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Appropriate Blood Pressure Measurement for Initial Diagnosis of Hypertension: A Best Practice Implementation Project

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Abstract

Background: The worldwide prevalence of hypertension people aged 25 and above is more than 40%. Data accuracy for blood pressure is important to diagnosis and treatment. In self-complaints among patients in cardiology outpatient clinic, the incidence of incorrect blood pressure measuring was 11.9%.

Aims: Enhanced accuracy for blood pressure measurement in the outpatient setting.

Method: Clinical audits were conducted using the JBI Practical Application of Clinical Evidence System (JBI PACES). With the 7 audit criteria recommended by best practice, improvement and audits were performed for 22 weeks for evaluation of improved quality for blood pressure measurement.

Result: Standard documentation complying with recommended clinical guidance was established, with the organized educational training program and environmental renovation, the project's performance in improvement was significantly enhanced, compliance with clinical practice guidelines before implementation of 35%-90% increased achieving 70%-100% after implementation. Noise in the outpatient setting of 62 dB decreased to 52 dB, with daily incidence of 11.9% for complaint in incorrect blood pressure measuring decreased to 1.1%.

Conclusion: Evidence-based practice project successfully enhanced the accuracy for blood pressure measurement in outpatients.

Recommendation: The empirical application of quality improvement in blood pressure measurement accuracy achieves progressive results. The important factors are the completion of environmental transformation, the establishment of standard documents, the education of patients and health care volunteers, and the maintenance of the effect through continuous review.

Keywords: audit, best practice, blood pressure determination, implementation, outpatients

1. Introduction

The worldwide prevalence of hypertension people aged 25 and above ismore than 40% (Leung et al., 2017), hypertension is a risk factor for ischemic and hemorrhagic stroke, coronary artery disease, and chronic renal disease (Gabb, Mangoni, & Arnolda, 2017; Leung et al., 2017; National Heart Foundation of Australia, 2016). In Taiwan, hypertension was ranked as the 4th position among the 10 leading causes of death in 2018, chronic diseases associated with hypertension accounted for one third of the total deaths. Among the population aged 15 and above, there were nearly 4 million cases suffering from hypertension with the incidence of 21.4%, and 35.0% for people aged 40, 56.6% for aged 65 and above. Regular blood pressure (BP) measurement has been recognized as very important by 76.9% of people, nevertheless, there are 58.7% of people not or seldom performing BP measurement (Ministry of Health and Welfare, 2020). An accurate BP reading is a crucial element for diagnosis and treatment.

There are 19 consultation rooms for cardiology outpatient clinic in a medical center, a total of about 94 outpatient clinic sessions have been conducted a week, with averagely 706 patients a day. The cardiology outpatient clinic is equipped with 22 nurses in total. In waiting area of the cardiology outpatient clinic, 4 BP monitors are provided, all patients are required to perform BP measurement before presenting to the clinic, healthcare volunteers may assist the waiting patients in measuring BP. The BP readings from BP monitors will be automatically uploaded to patient's electronic medical records for physician's immediate access of the data at consultation. Consultation practice in the hospital include: A reservation form for revisit treatment is issued by the physician based on changes of the illness, with revisit period of several days or several weeks for patients first diagnosed as hypertension. Nurses at outpatient clinic provide patients with nursing guidance leaflet and BP record sheet, offering health education guidance or instructing patients to nursing counselling and service station to receive further health education, providing instructions on continuous BP measurement after returning home. Moreover, patients are asked to bring back the BP record sheet at each revisit for physician's reference.

2. Aim

This project aims to facilitate patient's compliance with utilization of standard procedure through the approach of best evidence in implementation of BP measurement. The specific aims were:

(1) Patients understand the environment and postures required for BP measurement.

(2) Confirmation of completing the BP calibration method recommended by the manufacturer.

(3) Patients understand the timing for remeasuring.

(4) Patients received the education for hypertension management. Patients with hypertension are placed on a management plan with scheduled follow-up.

(5) Patients understand to provide BP data when presenting to the clinic.

(6) Healthcare volunteers assisting measurement completed training course for BP measurement and nurses at cardiology outpatient clinic completed training program for BP measurement.

3. Methods

This study was approved by the Human Experiment Committee, IRB No: 2020-02-017AC .The project used the JBI PACES software and Getting Research into Practice (GRiP) (Joanna Briggs Institute, 2020) audit/feedback tool. To identify gaps and barriers. The project was performed by three Phases:

Phase 1: Project team establishment and baseline audit

Activities in Phase 1 include establishment of team by item, setting confirmation, evaluation for sample size, method of patient's measurement and performing baseline audit. JBI PACES program was used by the team in selection of audit criteria and GRiP modules for identification of obstacles and developing improvement plan.

Team establishment:

The project team consisted of 12 members, including 1 attending cardiologist responsible for guidance and supervision, 1 chief nursing supervisor for project management, 1 outpatient clinic nursing manager for implementation management and organizing educational training, 6 outpatient clinic nurses for performing audit and data collection, 1 team member of equipment service team from engineering affairs office for supervision of service and maintenance for BP monitors, 1 senior social worker for planning of healthcare volunteers' on-the-job education, and 1 team leader from healthcare volunteers team for assistance in conducting on-the-job education. For enhanced immediateness and convenience of communication, the project team created a LINE group for required communication.

Setting and sample size

The enrolled sample size included 60 patients from cardiology outpatient clinic in a medical center, 60 healthcare volunteers, with records of service and calibration for 4 BP monitors.

Audit criteria

Table 1 shows audit criteria used for the assessment of compliance to best practice standards, from JBI PACES, 7 items of audit criteria were identified and audit tools were developed by the project team.

Table 1. Audit criteria

Audit criteria	Sample	Method used to measure % compliance with best practice
1.A third measure of BP is taken if the second measure is substantially different from the first.	60 patients.	Patient's knowledge with questionnaire survey: For he/she had correct answer, "correct". For he/she had wrong answer, "incorrect". Objective: 100% standard compliance.
2.BP measurement is performed in a standardized environment with the patient quiet and seated with arm outstretched and supported.	60 patients.	1.Patient's knowledge with questionnaire survey: For he/she had correct answer, "correct". For he/she had wrong answer, "incorrect". 2.Test using sound level meter: Lower than 55 dB of noise level, "correct". Objective: 100% standard compliance.
3. Devices for measuring BP are calibrated and maintained according to manufacturer's instructions and by a trained technician.	Calibration records of 4 BP monitors.	Examination of accuracy for service records: Calibration and maintenance were performed by technical personnel within 6 months, "correct". Calibration and maintenance were performed by non-technical personnel within 6 months, "incorrect". Objective: 100% standard compliance.
4.For patients with high blood pressure (> 140/90 mmHg) a second measure is taken in a relaxed temperate setting with the patient quiet and seated with arm outstretched and supported.	60 patients.	Patient's knowledge with questionnaire survey: For he/she had correct answer, "correct". For he/she had wrong answer, "incorrect". Objective: 100% standard compliance.
5.Healthcare volunteers taking BP have received training regarding BP measurement.	60 healthcare volunteers.	1.Presence for completion of healthcare volunteers' educational training with questionnaire survey: For he/she had correct answer, "correct". For he/she had wrong answer, "incorrect". 2.Objective: 100% standard compliance.
6.Patients with hypertension are placed on a management plan with scheduled follow-up.	60 patients.	Patient's knowledge with questionnaire survey: For he/she had correct answer, "correct". For he/she had wrong answer, "incorrect". Objective: 100% standard compliance.
7.The patient's BP has been taken when presenting to the clinic.	60 patients.	Patient's knowledge with questionnaire survey: For he/she had correct answer, "correct". For he/she had wrong answer, "incorrect". Objective: 100% standard compliance.

Baseline audit

All members of the project team participated in data collection for baseline audit, performing questionnaire survey. Started from December 27, 2019, the pre-implementation audit was performed for a period of one week. A consistent training on questionnaire survey was first conducted for the 6 nurses in the project team. After

completion of the training, the baseline questionnaire survey for 60 patients and 60 healthcare volunteers was regularly performed between 10:00 and 11:00 am on every Monday to Saturday. Moreover, for calibration and maintenance records of the 4 BP monitors, confirmation was performed to see if that were implemented by professional technical personnel within 6 months. In the same period, one member from the project team who working at ENT outpatient clinic was responsible for measuring ambient noise level at a distance of 1 meter from BP monitor using the calibrated sound level meter between 10:00 and 11:00 am on every Monday to Friday.

Phase 2: Strategies for Getting Research into Practice

The survey included 310 patients presenting to cardiology outpatient clinic indicated complaint on incorrect BP measuring results from 37 patients, the daily average incidence of complaints was 11.9%. Furthermore, no any educational training on BP measurement had been provided for nursing personnel by cardiology outpatient clinic. Posters for the method of correct BP measurement were currently available in outpatient BP measurement areas, but there had been no any instructions for a standard measuring method. In the BP record sheet provided for patients, the font-size was too small, without any instruction of correct BP measurement. There had been about 107 healthcare volunteers delivering their services at outpatient clinics in the hospital, among them, there were 42% perceived that they had knowledge regarding correct BP measurement but there had been no any educational training course on BP measurement arranged for healthcare volunteers by the social work department. Moreover, based on the standard issued by the Environmental Protection Administration, the hospital was categorized as a controlled sound level area (Leung et al., 2017) with the noise level no more than 55 dB(Environment Protection Administration,2020) between 7:00 am and 8:00 pm. During the period from 10:00 to 11:00 am when there was plenty of patients visiting, noise levels in BP measuring areas of each floor were tested by the professional personnel from the occupational safety department using sound level meter, the range indicated 52 to 62 dB of a moderate noise level. BP monitors are secondary instruments, manufacturers are required by the hospital to assign professional engineers in the hospital for scheduled calibration and maintenance every 6 months for ensuring the accuracy of BP monitors. First, during the morning meeting for outpatient clinic nurses, educational information on correct BP measurement was provided to 22 nurses, and results of baseline audit were reported. Based on the results, discussions were conducted between the project team and outpatient clinic nurses to identify barrier factors. With comprehensive discussions, major causes of incorrect BP measurement among outpatients were identified as follows:

●BP measurement was not performed in a standardized setting.

●Patients lacked of knowledge for correct BP measurement.

●Healthcare volunteers lacked of educational training on correct BP measurement.

The following questions were proposed by team members: (1) Why was standard documents for correct BP measurement unavailable? (2) Why no any educational training courses had been organized for nurses? (3) Why did healthcare volunteers lack of educational training? For evaluation of these questions, the team implemented “proper BP measures, used in initial diagnosis of hypertension” recommended by JBI, as shown in audit criteria of Table 1.

Barriers identified by the project team included: (1) Appropriate publication for standard measurement procedure was not provided in BP measuring areas. (2) Lacking of educational information resulted in patient’s lacking of proper knowledge on BP measurement. (3) Lacking of standardized measurement settings. (4) Healthcare volunteers were required to receive educational training. Team members actively discussed on how to provide patients with proper knowledge on correct BP measurement, how to reduce the environmental noise, and the measures to organize training courses for healthcare volunteers. By use of Lewin's Change Theory, a best practice implementation project for 22 weeks was conducted from January 18, 2019 to June 20, 2020.

Strategy of facilitating compliance with new approach

Used GRiP for determination of barriers, the changes were initiated by using Change Theory, including: (1) Unfreezing phase: Assign the manager for outpatient clinic nursing and team leader for inter-department communication by identifying a key person in the sector with working enthusiasm, establishing a team, organizing educational training on correct BP measurement for nursing personnel. The key person performed propaganda in inter-department morning meetings, explaining the implementation plan. (2) Changing phase: Correct method for BP measurement was published at conspicuous locations in BP measuring areas, which incorporated a QR code for patients’ self-learning of the content. When patients presenting to the clinic, nurses provided patients with BP record sheet, actively offering educational information on correct BP measurement,

facilitating health education; arranged healthcare volunteers to receive education on information about correct BP measurement provided by nursing personnel, completing training courses. (3) Refreezing phase: Confirmation of the completed changes was performed by continuously organizing reviews and audits, result audits included the proper awareness from patients and healthcare volunteers, as well as measuring the ambient noise levels.

Phase 3: Follow-up audit

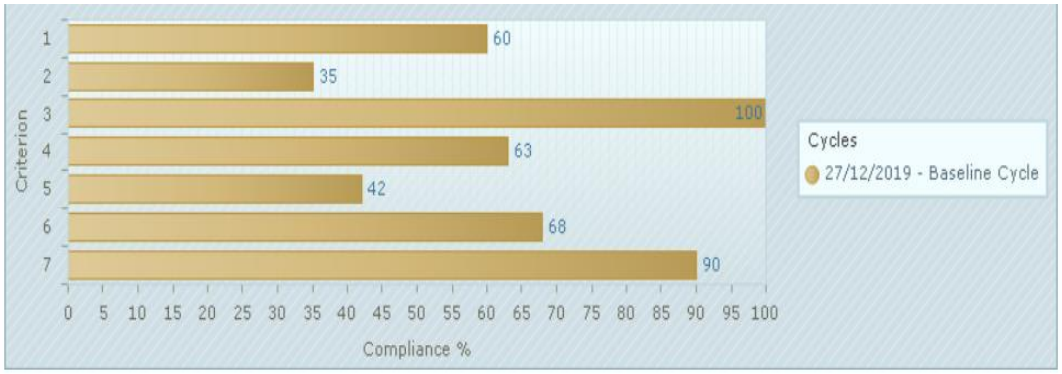
Compliance with evidence-based audit criteria

After the strategies implemented, the follow-up audit was performed within 2 weeks by the project team using the same methodology as the pre-implementation audit, for 60 patients, 60 healthcare volunteers and in BP measuring areas. Noise measurement audits were conducted for confirmation of effectiveness after implementation.

4. Result

Phase 1: Baseline audit

After the baseline audit completed, a figure for result of baseline audit was created by inputting the data in the JBI PACES (Figure 1). There was only 35% of achievement ratio for criterion 2, 100% will be acquired when setting, posture and appropriately supported arm are all completely correct. There was only 42% of achievement ratio for criterion 5, as healthcare volunteers have not received educational courses on BP measurement. There were only 60% to 68% of achievement ratio for criteria 1, 4, and 6, as patients did not receive instructions on comprehensive standard procedure for BP measurement. The achievement ratio for criterion 7 was 90% because BP data may be automatically uploaded to patient's electronic medical records but there still were 10% of patients who did not know they were required to take BP in BP measuring areas. The achievement ratio for criterion 3 was 100%, as BP monitors were confirmed to perform scheduled repair and maintenance by professional engineers, thus it will be unnecessary for subsequent improvement.



Criteria Legend

1. A third measure of blood pressure is taken if the second measure is substantially different from the first (60 of 60 samples taken)
2. Blood pressure measurement is performed in a standardised environment with the patient quiet and seated with arm outstretched and supported (60 of 60 samples taken)
3. Devices for measuring blood pressure are calibrated and maintained according to manufacturer's instructions and by a trained technician (4 of 4 samples taken)
4. For patients with high blood pressure (>140/90mmHg) a second measure is taken in a relaxed temperate setting with the patient quiet and seated with arm outstretched and supported (60 of 60 samples taken)
5. Health care workers taking blood pressure have received training regarding blood pressure measurement (60 of 60 samples taken)
6. Patients with hypertension are placed on a management plan with scheduled follow up (60 of 60 samples taken)
7. The patient's blood pressure has been taken when presenting to the clinic (60 of 60 samples taken)

Figure 1. Baseline audit compliance rates (%)

Phase 2: Strategies for Getting Research into Practice

Providing all patients and healthcare volunteers with documents and posters related to BP measurement standard was the most feasible strategy, which complied with the best practice for enhancement of accuracy in BP measurement; establishing the waiting lines for measuring BP; increasing the space and distance between BP

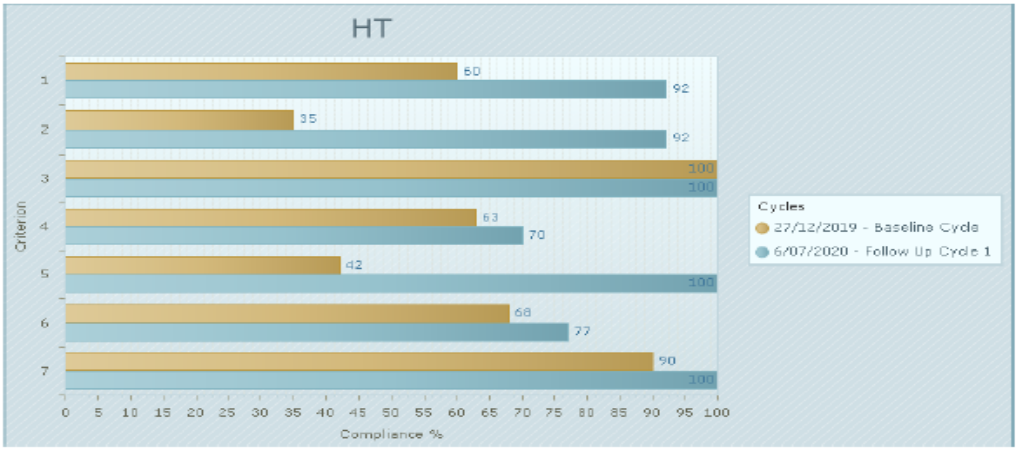
monitors to achieve a standardized quiet setting. The barriers and corresponding strategies are shown in Table 2.

Table 2. Barriers and corresponding strategies

Barriers	Strategies	Resources	Outcomes
Patients lacked of knowledge about correct BP measurement.	1.Patients initially diagnosed as with high BP were provided with health education guidance by nurses at consultation rooms, along with BP record sheet, and health education leaflets. 2.Knowledge about correct BP measurement was published in BP measuring areas. 3.QR-code self-learning materials were provided.	1. JBI Guide. 2. Nursing guidance from nursing personnel at consultation rooms, health education services from nursing counselling service station. 3.Health education leaflet on correct method for BP measurement. 4.Posters indicating correct method for measuring BP were posted in BP measuring areas. 4.Audit sheet. 5.Participation of the team leader for quality control team.	1.All patients presenting to cardiology outpatient clinic understood the knowledge about correct BP measurement. 2. 60 cardiology patients passed the audit.
The ambient noise in BP measuring areas.	Reduced ambient noise: 1.Increased space and distance between BP measuring seats. 2. Well-designed waiting lines with reduced interference from the crowd. 3.Posters indicating correct method for measuring BP were posted in BP measuring areas, enhancing patients' awareness in prevention of environmental interference. 4. Ambient sound levels were audited every month.	1. JBI Guide. 2. Posters indicating correct method for measuring BP were posted in BP measuring areas. 3.Audit sheet. 4.Participation of the team leader for quality control team.	The ambient noise level in BP measuring areas were less than 55 dB.
Healthcare volunteers lacked of educational training.	Training program included: 1. Organizing on-the-job education. 2.Providing instructions on knowledge about correct BP measurement.	1.JJBI Guide. 2.Audit sheet. 3.Participation of the team leader for quality control team.	1.All healthcare volunteers working at outpatient clinics have participated in the training course. 2. Based on questionnaire survey, 60 healthcare volunteers working at outpatient clinics understood the knowledge about correct BP measurement.

Phase 3: Follow-up audit

Results of audit after the 22-weeks implementation is shown as Figure 2. The criterion 1 "A third measure of BP is taken if the second measure is substantially different from the first", the compliance ratio increased from 60% to 92%. The criterion 2 "BP measurement is performed in a standardized environment with the patient quiet and seated with arm outstretched and supported" increased from 35% to 92%. The criterion 3 "Devices for measuring BP are calibrated and maintained according to manufacturer's instructions and by a trained technician" were 100% both before and after implementation. The criterion 4 "For patients with high blood pressure (> 140/90 mmHg) a second measure is taken in a relaxed temperate setting with the patient quiet and seated with arm outstretched and supported", increased from 63% to 70%. The criterion 5 "Healthcare volunteers taking BP have received training regarding BP measurement" increased from 42% to 100%. The criterion 6 "Patients with hypertension are placed on a management plan with scheduled follow-up" increased from 60% to 70%. The criterion 7 "The patient's BP has been taken when presenting to the clinic" increased from 90% to 100%, with noise levels decreased from 62 dB to 52 dB. The survey included 732 patients presenting to cardiology outpatient clinic indicated complaint on incorrect BP measuring results from 8 patients, the daily average incidence of complaints was 1.1%. Compared with the 11.9% before the project implemented, a decrease of 10.8% was found (Figure 4).



Criteria Legend

1	A third measure of blood pressure is taken if the second measure is substantially different from the first (60 of 60 samples taken)
2	Blood pressure measurement is performed in a standardised environment with the patient quiet and seated with arm outstretched and supported (60 of 60 samples taken)
3	Devices for measuring blood pressure are calibrated and maintained according to manufacturer's instructions and by a trained technician (4 of 4 samples taken)
4	For patients with high blood pressure (>140/90mmHg) a second measure is taken in a relaxed temperate setting with the patient quiet and seated with arm outstretched and supported (60 of 60 samples taken)
5	Health care workers taking blood pressure have received training regarding blood pressure measurement (60 of 60 samples taken)
6	Patients with hypertension are placed on a management plan with scheduled follow up (60 of 60 samples taken)
7	The patient's blood pressure has been taken when presenting to the clinic (60 of 60 samples taken)

Figure 2. Follow-up audit compliance rates (%)

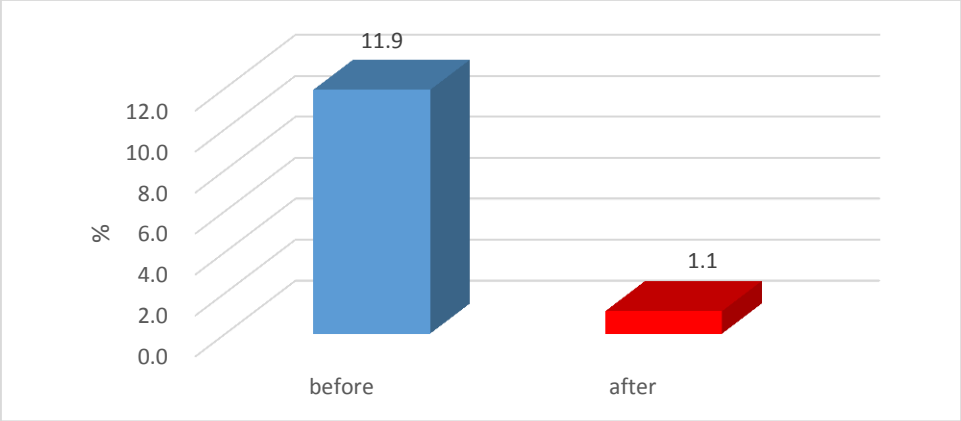


Figure 3. Follow-up audit complaint on incorrect BP (%)

5. Discussion

Improvement strategies were performed based on 7 criteria and audits were conducted. With health education leaflet on correct BP measurement and health education guidance provided by nursing personnel to 2,457 patients initially diagnosed as with high BP, announcement highlighting correct BP measurement posted in BP measuring areas, implementing improvement for ambient noise, and educational training provided for healthcare volunteers, inspections revealed improved knowledge among all participants, with decreased ambient noise levels of 48 to 52 dB (52 to 62 dB previously) as moderate noise levels.

There were 3 items with 100% of achievement ratio: The criterion 3 for BP monitors with scheduled maintenance by a trained technician were 100% both before and after inspection, as clear instrument maintenance regulations were available in the hospital; The criterion 5 for healthcare volunteers received training increased from 42% to 100%, as the enhanced knowledge about BP measurement due to the content in on-the-job educational courses and healthcare volunteers' expression on their compliance with the guidance information in the educational courses; The criterion 7 for the patient's BP has been taken when presenting to the clinic increased from 90% to 100%, as the hospital utilized the intellectual management policy with automatic upload system for BP measurement data. In the 2018 Hypertension Guideline (National Guideline, 2019), criteria for BP measurement include: ensuring that healthcare personnel performing BP measurement have received sufficient preliminary training, appropriate verification of devices used for measuring BP has been confirmed by healthcare provider, and scheduled maintenance by supplier, which is consistent with the measures implemented in this project (Environment Protection Administration, 2020).

The criterion 1 for a third measure of BP is taken if the second measure is substantially different from the first increased from 60% to 92%, indicating the enhanced knowledge among patients due to health education provided by nurses at consultation rooms, posters in BP measuring areas, and the self-learning approach by QR code; The criterion 2 for BP measurement is performed in a standardized environment increased from 35% to 92%, as the changed space among BP measuring seats, well-designed waiting lines, posters reminding patients' awareness of quiet environment.

Items with relatively lower achievement ratio include the criterion 4 for patients with high blood pressure (> 140/90 mmHg) a second measure is taken in a relaxed temperate setting with the patient quiet and seated with arm outstretched and supported, only increased from 63% to 70%, which probably resulted from white coat effect or patients' lacking of sufficient time to take the second measurement before presenting to the consultation rooms, leading to the lower achievement ratio of implementation in the hospital setting. The 2019 Hypertension Guideline indicates that when measuring BP in a clinic or at home, it is required to provide a standardized setting with relaxed temperate environment enabling people quiet and seated with arm outstretched and appropriately supported, which is consistent with the JBI guideline in this project (Joanna Briggs Institute, 2020; National Guideline, 2019). The criterion 6 for patients with hypertension are placed on a management plan with scheduled follow-up only increased from 63% to 77%, according to clinical practice in the hospital, physicians will develop treatment plan based on patient's illness and actively arrange a reservation for scheduled revisits. For patients first diagnosed as hypertension, nurses at consultation room will actively provide patients with nursing guidance leaflet, offering health education guidance or transferring patients to nursing counselling and service station to

receive further health education. The reason probably was that patients neglected the health education message received from healthcare personnel. Yi-Bing (Yi-Bing, De-Gui, Long-Le, & Le-Xin, 2013) found that only 4.9% perceived receiving counselling or health education provided by professionals, 26.1% understood the associated risks of cardiovascular disease with hypertension from media, 20.0% knew the comorbidities of hypertension, 17.2% understood the average levels of normal BP. Insufficient understanding about the illness has been a barrier to BP control, thus patients may perceive their insufficient information, which is consistent with results of this project. Lo (Lo, 2010) provided self-care knowledge and healthcare skills using the self-efficacy theory for 8 weeks, it was found that the effectiveness for BP control increased compared to the group with general routine health education ($P = 0.001$), health education guidance actually enhanced the efficacy of hypertension control. Zheng (Zheng et al., 2019) implemented health education measures for hypertension with follow-up for 1 year, it was found that BP control was negatively correlated to age and positively correlated to educational background ($P < 0.05$). In this project, the average age of cases was 64 years, the majority were university in educational level (36.6%), both are factors to be considered for implementing future educational programs.

6. Conclusion

Efficacy in improvement of accuracy for BP measurement was achieved through evidence-based application for quality improvement, with enhanced knowledge about correct BP measurement among outpatients and healthcare volunteers which also was practically applied in clinical practice. Success factors include, with the Change Theory, the leader team and project team acknowledged the importance of accuracy in BP measurement and were willing to fulfill a common goal, as well as completion of reforming the environment and establishment of standardized documents, which are all advantages of this project; it will be a challenge that patients and healthcare volunteers continuously receive education with application in practice, while based on persistent audits, amendment incorporating practice to ensure supporting this project and maintaining the changes developed by the project would be the subsequent crucial challenge.

7. Recommendation

The empirical application of quality improvement in blood pressure measurement accuracy achieves progressive results. The important factors are the completion of environmental transformation, the establishment of standard documents, the education of patients and health care volunteers, and the maintenance of the effect through continuous review.

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