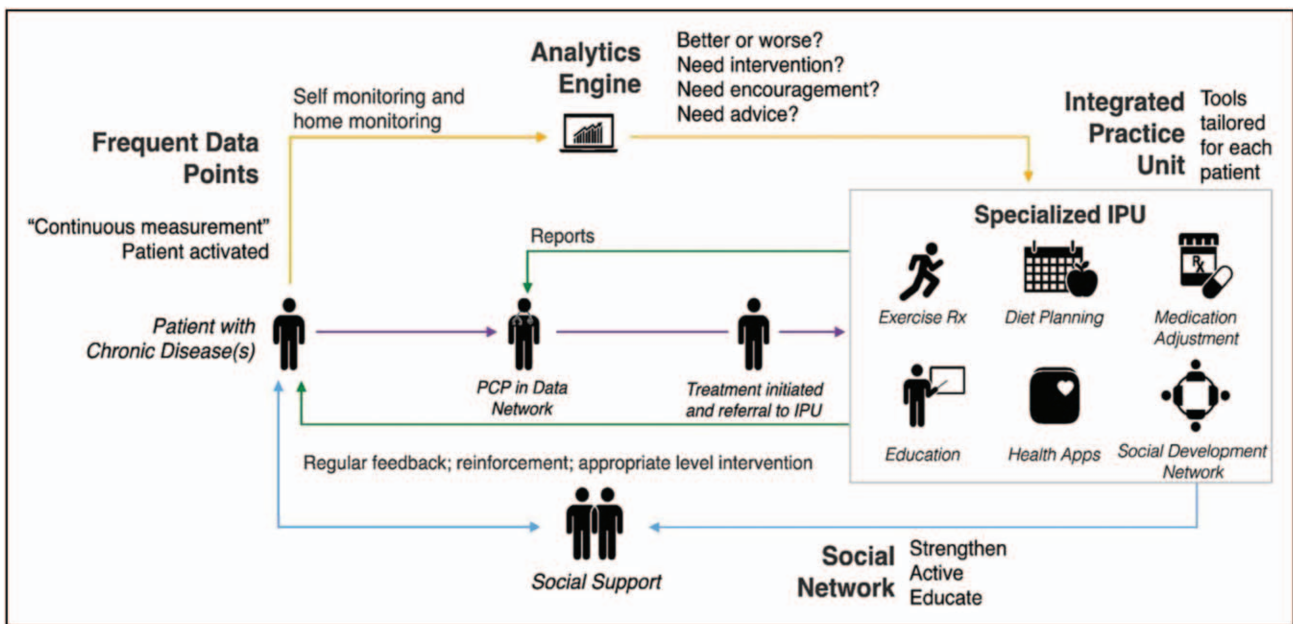

FIGURE 2. The use of technology-enabled care in managing patients with chronic disease. From: Milani *et al.* [45].

links to their EMR patient portal (Epic MyChart) on their smartphone (or tablet) and is asked to submit at least one BP measurement per week on their schedule [41]. Interactions with the care team are both synchronous and asynchronous and are completely virtual. Compared to standard of care, at 6-month patients in the digital medicine program have more BP measurements recorded in the EMR (93.0 versus 1.6), and more frequent interactions with their care team ('clinical touches') (130 versus 12) [48]. Furthermore, digital medicine patients demonstrate greater medication adherence as measured by the proportion of days covered [49]. (Fig. 3) Medication adherence improved 14% among patients in the digital medicine program and declined 2% among patients in usual care. Digital

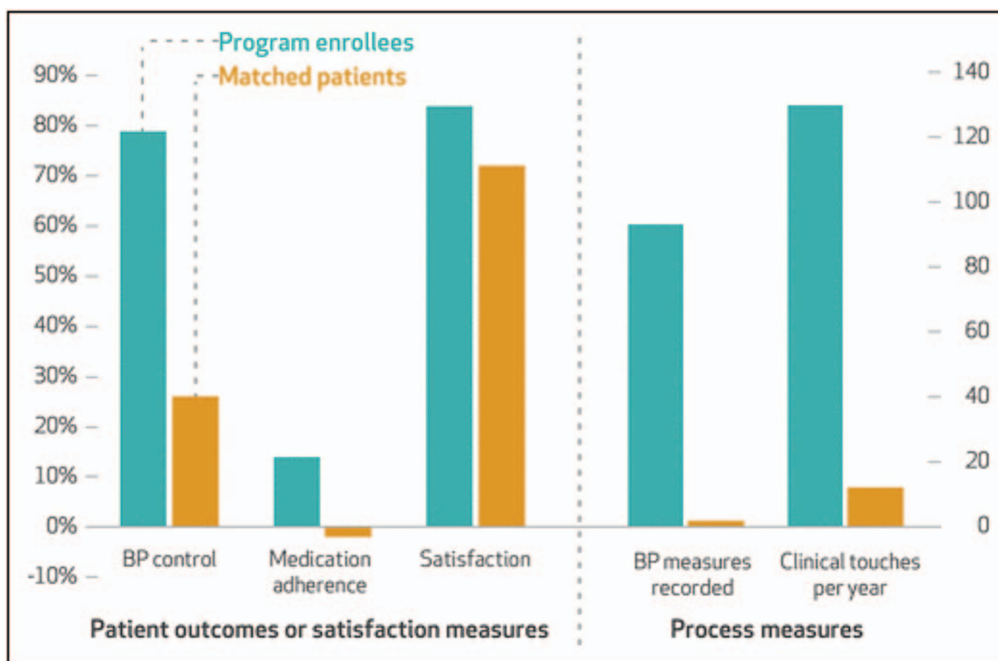

FIGURE 3. Six-month outcomes for patients enrolled in the Hypertension Digital Medicine program compared to propensity-matched patients in usual care. From: Tai-Seale *et al.* [48].

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medicine patients also achieved greater BP control (79% versus 26%) and exhibited higher levels of satisfaction (84% versus 72%) including a net promotor score of 87.5 [48]. These benefits accrued equally to young and old, including those with poor technology skills, confirming that the minimal skills required were surmountable for all participants.

There are additional benefits created when reengineering care delivery using this model. By virtue of the higher sampling rate of BP measurements, we can monitor patients who are in control to identify those who are beginning to trend toward loss of control. By detecting BP trends earlier, the IPU can intervene presently avoiding future loss of control. Additionally, this model can more readily assess other important features in HTN management including identification of masked HTN, white coat HTN, and BP variability. As an example, we have described a high prevalence of elevated systolic BP variability in usual care patients, exposing them to an increased risk for CVD outcomes, all-cause hospitalizations, and mortality. By virtue of the higher frequency of BP measurements and patient interactions, combined with a focused approach toward treatment, we have reported a significant and progressive reduction in BP variability over time (Fig. 4) [19▪]. Finally, we have reduced the burden of work on the primary care physician, decreasing the number of in-clinic visits from participating patients by 29%, enabling greater access for other patients.

Reengineering care delivery for chronic diseases such as HTN is today feasible by enabling inherent capabilities within EMRs, patient portals, and available technologies such as connected BP devices and smartphones. By reengineering how we consume patient-generated health information and intervene via dedicated teams, we can provide a more meaningful and convenient care experience for our patients while achieving superior clinical results. The fundamental characteristics contrasting digital and analog care are outlined in Table 1.

CONCLUSION

Management of HTN using an office-based model of care delivery has demonstrated suboptimal results in population-level BP control, patient engagement, and HTN-related clinical outcomes. New models of care delivery, incorporating patient-generated health data, high levels of patient connectivity and communication, tailored interventions incorporating individual social determinants, all administered through an IPU model, have demonstrated superior BP control, whereas at the same time achieving higher levels of patient engagement and satisfaction. A digital medicine program in the clinical care setting can be an effective mechanism of delivering HTN management, outperforming traditional office-based care, and is well accepted by patients.

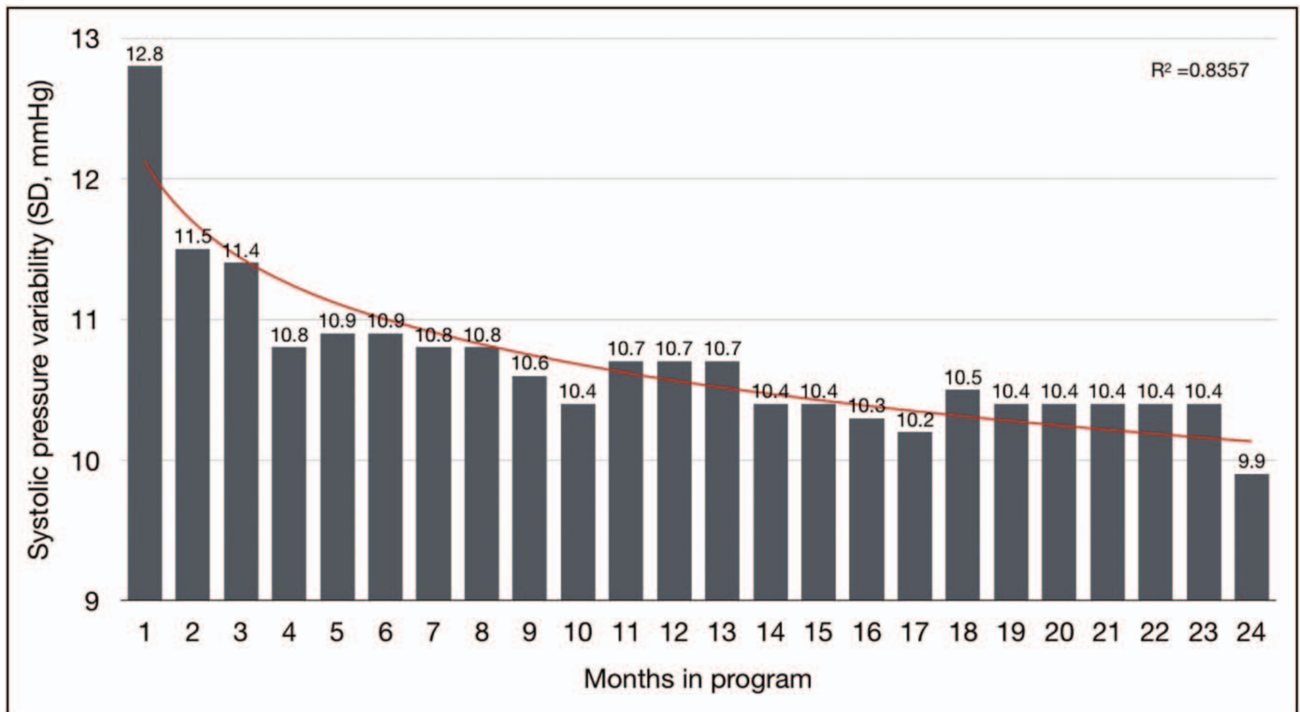

FIGURE 4. Changes in systolic BP variability over time in the digital medicine program. From: Milani *et al.* [19▪]. BP, blood pressure.

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Table 1. The fundamentals of hypertension care management between usual care and digital medicine

	Usual care	Digital medicine
Frequency of data to guide care	1–4/year	160–200/year
Care variation	High	Low
Guideline-based care adherence	∼50%	∼100%
Care team interactions	Openings in physician's schedule	Openings in patient's schedule
Ability to improve health behaviors	Poor	Better
Medication adherence over time	Decreases	Increases
Cost of care over time	Increases	Decreases
Patient satisfaction (NPS)	Average	Excellent

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Conflicts of interest

There are no conflicts of interest.
Disclosures: none

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