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Designing A Web Application for Self-Blood Pressure Monitoring and Control at Home

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Abstract

Information communication technology has led to the most important digital transformations in health care, although many people are unaware of the existence of digital health care. The use of digital health can empower people in general and patients by enabling them to access health services at the point of care or remotely that enhance their knowledge, skills and provide guidance for health management and disease control. This study designed a self-blood pressure home-measured web application for blood pressure monitoring and control at home. The study was conducted in three phases:(1) Created a self-blood pressure home-measured monitoring wireframe (2) designed a self-blood pressure home-measured monitoring web application and (3) Tested and evaluated the usability and applicability of a web application. A developed web application has two grids systole and diastole, and two call-to-action buttons. The first is the "Measure button" which informs the application to categorize measurements and the second is the "Blood Pressure Category and Control Activities button" which leads to the blood pressure categories that help a person to interpret readings and find action to take for self-blood pressure monitoring and control at home. A developed web application can enhance the quality and accessibility of care, and when it is combined with clinical support for self-blood pressure can improve knowledge and skills in the prevention and control of hypertension, assess blood pressure control, make early diagnoses of hypertension, and allow people to actively participate in the management of their blood pressure. Further interventional research is needed to assess its effectiveness.

Keywords*: Self-Blood Pressure, Control, Web Application.*

Introduction

Information communication technology (ICT) has led to the most important digital transformations in health care, although many people are unaware of the existence of digital health care. The use of digital health can empower people in general and patients by enabling them to access health services at the point of care or remotely that enhance their knowledge, and skills and provide guidance and assistance for health management and disease control [1]. The 2030 Agenda for Sustainable Development highlights that the spread of information and communications technology and global interconnectedness has great potential to accelerate human progress to bridge the digital divide and develop knowledge societies [2].

With the recognition that information and communications technologies present new opportunities and challenges for the achievement of all 17 sustainable development Goals, there is a growing consensus in the global health community that the strategic and innovative use

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of digital and Cutting-edge information and communications technologies will be an essential enabling factor toward benefit from universal health coverage that 1 billion more people are better protected from health emergencies and that 1 billion more people enjoy better health and well-being [3, 4]. Digital tools and health solutions have provided critical support during the COVID-19 response. Most strategies focus on developing instant, quality health services via mobile apps [5].

Hypertension is a significant public health issue in the world. According to WHO 2023, an estimated 1, 28 billion adults aged 30-79 years worldwide have hypertension, two-thirds of them living in low and middle-income countries, 46 % of adults with hypertension are unaware that they have the condition, and less than half of adults (42%) with hypertension are diagnosed and treated [6]. The systematic review and meta-analysis of hypertension prevalence in Chinese adults from 1959 to 2018 showed that the prevalence of hypertension in Chinese adults has been increasing, indicating that more efforts should be strengthened for hypertension management in China [7].

Following the international guidelines, in Taiwan HPB monitoring has been implemented in diagnostic confirmation of hypertension, identification of hypertension phenotypes, guidance of anti-hypertensive, and treatment, and detection of hypertensive [8]. Self-BP measurement at home is a validated approach for out-of-office BP measurement that has been evidenced as an efficient method associated with a reduction in BP and improved BP control, and its benefits are greatest when done along with cointerventions [9]. OBP determined using ambulatory BP monitoring (ABPM) and /or home BP monitoring (HBPM) is recommended for the diagnosis of hypertension in the major international guidelines [8].

The accurate measurement of BP is essential for the diagnosis and management of hypertension [10]. The study assessed the relationship between OBP, HBP, and ABP revealed that one week of HBP monitoring may be the best approach for diagnosis of hypertension among others [11]. A further study examined whether self-monitoring could reduce clinic BP in patients with hypertension-related co-morbidities and showed that self-monitoring lowers BP regardless of the number of hypertension-related co-morbidities, especially in conditions such as obesity or stroke when combined with high-intensity co-interventions [12]. HBPM appears to be a very useful approach to hypertension management so far it allows obtaining multiple measurements in the usual environment of each individual that allows the detection of hypertension phenotypes such as white coat and masked hypertension and appears to have superior prognostic value than conventional office BP measurements [13].

The Latin American Society of Hypertension recommended that HBPM should have a primary role in the diagnosis, treatment adjustment, and long-term follow-up of most cases with hypertension in Latin America [13]. Referring to the advantages of HBPM as a tool to diagnose and support hypertension treatment including the prevention of cardiovascular diseases and target organ damage, the study explored the prevailing knowledge and current recommendation of HBPM in daily practice by physicians in India, low knowledge and practice toward HBPM among followed patient linked to the poor physician instructions and practical educational materials and sessions were recommended to improve the understanding of HBPM among physicians [14].

European Society of Hypertension in 2021 position paper by the working group on blood pressure monitoring and cardiovascular variability of HBPM provided new indications on the methodology of HBPM that the use of wide-range cuffs with oscillometer devices is useful for HBPM [15].

The main characteristics of the preferred HBPM device include upper arm cuff and diagnostic thresholds for hypertension at least 135/85 mmHg corresponding to at least 140/90

mmHg clinic BP whereas HBP at least 130/80 mmHg may correspond to at least 130/80 mmHg clinic BP threshold for grade one hypertension and treatment target should be systolic HBP between 125-130 mmHg and diastolic BP less than 80mmgh are now considered reasonable goal [15]. Small wearable monitoring devices for remote blood pressure monitoring approach has also been evidenced to be efficient in HBPM monitoring approach allowing accurate detection of phenotypes of hypertension by increasing the number of measurements [16].

The trial tested a digital intervention for hypertension management in primary care by combining self-monitoring of blood pressure with guided self-management, the home BP digital intervention for the management of hypertension by using self–monitored blood pressure led to better control of systolic blood pressure with low incremental cost [17].

Digital tools have been proven to help in self-blood pressure readings during pregnancy in the hy-result e-health prospective study 88% of pregnant women who performed HBPM successfully and 87% perceived the software to be reliable and self-interpretation of their readings as reassuring [18]. In Ethiopia, a low proportion of knowledge and practice of self-blood pressure home-measured was revealed in the studies that assessed the knowledge, attitude and practice toward self-blood pressure home measurement in Ethiopia [19, 20]. The use of mobile health applications for self-blood pressure monitoring using automatized blood pressure devise improved medication adherence, social support, and blood pressure control in rural Uganda [21].

In Rwanda, office-based blood pressure measurement is the primary approach used to measure and diagnose hypertension at health facilities, and there no study about self-blood pressure monitoring at home in Rwanda found in the literature, also, there is no strategy yet developed to encourage people to self-measure blood pressure at home. The present study will develop web application to help people for self-blood pressure measurement and interpretation of readings at home to contribute to the prevention and control of hypertension diseases in RWANDA.

Methods

The blood pressure monitoring and control web application was developed in the following three steps. **Step 1:** Created a blood pressure home-measured monitoring wireframe referring to the literature review, **Steps 2:** designed a self-blood pressure home-measured monitoring website and **Step 3:** Tested and evaluated the usability and applicability of a web application.

Step1: Creating a Blood Pressure Monitoring and Control Wireframe

A wireframe is a layout of a web page that demonstrates what interface elements will exist on key pages. It is a critical part of the interaction design process that aims to provide a visual understanding of a page early in the project to get stakeholder and project team approval before the creative phase gets underway. It can also be used to create global and secondary navigation to ensure the terminology and structure used for the site meet user expectations [22]. The wireframe for the development of the website was created based on a how to guide book an output of the last study titled developing a tool for self-blood pressure monitoring and control at home found at: https://self-blood-pressure-control.netlify.app/publications

Step 2: Designing a Self-Blood Pressure Home-Measured Monitoring Website

After creating a wireframe, this was taken to the web designer to design a web application. The designing of the application passed through three phases that are: **1) Design**: designer looked for information architecture, visual design, user experience (UX) design, and interaction design. **2) The development phase:** The designer used front-end development and back-end development. **3) Deployment and hosting**: The designer created a link between a website and database to store and fetch data as well as

creating a backup in case of data lost the applied the code pushing to move website files from where they are created to a web server then after making an online site live and available to the public.

Phase 3: Testing and Evaluation of the Usability And Applicability Of The Website

In this phase of testing and evaluation, quantitative analytical cross-sectional study design was applied to evaluate the applicability and usability of websites toward self-blood pressure monitoring and control at home. Thirty-two (32) participants included 2 PhD holders, 16 masters' holders, 5 Bachelor holders, and 9 with advanced certificate were conveniently given blood pressure machine and link of website to test the usability and applicability of the website toward self-blood pressure monitoring and control at home.

Data were collected through 2 different structured questionnaires: One was the evaluation of the applicability of the website for monitoring and control of blood pressure at home measured with 4 Likert scale (Very easily applicable, Applicable, Applicable with difficulty and not applicable) scored as 3,2,1,0 respectively to rate six dimensions of the applicability of (1) Self-measuring blood pressure using an oscillometer, (2) Entering systole and diastole measurement in the system, (3) Finding the blood pressure category, (4) opening measures and activities to take toward blood pressure control, (5) Reading the activities to take for blood pressure control and (6) applicability of the practice of provided activities.

The second questionnaire was an evaluation of the usability of the website structured questionnaires with 10 dichotomous questions and one rating question. For dichotomous questions, the participants were asked to respond by Yes or Not on the following questions: (1) Can you find buttons on the website? (2) Do you like the colors on the website? (3) Do you like the colors on the website? (4) Do the images on the website help you understand the content, (5) Did you like the placement of the menu on the website? (6) Were you able to navigate across the whole site? (7) Was the content easy to understand at a glance? (8) Was the size of the call-to-action buttons appropriate for your smartphone? (9) Were you able to access all the features of the website on your smartphone? And (10) Were you able to see all of the text, design, and images on the website? The one scaring question was How would you rate the performance of the website? The participant had rate as Excellent with 3 scores, Perfect with 2 scores, Good with 1 score, and worse with 0 score. As the study involved humans, the ethical principles of confidentiality and willingness to participate in the study were considered.

After data collection, the data were checked for completeness then entered into the statistical package for the social sciences (SPSS) database vision 29 and Descriptive statistical analysis using frequencies and percentages were used for analysis.

Results for Evaluation of the Usability and Applicability of the Website

Table 1 describes social demographic characteristics of participants contributed to the evaluation of the usability and applicability of self-blood pressure. Among 32, 20(62.5%) were Male while 12(37.5%) were female. The highest number have master's level of education 16(50%), followed by advanced certificate level 9(28.1%). The participants with bachelor's degree were 5(15.6%), and PhD holders were 2(6.2%).

Table 1. Characteristics of Participants

Item	Frequent	Percent
Gender		
Male	20	62.5%8.1
Female	12	37.5
total	32	100
Level of study		
PhD	2	6.2
MASTERS	16	50
Bachelor	5	15.6
Advanced Certificate	9	2

The majority rated that the website is very applicable: Self-measuring blood pressure using an oscillometer at 25(78.1), Entering systole and diastole measurement in the system 26(81.), Finding the blood pressure category 24 (75), Opening measures and activities to take toward blood pressure control20(62.5), Reading the activities to take for blood pressure control 24(75), Applicability of the practice of provided activities23(71.9) (table 2).

Table 2. Evaluation of the Applicability of the Website Findings

Items	very easy applicable n (%)	Applicable n (%)	Applicable with difficulty n (%)	**Not applicable** n (%)
Self-measuring blood pressure using oscillometer	**25(78.1)**	**7(21.9)**	**0(0.00)**	**0(0.00)**
Entering systole and diastole measurement in the system	**26(81.)**	**4(12.5)**	**2(6.3)**	**0(0.00)**
Finding the blood pressure category	**24(75)**	**5(15.6)**	**3(9.4)**	**0(0.00)**
Opening measures and activities to take toward blood pressure control	**20(62.5)**	**8(25)**	**4(12.5)**	**0(0.00)**
Reading the activities to take for blood pressure control	**24(75)**	**4(12.5)**	**4(12.5)**	**0(0.00)**
Applicability of the practice of provided activities	**23(71.9)**	**(6(18.8)**	**3(9.4)**	**0(0.00)**

The website usability was assessed among 32 participants (table 3): The majority of participants rated that the website is functional and usable: Thirty- two (32(100), found the buttons on the website, 30(93.8) liked the colors on the website, 28(87.5) showed that images on the website help to understand the content, all participant 32(100), liked the placement of the menu on the website and were able to navigate with across the whole site. Thirty 30(93.8) showed that the content is easy to understand at a glance, and all participants 32(100%) showed that the size of the call-to-action buttons appropriate for your smartphone, Able to access all the features of the website on your smartphone and are able to see all of the text, design, and images on the website.

Table 3. Evaluation of the Usability of the Website Findings

Items	**Yes n (%)**	**No (n%)**
Finding buttons on the website	**32(100)**	**0(0.00)**
Like the colors on the website	**30(93.8)**	**2(6.2)**
Images on the website help you understand the content	**28(87.5)**	**4(12.5)**
Like the placement of the menu on the website	**32(100)**	**0(0.00)**
Able to navigate with across the whole site	**32(100)**	**0.00)**
The content easy to understand at a glance	**30(93.8)**	**2(6.2)**
The size of the call-to-action buttons appropriate for your smartphone	**32(100)**	**0(0.00)**
Able to access all the features of the website on your smartphone	**32(100)**	**0(0.00)**
Able to see all of the text, design, and images on the website	**32(100)**	**0.00)**

The (table 4) indicates the participants' suggestions regarding the improvement of the applicability and usability of the website. Ninety (50.8%) were increasing images for more attractions and 87(49.2%) suggested clearly indicate action to take button.

Table 4. Participant Suggestion to Improve the Applicability and Usability of the Website

Suggestion	**Frequent**	**percent**
Images are not enough increase the images for more attraction	90	50.8

Indicate clearly action to take button	87	49.2
Total	177	100

Self-Blood Pressure Monitoring And Control At Home Web Application Output

Figure 1 indicates the web application layout. A developed Self-blood pressure monitoring and control at home web application presents two grids: systole and diastole. The systole grid is where the participant enters the readings of systole when measuring BP. The Diastole grid is where the participant enters the readings of diastole when measuring BP at home. It presents also two call-to-action buttons: The first call-to-action button is" MEASURE "that informs the application to categorize the measurements. The second "Blood Pressure Category and Control activities "leads the participant to the category of measured blood pressure. In addition, under the category, the participant will find and read which action is needed to control her/his blood pressure.

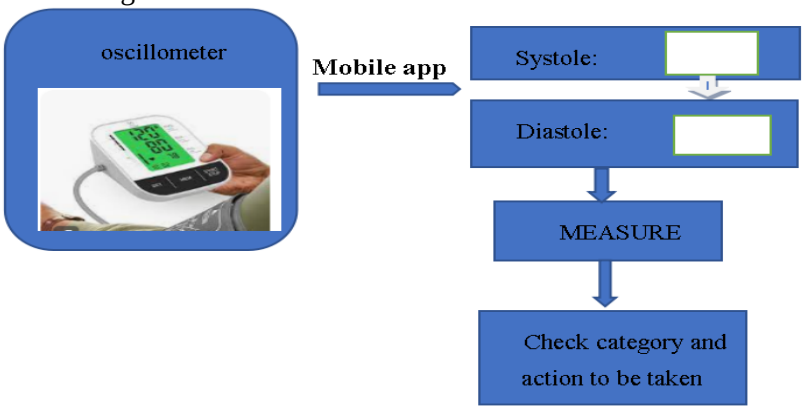

Figure 1. Self-Blood Pressure Monitoring and Control at Home Web Application Layout

The category should be one among the categorized blood pressure values summarized in (table 5). In addition, under the category, the users are indicated to which actions are needed to control her/his blood pressure. (Click here to navigate the website: https://self-blood-pressure-control.netlify.app/

Table 5. Classification of Hypertension Based on Office Blood Pressure (BP) Measurement

Category	Systolic (mmHg)		Diastolic (mmHg)
Normal BP	<130	And	<85
High normal BP	130-139	And/or	85-89
Grade 1hypertension	140-159	And/or	90-99
Grade2 hypertension	160-179	And/or	100-109

Discussion

The use of digital health empower general population and patients by enabling them to access health services at the point of care or remotely and enhance their knowledge, skills and provide guidance and assistance for health management and disease control [1]. The present study developed a web application for self-monitoring and controlling blood pressure at home. The study responds to the rapid change in the health information technology landscape. This also enhances the consumer's interest in the use of health apps and health technology growth, driven by the increasing prevalence of mobile devices such as smartphones and tablets [23]. Similar to this digital tool for self-blood pressure monitoring and control, the American Medical Association reported that when it is combined with clinical support self-blood pressure can enhance the quality and accessibility of care for people with high blood pressure, to assess blood pressure control, to make a diagnosis of hypertension and allow patients to actively participate in the management of their blood pressure and have been shown to improve adherence to antihypertensive medications [24].

Furthermore, in an article on home blood Pressure and telemedicine; a modern approach to managing hypertension during and after the COVID-19 pandemic, home blood pressure monitoring has been proposed as one of the effective interventions for improving blood pressure control particularly suitable for telemedicine and mobile health solutions [25]. The present developed web application for blood pressure monitoring and control can help physicians in the supervision of hypertensive patient blood pressure measurement. These are supported by the observational cohort study that tested whether a physician-supervised web app integrated with an electronic medical record helps in improving blood pressure management in clinical practice and revealed that the use of a mHealth app in clinical practice is associated with a significant reduction in blood pressure for average patients as well as high severity patients [26].

Conclusion

The current study developed a web application for self-blood pressure monitoring and control at home. A developed Web application has two grids systole and diastole, and two call-to-action buttons. The first is the "Measure button" which informs the application to categorize measurements and the second is the "Blood Pressure Category and Control Activities button" which leads to the blood pressure categories that help a person to interpret readings and find action to take for self-blood pressure control at home. A developed web application can enhance the quality and accessibility of care when it is combined with clinical support. Self-blood pressure can also enhance knowledge and skills in the prevention and control of hypertension, assess blood pressure control, make early diagnoses of hypertension, and allow people to actively participate in the management of their blood pressure. The researcher recommends further interventional study to assess web application effectiveness.

Conflict of Interest

The authors certify that they have no affiliations with any organization with any financial, personal, knowledge, or beliefs interest in the subject matter or materials discussed in this manuscript.

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References

[1]. Al-Shorbaji, N., 2021, Improving Healthcare Access through Digital Health: The Use of Information and Communication Technologies.

[2]. Khan, M.A., Mega Risks: Digital Transformation and Sustainability, in Cities and Mega Risks: COVID-19 and Climate Change, M. A. Khan, Editor. 2022, *Springer International Publishing: Cham*. p. 81-111.

[3]. Ibeneme, S., et al., 2022, Strengthening Health Systems Using Innovative Digital Health Technologies in Africa. Frontiers in Digital Health, 4.

[4]. Okuzu, O., et al., 2022, Role of Digital Health Insurance Management Systems in Scaling Health Insurance Coverage in Low- And Middle-Income Countries: A Case Study from Nigeria. *Frontiers in Digital Health*, 4.

[5]. Yang, S., et al., 2020, The Use of ICT During COVID-19. Proceedings of the Association for Information Science and Technology, 57(1).

[6]. Ihm, S.H., et al., 2022, Home Blood Pressure Monitoring: A Position Statement from the Korean Society of Hypertension Home Blood Pressure Forum. *Clin Hypertens*, 28(1): p. 38.

[7]. Bao, M. and L. Wang, 2020, The Longitudinal Trend of Hypertension Prevalence in Chinese Adults from 1959 to 2018: A Systematic Review and Meta-Analysis. *Ann Palliat Med,* 9(5): p. 2485-2497.

[8]. Chiang, C. E., et al., 2015, guidelines of the Taiwan Society of Cardiology and the Taiwan Hypertension Society for the Management of Hypertension. *J Chin Med Assoc*, 78(1): p. 1-47.

[9]. Shimbo, D., et al., 2020, Self-Measured Blood Pressure Monitoring at Home: A Joint Policy Statement from the American Heart Association and American Medical Association. *Circulation*, 142(4): p. e42-e63.

[10]. Muntner, P., et al., 2019, Measurement of Blood Pressure in Humans: A Scientific Statement from the American Heart Association. *Hypertension*, 73(5): p. e35-e66.

[11]. Schwartz, J. E., et al., 2020, Reliability of Office, Home, and Ambulatory Blood Pressure Measurements and Correlation with Left Ventricular Mass. *J Am Coll Cardiol*, 76(25): p. 2911-2922.

[12]. Sheppard, J. P., et al., 2020, Self-Monitoring of Blood Pressure in Patients with Hypertension-Related Multi-morbidity: Systematic Review and Individual Patient Data Meta-analysis. *American Journal of Hypertension*, 33(3): p. 243-251.

[13]. Villar, R., et al., 2020, Recommendations for Home Blood Pressure Monitoring in Latin American Countries: A Latin American Society of Hypertension Position Paper. *The Journal of Clinical Hypertension,* 22(4): p. 544-554.

[14]. Wang, T. D., et al., 2023, Current Realities of Home Blood Pressure Monitoring from Physicians' Perspectives: Results from Asia HBPM Survey 2020. *Hypertens Res*, 46(7): p. 1638-1649.

[15]. Parati, G., et al., 2021, Home Blood Pressure Monitoring: Methodology, Clinical Relevance and Practical Application: A 2021 Position Paper by The Working Group on Blood Pressure Monitoring and Cardiovascular Variability of the European Society of Hypertension. *J Hypertens*, 39(9): p. 1742-1767.

[16]. Kario, K., 2021, Management of Hypertension in the Digital Era: Small Wearable Monitoring Devices for Remote Blood Pressure Monitoring. *Hypertension,* 2020. 76(3): p. 640-650.

[17]. Home and Online Management and Evaluation of Blood Pressure (HOME BP) Using A Digital Intervention in Poorly Controlled Hypertension: Randomised Controlled trial. *BMJ*, 2022. 379: p. m2216.

[18]. Postel-Vinay, N., et al., 2022, Home Blood Pressure Measurement and Self-Interpretation of Blood Pressure Readings During Pregnancy: Hy-Result e-Health Prospective Study. *Vasc Health Risk Manag*, 18: p. 277-287.

[19]. Wake, A. D., D. M. Bekele, and T. S. Tuji, 2020, Knowledge and Attitude of Self-Monitoring of Blood Pressure Among Adult Hypertensive Patients on Follow-Up at Selected Public Hospitals in Arsi Zone, Oromia Regional State, Ethiopia: A Cross-Sectional Study. *Integr Blood Press Control*, 13: p. 1-13.

[20]. Edmealem, A., et al., 2023, Blood pressure self-monitoring practice and associated factors Among Adult Hypertensive Patients on Follow-up at South Wollo Zone Public Hospitals, Northeast Ethiopia. *Open Heart*, 10(1).

[21]. Mugabirwe, B., et al., 2021, Acceptability and Feasibility of a Mobile Health Application for Blood Pressure Monitoring in Rural Uganda. *JAMIA Open*, 4(3): p. ooaa068.
[22]. Gudonienė, D., et al., 2023, The Scenarios of Artificial Intelligence and Wireframes Implementation in Engineering Education. *Sustainability*, 15(8): p. 6850.
[23]. Wall, H. K. and S. S. Shantharam, Self-Measure Blood Pressure Monitoring (SMBP) Interventions: Resources for Planning and Implementation.
[24]. Shimbo, D., et al., 2020, Self-Measured Blood Pressure Monitoring at Home: A Joint Policy Statement from the American Heart Association and American Medical Association. *Circulation*, 142(4): p. e42-e63.
[25]. Citoni, B., et al., 2022, Home Blood Pressure and Telemedicine: A Modern Approach for Managing Hypertension during and after COVID-19 Pandemic. *High Blood Pressure & Cardiovascular Prevention,* 29(1): p. 1-14.
[26]. Agnihothri, S., et al., 2021, Mobile Health Application Usage Aand Quality of care at a Hypertension Clinic: An Observational Cohort Study. *Journal of Hypertension*, 39(11): p. 2265-2271.