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Mobile Application for Blood Pressure Monitoring andControl

Perumalraja R [1], Prasanthini S [2], Soundariya S [3], Vishnupriya M[4]

[1]Professor & Head, Department of IT, Velammal College of Engineering and Technology
[2][3][4]UG Students, Department of IT, Velammal College of Engineering and Technology, Madurai, Tamil Nadu, India.

Abstract - *Day by day, the percentage of people with hypertension is increasing due to a fast-paced lifestyle in this modern era, and this phenomenon is widely concerning. Hypertension is the major root cause for life threatening disease such as, acute myocardial infarction, stroke, kidney failure, congestive heart failure, cardiovascular disease, etc. Many people believe that stress is the main cause of hypertension that induces headache, palpitations and dizziness, etc., but hypertension may not produce any symptoms initially. Hence people may fail to adhere to treatment during periods of low stress or in the absence of symptoms. As a result, only ~14% of adults with hypertension worldwide have their BP controlled. Hence, wireless home BP monitors have evolved as a personal device to monitor the BP continuously even during regular activities and Mobile Apps have been introduced for preparing reports. Similarly, various Mobile Apps are introduced for a healthy lifestyle by recommending simple workouts and diet plans. However, there is a need for a system to monitor BP periodically, log data and provide personalized lifestyle recommendations based on the history that remains weak. Therefore, we propose a recommender system to monitor BP accurately, log BP, compute disease predictions based on the statistical evidence and provide personalized lifestyle recommendations in terms ofreport.*

Keywords: Systolic Blood Pressure, Diastolic Blood Pressure, Blood-pressure Variability, Mean Arterial Blood Pressure, Personalized lifestyle recommendation, Chronic kidney disease, Ambulatory Blood Pressure Monitoring.

I. INTRODUCTION

Blood is carried around the body in blood vessels for three important functions, such as Transportation, Regulation and Protection. In transportation, blood takes oxygen from the lungs to cells of the body as well as takes carbon dioxide from the body's cells to the lungs where it is breathed out. Also, blood carries nutrients, hormones and wasteproductaround the body. Regulation process is used to keep certain values of the body in balance, like maintaining temperature, etc.

Protection function of the blood plays an important role in the immune system with the help of white blood cells and other messenger substances.

Blood Pressure (BP) is the measurement of a pressure in the walls of blood vessels called arteries. BP readings are written in two numbers separated by a line. The top number represents the Systolic Blood Pressure (SBP) and the bottom number represents the Diastolic Blood Pressure (DBP). SBP is the pressure in the arteries as the heart contracts pushing the blood forward whereas DBP is the pressure in the arteries as the heart relaxes. Ideally, blood pressure should be below 120/80 mmHg to maintain good health and reduce the risk of stroke, heart disease and other conditions.

There are several factors that may cause high blood pressure, but the exact cause is unknown. The following factors may increase one's risk for high blood pressure: Having an abnormal blood pressure pattern, such as high blood pressure during the night or early in the morning, can mean that you have a health problem. Similarly, if a person has diabetes, kidney disease or other health conditions, monitoring and treatment to control BP is highly advisable.

The associated conditions include:

- Kidney disease
- Diabetes
- Thyroid problems
- Nervous system problems
- Cardiovascular disease
- Poorly controlled high blood pressure

Risk factors for developing an abnormal blood pressure pattern include:

- Night-shiftworks
- Tobacco use
- Anxiety
- Too much stress

Table 1: Risk factors which can be controlled and cannot be controlled.

Risk Factors that can be controlled	Risk Factors that cannot be controlled
• Overweight or obese • Sedentary lifestyle (lack of physical activity) • Tobacco usage • Unhealthy diet (high sodium consumption) • Excessive alcohol usage • Stress • Sleep apnea • Diabetes	• Age • Race • Family History

Hypertension is sometimes referred to as a "silent killer" as it may not produce any symptoms, even if you have had it for years. Symptoms may be present in those who have an extremely high blood pressure,i.e. malignant hypertension. Symptoms are,

- Severe headaches
- Fatigue
- Chest pain
- Irregular heartbeat
- Difficulty inbreathing

II. LITERATURE SURVEY

A. Hypertension: the silent killer: updated jnc-8 guideline recommendations

Kayce Bell and June Twiggs, et al. [2] mention about the classification of blood pressure in adults (18 years and older) is based on the average of two or more properly measured. Blood pressure readings from two or more clinical visits. If the systolic blood pressure and diastolic blood pressure values fall into different categories, the overall classification is determined based on the higher of the two blood pressures.

Blood pressure is classified into one of four categories: Normal, Prehypertension, Stage 1 HTN and Stage 2 HTN.

B. 3 types of blood pressure monitoring devices phygmomanometer

Dr.Aj Thomas[9] described various sphygmomanometers for monitoring blood pressure. These existing blood pressure method shave challenges too. To overcome these challenges we are using oscillometric methods.

Figure 1: Mercury Sphygmomanometer

Figure2:Types of Aneroid Sphygmomanometer

C. Comparison of Artificial Intelligence Based Oscillometric Blood Pressure Estimation Techniques

Ekambir Sidhu, Voicu Groza [1] gives astudy and comparison of various AI based BP estimation techniques and algorithms which have been developed by various researchers in the recent years for automated measurement of blood pressure. We also learnt the differences between the various non-invasive methods commonly used for the estimation and measurement of blood pressure. Though these methods look promising and helpful, there are some challenges, when it comes to research or project. The application areas and the tools for blood pressure monitoring were also discussed. Some major challenges were citedandthe possible solutions were also given, which are in the developing stage.

Table 2: Comparison of Auscultatory, Palpatory and Oscillatory methods [1]

S. No.	Parameter	Ausculatory method	Palpatory method	Oscillatory method
1	Working Principle	Detection of Korotkoff sounds by placing stethoscope over brachial artery with pressure cuff inflated and deflated slowly	Pulse detection by placing finger over radial artery with pressure cuff inflated and deflated slowly	Estimation of pressure from the oscillometric waveforms generated from cuff deflation or inflation waveform
2	Body target source employed for measurement	Brachial artery at upper arm	Radial artery at wrist	Brachial artery at upper arm or Radial artery at wrist
3	Output readout	Mercury Manometer	Mercury Manometer	Digital Display
4	Nature	Manual	Manual	Automated
5	Complexity	Less	Less	High

III. PROPOSED WORK FOR BLOOD PRESSURE MONITORING ANDCONTROL

In this section, the proposed system for blood pressure monitoring is described. Blood-pressure variability (BPV) is a complex phenomenon that includes short-term fluctuations occurring within a 24h period as well as blood pressure changes over more-prolonged periods of time.

Mounting evidence indicates that the adverse cardiovascular consequences of high blood pressure could also be the result of increased BPV, and notonly of elevation of mean blood pressure values Short- term and long-term BPV are independently associated with the development, progression, and severity of cardiac, vascular, and renal damage and with an increased risk of cardiovascular events and mortality. Therefore, we consider mean BPV and mean BP for continuous monitoring of BP and hypertension control.

Our proposed recommender system provides personalized recommendations for a user to keep their BP within the allowable limit. In that, the Omron BP measuring unit is used to measure the current BP values. This device uses an electronic pressure sensor for measuring the blood pressure and the readings are given out digitally on a display. Then, Omron device communicates BP values to the Mobile Application, where Mobile App is designed to be a more interactive application to collect user details and to give personalized recommendations based on the average BP value.

DEVICE USED TO MEASURE BP

Figure 3: Omron Device

At the time of user registration, personalized history of data is being collected such as, Name, Phone number, Age, Gender, Height, Weight, if BP exists, how long the user has and medication details, Nature of food habit, Regular workout, Smoking / drinking habits . Once the registration is over, the user has to measure the BP using an Omron device and enters the SBP and DBP value in both morning and evening pages. A message notification will be given to the registered mobile.

BLOCK DIAGRAM

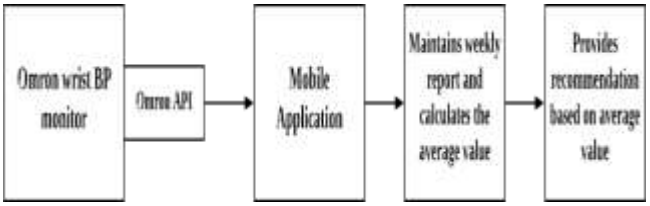

Figure 4: Block diagram of Blood Pressure Monitoring

The proposed system is a mobile application which monitors blood pressure. Generates the weekly and monthly report by analyzing various factors. It provides the average of the readings weekly/monthly. It provides personalized lifestyle recommendation in terms of medication, based on the average value.

IV. RECOMMENDATIONS

The recommendations are provided based on the average SBP and DBP values. This includes healthy lifestyles, workout, diet charts based on average BP value. The developed mobile application will provide the diet charts for both high blood pressure and low blood pressure. These diet charts contain Do's and Don'ts to be followed by the user.

In continuous BP monitoring and control, we consider mean BPV and mean BP to consider the fluctuations that may contribute to hypertension. When BP is approximately stable for a healthy person, the mean BPV for that person is less and which was shown in the flowchart. When the mean BP is in

borderline and some limited variations in BP, i.e. mean BPV, the system will give personalized recommendations.

Table 3: Recommendations for various SBP and DBP values [2]

SBP in mmHg	DBP in mmHg	Actions / Recommendations
Below 120	Below 80	Maintain or adopt healthy lifestyle
120-139	80-89	Adopt healthy lifestyle. Borderline
140-159	90-99	Adopt healthy lifestyle. If goal isn't reached in a month, consult doctor for taking medication. STAGE 1
>160	>100	Adopt healthy lifestyle. Talk to your health care professional about taking medication(s). STAGE 2
>180	>120	A serious hypertension crisis may occur, known as a malignant hypertension. This can lead to stroke, kidney damage, heart attacks, or loss of consciousness.

The following recommendations are provided by the system to the user at various BP conditions.

Recommendation 1:

After the registration process is over, during first BP measurement, when BP>= 140/90 mmHg and the user is taking BP medications then recommend to Perform ABPM and meet the doctor to modify treatment for a controlled BP.

Recommendation 2:

After registration process is over, during first BP measurement, when BP>= 160/100 mmHg and the user is not taking any BP medications then recommend to Perform ABPM and meet the doctor to initiate treatment for a controlled BP.

Recommendation 3:

Provide complete orientation on BP for all users. Orientation on BP includes

- Need for continuous monitoring
- About various BP terminologies, like White Coat, MUCH, Office BP, Home BP, ABPM, Nocturnal BP,etc.
- Major contributing root causes, like, BMI, Heredity, Age, Sex,Lifestyle;

Recommendation 4:

Adopt recommended medication by the doctor and follow the healthy lifestyle for two weeks, i.e. initial waiting time period to adopt new changes.

Recommendation 5:

For continuous BP monitoring, perform the following steps

- If mean BPV <=5 and mean BP== normal BP value, continue from the step1,
- If mean BPV<10 and mean BP<140 provide personalized recommendation, everyday measure BP and do followup.
- If mean BPV>=10 and mean BP>=140, Perform ABPM and meet the doctor. Every day measure BP and do followup.

Recommendation 6:

For a person who is having any lifethreatening disease,

- Perform ABPM once in a month, if mean BP>140/90,consult the doctor for better control of BP
- If user gets CKD initiate and treat to lower MBP<140/90mmHg
- If user gets diabetes initiate and treat to lower MBP<140/90mmHg

Recommendation 7:

For a person who is taking BP medication and a person who is going to get a high chance of BP but healthy, perform ABPM for a six months interval to find nocturnal BP, stress inducing activity (sometime may be your job).

Recommendation 8:

At any time when the user feels high BP (under stress) measure BP three times in thirty seconds interval. If the mean BP of three measurements is >=180/100 mmHg, consult the doctor immediately.

Recommendation 9:

Using machine learning approach fine tune the personalized LSM for every month

Recommendation 10 (future work):

From historical data of a specific user and other BP patients data, predict the chance of getting high risk diseases using suitable AI algorithms

FLOWCHART

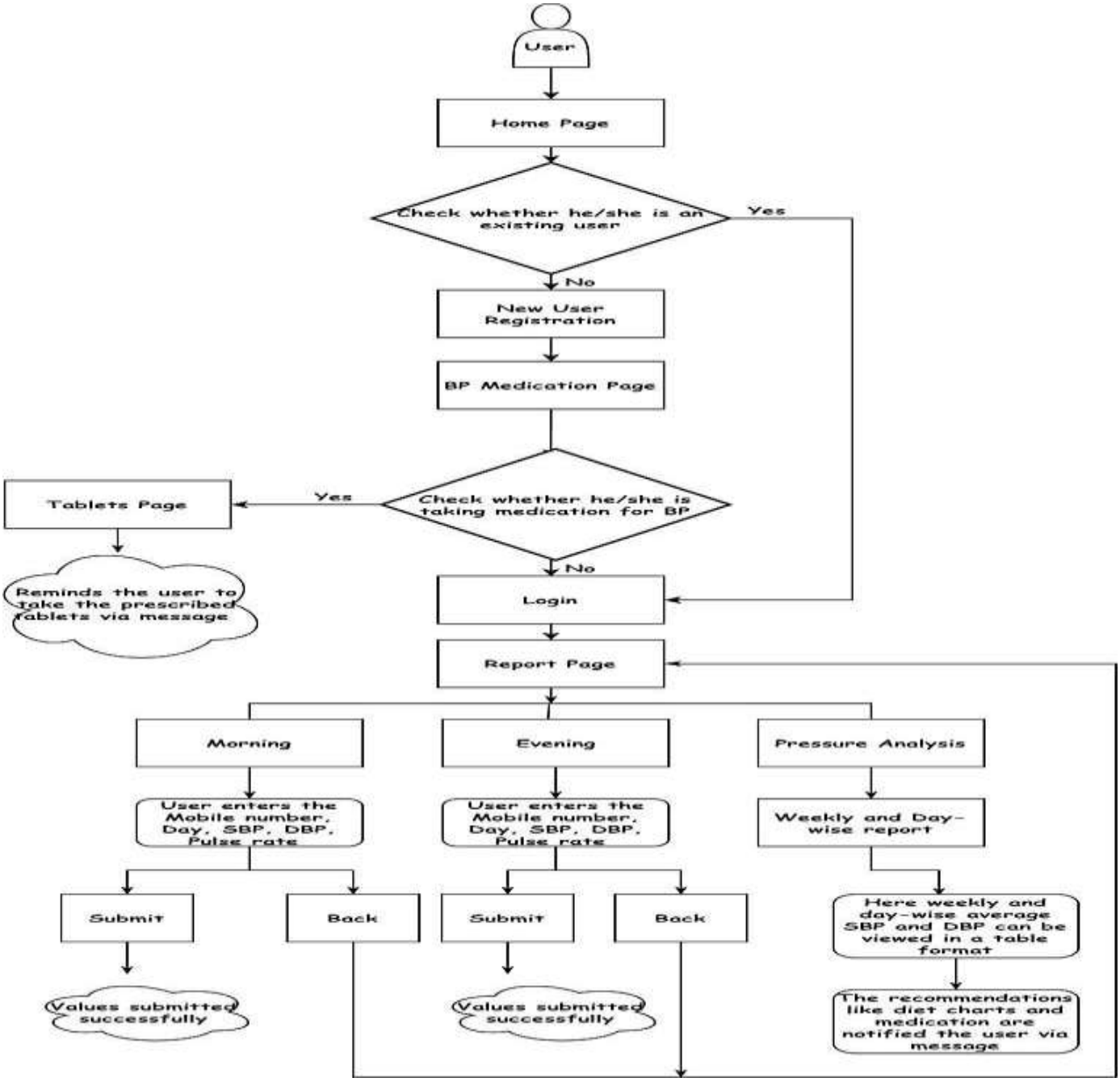

Figure 5: Flowchart for Recommender System for BP monitoring and control

V. RESULTS ANDDISCUSSION

As per the flowchart, the user enters the login credentials if he/she is an existing user; otherwise they fill the new user registration form. Then the details regarding the medication will be obtained from the user. Then the user enters the SBP and DBP values in both the morning and evening page. If not, the user will be notified via message to enter the values. After a week the user can visualize the average SBP and DBP values in a table format. A message will be sent to the user regarding their BP values, diet chart to be followed and some recommendations based on the values.

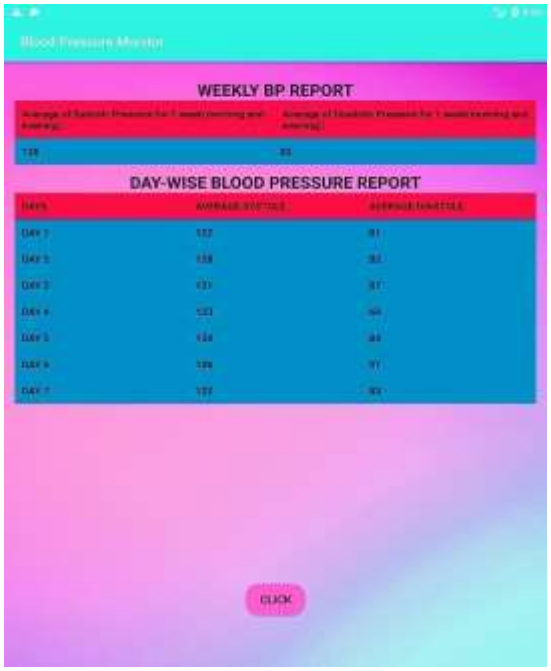

Figure 6:Table showing weekly and day-wise BP report

Figure 7:Notification sent to the user regarding Average BP value

Figure 8: Table representing the low, normal and high BP range

Figure 9: Table representing the diet chart

Future Enhancements

Till now we have provided a brief outline about a mobile application which keeps logs of BP values and provides recommendations based on average BP value. Further we would like to extend our project by developing a mobile application which concentrates more on BPV and to interpret the values in the form of graphical representation.

VI. CONCLUSION

In today's healthcare market there is a need for a system to monitor BP periodically and to provide personalized lifestyle recommendations based on the history that remains weak. Here, we proposed a recommender system to monitor BP accurately, log BP, and provide personalized lifestyle recommendations in terms of medication and diet chart. Our BP recommender system will be very useful to the general public, healthcare service providers, doctors and data scientists and finally for the pharmaceutical company. Our mobile application notifies the user regarding their average SBP and DBP values, the diet chart to be followed and it reminds the user to enter the BP values if they failed to enter. Thus this mobile application helps the user to monitor their blood pressure and helps the user to control both hypertension and hypotension by following the diet chart, regular workouts and prescribed medication.

VII. REFERENCES

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