COMPUTER METHODS AND PROGRAMS IN BIOMEDICINE 132 (2016) 105–113

journal homepage: www.intl.elsevierhealth.com/journals/cmpb

Cloud-based BP system integrated with CPOE improves self-management of the hypertensive patients: A randomized controlled trial

Peisan Lee [a,b,1], *Ju-Chi Liu* [c], *Ming-Hsiung Hsieh* [d], *Wen-Rui Hao* [e], *Yuan-Teng Tseng* [e,f], *Shuen-Hsin Liu* [e], *Yung-Kuo Lin* [d], *Li-Chin Sung* [e], *Jen-Hung Huang* [d], *Hung-Yu Yang* [d], *Jong-Shiuan Ye* [d], *He-Shun Zheng* [d], *Min-Huei Hsu* [b,g,h,i], *Shabbir Syed-Abdul* [b,g,i], *Richard Lu* [b,g,i], *Phung-Anh Nguyen* [b,g,i], *Usman Iqbal* [b,g,i,j], *Chih-Wei Huang* [b,g,i], *Wen-Shan Jian* [b,i,k,l,1], *Yu-Chuan (Jack) Li* [b,g,i,m,*]

[a] *Institute of Biomedical Informatics, National Yang-Ming University, Taipei, Taiwan*
[b] *College of Medical Science and Technology, Taipei Medical University, Taipei, Taiwan*
[c] *Division of Cardiology, Department of Internal Medicine, Taipei Medical University, Taipei, Taiwan*
[d] *Division of Cardiovascular Medicine, Department of Internal Medicine, Wan Fang Hospital, Taipei Medical University*
[e] *Department of Cardiovascular Medicine, Shuang Ho Hospital, Taipei Medical University, Taipei, Taiwan*
[f] *Saint Mary's Hospital Loudong, Loudong, Taiwan*
[g] *Graduate Institute of Biomedical Informatics, Taipei Medical University, Taipei, Taiwan*
[h] *Office of International Cooperation, Ministry of Health and Welfare, Taiwan*
[i] *International Center for Health Information Technology (ICHIT), Taipei Medical University, Taiwan*
[j] *Health Informatics Department, COMSATS Institute of Information Technology, Islamabad, Pakistan*
[k] *School of Health Care Administration, Taipei Medical University, Taipei, Taiwan*
[l] *Faculty of Health Sciences, Macau University of Science and Technology, Macau*
[m] *Department of Dermatology, Wan Fang Hospital, Taipei Medical University, Taipei, Taiwan*

ARTICLE INFO

Article history:
Received 30 December 2015
Received in revised form
4 April 2016
Accepted 6 April 2016

ABSTRACT

Background: Less than 50% of patients with hypertensive disease manage to maintain their blood pressure (BP) within normal levels.
Objective: The aim of this study is to evaluate whether cloud BP system integrated with computerized physician order entry (CPOE) can improve BP management as compared with traditional care.
Methods: A randomized controlled trial done on a random sample of 382 adults recruited from 786 patients who had been diagnosed with hypertension and receiving treatment for hypertension in two district hospitals in the north of Taiwan. Physicians had access to cloud BP data from CPOE. Neither patients nor physicians were blinded to group assignment. The study was conducted over a period of seven months.

* Corresponding author. 250-Wuxing Street, Xinyi District, Taipei 11031, Taiwan. Tel.: +886 2 6636 2530 Ext. 7601; fax: +886 2 6638 7537.
E-mail address: jack@tmu.edu.tw; jaak88@gmail.com (Y.-C.(J.) Li).
[1] Equal contribution.

http://dx.doi.org/10.1016/j.cmpb.2016.04.003

Keyword:
Cloud-based BP system
CPOE
Self-management
Hypertension
Randomized controlled trial

Results: At baseline, the enrollees were 50% male with a mean (SD) age of 58.18 (10.83) years. The mean sitting BP of both arms was no different. The proportion of patients with BP control at two, four and six months was significantly greater in the intervention group than in the control group. The average capture rates of blood pressure in the intervention group were also significantly higher than the control group in all three check-points.
Conclusions: Cloud-based BP system integrated with CPOE at the point of care achieved better BP control compared to traditional care. This system does not require any technical skills and is therefore suitable for every age group. The praise and assurance to the patients from the physicians after reviewing the Cloud BP records positively reinforced both BP measuring and medication adherence behaviors.

1. Introduction

Hypertension is one of the leading causes of death worldwide [1]. Approximately 35% of men and 25% of women have blood pressure (BP) in prehypertension range, which can be defined as a sustained systolic blood pressure (SBP) and diastolic blood pressure (DBP) of above 140 and 90 mmHg [2,3]. However, it was reported that less than 50% of patients with hypertension have controlled their BP [3,4].

Many types of intervention studies have demonstrated modest improvements in BP, and modern systematic reviews summarizing more than three decades of research have concluded that the most effective method to improve BP involves a reorganization of clinical practice and empowerment of nonphysician practitioners to adjust antihypertensive therapy [5,6]. On the other hand, repeated assessment of BP at the physician's office compared to self-monitoring at home was more reliable This is due to the greater number of BP measurements, the absence of the white-coat syndrome, and the lack of observer bias when automated devices are used [7–9]. Home BP monitoring also has been identified as a useful adjunct to team-based care for hypertension because it can help physicians make treatment decisions for antihypertensive therapy adjustment [10,11].

In the past, manually recorded BP logs have often been demonstrated to be inaccurate, with substantial under-reporting of BP [12]. Multiple studies have demonstrated that BP telemonitoring interventions can be effective in the control of hypertension. However, most studies required some technological skills from the participants in order to transmit data through telephone, fax, Internet or Bluetooth back to the server [13–15]. Also, none of them reported an integration to the computerized physician order entry (CPOE) system. We believe that a home BP monitoring system integrated with CPOE can provide just-in-time information for physicians' therapeutic decision making. Therefore, the objective of this study was to determine whether Cloud-based BP system integrated with CPOE is useful for improving BP control as compared with traditional care.

2. Methods

2.1. Design, setting and patients

A randomized controlled trial was designed to compare two interventions to improve hypertension control. Potential participants were identified by the use of electronic searches through a hospital electronic medical record system. Patients between the ages of 18 to 85 years were eligible for enrollment if they had been diagnosed with hypertension and were receiving treatment for hypertension with antihypertensive drugs for at least six months from the cardiology department. Patients also had to be willing to monitor their own BP at home. Medical exclusion criteria were as follows: 1) secondary hypertension; 2) expectant mother; 3) stroke, myocardial infarction or had surgery within 3 months; 4) atrial fibrillation; 5) inter-arm difference (IAD) > 20 mm Hg; and 6) unsuitability as recognized by physicians. Other exclusion criteria included being 1) unable to participate in this trial for the whole process, 2) lived alone and were unable to read Short Message Service (SMS).

2.2. Randomization and masking

This trial adopted permuted-block design to overcome disadvantages of simple randomization by forcing periodic balance in the numbers of patients assigned to each group. Patients were randomly assigned in a 1:1 ratio to either the intervention group or the control group. Neither patients nor physicians were masked to the group assignments in this trial.

2.3. Procedures

This trial was undertaken from December 2011 to September 2013. The study protocol was approved by the University's Institutional Review Board in 2011 (approval number: 201107013).

Patients were enrolled after a two-arm BP monitoring exam and follow-up. The patients allocated to the intervention group were trained to monitor their BP using an automated electronic sphygmomanometer. Physicians were able to access the Cloud-based BP records from the CPOE system by clicking on the Cloud BP review button on the screen. People allocated to the control group were asked to keep their BP records on paper. They were required to bring their paper-based records with them when they met their cardiologist. Participating cardiologists were encouraged to check on patients' BP records during each visit before giving the prescription. All patients were requested to self-monitor their own BP at home and received information based on literatures/guidelines produced by the European Society of Hypertension (ESH). They were instructed to monitor their own BP four times a day (twice in the morning when they awoke and twice in the evening before they went to bed). The frequency was once a week and seven consecu-