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# Digital health technology and hypertension management: a qualitative analysis of patient and specialist provider preferences on data tracking

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## Abstract

**Aim:** Digital health for hypertension management holds potential for improving the quality of care but requires long-term patient engagement to track health data. We explored patient and hypertension specialist perceptions of clinical utility for data tracking including standardized patient-reported outcome measures (PROMs), home blood pressure (BP) measurement, and other health metrics.

**Methods:** Participants reviewed general health status, patient satisfaction, and hypertension-specific PROMs. Semi-structured focus groups ( $n = 15$ ) with nine patients with hypertension and six hypertension specialists were audio-recorded and thematically analyzed.

**Results:** Key themes identified from patients included: (1) comfort and appreciation of home BP monitoring but only during important periods of hypertension care; (2) preference for tracking new symptoms and medication side effects; (3) patients perceived tracking other health measures including general PROMs, diet and exercise as less relevant to their care; and (4) visually represented BP trends evaluating associations with changes in other health



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parameters were perceived as useful. Key themes identified by hypertension specialists included: (1) concerns about patient digital literacy; (2) utilizing visual representations of long-term BP data trends for patient empowerment; and (3) unclear relevance of tracking medication adverse effects, PROMs, and other non-BP health metrics.

**Conclusion:** Patients and hypertension specialists had similar perspectives for most aspects of data monitoring but differed in preference for a few aspects that were germane to patients, including monitoring medication adverse effects and symptoms. Including views on data tracking from both patients and providers are essential for designing digital tools to optimize hypertension management.

**Keywords:** Hypertension, qualitative, patient-reported outcome measures

## INTRODUCTION

Digital health interventions for chronic disease management including hypertension may enhance patient-centered care and the patient's health care experience. Patient-centered care incorporates self-management and puts patients at the forefront of their healthcare, and enhances relevance to empower and improve patient engagement<sup>[1,2]</sup>. Patient online portals, for example, are associated with improved management of hypertension, physical activity, smoking cessation, and weight loss<sup>[2-5]</sup>. Digital tools, including those enabling blood pressure (BP) tracking, are acceptable by patients<sup>[3]</sup> and associated with reduced BP and 10-year cardiovascular Framingham risk scores compared with usual care<sup>[2,4-7]</sup>. Digital tools are even more relevant since the COVID-19 pandemic, as a substantial number of patients receive hypertension care virtually<sup>[8]</sup>. These digital tools often rely on long-term patient tracking of home BP and other data parameters. While studies examined patient understanding and perspectives of home BP monitoring, there are limited data on the perspectives of patients on tracking other health data for hypertension self-management, including the use of patient-reported outcome measures (PROMs)<sup>[9]</sup>. Further, there are few studies examining the perspectives and understanding of health data tracking by hypertension specialists who provide care for patients with complex and severe hypertension<sup>[10]</sup>. To ensure that data tracking tools for virtual care are usable, relevant, and engaging for end-users, both patients' and providers' views must be considered in designing digital tools. Including views from both patients and hypertension specialists is critical to co-creating digital health tools as these groups tend to have differing views on priorities in hypertension management<sup>[10,11]</sup>, and poor physician engagement is associated with low uptake of digital health tools in clinical care<sup>[12,13]</sup>. This study aimed to explore patient and hypertension specialist care provider perceptions of data monitoring including the use of PROMs to inform the design of digital health tools for hypertension management and to understand the differences and similarities between patient and specialist provider perspectives. These research data were used as part of a larger study to design a novel patient-centered digital tool for hypertension management.

## METHODS

We used the consolidated criteria for reporting qualitative research (COREQ) checklist as a methodological and reporting guide for this study<sup>[14]</sup>. The Clinical Research Ethics Board at the University of British Columbia approved this study.

### Participant selection

Patients aged 19 years and older referred to hypertension specialty clinics at two tertiary care academic hospital sites in Vancouver, Canada, were invited to participate in two focus group sessions. Criterion sampling based on sex and age was used to select focus group participants with the inclusion of men and women both above and below the age of 65 years. Patient inclusion criteria were a confirmed diagnosis of

hypertension requiring any antihypertensive drug therapy and English fluency. All patients referred to these clinics were instructed to measure home BPs as a part of best practices care. Patients were not instructed on the use of any digital programs or applications to assist in their BP management. Patients with cognitive impairment were excluded. The sample size was determined by saturation of data where there was informational redundancy from the focus groups and no new themes emerged from individual data probing<sup>[15]</sup>. The current sample size is noted to achieve 80% of all themes and the most prevalent themes<sup>[15]</sup>.

Hypertension specialist physicians with training in Internal Medicine and American Society of Hypertension Clinical specialist certification, working at hypertension clinics at two tertiary care academic hospitals and one community hospital in Vancouver and Surrey, Canada, were also recruited to this study for interviews.

### **Semi-structured focus groups**

The research team developed the facilitator topic guide from literature in this area and findings from a previous national survey on patient preferences in the management of hypertension conducted in Canada using the James Lind Alliance approach<sup>[11]</sup> (see [Supplementary Material](#)). Focus group sessions included barriers/facilitators to patient data monitoring. Participants were asked to review various standardized PROMs including general health status, perceived quality of life, and experience with care questionnaires, and evaluate how useful they felt these measures would be in identifying what mattered most to patients to improve their hypertension care. These questionnaires included the Patient Health Questionnaire (PHQ-9)<sup>[16]</sup>, the Short-Form Patient Satisfaction Questionnaire (PSQ-18)<sup>[17]</sup> and Hyper-PRO, a hypertension specific PROM, validated and translated hypertension specific patient-reported outcome measure that included domains on psychological symptoms, satisfaction with care, social support, and somatic symptoms<sup>[18]</sup>.

Focus groups were semi-structured lasting 60 mins and were held separately for patients and hypertension specialist providers. Due to the COVID-19 pandemic, all four focus groups (two patient and two physician focus groups) were conducted over digital teleconferencing with audio recording software (Zoom) led by an experienced facilitator.

### **Transcription and thematic analysis**

Audio files recorded from the interviews were fully transcribed manually. Each transcript was then checked against the recording for accuracy. Transcribed conversations and field notes from patients and physicians underwent thematic analysis: a qualitative analysis used to identify patterns/commonalities among conversations. The five stages of thematic analysis (familiarization, generation of codes, searching for themes, reviewing themes, and defining themes) have been described elsewhere<sup>[19]</sup>. In brief, to aid in the coding of transcripts, we used QSR NVivo X software to generate codes, and categorize and organize text data. Analysis was carried out by adopting techniques from grounded theory, such as the use of the constant comparative method, conducting line-by-line analysis of each interview, and identifying deviant cases. The themes emerging from the interviews were used to create categories and subcategories for the coding framework. Patient and physician data were coded separately<sup>[20]</sup>. Using NVivo X, the qualitative methodologist coded and analyzed focus group data using an *a priori* coding approach. Key themes were summarized under each code to address questions of interest from the research team. We then employed an investigator triangulation approach with three observers present in the focus groups to verify the credibility of the findings. Two researchers independently reviewed the transcripts to ensure that the comments and themes were traceable and clearly documented to ensure the dependability and confirmability of the final themes<sup>[20]</sup>.

## RESULTS

Of the 21 patients approached, there were nine patient participants (44% women) and six physician participants (67% women) included in the study [Table 1]. All patients were diagnosed with hypertension and used antihypertensive medications. Most were proficient with computer navigation and all had experience with home BP monitoring, with most participants with greater than two years of home BP monitoring.

Key themes identified in patient focus groups included the: (1) comfort and appreciation of home blood pressure monitoring; (2) interest in tracking data on medication side effects; (3) mixed opinions regarding tracking other health measures such as diet and exercise; and (4) desire for visually represented data but not standard PROMs.

Key themes identified in hypertension specialist focus groups included: (1) general favor of utilizing electronic medical record (EMR)-integrated digital hypertension monitoring tools, but concerns about patient digital literacy; (2) utilizing visual representations of long-term blood pressure data for both physician and patient empowerment; and (3) disagreement between physicians regarding what health parameters patients should monitor (See Figures 1 and 2 for a summary of the thematic analysis for patients and physicians, respectively).

### Patient focus group results

Theme 1: Home blood pressure monitoring varied based on patients' perceived utility

Participants reported that home blood pressure monitoring using an upper arm automated oscillometric BP monitor was a common self-monitoring practice among participants. Most patients expressed that home BP measurement was valuable, but the frequency of home BP data collection and the value of home readings depended on their level of BP control, physician appointments, need for medication adjustment and their personal preference.

*“And I used to do it regularly before while it was high until we got it settled down. And I don't actually monitor it much anymore, except when I'm going into the doctor for a specific reason, [because] usually times elapsed, [my doctor] just likes to keep an eye on it, then I'll track it for two weeks in a row...” (M > 65)*

Patients reported that home blood pressure measurement allowed for more self-control and efficient care, especially for medication titration, as patients described feeling supported in understanding how to effectively track their own blood pressure:

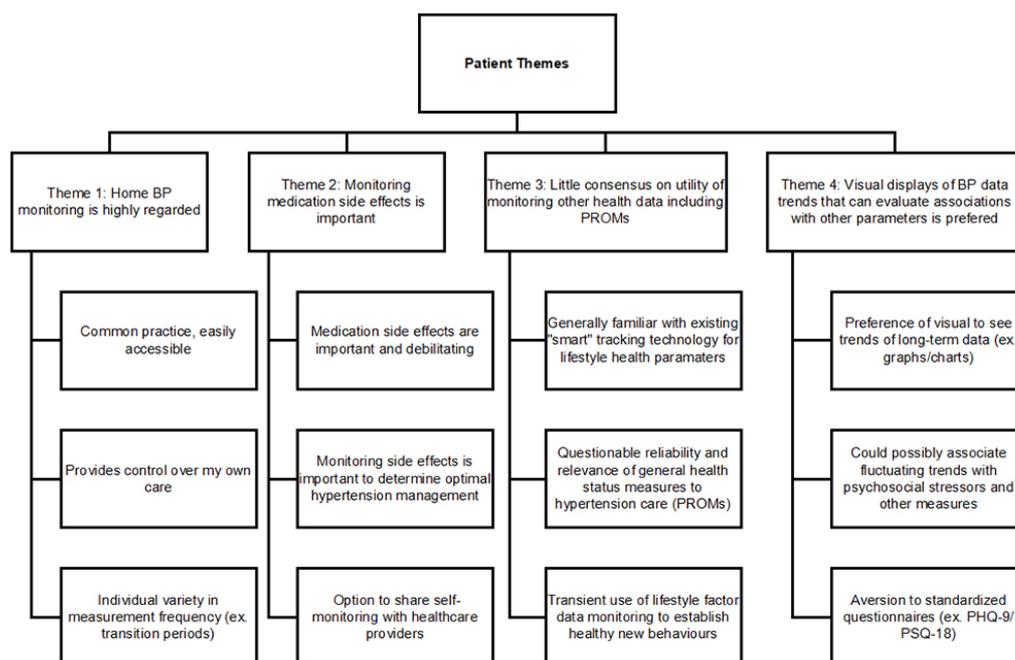
*“Well, for me, I would say that being able to check it at home has been critical for my management, because I've been adjusting my medications gradually, over years now. And that, you know, if I was just going to wait for the readings at the doctor's office and sort of tried to make decisions based on that...so by sort of having control at home, taking my blood pressure, being able to track it, and then make sort of decisions based on that has made a huge difference for me.” (M < 65)*

Participants demonstrated a need to track their blood pressure during transition periods, such as during medication adjustments:

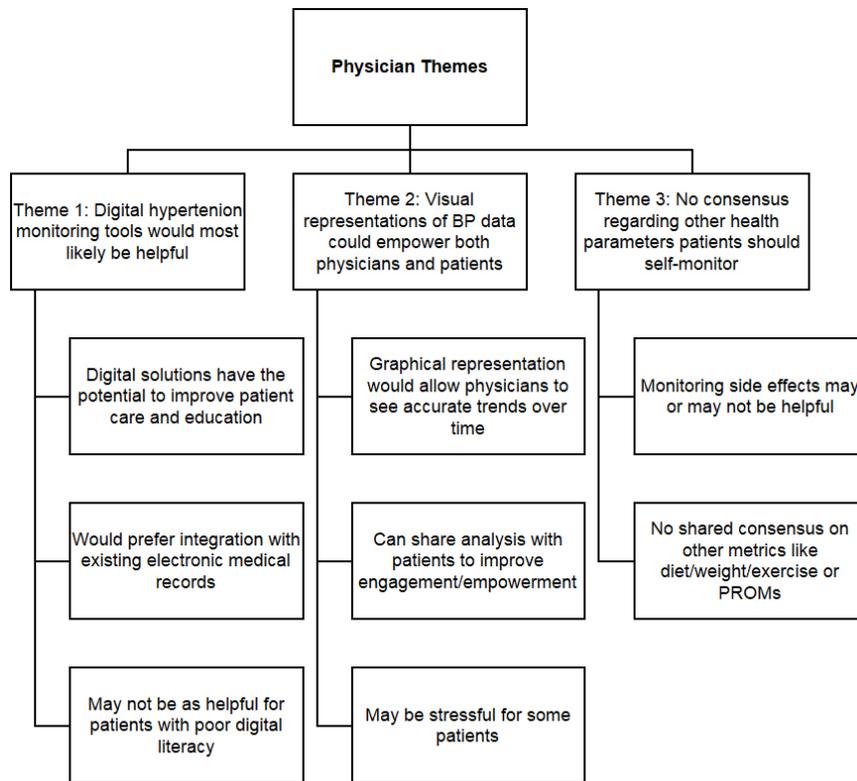
**Table 1. Baseline characteristics of patients and physicians, %(n)**

| Baseline characteristics                                     | Patients (n = 9) | Physicians (n = 6) |
|--|------------------|--------------------|
| Age > 65 years   | 44 (4)           | 0 (0)              |
| Woman  | 44 (4)           | 67 (4)             |
| Urban living   | 78 (7)           | 100 (6)            |
| White ethnicity  | 89 (8)           | 50 (3)             |
| Hypertension duration  |                  | -                  |
| < 5 years  | 22 (2)           |                    |
| > 10 years   | 44 (4)           |                    |
| Home BP monitoring experience > 2 years*                     | 89 (8)           | -                  |
| Home BP readings recording                                   |                  | -                  |
| Paper  | 78 (7)           |                    |
| Online or use of applications                                | 22 (2)           |                    |
| Automated teletransmission of readings                       | 0 (0)            |                    |
| Comorbidities  |                  | -                  |
| Dyslipidemia   | 44 (4)           |                    |
| Diabetes   | 11 (1)           |                    |
| Asthma   | 11 (1)           |                    |
| Obstructive sleep apnea                                      | 22 (2)           |                    |
| Cerebrovascular disease                                      | 11 (1)           |                    |
| Ischemic heart disease                                       | 22 (2)           |                    |
| Antihypertensive medication use                              | 100 (9)          | -                  |
| Computer usage daily   | 89 (8)           | 100 (6)            |
| High level of self-reported comfort with computer navigation | 89 (8)           | 100 (6)            |
| Physician years of hypertension specialty practice > 5 years | -                | 50 (3)             |
| Physician practice setting (multiple settings included)      | -                |                    |
| Academic tertiary care center                                |                  | 100 (6)            |
| Community hospital   |                  | 17 (1)             |
| Private community clinic                                     |                  | 33 (2)             |
| Telehealth BP monitoring experience > 1 year                 |                  | 100 (6)            |

\*Missing data in one person. BP: Blood pressure.



**Figure 1.** Overview of patient sub-themes and overarching themes. BP: Blood pressure; PROMs: patient-reported outcome measures.



**Figure 2.** Overview of physician sub-themes and overarching themes. BP: Blood pressure; PROMs: patient-reported outcome measures.

*“And I basically take my blood pressure at various times throughout the day. At a time or, or a period of time when I feel there’s a good reason to do...so either if I’m adjusting medications, if I have symptoms...” (M < 65)*

Theme 2: Preference for tracking data of new symptoms and medication side effects

Participants highlighted the need for tracking data on medication side effects as this interfered with personal blood pressure management and overall quality of life:

*“The biggest issue for me is side effects of multiple medications...I’ve had a lot of side effects... And that’s my main problem.” (M > 65)*

To better manage blood pressure, participants mentioned the desire to connect data, including blood pressure and other health information (e.g., new symptoms and medication-related side effects) between all of their health care providers to ensure continuity of care and a shared understanding among providers of patient needs:

*“...I don’t think I report any of this to them [family doctor]. I only really do it in the follow-up clinic, the hypertension clinic, so maybe that’s something that doctors should do with it, like connect between doctors...” (F < 65)*

*“Well, I’ve had trouble with the medication, so I’ve involved my family doctor with that. And recently was good because one of the things I’ve been trying to do, I get severe muscle cramping from my head to my toes,*

*with and with a side effect of one of the medications...and so I've been involving my family doctor more. (F > 65)*

Theme 3: Data tracking other health measures such as diet and exercise and PROMs had perceived limited utility

Overall, participants were familiar with mobile health tracking applications on smartphones and other wearable devices that track general health metrics such as physical activity (i.e., running, walking) and other health conditions (i.e., migraines, menstrual cycles). Some participants demonstrated an interest in such applications, showing particular interest in evaluating trends over time:

*"And it's interesting, the tracking, I really love the tracking to see the trends and be like, oh, this time last month, I felt the exact same thing or, or see that or, you know, did this around that time or ate this around that time, and my blood pressure was higher than normal...I have started keeping track of just general overall wellness..." (F < 65)*

Despite a familiarity with these health-tracking applications, participants also questioned the reliability of tracking technology, as well as its relevance to blood pressure management:

*"I'm not sure how reliable it is. It basically, you know, it doesn't say much about the blood pressure, but what uh, you know, says you're not, you didn't meet your walking goal today or whatever." (M > 65)*

One participant described the utility of health tracking applications during a conditioning period to help develop new habits; once the new behavior was sustained, the application would no longer provide significant benefit:

*"[I] used devices in the past, more as a short-term thing, like if I need to get more active, then I'll use it for a little while too. And then once I figure out like, Oh, you know, I know if I walk this far, I'm already hitting 15,000 steps a day. So, I don't need to wear the tracker anymore. I know what my lifestyle is. If I need to drink more water, that's been a big one for me; holding myself accountable to tracking the water, made sure I drank water. So, in and then once you get into that habit, then I don't need to keep tracking that anymore." (F < 65)*

Participants highlighted several ways in which tracking applications and other blood pressure technologies could be enhanced to provide more meaningful outputs for patients and health care providers. This included the ability to take an average of several readings, compare time periods, or observe trends after changes to medications. Additionally, patients described the benefits of telemonitoring, where personal data would be uploaded in a confidential and secure way for health care providers to access and interpret:

*"Yeah, it'd be good if we coordinated in a non-identifiable way, just data, you know, this person has these characteristics, this kind of blood pressure with here's the history, here are the drugs that they are on. If it was all tracked, and it was uploaded by something, it seems to me, it might be useful for [physicians] to have access to data like that on an ongoing basis." (M > 65)*

For most participants, the standardized questionnaires (PHQ-9 and PSQ-18) were not regarded as directly relevant to hypertension or their care. However, they considered a more hypertension specific patient-related outcome or experience measures would be more relevant and possibly useful:

*“If it’s just a kind of generic, ‘how happy are you?’, I think it’s useless. But if it flags, particular issues, either side effects, or mood... if readings are very low or very high, there may be symptoms...” (M > 65)*

Theme 4: Preference for visually represented blood pressure data and that allowed for inspecting associations between clinical parameters

Participants indicated that documenting data trends (i.e., a series of blood pressure measurements taken over a period of time) would be useful for managing hypertension, as trend reporting may provide more meaningful information for both patients and health care providers:

*“...I think the doctor would be more interested in the general trend over a period of time, the slope, the, you know, the area under the curve, whatever, rather than any particular reading.” (M > 65)*

Specifically, hypertension trend lines may be useful for uncovering stressful times of the month or events leading to a rise in blood pressure:

*“But I can imagine for my hypertension that could also be useful, like, “Oh, this time of month, my hypertension always seems to be higher”. And that like a particularly stressful time, or something else, like I could imagine something chronological maybe could also be interesting, if there are variations.” (F < 65)*

Other useful visualizations indicated by participants included pictorial representations, bar charts, pie charts, and diagrams.

### **Physician focus group results**

Theme 1: Consensus about employing EMR-integrated digital solutions to improve hypertension management, but concerns about patient digital literacy

Most physicians preferred using technology such as electronic medical records to view patient health data to improve patient care and education. However, some physicians raised concern that not all patients would be able to effectively utilize digital health tools because of gaps in digital literacy.

*“I think my dream is just to see really clear, clear, clear data that will help guide what I’m doing with a patient. So I think seeing those blood pressures, seeing those trends, would be really nice. But it would also be really nice for me and the patient to be able to see the same data. So, therefore, we’re on the same page.” (F)*

*“It’s actually much harder than most, for a 60-year-old to remember how to scan something with their phone, for them to know that you have to connect to Wi-Fi, for them to have a log in an email to upload this information. So for many times...they don’t know how to transmit the information back to me, so it becomes useless...” (M)*

There was a general consensus among physicians that digital monitoring tools would be most beneficial if they were incorporated into existing EMR systems as this would lead to more seamless workflow and physician uptake.

*“I always care about how the data is transmitted to the practitioner, because, if it’s integrated to an EMR where I can just copy and paste something and it’s already prepopulated, we would have a very high uptake.” (M)*

Theme 2: Graphical representation of long-term BP monitoring could empower both physicians and patients

Physicians preferred visualizing BP trends graphically with a preference for line graphs. They also wanted to be able to average BP readings over any specific time frames among available data, and expected data monitoring would be more or less frequent depending on the clinical situation (e.g., adjusting medications).

*“I think I like the seven-day average overall, but it will change based on the patient and where they are, if they’re starting medications that we probably would like to see more close monitoring of their blood pressure. But once they become stable, then we probably don’t need weekly, we can probably get away with monthly averages.” (F)*

They noted the utility of BP data tracking to not only guide decision making, but to enhance patient and physician engagement. One physician described that giving the patient a copy of their blood pressure data could be used as a “report card” for patients to improve engagement and physician empowerment.

*“I think seeing the progression of the patients clinical values and their blood pressures... I think that would be really powerful, not just for the patient, but also for us to see their trajectory. Because right now, what I’m doing is just going to my previous consult notes and kind of picking up the values. But if I can see a graph or, you know, something we can print out as a report card to give to the patient or email it to them or send it to their GP.” (F)*

Theme 3: Unclear relevance of data tracking of other health parameters for patient self-monitoring

Some physicians argued that symptom tracking with a digital monitoring tool would bring unnecessary anxiety to patients. Monitoring medication side effects for some patients can lead to false over-inflation of adverse effects. With tracking, providing a plan in the event of medication side effects can help assuage anxiety from patients.

*“I don’t think (monitoring side effects) is super helpful, unfortunately. Because if the patient is dizzy or nauseous, the data still needs to be interpreted. It may or may not be from the medication. Also, if a physician has 100 to 1000 hypertensive patients and everyone says, ‘I’m dizzy or I’m not,’ it becomes overwhelming. And once it’s overwhelming, then it kind of defeats the purpose.” (M)*

*“... I like giving (patients) a game plan of what to do when you have a side effect or something. And then I think just to recognize, like, a lot of people may not have true side effects, but it’s true to them. And you know, they’re going to stop the medication, even if you continue it.” (F)*

Some physicians believed that monitoring symptoms related to medication are beneficial with a digital monitoring tool. Those in favor of symptom tracking believed symptoms should be monitored at baseline, before initiating medications and during medication use. The onset and characteristics of symptoms should be time stamped so that they can be temporally evaluated with medication adjustments. Physicians noted that tracking symptoms would improve patient engagement in their hypertension care.

*“I think having a way of helping a patient help track of reactions to medications is useful, because often people feel like, ‘I don’t know what happened. I stopped it because I had some interaction sometime,’ and I don’t know what it was. ...so having some way of logging them, keeping track of what medications they’ve tried, and any*

*allergies or reactions to medications would be something that would be potentially helpful. And that could even be on a timeline with what their what their medications were matched up to what their blood pressure was.”* (M)

One physician attested that tracking inherently puts patients in control of their own health, regardless of whether or not tracking medication side effects was clinically useful.

*“I had (a patient) that would track every single symptom, every single blood pressure for the entire month and color coded, and circle things and then bring that to me every month. And I just found it so confusing. And she found it so confusing, but I think that gave her control on something that she could track it. And if she could track it, she could show her physician what she was going through.”* (F)

In addition to symptom tracking and blood pressure measurement, physicians also cited diet and exercise data, and additional parameters would ideally be monitored. The desire to monitor patient weight was more ambiguous, with some physicians feeling it is important while others saying the contrary.

*“I don’t necessarily know if weight would be useful to track... sometimes that causes them more anxiety.”* (F)

*“I want to know what their diet is. I always ask about their diet. How much kind of potassium rich foods they get, how much processed foods they eat, how often they go to restaurants. I want to know what their weight is, whether it’s going up or down. I also want to know what their physical activity is.”* (F)

## DISCUSSION

Digital health interventions for chronic disease patient self-management, including hypertension, rely on long-term patient tracking of multiple clinical and non-clinical data parameters. Previous studies examined patients’ understanding and perceptions of home BP self-monitoring; few studies examine patient understanding and preferences of data tracking for standardized PROMs and other health metrics that are being increasingly used in self-management tools and clinical assessments. Further, most patient self-management digital tools are patient-facing, but these tools can provide valuable health information to care providers<sup>[21]</sup>, especially hypertension specialists who provide care for challenging and complex hypertension cases<sup>[10]</sup>. This study provides novel comparisons between patients’ and hypertension specialists’ understanding and perceptions of data tracking for patient self-management.

Our study found both patients and hypertension specialists saw value in home BP monitoring, with patients acknowledging that BP data self-monitoring was useful and utilized largely at key points in hypertension care, for self-medication adjustment, and prior to physician visits, whereas hypertension specialists described its clinical utility and potential for patient empowerment and medication adjustment. Both groups expressed a desire for visual representations of BP data trends with annotation capacity, which is consistent with a recent qualitative study<sup>[22]</sup>, but with an additional ability to simultaneously evaluate associations of BP changes with multiple other data metrics, particularly medication use and adverse effects. Patients reported tracking adverse symptoms associated with medication use was of high importance, yet, other data tracking, including PROMs that measure overall health status and patient satisfaction, were deemed less relevant. Hypertension specialists similarly had little consensus on which health metrics beyond BP should be monitored by patients, with some physicians questioning the utility of digital tracking tools due to inconsistent digital literacy.

Although there are numerous studies on patient and provider barriers and facilitators of home BP self-monitoring, there is little information on how self-measured BP monitoring is systematically used by patients and how it is linked to a person's system of care<sup>[23]</sup>. Our findings that patients perceive the utility of home BP monitoring corresponding to needs during their hypertension management either because of significantly elevated BPs or prior to health care visits are consistent with other studies where patients reported performing home BP monitoring when specifically instructed by care providers<sup>[24,25]</sup> and when BP is poorly controlled. These findings suggest that long-term data tracking of BP will vary among individuals with more intense tracking at critical decision-making time points and that they may require ongoing integration of home BP measures in this decision making with care providers to retain relevance and engagement with home BP measurement.

PROMs are increasingly used for clinical health assessments as objective, independent, standardized, and patient-centered measures of health status. However, there are few studies that examine patient and provider perspectives on tracking PROMs as a part of hypertension management. Our findings that patients and hypertension specialists perceive a limited relevance in questionnaires on general health status and patient satisfaction in hypertension clinical practice are novel as most PROMs evaluated in hypertension patients focus on mental health measures of depression<sup>[26]</sup>. These findings may be explained by a lack of awareness and understanding of the potential utility of standardized assessments by patients and providers, provider and patient preferences for only minimal data collection that is directly relevant to clinical decision making for hypertension<sup>[9]</sup> and overly lengthy or insufficiently patient-centered, standardized assessments specific to hypertension<sup>[27]</sup>. Currently, the Hyper-PRO originally developed in China is the only hypertension-specific PROM to our knowledge, and this has not been validated across multiple populations for usability or acceptability<sup>[18]</sup>. Further research is required to develop novel standardized PROMs that are relevant to patients with hypertension, including measures that focus on aspects of hypertension management that matter most to patients, including experiences and perceptions of their health related to BP monitoring, medication taking, and adverse effects of drug therapies.

Patient participants indicated monitoring side effects were important as medication side effects were the most significant barrier to optimal medication adherence and BP control. Providers appeared to have mixed opinions on tracking side effects proactively. To improve medication taking behaviors, mobile health applications include text reminders, education on medication adverse effects, and some include reporting of adverse effects when such effects arise<sup>[28]</sup>. These interventions using mobile health technology have not been associated with significant improvements in medication adherence but may assist in timely reporting of adverse events to providers to adjust medications<sup>[28,29]</sup>. However, there are little data on the utility of prospectively tracking medication adverse effects using digital health interventions, and it is unclear whether this would improve medication-taking behavior<sup>[29]</sup>. Further study on medication adverse event data tracking is needed.

There are several limitations to note in this exploratory study. There is a possibility of social desirability bias as participants might have presented their experiences in a more positive light. Although we used purposive sampling across gender and age strata, we had few young men participants in the focus groups, and thus these results may not be generalized to that patient subgroup. As the sample size was relatively small, we were also not able to evaluate whether perceptions would differ in other populations, including immigrants, other ethnic groups, and those with poor digital literacy. Further, although patients mentioned some software applications they used as part of their health care, we did not collect specific information on patients' or providers' past experience with hypertension management or BP measurement software applications. Their past exposure to different digital programs may have shaped their perceptions of data

monitoring.

In conclusion, although perceptions of data tracking were largely similar between patients with hypertension and hypertension specialists, there were several important differences, especially on the utility of medication adverse effects monitoring, indicating that both perspectives are needed when designing digital health tools for patient self-management and ensuring integration into clinical care. Further research is required to develop electronic PROMS that are directly relevant and acceptable to patients with hypertension.

## DECLARATIONS

### Authors' contributions

Design of the study: Khan NA, Forde B, Sawatzky R, Tran KC

Data collection: Khan NA, Patiño AG, Chow R, Bittman J

Data analysis: Khan NA, Chow R

Had full access to all the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis: Khan NA, Chow R

All authors contributed to interpretation of the results, and meaningful contribution to writing and accepting the final manuscript.

### Availability of data and materials

Data will be made available upon reasonable request.

### Financial support and sponsorship

Funding for this project was obtained through competitive provincial peer review grant funding from the Michael Smith Health BC Support Unit PCM-001. The funder played no role in the collection of data or interpretation of results or were involved in manuscript writing.

### Conflicts of interest

Co-authors Forde B is a CEO and Patiño AG is an employee of Cambian Ltd, an information systems integrator and application developer private company (<https://www.cambian.com/>). The other researchers have no conflicts of interest to declare with this work.

### Ethical approval and consent to participate

Retrospective study, informed consent obtained on all patients prior to surgery.

### Consent for publication

Not applicable.

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