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Blood pressure monitoring of hypertensive patients in primary care: barriers and facilitators to ambulatory, office, and home blood pressure monitoring in the context of the Triple Aim

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**Blood pressure monitoring of hypertensive patients in primary care:
barriers and facilitators to ambulatory, office, and home blood
pressure monitoring in the context of the Triple Aim**

By

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requirements for the degree of

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Introduction

Hypertension is a major public health issue in the United States. According to the National Health and Nutrition Examination Survey for the year of 2011–2012, 29.1% of the adult population in the United States has been diagnosed with hypertension and 76% of individuals with hypertension are treated with blood pressure medications (Centers for Disease Control and Prevention, 2013). In 2010, the direct spending to treat hypertension in the United States was \$42.9 billion, and of that total, \$20.4 billion was spent on antihypertensive medications (Davis, 2013). Unfortunately, the trend is only expected to increase as the current population continues to age.

Hypertension represents a population health issue in that many patients are misdiagnosed and over-or-under medicated. Research has indicated that overestimating the true blood pressure by 5 mmHg leads to over 30 million Americans being inappropriately treated with blood pressure medication (Handler, 2009). Underestimates of true blood pressure by 5 mmHg may lead to an incorrect diagnosis of pre-hypertension, when the patient is in fact hypertensive (Handler, 2009). Although 24-hour ambulatory and home blood pressure monitoring are more reliable methods of measuring hypertension, office blood pressure measurement remains the standard protocol to diagnose and manage this chronic disease (Centers for Disease Control and Prevention, 2013). Blood pressure measurements taken in the office are often inaccurate due to patient behaviors, improper technique, and observer errors, yet providers are still using this method to diagnose hypertension. Therefore, considering other methods of blood pressure for the diagnosis and management of hypertension is important to the healthcare quality for millions of Americans.

The main objective of this capstone research is to identify, categorize, and assess the barriers and facilitators to ambulatory, office, and home blood pressure monitoring, using both an

evidence-based review of literature and the qualitative perspective of key informants from primary care practices around Maine. This research was examined within the context of the Triple Aim categories of *population health*, *experience of care*, and *per capita cost* (Institute for Healthcare Improvement, 2014). The goal is to provide primary care practices with the necessary background to make informed decisions about when and why these various blood pressure monitoring methods should be used in order to improve the patient experience and population health, and reduce healthcare costs.

Methods

Literature Review

A literature review was conducted to discover the benefits, drawbacks, barriers, and facilitators of the three primary blood pressure monitoring methods, both from a clinical and qualitative perspective. These methods were compared in terms of clinical outcomes, variability and number of readings, measurement error, white coat hypertension, diagnostic accuracy, cost, and patient experience. Numerous studies were reviewed to compare these aspects of the different methods of blood pressure monitoring. Additionally, a secondary review of hypertension diagnosis and management studies focused on the barriers and facilitators to the Triple Aim was initiated in order to support findings from the key informant interviews.

The evidence-based and peer-reviewed literature search was conducted using the following databases: CINAHL, Health Source: Nursing/Academic Edition, MEDLINE, Nursing and Allied Health Collection, and Google Scholar. The key words used in the searches were *hypertension*, *white coat hypertension*, *blood pressure measurement*, *hypertension management*, *ambulatory blood pressure measurement*, *office blood pressure measurement*, and *home blood pressure measurement*.

Key Informant Interviews

Key informant interviews were conducted with healthcare professionals from primary care practices in Maine. Inclusion criteria required that the participant have a significant amount of knowledge about the various blood pressure monitoring methods available, the protocols for diagnosing and managing hypertension within their practice, as well as a basic understanding of the Triple Aim framework; population health, experience of care, and per capita cost. The key informants were practice managers, medical directors, or clinical quality coordinators in primary care practices. All of the study participants had a great deal of expertise in the area of quality improvement and clinical processes, as well as any population health initiatives being implemented within their practice focusing on hypertension management.

Informed consent was obtained from all study participants. The recruitment letter, consent form, and interview questions were approved by the University of Southern Maine's Institutional Review Board before any portion of the key informant interviews were conducted. The data collected from each interview was analyzed and compared qualitatively to the other practices interviewed, and then cross analyzed with the current research available with respect to the Triple Aim. Five primary care practices were selected in advance and three practices agreed to participate in the interview process. (The general recruitment letter and interview questions are included in the Appendices).

Definitions

The following terms are defined to ensure consistency in data interpretation:

Hypertension is diagnosed when two or more readings are greater than or equal to 140/90 mmHg on two or more occasions taken by a health care provider in the office. When using 24-hour ambulatory blood pressure monitors, a hypertension diagnosis is made when the average

blood pressure is greater than 135/85 mmHg (U.S. Department of Health and Human Services, 2004).

White coat hypertension is a phenomenon in which patients present with a much higher blood pressure reading in the office as compared to the home and ambulatory blood pressure measurement methods. This is thought to be due to the anxiety that they experience when encountering a health care professional (Pickering, Gerin, & Schwartz, 2002). For example, an individual with white coat hypertension may have daytime blood pressure values less than 135/85 mmHg, but office values greater than or equal to 140/90 mmHg (Veglio, et al., 2001).

Office blood pressure measurement/monitoring (OBPM) is conducted in the clinic setting by an experienced health care professional. For the purposes of this particular study, manual equipment is used to record blood pressures in the medical office setting.

Home blood pressure measurement/monitoring (HBPM) is performed by the patient or assisted by another individual in the comfort of their home, usually on a daily basis. The equipment is automated and user-friendly.

24-hour ambulatory blood pressure measurement/monitoring (ABPM) is a method in which the patient is fitted with blood pressure equipment and wears it continuously for 24 hours. Readings are taken automatically throughout the day and night, generally every 15 minutes. The daytime readings are then averaged together to obtain an average blood pressure reading. This method requires an initial office visit and follow-up office visit in 24 hours (U.S. Department of Health and Human Services, 2004). Ambulatory blood pressure measurement is considered the “gold standard” in terms of accuracy of blood pressure measurement (Kaczorowski, Dawes, & Gelfer, 2012).

Results

Literature Finding

Clinical Outcomes

Ambulatory blood pressure monitoring is considered to have “demonstrated superiority over office blood pressure in terms of...relation to the impact on target organs and ability to predict cardiovascular events” (Gosse & Coulon, 2009, p. 234). Several researchers (Kaczorowski, Dawes, & Gelfer, 2012; Lovibond, et al., 2011; Rodriguez-Roca, et al., 2006; Vilaplana, 2006; Vollmer, et al., 2005) have also presented evidence that ambulatory blood pressure monitoring is more accurate at identifying target organ damage and predicting cardiovascular events than office blood pressure monitoring. Kaczorowski, Dawes, and Gelfer (2012) stated that the “combination of many accurate readings results in a better predictor of mortality and morbidity associated with hypertension” (p. 401). This prediction aspect of ABPM can improve the health of the hypertensive patient population by providing further data on the many morbidities associated with hypertension. ABPM has the ability to predict cardiovascular events because it records the percentage of elevated blood pressure readings, as well as the how much the blood pressure decreases during sleep. A patient is at significant risk for a cardiovascular event should the blood pressure not decrease during the sleep cycle (Vilaplana, 2006).

Improved clinical outcomes for hypertensive patients are also observed with regular home blood pressure monitoring if patients use a validated home blood pressure machine correctly. “Home monitoring also correlates better with target organ damage and cardiovascular mortality than office measurement, enables the prediction of sustained hypertension in patients with borderline hypertension and...can better assess drug efficacy” (Kaczorowski, Dawes, & Gelfer, 2012, p. 402). Vilaplana (2006) supports this conclusion and also adds that home blood pressure can be more reproducible than office values and may also provide information on a patient’s response to antihypertensive medications.

Unfortunately, the most commonly used form of blood pressure monitoring, OBPM, is not a predictor of cardiovascular events and cannot identify target organ damage. The evidence-based and peer-reviewed literature indicate that due to its inability to improve health outcomes compared to ABPM and HBPM, it is not a facilitator for the population health aspect of the Triple Aim.

Variability and Number of Readings

Both ambulatory and home blood pressure monitoring can capture multiple measurements and reduce the variability of the readings (Gosse & Coulon, 2009; Vollmer, et al., 2005). The added benefit of home blood pressure monitoring's ability to obtain multiple readings is that it "provides us with values from different days, in settings as close to daily life as possible" (Vilaplana, 2006, p. 212). This feature also makes home blood pressure monitoring superior to ambulatory blood pressure monitoring because ambulatory blood pressure monitoring is done over the course of 24 hours, where as home monitoring can occur multiple times a day and is also done daily over a long period of time. However, ambulatory blood pressure monitoring is still more effective than office blood pressure monitoring due to its ability to take multiple readings over 24 hours and is sometimes used as a supplemental diagnostic tool, especially due to variability concerns with the office measurement. OBPM generally consists of a single measurement at an office visit, nurse visit, or physical exam and can vary greatly from visit to visit.

Measurement Error

The main issues surrounding blood pressure measurement error are improper technique, inadequate training, and observer bias. Ambulatory and home blood pressure monitoring eliminate observer bias due to the automation of the equipment (Gosse & Coulon, 2009)

(Vollmer, et al., 2005). However, it is important to note that clinicians do need to be trained to properly apply ambulatory blood pressure monitoring equipment on the patient. There can be measurement error with home blood pressure monitoring, as well. Patients may not follow the proper techniques to obtain an accurate blood pressure reading or the equipment may not be validated, and can therefore become an unreliable source of blood pressure readings (Gosse & Coulon, 2009).

Office blood pressure monitoring is much more vulnerable to measurement error than the other two methods. Kaczorowski, Dawes, and Gelfer (2012) found that “there is growing evidence that because of poor measurement techniques that include the use of uncalibrated sphygmomanometers, inappropriate cuff size, zero-digit bias, patient clinician interaction during measurement, and failure to reduce patient anxiety, the blood pressure readings obtained in routine clinical practice are often imprecise and inconsistent (p. 400)”. These issues are also cited in online training program developed by MCD Public Health (2014). Gosse and Coulon (2009) found that office blood pressure readings often result in a false positive diagnosis of hypertension, especially when the measurement is near the cutoff point for normal blood pressure. Additionally, improper measurement techniques can lead to both over- and underestimation of blood pressure values (Kaczorowski, Dawes, & Gelfer, 2012). Measurement error is costly in terms of prescribing unnecessary antihypertensive medications and population health.

White Coat Hypertension

White coat hypertension occurs mainly in the office or clinical setting. It stems from the anxiety patients have when they are around health care professionals in white coats. “Frequently, the patient is [white coat hypertensive] and may demonstrate office hypertension; office blood

pressure is often higher than home and ambulatory blood pressure” (Veglio, et al., 2001, p. 208). Therefore, office blood pressure measurement and monitoring is subject to white coat hypertension (Gosse & Coulon, 2009). In the study performed by Rodriguez-Roca, et al., (2006) the researchers found that 20% of hypertensive patients that are diagnosed using office blood pressure readings are false-positives, mainly due to white coat hypertension. Oftentimes, patients are prescribed blood pressure lowering medications when they are, in fact, white coat hypertensive and do not need medication (Ogedegbe, et al., 2008). The treatment of white coat hypertension is very wasteful of limited healthcare resources, costly, and can result in negative side effects for the patient (Zawadzka, Bird, Casadei, & Conway, 1998).

Ambulatory blood pressure monitoring is considered to be superior in identifying white coat hypertension compared to home blood pressure monitoring and office blood pressure monitoring (Carney, Gillies, Garvey, & Smith, 2005). However, home blood pressure monitoring still has the ability to identify and evaluate white coat hypertension (Gosse & Coulon, 2009) (Vilaplana, 2006). In the study performed by Zawadzka, Bird, Casadei, and Conway (1998), they sampled 410 patients that had been diagnosed with hypertension, but were not on any antihypertensive medications and used ambulatory blood pressure monitoring to confirm the hypertension diagnosis. Out of 410 subjects, 124 of the participants actually had white coat hypertension, over 30% of the patient population had been incorrectly diagnosed with hypertension due to the inability of office blood pressure monitoring to identify white coat hypertension.

Diagnostic Accuracy

Ambulatory blood pressure monitoring is far more accurate in identifying hypertension compared to office and home blood pressure monitoring. “This means that fewer people who are not hypertensive will be incorrectly diagnosed as positive. This results in fewer people being

offered antihypertensive medications” (National Institute for Health and Clinical Excellence, 2011, p. 13). Due to its accuracy, it also identifies more true hypertensive patients than office blood pressure monitoring and can therefore aid in improving population health and the patient experience by ensuring that people will receive the treatment they need. ABPM has a high specificity and enhanced precision compared to the other two methods and has been noted in several studies to improve health outcomes and reduce the need of antihypertensive medications due to its accurate measurements (Lovibond, et al., 2011; Rodriguez-Roca, et al., 2006; Vollmer, et al., 2005). In the Lovibond, et al. (2011) study, part of their research indicated that ambulatory blood pressure monitoring improved health outcomes in male and female hypertensive patients over the age of 50 due to an increase in quality-adjusted life years (QALY) compared to office and home blood pressure monitoring. However, home blood pressure monitoring is still much more accurate in diagnosing hypertension compared to office blood pressure monitoring (Kaczorowski, Dawes, & Gelfer, 2012).

Cost

Diagnostic accuracy and identifying white coat hypertension are key contributors to cost. There are contradictory findings about which blood pressure monitoring methods cost more. Gosse and Coulon (2009) cited cost as a barrier to the availability of ambulatory blood pressure monitoring and found that many health insurances do not cover the use of ABPM. Vilaplana (2006) also stated that the cost of ABPM equipment is a barrier to accessibility. However, three cost-effective analysis studies found that ABPM is the most cost-effective strategy in the diagnosis and management of hypertension. The National Institute for Health and Clinical Excellence (NICE) (2011) found that although ambulatory blood pressure monitoring is more costly than home and office blood pressure monitoring initially due to the high cost of the device

and staff training, there are many cost savings through a decreased expenditure on antihypertensive medications and annual monitoring appointments with primary care physicians. NICE conducted a cost report to identify the savings incurred from using ABPM as a supplementary diagnostic tool. The following table shows the savings for the National Health Service in the United Kingdom:

Table 1: Cost savings with implementation of ABPM as a secondary diagnostic tool

Year	Change in Diagnosis Cost	Change in Treatment Cost	Net Resource Impact
1	\$8,550,000.00	-\$4,170,000.00	\$4,380,000.00
2	\$8,550,000.00	-\$9,679,000.00	-\$1,129,000.00
3	\$8,550,000.00	-\$15,188,000.00	-\$6,638,000.00
4	\$8,550,000.00	-\$20,696,000.00	-\$12,146,000.00
5	\$8,550,000.00	-\$26,206,000.00	-\$17,656,000.00

*Adapted from: (NICE, 2011, p. 17)

The values have been adapted from Euros to U.S. dollars. In the first year additional costs associated with the implementation of ABPM will incur, but years four and five show a significant savings from ABPM due to savings in medication costs and reduced office visits. The savings may vary based on the fundamental differences of our healthcare system compared to the United Kingdom, but savings are still expected with the increase in ABPM utilization.

The cost-effective analysis conducted by Kaczorowski, Dawes, and Gelfer (2012) revealed that ambulatory monitoring is a more cost effective strategy compared to home and office blood pressure monitoring. “The savings with ambulatory monitoring compared with monitoring in the clinic and home were primarily because of the costs of hypertensive treatment that were avoided because of the higher specificity of ambulatory monitoring” (Lovibond, et al., 2011, p. 1224). This study assessed cost effectiveness by calculating costs, QALY, and incremental costs per

QALY, and analyzed cost of antihypertensive treatment, cost of diagnosis, and the costs of the management of cardiovascular disease.

Their analysis revealed reduced treatment costs for men over 60 years of age when ambulatory or home blood pressure monitoring was implemented. Treatment costs for office blood pressure monitoring were calculated to be \$1306, home blood pressure monitoring cost \$1252, while ambulatory only cost \$1062 per patient (Lovibond, et al., 2011). Lastly, in the study performed by Rodriguez-Roca, et al. (2006), it was found that ABPM fostered a reduction in direct costs associated with hypertension compared to OBPM and the initial and additional costs of ABPM would be paid off after the first year of implementation.

Home blood pressure monitoring is also considered to be a less expensive option for hypertension management compared to office blood pressure monitoring. Home blood pressure monitoring leads to a reduction in office visits and a “29% mean adjusted cost reduction when compared to usual care” (Carney, Gillies, Garvey, & Smith, 2005, p. 154). However, the use of home blood pressure equipment requires clinicians to train patients how to properly use the machine and this can be very time consuming and costly to a health care organization (Gosse & Coulon, 2009). A research study comparing office blood pressure and home-blood pressure monitoring found that those using home-blood pressure monitors used less medication and this resulted in difference of \$1000 per month between the two groups (Verberk, et al., 2007). Other sources have cited the cost-effectiveness of home blood pressure monitoring compared to office blood pressure monitoring because of fewer office visits and a decrease in antihypertensive medications, but none of the studies identified HBPM as being more cost effective than ABPM (Lovibond, et al., 2011; Vilaplana, 2006).

Office blood pressure monitoring is considered the most costly method of managing hypertension for several reasons; higher treatment costs, increased prescription of antihypertensive medications, and more office visits (Lovibond, et al., 2011). Additionally, “obtaining high quality office-based measurements requires extensive staff training and ongoing quality control monitoring” (Vollmer, et al., 2005, p. 81). Many health care organizations are implementing training programs for their staff to ensure that their clinicians know how to take a proper blood pressure measurement. The cost of developing these training programs is high, but it is also necessary and all blood pressure measurement methods require training of some sort.

Patient Experience

One of the most beneficial aspects of ambulatory and home blood pressure monitoring is that the individual is able to be in their own environment when the blood pressure readings are taken, which is a far more comfortable atmosphere for the patient and produces more accurate results compared to office blood pressure monitoring (Gosse & Coulon, 2009; Rodriguez-Roca, et al., 2006). However, a study conducted by Vollmer, et al. (2005) included a survey for patients to assess whether the ambulatory blood pressure monitoring equipment interfered with their activities of daily living (ADLs) and found that 45% of the patients surveyed felt that wearing the monitor somewhat interfered with their ADLs and 5-10% of patients felt that wearing the monitor interfered with their ADLs significantly. Another study revealed that many patients disliked the ambulatory blood pressure equipment because the inflation of the cuff was relatively uncomfortable (Rodriguez-Roca, et al., 2006). The interference and discomfort of the ABPM equipment seems to be a barrier to improving the patient experience.

The findings regarding home blood pressure monitoring indicated that patients adhered to their treatment regimen and were more participative in managing their hypertension (Carney,

Gillies, Garvey, & Smith, 2005; Vilaplana, 2006). However, there is a concern that patients will not document their measurements correctly or may change their medications before checking with their physician (Vilaplana, 2006).

Key Informant Interview Findings

Study participants were recruited from primary care practices around Maine. Three key informants chose to participate in the interview process and met the inclusion criteria for the capstone research. The aim of the key informant interviews was to identify barriers and facilitators to each of the components of the Triple Aim, provide information about their most commonly used blood pressure monitoring method, and identify any current or future protocols in the diagnosis and management of hypertension within their practice.

Interviewees One and Two revealed that their electronic health records are not designed to provide patient population health data such as the percentage of hypertensive patients within a practice. However, the second interviewee was able to provide an estimate of 27% of their patient population having a diagnosis of hypertension, well in line with the national percentages. The third interviewee was also able to provide an approximation of 28% of the patient population having a diagnosis of hypertension within their organization, and did not note any limitations of their electronic health records to capture population health data. All key informant interviewees stated that all hypertension diagnoses are made with manual blood pressure equipment and diagnoses are determined using the 8th Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure and that manual office blood pressure method was the only method acceptable by the Joint National Committee for the diagnosis of hypertension. Interviewee One and Two do not currently have a protocol in place for the management of hypertension, but Interviewee Three indicated that there is a standard

clinical training protocol in place within their organization, although some staff have yet to receive the training. Interviewee One stated that there are pilot studies in place to design a protocol and Interviewee Two stated that it is up to the primary care physicians to design a management plan, and generally, when there is a medication change, the provider will request that the patient comes back in one to two weeks and then monthly until the patient is well-controlled. Again, all organizations encourage and recommend home blood pressure monitoring for hypertension management, but cite that there are barriers to this method such as cost to the patient, errors associated with patient application and positioning of the cuff, willingness of the patient to become engaged in this method, and that the blood pressure equipment may not be validated.

Organization One differed from Organization Two and Three in that they use the ABPM for patients that are suspected of having white coat hypertension, or are on multiple antihypertensive medications but are still not controlled. Organization Two does not have any ambulatory blood pressure monitoring equipment available to them at this time and Organization Three will consult with a cardiologist and possibly refer a patient to have the ABPM conducted.

Organizations One and Three stated that the barriers to office blood pressure monitoring are the availability of exam rooms and the cost to the patient; blood pressure checks require a copayment for the insured or the entire cost of a nurse visit for those that are uninsured. Barriers to ambulatory blood pressure monitoring are synonymous to the findings from the literature review; insurance may not cover the cost of ABPM and the machine and cuff interfere with a patient's normal routine and is difficult to wear for 24 hours. Organization Two cited transportation issues as a major barrier to OBPM, but the cost to the patient is a facilitator because there is no charge for blood pressure checks and they offer prescription assistance to

those who cannot afford medication. A barrier to HBPM is the cost of the equipment; they have found that many people cannot afford a validated HBPM machine.

Interviewee Three offered a comprehensive list of barriers that included the fact that electronic health records cannot currently integrate home blood pressure monitoring values into a patient's chart, the amount of time and skill of the staff to calibrate home blood pressure monitors, and the cost differential between the three methods which encompass training, staff preferences, and the cost of calibration and maintenance of the blood pressure equipment within the practice. All interviewees noted that the continued use of office blood pressure monitoring compared to other methods is due to the provider's viewpoint that they have always used office measurements to diagnose and manage hypertension and do not see a reason to change or integrate another method.

The matrices on the following pages help to summarize the information gathered from the research. Matrix one covers advantages and disadvantages of each method from a clinical perspective and matrix two summarizes key barriers and facilitators to each method of blood pressure measurement in terms of cost, patient experience, and population health.

Matrix One: A clinical perspective of advantages and disadvantages of ABPM, HBPM, and OBPM.

	ABPM	HBPM	OBPM
Clinical Outcomes	Predicts cardiovascular (CV) events, identifies target organ damage, better predictor of mortality and morbidity associated with hypertension	Improves clinical outcomes as well as ABPM, enables prediction of sustained hypertension, and can predict CV events and identify target organ damage	Does not really predict CV events and cannot identify target organ damage
Multiple Measurements/ Variability	Multiple measurements can be taken, variability of readings can be reduced, only provides values for 24 hours, used as a supplemental diagnostic tool when there are variability concerns with OBPM	Multiple measurements can be taken, variability of readings can be reduced, provides values from different days over a long period of time	Normally consists of one measurement at an office visit and can vary greatly from visit to visit
Measurement Error	Eliminate observer bias, requires staff training	Eliminate observer bias, requires patient training, patients may not follow proper techniques, equipment may not be validated	Subject to observer bias, requires extensive staff training and quality control monitoring. Poor measurement techniques: uncalibrated equipment, wrong cuff size, talking during measurement, zero-digit bias, failure to reduce patient anxiety. Leads to over and underestimation of blood pressure values
White Coat Hypertension	Eliminates white coat hypertension and identifies white coat hypertension better than HBPM and OBPM	Eliminates white coat hypertension	20-30% of patients diagnosed with hypertension by OBPM are white coat hypertensive
Diagnostic Accuracy	Most accurate in identifying hypertension. High specificity and enhanced precision, reduces need of antihypertensive medications	2nd most accurate in identifying hypertension, reduces need of antihypertensive medications	Least accurate due to improper technique and observer bias

Matrix Two: Barriers and facilitators to ABPM, HBPM, and OBPM in the context of the Triple Aim.

	ABPM	HBPM	OBPM
Cost	Contradictory evidence. Initial expense of equipment to practice-Barrier (B). Insurance may not cover cost (B). Results in lack of availability to patient and provider (B). Considered most cost-effective strategy due to reducing need for medications and reduction in office visits- Facilitator (F). Reduced treatment costs.	Costly for some patients (B). However, there is a 29% mean adjusted cost reduction when compared to usual care (F).	Most costly to patients due to higher treatment costs, increased prescribing of antihypertensive medications, and more office visits (B). Can be costly to practices because of quality control monitoring and extensive staff training (B). Can be less costly when there is no charge for a blood pressure check (F).
Patient Experience	Patient is in a familiar, comfortable environment (F). Accurate results lead to correct hypertension diagnosis and proper medication, if necessary (F). Interferes with daily routine (B). Uncomfortable to wear (B). Limited availability to patients (B).	Patient is in a familiar, comfortable environment (F). Accurate results lead to correct hypertension diagnosis and proper medication, if necessary (F). Increased adherence to treatment regimen (F). Increased participation in management of hypertension (F). Patients may not have validated equipment (B). Patients may change medication dosage before checking with their physician (B). Patients may incorrectly place blood pressure cuff (B). Patients may not want to engage in HBPM (B).	Patients can find it difficult to find transportation to appointments (B). Inaccurate measurements lead to over or underestimating blood pressure- patients may be over or under treated (B). Widely available to all patients and providers (F). Most common way of diagnosing hypertension (F).
Population Health	Prediction of CV events can improve pop. health. Accuracy of equipment will ensure patients receive the correct treatment (F). Inability of EHR's to quickly identify percentage of patient population that is hypertensive (B).	Prediction of CV events can improve pop. health. Accuracy of equipment will ensure patients receive the correct treatment (F). Inability of EHR's to quickly identify percentage of patient population that is hypertensive (B).	Inability to predict CV events (B). Inaccurate readings are common and lead to over or under medicating (B). Fastest, most convenient way to identify normotensive patients (F).

Limitations

Limitations of this research study can be partly attributed to recruiting challenges regarding the key informant interviews. It is possible that organizations did not participate due to transitions caused by the major reform of health systems. Many primary care practices are working on accreditations and certifications to remain on par with other organizations. Many upper-level staff are occupied with ensuring the appropriate requirements are fulfilled; this leaves little time to focus on outside requests for interviews. Another issue pertaining to the interviews was the small number of primary care practices that were selected to participate; this author made an assumption that all recruited organizations would agree to an interview. Additionally, due to the stipulations provided through the Institutional Review Board, potential subject organizations had to be selected in advance. For future research, the selection of possible practices should be much larger, allowing for negative responses while still managing to gather sufficient and reliable qualitative data.

Additional limitations include the difficulty of evaluating qualitative data, as well as the lack of sources comparing all three methods of blood pressure monitoring. Many of the studies compared ambulatory or home blood pressure monitoring to office blood pressure monitoring, making it difficult to accurately assess some aspects of the literature findings.

Discussion

The results of the literature indicate that ambulatory blood pressure monitoring is the most accurate blood pressure method due to its specificity and ability to eliminate both observer bias and the white coat effect. Home blood pressure monitoring is also an accurate method, but can be inaccurate if the patient puts on the cuff incorrectly or does not have validated equipment. Many studies indicated that both home and ambulatory blood pressure monitoring reduce health care

costs associated with hypertension because fewer visits are needed and a reduction in antihypertensive medications occurs. However, office blood pressure monitoring still remains the single method in diagnosing and managing hypertension, partly due to the longstanding tradition of office blood pressure measurement, even though it can be highly inconsistent and inaccurate. In 2011, NICE made a recommendation that “if the clinic blood pressure is 140/90 mmHg or higher, offer ambulatory blood pressure monitoring to confirm the diagnosis of hypertension” (NICE, 2011, p.12). Essentially, all individuals that are diagnosed with hypertension should undergo a secondary analysis using ABPM. Another study advised that patients under the age of 50, with low cardiovascular risk, that have office blood pressure readings in the high normal and low hypertensive range be reevaluated by a supplemental blood pressure measurement method of either ABPM or HBPM (Krakoff, Pickering, & Phillips, 2002).

One of the main barriers to both ambulatory and home blood pressure monitoring for practices in Maine is the cost of the equipment. Patients may not be able to afford a home blood pressure machine or their insurance may not cover the use of ABPM. Practices also find that the cost of the equipment and the necessary staff training will be too high to receive any return on investment. Contradictory to this perception, the literature reviewed in the previous section suggests that ABPM is the most cost effective method of diagnosing and managing hypertension.

Another benefit of both home and ambulatory blood pressure monitoring is the ability to predict cardiovascular events and identify target organ damage, whereas OBPM does not have that capability. This fact alone makes ABPM and HBPM superior to OBPM and is a facilitator to improving population health.

In the context of the Triple Aim, it is time that primary care practices should consider the accuracy of 24-hour ambulatory and home blood pressure monitoring when diagnosing patients

with hypertension. It is also important that these practices address the barriers as to why there is limited use of the “gold standard” of blood pressure monitoring methods. Although the ABPM cuff may be uncomfortable for patients and interfere with their normal routine, the fact that it can improve health outcomes for hypertensive patients makes it a viable blood pressure method that should be part of the diagnostic pathway for hypertension.

This author suggests that primary care practices develop and initiate pilot projects that utilize either ABPM or HBPM as a supplemental diagnostic tool. Also recommended for improved management of hypertension is the inclusion of home blood pressure monitoring as part of the hypertensive patient care management plan. As primary care practices begin to implement different methods of obtaining accurate blood pressure readings, and address the barriers and facilitators to these methods within their practice, it is predicted these changes will result in a reduction in overall costs to patients, an increase in population health, and improve the patient experience.

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Appendix A

Recruitment letter for primary care practices to participate in key informant interviews:

Dear _____,

My name is Elizabeth Andrews and I am in my final semester of the Master of Public Health Program at the University of Southern Maine's Muskie School of Public Service. In order to receive my degree, I must complete a final project called a capstone. I have chosen to do my capstone on blood pressure monitoring of hypertensive patients in primary care. Focusing on the barriers and facilitators to ambulatory, office, and home blood pressure monitoring in the context of the Triple Aim; population health, the patient experience, and per capita cost. This is a very interesting topic to me due to the increasing number of people diagnosed with hypertension, the high costs surrounding the management of this disease, and the true accuracy of each method of blood pressure measurement/monitoring.

In order to gain a more informed qualitative perspective on the benefits and drawbacks of each blood pressure monitoring method, I wish to conduct a small interview with you to learn how your practice uses the different blood pressure monitoring methods to diagnose and manage hypertension.

The interview should not take more than 15 minutes of your time and if you decide to participate, you can e-mail your responses to me, agree to a phone interview that fits best with your schedule, or send your responses by mail (if you choose this method, I will mail a copy of the questions along with a self-addressed, stamped envelope.)

I have attached the interview questions and consent form to this e-mail to give you an opportunity to review the consent form and questions and decide whether you wish to participate in this research project or not. Your name and the name of your organization will not be reported in the research, nor will any possibly identifiable information be included in the final project.

Thank you for your time. I would greatly appreciate your involvement in my final project at Muskie and hope to hear from you soon!

Sincerely,
Elizabeth Andrews
Phone: 207-329-8653
E-mail: elizabeth.r.andrews@maine.edu

Appendix B

Interview questions for participating primary care practices:

Interview Questions

Blood pressure monitoring of hypertensive patients in primary care: barriers and facilitators to ambulatory, office, and home blood pressure monitoring in the context of the Triple Aim

By: Elizabeth Andrews

1. Can you provide an estimate as to the percentage of your organization's patient population that has a diagnosis of hypertension?
2. Does your organization have any standard protocol in place for diagnosing hypertension regarding blood pressure measurement? If yes, please describe.
3. Does your organization have a protocol for the continued management of hypertensive patients? (i.e. antihypertensive medication, regular office blood pressure checks, home-monitoring) If yes, please describe.
4. Please rate the following blood pressure measurement methods on a scale of most commonly to least commonly used in your practice for the diagnosis and management of hypertension:
 - a. Clinic blood pressure monitoring
 - b. Home blood pressure monitoring
 - c. 24-hour ambulatory blood pressure monitoring
5. Does your practice recommend home blood pressure monitoring to all of your hypertensive patients? If so, do you find that the patients who participate in their care are more controlled and involved in the management of their hypertension?
6. Does your practice ever prescribe 24-hour ambulatory blood pressure monitoring in order to diagnose or monitor hypertensive patients? If so, why would a patient be asked to participate in ambulatory blood pressure monitoring?
7. Please identify any barriers to clinic, home and ambulatory blood pressure monitoring methods in terms of accessibility, cost, and the patient experience.
8. Can you list some benefits to each of the aforementioned methods in terms of accessibility, cost, and the patient experience?
9. Can you explain why the selected blood pressure monitoring method from Question 4 is the most commonly used in your practice for the diagnosis and management of hypertension?