Perspective

Telemonitoring for Hypertension Management: The Time Is Now
Sabine Karam and Paul E. Drawz

Introduction
Over the past 2 years, the coronavirus disease 2019 pandemic has challenged our beliefs about the optimal way to deliver health care and has also revealed major deficiencies in the traditional health care model centered around fee-for-service structures (1). The pandemic also led to disruptive innovation by increasing exponentially the use of telemedicine to serve isolated patients. Furthermore, telehealth has indirectly allowed underserved populations, such as patients in rural areas and those with impaired mobility, to have access to services that were not readily available. In that regard, changes in health care delivery have the potential to benefit patients with hypertension, the most common and important risk factor for cardiovascular disease worldwide (2). However, the potential benefits of telehealth strategies for the management of hypertension are not only limited to improving access and accessibility and were highlighted before the pandemic by the 2017 Hypertension Clinical Practice Guidelines, which suggest that telehealth can be a useful adjunct to interventions shown to reduce BP for adults with hypertension (3). In fact, of common chronic conditions, hypertension may be best suited to telemonitoring and telehealth (2).

Telemonitoring for Hypertension
Telemonitoring for hypertension involves the remote measurement and transmission of BP, heart rate, and weight (2). Telemonitoring is just one aspect of a comprehensive telehealth program. Comprehensive telehealth for hypertension involves the provision of services via information communication technology, including phones, video visits, web-based technology, and email. Telehealth services can be multidisciplinary and include assessment of medication adherence, provision of education regarding diet and exercise, and one-on-one consultations (see Figure 1). Studies of telehealth-based hypertension management report a high average patient adherence and were very well received, with excellent acceptability (4). As discussed below, comprehensive telehealth programs are associated with treatment intensification and improved BP control.

Utility of Out-of-Office BP Measurements and Transmission Using Telemonitoring
Telemonitoring is ideally suited for hypertension. The rationale for using BP measurements outside of the traditional clinical setting is highly relevant for both the diagnosis and the management of hypertension as pointed out by the US Preventive Services Task Force, which recommends obtaining measurements outside of the clinical setting for diagnostic confirmation before starting treatment (5). The limitations of diagnosing hypertension solely in the office setting are well known and include measurement errors, the limited number of measurements that can be made, and the non-negligible prevalence of white-coat hypertension (WCH) and masked hypertension (MH) (6). In an international database of patients with CKD, the prevalence of MH was found to be 16%, whereas that of WCH was 20% (7). Relative to patients with sustained elevation in clinic and out-of-office BP, WCH appears to be a relatively low-risk condition (8). On the other hand, patients with MH are at increased risk for adverse cardiovascular and kidney events. This increased risk is seen in those with and without CKD. Moreover, self-monitoring is important because it empowers patients and promotes patient engagement and commitment to care (9).

Beyond the location and the number of measurements, using the correct technique is key (10) and has been described in detail by all of the major bodies issuing hypertension guidelines (3,11–14). Specific training is therefore important to ensure proper measurement technique and seems to be done so far in a minority of cases (15,16). Passive measures that include posters, handouts, information booklets, and other educational tools are of limited value (17); teaching patients to perform self-measurements properly during office visits could be most effective. Video visits and adequacy of number of readings may be utilized to assess and monitor proper technique (18). The use of validated and calibrated upper-arm devices is critical for obtaining accurate BP measurements both in clinic and at home. Fortunately, several online listings of validated devices issued by national and international scientific societies are freely available and easily accessible (19–22).

Division of Nephrology and Hypertension, University of Minnesota, Minneapolis, Minnesota

Correspondence: Dr. Paul E. Drawz, University of Minnesota, Division of Renal Diseases and Hypertension, 717 Delaware St. SE, Suite 355, Minneapolis, MN 55414. Email: draw0003@umn.edu

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Timely communication of results with health care providers is important. Transmission of home BP recordings directly into electronic health records is now feasible from some home BP monitors or via mobile smartphone apps. Direct transmission of BPs into the electronic health record simplifies data collection, but whether it is associated with better outcomes is unknown.

It is, however, important to note that self-monitoring alone is not associated with meaningful changes in mean clinic or ambulatory BP or the proportion of patients with controlled BP. Co-interventions are required to achieve BP control and include systematic medication titration, education, pharmacist co-management, and lifestyle counseling (23). An illustrative example is the HOME BP randomized trial where a digital intervention comprising self-monitoring of BP with reminders and predetermined drug changes combined with lifestyle change support resulted in better control of systolic BP compared to usual care, with low incremental costs (24). Reorganizing care with integration of allied health professionals for a team-based approach and empowerment of nurses and pharmacists to adjust antihypertensive therapy improves BP control (25).

In the Hyperlink study (26,27), using a cluster randomized trial design, investigators evaluated the effect of a telehealth intervention on BP control. The 12-month telehealth intervention included (1) home BP monitoring with transmission of BP data to a secure website and (2) pharmacist co-management, including hypertension and lifestyle education, medication review, and management of antihypertensive drug therapy. From a baseline of 148 mm Hg, the telehealth intervention resulted in lower BP at 12 months (126 versus 135 mm Hg in the usual care group) and at 18 months (127 versus 133 mm Hg in the usual care group). This improvement in BP in the telehealth arm was achieved through increased number of medication classes and a reduction in the proportion of participants who added salt to their food (27). Key components of the intervention included automated transmission of BP data, co-management by a multidisciplinary team, and a multifaceted intervention, including education and medication review. Moreover, the intervention had sustained effects for up to 12 months after the intervention ended; however, such effects were not sustained at 54 months, suggesting that long-term maintenance of BP control is likely to require continued monitoring and resumption of the intervention when needed (27). Finally, despite a cost of $1511 per patient, the Hyperlink telemonitoring intervention ended up with a net cost saving of $1900 per patient over 5 years due to a reduction in cardiovascular events (28). In addition to Hyperlink, a number of other randomized controlled trials have demonstrated that telemonitoring combined with lifestyle interventions and multidisciplinary care improves BP control (24,29–31). These studies should inform multilevel implementation of telehealth and telemonitoring for BP control in routine clinical practice.
Conclusion

The expansion of telemonitoring is a welcome adjunct to the multiple strategies already implemented for the control of hypertension. The importance of acquiring longitudinal BP data outside the office for diagnosis and control makes hypertension an ideal candidate for telemonitoring. The plethora of available tools rendering the transmission of data feasible and accessible in a multitude of settings calls for further expansion of this modality. Recent changes in reimbursement policies provide coverage for self-measured BP monitoring (18). Telehealth programs should ensure accurate and reliable BP measurements using techniques adherent to guideline recommendations. Implementation of telehealth and telemonitoring programs need to account for the digital divide and avoid worsening inequities in communities that may not be digitally literate or financially capable of acquiring devices and the required technologies necessary to transmit home BPs. Telemonitoring should by no means replace in-person visits because this modality is not appropriate for all types of encounters. As is the case for any chronic disease, in-person interaction with providers is important for an optimal exchange of emotions and empathy and constitutes an essential therapeutic tool.

In the future, determining the ideal ratio of in-person visits to virtual visits, the optimal use of remote device monitoring, and the right mix of health professionals will be important to optimizing hypertension care.

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Author Contributions

P.E. Drawz was responsible for the conceptualization and supervision; S. Karam wrote the original draft of the manuscript; and both authors reviewed and edited the manuscript.

References

1. Chin MH: Uncomfortable truths—What COVID-19 has revealed about chronic-disease care in America. N Engl J Med 385: 1633–1636, 2021 https://doi.org/10.1056/NEJMmp2112063
2. Omboni S, McManus RJ, Bosworth HB, Chappell LC, Green BB, Kario K, Logan AG, Magid DJ, McKinstry B, Margolis KL, Parati G, Wakefield BJ: Evidence and recommendations on the use of telemedicine for the management of arterial hypertension: An international expert position paper. Hypertension 76: 1368–1383, 2020 https://doi.org/10.1161/HYPERTENSIONAHA.120.15873
3. Whelton PK, Carey RM, Aronow WS, Casey Jr DE, Collins KJ, Jones DW, MacLaughlin EJ, Muntner P, O’Neill B, Smith Jr SC, Spencer CC, Stafford RS, Talier CJ, Williams Jr KA, Williamson JD, Wright Jr JT: 2017 ACC/AHA/ACP/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: A report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines [published correction appears in Hypertension 71: e140–e144, 2018 10.1161/HYP.000000000000076]. Hypertension 71: e13–e115, 2018 https://doi.org/10.1161/HYP.000000000000065
4. Omboni S, Ferrari R: The role of telemedicine in hypertension management: Focus on blood pressure telemonitoring. Curr Hypertens Rep 17: 353, 2015 https://doi.org/10.1007/s11906-015-0535-3
5. Siu AL: US Preventive Services Task Force: Screening for high blood pressure in adults: U.S. Preventive Services Task Force recommendation statement. Ann Intern Med 163: 778–786, 2015 https://doi.org/10.7326/M13-2223
6. Piper MA, Evans CV, Burda BU, Margolis KL, O’Connor E, Smith N, Webber E, Perdue LA, Bigler KD, Whitlock EP: Screening for High Blood Pressure in Adults: A Systematic Evidence Review for the US Preventive Services Task Force. U.S. Preventive Services Task Force Evidence Syntheses, formerly Systemic Evidence Reviews, Report No. 13-05194-EF-1, Rockville, MD, Agency for Healthcare Research and Quality (US), 2014
7. Drawz PE, Brown R, De Nicola L, Fuji N, Gabbai BF, Gassman J, He J, Imuro S, Lash J, Minutolo R, Phillips RA, Rudser K, Ruijloe L, Steigerwalt S, Townsend RT, Xie D, Rahman M; CRIC Study Investigators: Variations in 24-hour BP profiles in cohorts of patients with kidney disease around the world: The I-DARE study. Clin J Am Soc Nephrol 13: 1348–1357, 2018 https://doi.org/10.2215/CJN.13181117
8. Stergios AS, Asayama K, Thijss L, Kollias A, Niiranen TJ, Hozawa A, Boggia J, Johansson JK, Ohkubo T, Tsuji I, Jula AM, Imai Y, Staessen JA; International Database on Home blood pressure in relation to Cardiovascular Outcome (IDHO1CO) Investigators: Prognostic of white-coat and masked hypertension: International Database of Home blood pressure in relation to Cardiovascular Outcome. Hypertension 63: 675–682, 2014 https://doi.org/10.1161/HYPERTENSIONAHA.113.02741
9. White WB, Asmar R, Imai Y, Mansoor GA, Padfield P, Thijss L, Waebser B: Task force VI: Self-monitoring of the blood pressure. Blood Press Monit 4: 343–351, 1999 https://doi.org/10.1097/00126097-199912000-00007
10. Muntner P, Shimbo D, Carey RM, Charleston JB, Gaillard T, Misra S, Myers MG, Ogedegbe G, Schwartz JE, Townsend RR, Urbina EM, Viera AJ, White WB, Wright Jr JT: Measurement of blood pressure in humans: A scientific statement from the American Heart Association. Hypertension 73: e35–e66, 2019 https://doi.org/10.1161/HYPERTENSIONAHA.118.116007
11. Cheung AK, Chang TJ, Cushman WC, Furth SL, Hou FF, Ix JH, Knoll GA, Muntner P, Pecuit-Filho R, Samak MJ, Tobe SW, Tomson CRV, Lytvyn L, Craig JC, Tunnicliffe DJ, Howell M, Tonelli M, Cheung M, Earley A, Mann JFE: Executive summary of the KDIGO 2021 clinical practice guideline for the management of blood pressure in chronic kidney disease. Kidney Int 99: 559–569, 2021 https://doi.org/10.1016/j.kint.2020.10.026
12. Williams B, Mancia G, Sipiering W, Agabiti Rosei E, Azizi M, Burnier M, Clement DL, Coca A, de Simone G, Dominiczak A, Kahan T, Mahfoud F, Redon J, Ruiolpe L, Zanchetti A, Kerins M, Kjeldsen SE, Kreutz R, Laurent S, Lip GYH, McMurray J, Narkiewicz K, Ruschitzka F, Schmieder RE, Shlyakhto E, Tsoufis C, Aboyans V, Desaormes I; Authors/Task Force Members: 2018 ESC/ESH guidelines for the management of arterial hypertension: The Task Force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension: The Task Force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension. J Hypertens 36: 2013–2041, 2018 https://doi.org/10.1097/HJH.0000000000002390
13. Unger T, Borghi C, Charchar F, Khan NA, Poulter NR, Prabhakaran D, Ramirez A, Schlaich M, Stergiou CS, Tomaszewski M, Wainford RD, Williams B, Schutte AE: 2020 International Society of Hypertension global hypertension practice guidelines. J Hypertens 38: 982–1004, 2020 https://doi.org/10.1097/HJH.0000000000002453
14. Drawz PE, Beddhu S, Bignall 2nd ONR, Cohen JB, Flynn JT, Ku E, Rahman M, Thomas G, Weir MR, Whelton PK: KDQOI US commentary on the 2021 KDIGO clinical practice guideline for Telemonitoring for Hypertension 1963

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the management of blood pressure in CKD. *Am J Kidney Dis* 79: 311–327, 2022 https://doi.org/10.1053/j.ajkd.2021.09.013

15. Logan AG, Dunai A, McIesaac WJ, Irvine MJ, Tisler A: Attitudes of primary care physicians and their patients about home blood pressure monitoring in Ontario. *J Hypertens* 26: 446–452, 2008 https://doi.org/10.1097/HJH.0b013e3282f1fdd4

16. Milot JP, Birnbaum L, Larocheille P, Wisnaff R, Laskine M, Van Nguyen P, Lamarre-Cliche M: Unreliability of home blood pressure measurement and the effect of a patient-oriented intervention. *Can J Cardiol* 31: 658–663, 2015 https://doi.org/10.1016/j.cjca.2015.03.006

17. Leblanc ME, Cloutier L, Veiga EV: Knowledge and practice outcomes after home blood pressure measurement education programs. *Blood Press Monit* 16: 265–269, 2011 https://doi.org/10.1097/HBP.0b013e32834b667a

18. Shimbo D, Attinian NT, Basile JN, Krakoff LR, Margolis KL, Rakotz MK, Wozniak G; American Heart Association and the American Medical Association: Self-measured blood pressure monitoring at home: A joint policy statement from the American Heart Association and American Medical Association. *Circulation* 142: e42–e63, 2020 https://doi.org/10.1161/CIR.0000000000000803

19. American Medical Association: US Blood Pressure Validated Device Listing. Available at: https://www.validatebp.org/. Accessed October 12, 2022

20. STRIDE BP: Validated Blood Pressure Monitors. Available at: https://stridebp.org/bp-monitors/. Accessed October 12, 2022

21. Hypertension Canada: Blood Pressure Devices. Available at: https://hypertension.ca/bpdevices. Accessed October 12, 2022

22. British and Irish Hypertension Society: BP Monitors. Available at: https://bihsoc.org/bp-monitors/. Accessed October 12, 2022

23. Tucker KL, Sheppard JP, Stevens R, Bosworth HB, Bove A, Bray EP, Earle K, George J, Godwin M, Green BB, Hebert P, Hobbs FDR, Kantola I, Kenny SM, Leiva A, Magid DJ, Mant J, Margolis KL, McKinstry B, McLaughlin MA, Omboni S, Ogedegbe O, Parati G, Qamar N, Tabaei BP, Varis J, Verberk WJ, Wakefield BJ, McManus RJ: Self-monitoring of blood pressure in hypertension: A systematic review and individual patient data meta-analysis. *PloS Med* 14: e1002389, 2017 https://doi.org/10.1371/journal.pmed.1002389

24. McManus RJ, Little P, Stuart B, Morton K, Raferty J, Kelly J, Bradbury K, Zhang J, Zhu S, Murray E, May CR, Mair FS, Michie S, Smith P, Band R, Ogburn E, Allen J, Rice C, Nuttall J, Williams B, Yardley L; HOME BP Investigators: Home and Online Management and Evaluation of Blood Pressure (HOME BP) using a digital intervention in poorly controlled hypertension: Randomised controlled trial. *BMJ* 372: m4858, 2021 https://doi.org/10.1136/bmj.m4858

25. Walsh JM, McDonald KM, Shojainia KG, Sundaram V, Nayak S, Lewis R, Owens DK, Goldstein MK: Quality improvement strategies for hypertension management: A systematic review. *Med Care* 44: 646–657, 2006 https://doi.org/10.1097/01.mlr.0000220260.30768.32

26. Margolis KL, Asche SE, Bergdall AR, Dehmer SP, Groen SE, Kadrmas HM, Kerby TJ, Klotzle KJ, Maciosek MV, Michels RD, O’Connor PJ, Pritchard RA, Sekenski JL, Sperl-Hillen JM, Trower NK: Effect of home blood pressure telemonitoring and pharmacist management on blood pressure control: A cluster randomized clinical trial. *JAMA* 310: 46–56, 2013 https://doi.org/10.1001/jama.2013.6549

27. Margolis KL, Asche SE, Dehmer SP, Bergdall AR, Green BB, Sperl-Hillen JM, Nyboer RA, Pawloski PA, Maciosek MV, Trower NK, O’Connor PJ: Long-term outcomes of the effects of home blood pressure telemonitoring and pharmacist management on blood pressure among adults with uncontrolled hypertension: Follow-up of a cluster randomized clinical trial. *JAMA Netw Open* 1: e181617, 2018 https://doi.org/10.1001/jamanetworkopen.2018.1617

28. Margolis KL, Dehmer SP, Sperl-Hillen J, O’Connor PJ, Asche SE, Bergdall AR, Green BB, Nyboer RA, Pawloski PA, Trower NK, Maciosek MV: Cardiovascular events and costs with home blood pressure telemonitoring and pharmacist management for uncontrolled hypertension. *Hypertension* 76: 1097–1103, 2020 https://doi.org/10.1161/HYPERTENSIONAHA.120.15492

29. Pan F, Wu H, Liu C, Zhang X, Peng W, Wei X, Gao W: Effects of home telemonitoring on the control of high blood pressure: A randomised control trial in the Fangzhuang Community Health Center, Beijing. *Aust J Prim Health* 24: 398–403, 2018 https://doi.org/10.1071/PY17187

30. Green BB, Cook AJ, Rashon JD, Fishman PA, Catz SL, Carlson J, Carrell D, Tylr L, Larson EB, Thompson RS: Effectiveness of home blood pressure monitoring, Web communication, and pharmacist care on hypertension control: A randomized controlled trial. *JAMA* 299: 2857–2867, 2008 https://doi.org/10.1001/jama.299.24.2857

31. Persell SD, Peprah YA, Lipiszko D, Lee JY, Li JI, Ciolino JD, Karmali KN, Sato H: Effect of home blood pressure monitoring via a smartphone hypertension coaching application or tracking application on adults with uncontrolled hypertension: A randomized clinical trial. *JAMA Netw Open* 3: e200255, 2020 https://doi.org/10.1001/jamanetworkopen.2020.0255

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