

Patient Blood Pressure and Pulse Rate Monitoring With an Alert System Using the Omron 790it Blood Pressure Monitor

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Abstract

Blood pressure and pulse rate are two of the vital signs of humans and it is imperative that the chronically ill and the elderly patients need to have their blood pressure and pulse rate checked from time to time. This paper describes the use of the Omron 790it blood pressure monitor to check the blood pressure and the pulse rate of patients. This is achieved by transferring the readings taken by the Omron blood pressure monitor into the computer and using an Applications program developed with Visual Basic compiler called the Blood Pressure Loader (BPL) to automatically upload the blood pressure and pulse rate readings taken by the Omron blood pressure monitor directly into the hospital database. An alert can also be sent to the doctor's phone wherever he is so that he can proffer a solution. The result of this research work is that patients can monitor their own blood pressure and pulse rate even from their homes and transfer the readings into the computer after which it can be uploaded into the hospital's database. This has the capacity of giving the doctor a timely and detailed medical information on the vital signs of patients and will save many lives that may be lost.

Keywords: Omron 790it, Blood Pressure Loader, CSV, Alert System

Introduction

The *Omron HEM-790IT* is the ultimate tool for keeping accurate track of the blood pressure and pulse rate ^[1]. This automatic blood pressure monitor is the highest specification of the Omron home use BP monitors with an arm cuff. It combines ease of use, precision and comfort along with making use of the ultimate in computer technology to allow you to see any fluctuations in your blood pressure in one easy glance. Ideal for both medium and large sized arms, the Omron HEM-790IT with Advanced Omron Health Management Software is fitted with the innovative 'Comfit Cuff', specifically

designed for quick and correct positioning along with ultimate comfort. No need for a second person to aid you, simply wrap the cuff around your arm and, at a single press of a button, your blood pressure, pulse rate and any *cardiac arrhythmias* (heart beat irregularities) are calculated. The monitor benefits from Omron's 'IntelliSense' technology ^[1].

This is a great feature which takes your blood pressure into account and inflates the cuff to the individual needs at that exact point. This is especially important for those people with various arrhythmias or cardiac conditions which can cause

blood pressure fluctuations. It also avoids unnecessary over inflation of the cuff which can prove uncomfortable. The Omron 790-ITn which includes Omron Health Management Software enables you to easily download your blood pressure results via USB to your computer. Within a few seconds you will have a simple to understand graph which will show the exact trends of both your blood pressure and pulse rate over a period of time; perfect for noting any times of day when hypertension seems to be at a maximum. This software supports two separate users and clearly shows both systolic and diastolic blood pressures.

The blood pressure and the pulse rate are two of the vital signs of human beings. It becomes very important to monitor these vital signs especially in the chronically ill and elderly patients. The continuous monitoring of these vital signs can go a long way to reduce the number of avoidable deaths in our hospitals.

Blood pressure (BP) is the pressure exerted by circulating blood upon the walls of blood vessels, and is one of the principal vital signs [2]. When used without further specification, "blood pressure" usually refers to the arterial pressure of the systemic circulation. During each heartbeat, BP varies between a maximum (systolic) and a minimum (diastolic) pressure [3]. The mean BP, due to pumping by the heart and resistance to flow in blood vessels, decreases as the circulating blood moves away from the heart through arteries. Blood pressure drops most rapidly along the small arteries and arterioles, and continues to decrease as the blood moves through the capillaries and back to the heart through veins [4]. Gravity, valves in veins, and pumping from contraction of skeletal muscles are some other influences on BP at various places in the body.

The measurement *blood pressure* without further specification usually refers to the systemic arterial pressure measured at a person's upper arm. It is measured on

the inside of an elbow at the brachial artery, which is the upper arm's major blood vessel that carries blood away from the heart. Blood pressure readings are measured in millimeters of mercury (mmHg) using sphygmomanometer. Two pressures are measured and recorded namely as systolic and diastolic pressures. Systolic pressure reading is the first reading, which represents the maximum exerted pressure on the vessels when the heart contracts, while the diastolic pressure, the second reading, represents the minimum pressure in the vessels when the heart relaxes [5]. A person's BP is usually expressed in terms of the systolic pressure over diastolic pressure (mmHg), for example 140/90 [5].

- **Systemic arterial blood pressure**

Table 1.1: Systemic arterial blood pressure

Classification of blood pressure for adults		
Category	systolic, mmHg	diastolic, mmHg
Hypotension	< 90	< 60
Desirable	90–119	60–79
Prehypertension	120–139	or 80–89
Stage 1 Hypertension	140–159	or 90–99
Stage 2 Hypertension	160–179	or 100–109
Hypertensive Crisis	≥ 180	or ≥ 120

Source: *Physiol* Vol. 84, Issue 6, 2033-2042, June 1998

Normal Pulse Rates - Normal pulse rates at rest, in beats per minute (BPM):

Table 1.2: Normal Pulse Rates

newborn	1 – 12 months	1 – 2 years	2 – 6 years	7 – 12 years	13 years – adults	adult athletes
120 – 160	80 – 140	80 – 130	75 – 120	75 – 110	60 – 100	40 – 60

Source: *Physiol* Vol. 84, Issue 6, 2042-2051, June 1998

2. The Architecture

Figure 2.1 below shows the overview of the architecture of the blood pressure monitoring and alert system. The patient fixes the cuff of the blood pressure monitor on his upper left arm and presses the start button. This activates the blood pressure monitor which inflates the cuff automatically until when it gets to its peak, after which the cuff will start to deflate. After the deflation, the blood pressure and the pulse rate readings appear on the window of the monitor. If the patient is at home, he can take the readings from time

to time until after about one week, when he takes the monitor to the nurse in the hospital for the analysis. The patient can transfer the readings to the laptop using the USB cable provided. If the patient is in the hospital, the nurse can take the readings at an interval depending on the condition of the patient.

The nurse or the patient transfers the readings to the computer using the USB cable provided. A CSV (Comma-Separated Values) file will be created which puts the readings in a tabular form.

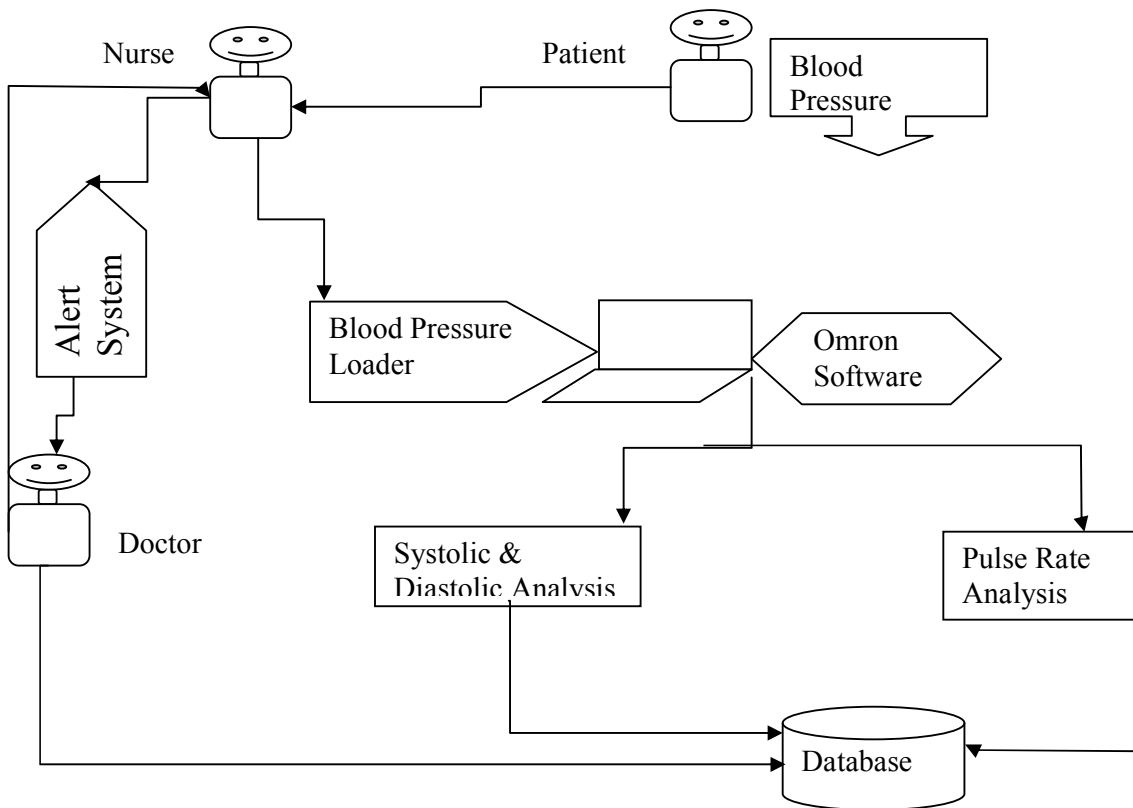


Fig. 2.1: The Architecture of the Blood Pressure Monitoring and Alert System

A program called the Blood Pressure Loader uploads the CSV file in the computer automatically into the database and is able to send an alert into the doctor's phone so that wherever the doctor is, he will be able to proffer a solution. If the program is hosted on the internet, it means the doctor on getting the alert can go to the internet wherever he is to view the patient's vital sign history and also proffers a solution.

The nurse on receiving the patient's readings transfers it into the computer. She launches the blood pressure loader and uploads the patient's readings into the computer. She can also send an alert to the doctor if the patient has abnormal readings. If the patient is in the hospital, the nurse will be the one to take the readings and transfer them into the computer as the case may be.

3. Discussion

A patient's blood pressure and pulse rate can be conveniently monitored even if the patient is at home. All the patient needs to do is to always check his blood pressure at the interval prescribed by the doctor. After getting a considerable number of results, the patient transfers the readings into his computer. He creates a CSV file using the Omron software. He then launches the Blood Pressure Loader program, uploads the CSV file into the database (if the patient is literate enough). Otherwise the patient takes the readings

(BPL) was written in Visual Basic which and after about one week, he takes the blood pressure monitor to the nurse so that she can transfer the readings to the computer and then create a CSV file which she stores in the computer. The nurse can also look at the database and view the different patients' data and if there is an abnormality, she initiates and sends the alert to the doctor on his phone. The doctor in turn will check the database for the patient's records looks at it and proffers his solution.

The patient can also initiate the alert system if he has been tutored on the trend of blood pressure and pulse rate measurement. He (the patient) can as well send the alert to the doctor directly and the doctor will instruct him on what to do.



Fig. 3.1: Omron HEM-790IT blood pressure monitor



Fig. 3.2: The blood pressure Loader

This is the output of the program written in visual Basic. The nurse or the patient uses it to upload the patient's readings into the hospital database. She can also initiate and send an alert to the doctor using this program.

- **Setting the port number**

The com port to be selected depends on the com port assigned to the particular phone or modem used to establish this connection.

To check the com port on your Bluetooth device

- Click on start – Control Panel
- Click on Bluetooth devices
- Select the Bluetooth device you want to check
- Click on Properties
- Click on Services

- The com port with other services rendered by the Bluetooth device is displayed.

A smart phone is used to initiate a connection with the computer using a Bluetooth. Therefore the port number used to establish this connection must be stated. (the port number assigned to the smart phone I am using is com port 5). If the patient is only uploading his data without sending an alert, he will select 'Anyone'. In that case he does not need to type the doctor's name and phone number, he simply uploads his data, but if he is sending it to a particular doctor, then he needs to select "A doctor" and then types the doctor's name , phone number, the key and his message. He will then open his already saved CSV file and click "Upload CSV Data Now". The patient's information is uploaded automatically into the hospital's server.

Because this data travels over networks, it is encrypted. The patient enters the encryption key under "key 1" which appears as a plus sign. The key used for this encryption appears on the doctor's phone when he gets the message so that he can use that key to decrypt it.

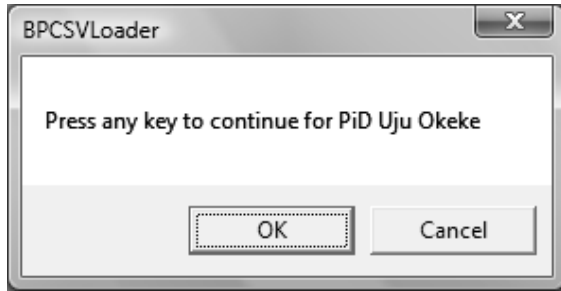


Fig. 3.3: BPCSV Loader

This is used to continue the uploading. Clicking Ok continues with the upload and clicking Cancel, cancels it.



Fig. 3.4: Doctor Alert

When the patient or the nurse clicks on yes to send a message to the doctor, a connection is established between the computer and the phone's Bluetooth and with that, the alert is sent directly to the doctor's phone number indicated.

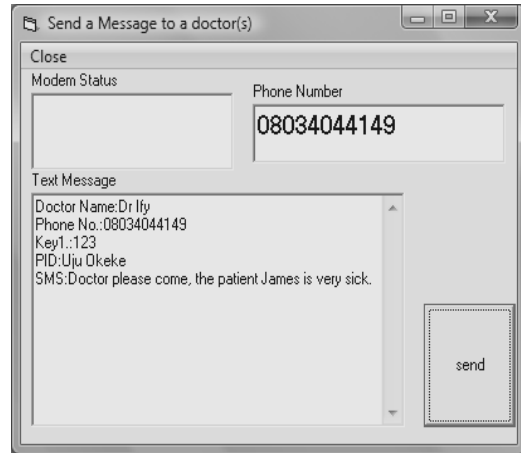


Fig. 3.5: Send a message to a doctor
This shows the details of the information sent to the doctor. Clicking send will send the information displayed above to the doctor's number stated above.



Fig. 3.6: Message Sent

When this appears on the screen, it shows that the message has been sent. The doctor will receive the message on his phone; he can check the database, view the patient's readings and then give his expert advice.

User Name	Memo 1	Memo 2	Date	Time	SVS (mmHg)	DIA (mmHg)	Pulse (Pulses/min)	Irregular	Excessive	Memo (y)	MsCnt1	MsCnt2	MsCnt3	InputType	MeasureType
Uju Okeke	Ph.D Student	2nd Seminar	4/24/2011	11:35:36 PM	118	84	66	n	n	n	0	0	0	0	2
Uju Okeke	Ph.D Student	2nd Seminar	4/30/2011	2:35:52 PM	123	82	83	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	4/30/2011	2:36:32 PM	121	83	72	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	4/30/2011	2:37:14 PM	119	81	74	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	5/2/2011	11:46:24 AM	103	69	72	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	5/2/2011	11:47:12 AM	96	63	79	n	y	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	5/2/2011	11:48:42 AM	96	70	74	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	5/2/2011	11:50:05 AM	110	77	93	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	5/2/2011	11:51:07 AM	110	79	83	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	5/2/2011	11:52:13 AM	120	82	85	n	y	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	5/2/2011	11:53:04 AM	125	89	75	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	5/26/2011	9:18:49 AM	135	79	79	n	n	n	0	0	0	0	0
Uju Okeke	Ph.D Student	2nd Seminar	5/26/2011	9:19:37 AM	130	83	77	n	n	n	0	0	0	0	0
Uju Okeke	Ph.D Student	2nd Seminar	5/26/2011	9:38:34 AM	120	78	82	n	n	n	0	0	0	0	0
Uju Okeke	Ph.D Student	2nd Seminar	5/27/2011	10:31:30 PM	115	78	78	n	n	n	0	0	0	0	2
Uju Okeke	Ph.D Student	2nd Seminar	5/27/2011	10:32:23 PM	113	80	78	n	n	n	0	0	0	0	2
Uju Okeke	Ph.D Student	2nd Seminar	5/27/2011	10:33:16 PM	117	79	77	n	n	n	0	0	0	0	2
Uju Okeke	Ph.D Student	2nd Seminar	5/27/2011	10:34:00 PM	110	79	80	n	n	n	0	0	0	0	2
Uju Okeke	Ph.D Student	2nd Seminar	5/27/2011	10:34:45 PM	111	77	79	n	n	n	0	0	0	0	2
Uju Okeke	Ph.D Student	2nd Seminar	6/21/2011	10:32:32 AM	119	81	66	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	6/21/2011	10:33:22 AM	123	76	62	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	6/21/2011	10:34:06 AM	114	72	61	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	6/21/2011	10:34:49 AM	109	72	62	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	6/21/2011	10:35:34 AM	112	75	64	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	6/21/2011	10:36:16 AM	114	72	65	n	n	n	0	0	0	0	1
Uju Okeke	Ph.D Student	2nd Seminar	7/26/2011	12:32:04 AM	122	69	73	n	n	n	0	0	0	0	2

Fig. 3.7: CSV file

This is an overview of the CSV file created by the Omron Software.

4.0 The Analysis and Results

The Blood Pressure readings of the patient ‘A’ taken over a period of one week is shown in the table below.

Table 4.1: Blood Pressure Readings of Patient ‘A’

Date	Time	SYS (mmHg)	DIA (mmHg)	Pulse (Pulses/min)
24/04/2011	7:35:36 AM	118	84	66
24/04/2011	2:35:52 PM	123	82	83
24/04/2011	9:36:32 PM	121	83	72
25/04/2011	7:37:14 AM	119	81	74
25/04/2011	2:46:24 PM	103	69	72
25/04/2011	9:47:12 PM	96	63	79
26/04/2011	7:48:42 AM	96	70	74
26/04/2011	2:50:05 PM	110	77	93
26/04/2011	9:51:07 PM	110	79	83
27/04/2011	7:52:13 AM	120	82	85
27/04/2011	2:53:04 PM	125	89	75
27/04/2011	9:32:04 PM	135	79	79
28/04/2011	7:18:49 AM	130	83	77
28/04/2011	2:19:37 PM	120	78	82
28/04/2011	9:38:34 PM	115	78	78
29/04/2011	7:34:00 AM	113	80	78
29/04/2011	2:32:23 PM	117	79	77
29/04/2011	9:33:16 PM	110	79	80
30/04/2011	7:33:22 AM	111	77	79
30/04/2011	2:34:45 PM	119	81	66
30/04/2011	9:32:32 PM	123	76	62

$$\text{Blood Pressure} = \frac{\text{Systolic Pressure}}{\text{Diastolic Pressure}} \quad (1)$$

Table 4.1 above shows the readings of blood pressure and the pulse rate of the patient 'A' taken over a period of one week using the Omron 790IT blood pressure monitor. From the readings, it can be seen that the blood pressure and the

pulse rate kept fluctuating so it is necessary to take the average of the readings every day to determine the blood pressure for the patient for that particular day.

The average blood pressure and pulse rate readings for patient 'A' on 24/04/11 is

Table 4.2: Blood Pressure readings of Patient 'A' on 24/04/11

Time	Systolic Pressure	Diastolic Pressure	Pulse Rate
7:35:36 AM	118	84	66
2:35:52 PM	123	82	83
9:36:32 PM	121	83	72
Total	362	249	221

The mean blood pressure and pulse rate =

$$\text{Sys} = \frac{362}{3}; \text{Dia} = \frac{249}{3}; \text{Pulse} = \frac{221}{3}$$

$$\text{Sys} = 120.6; \text{Dia} = 83; \text{Pulse} = 73.6 \quad (2)$$

So the blood pressure for the patient 'A' on 24/04/11 is

$$\text{Blood Pressure} = \frac{\text{Sys}}{\text{Dia}} = \frac{121}{83} \text{ and the pulse rate is } 74 \quad (3)$$

On 25/04/11

Table 4.3: Blood Pressure readings of Patient 'A' on 25/04/11

The mean blood pressure and pulse rate =

$$\text{Sys} = \frac{319}{3}; \text{Dia} = \frac{232}{3}; \text{Pulse} = \frac{225}{3}$$

Time	Systolic Pressure	Diastolic Pressure	Pulse Rate
7:48:42 AM	96	70	74
2:50:05 PM	110	77	93
9:51:07 PM	110	79	83
Total	316	226	250

$$\text{Sys} = 106; \text{Dia} = 77.3; \text{Pulse} = 75$$

So the mean blood pressure for the patient 'A' on 25/04/11 is

$$\text{Blood Pressure} = \frac{\text{Sys}}{\text{Dia}} = \frac{106}{77} \text{ and the pulse rate is } 75$$

On 26/04/11

Table 4.3: Blood Pressure readings of Patient 'A' on 26/04/11

The mean blood pressure and pulse rate =

$$\text{Sys} = \frac{316}{3}; \text{Dia} = \frac{226}{3}; \text{Pulse} = \frac{250}{3}$$

$$\text{Sys} = 105.3; \text{Dia} = 75.3; \text{Pulse} = 83.3$$

Time	Systolic Pressure	Diastolic Pressure	Pulse Rate
7:52:13 AM	120	82	85
2:53:04 PM	125	89	75
9:32:04 PM	135	79	79
Total	380	250	239

So the mean blood pressure for the patient 'A' on 26/04/11 is

$$\text{Blood Pressure} = \frac{\text{Sys}}{\text{Dia}} = \frac{105}{75} \text{ and the pulse rate is } 83$$

On 27/04/11

Table 4.4: Blood Pressure readings of Patient 'A' on 27/04/11

The mean blood pressure and pulse rate =

Time	Systolic Pressure	Diastolic Pressure	Pulse Rate
7:37:14 AM	119	81	74
2:46:24 PM	103	69	72
9:47:12 PM	96	63	79
Total	318	231	225

$$\text{Sys} = \frac{380}{3}; \text{Dia} = \frac{250}{3}; \text{Pulse} = \frac{239}{3}$$

$$\text{Sys} = 126.7; \text{Dia} = 83.3; \text{Pulse} = 79.6$$

So the blood pressure for the patient 'A' on 27/04/11 is

$$\text{Blood Pressure} = \frac{\text{Sys}}{\text{Dia}} = \frac{127}{83} \text{ and the pulse rate is } 80$$

On 28/04/11

Time	Systolic Pressure	Diastolic Pressure	Pulse Rate
7:18:49 AM	130	83	77
2:19:37 PM	120	78	82
9:38:34 PM	115	78	78
Total	365	239	237

Table 4.5: Blood Pressure readings of Patient 'A' on 28/04/11

The mean blood pressure and pulse rate =

$$\text{Sys} = \frac{365}{3}; \text{Dia} = \frac{239}{3}; \text{Pulse} = \frac{237}{3}$$

$$\text{Sys} = 121.6; \text{Dia} = 79.7; \text{Pulse} = 79$$

So the blood pressure for the patient 'A' on 28/04/11 is

$$\text{Blood Pressure} = \frac{\text{Sys}}{\text{Dia}} = \frac{122}{80} \text{ and the pulse rate is } 79$$

On 29/04/11

Table 4.6: Blood Pressure readings of Patient 'A' on 29/04/11

Time	Systolic Pressure	Diastolic Pressure	Pulse Rate
7:34:00 AM	113	80	78
2:32:23 PM	117	79	77
9:33:16 PM	110	79	80
Total	340	238	235

The mean blood pressure and pulse rate =

$$\text{Sys} = \frac{340}{3}; \text{Dia} = \frac{238}{3}; \text{Pulse} = \frac{235}{3}$$

$$\text{Sys} = 113.3; \text{Dia} = 79.3; \text{Pulse} = 78.3$$

So the blood pressure for the patient 'A' on 29/04/11 is

$$\text{Blood Pressure} = \frac{\text{Sys}}{\text{Dia}} = \frac{113}{79} \text{ and the pulse rate is } 78$$

On 30/04/11

Table 4.7: Blood Pressure readings of Patient 'A' on 30/04/11

Time	Systolic Pressure	Diastolic Pressure	Pulse Rate
7:33:22 AM	111	77	79
2:34:45 PM	119	81	66
9:32:32 PM	123	76	62
Total	353	234	207

The mean blood pressure and pulse rate =

$$\text{Sys} = \frac{353}{3}; \text{Dia} = \frac{234}{3}; \text{Pulse} = \frac{207}{3}$$

$$\text{Sys} = 117.6; \text{Dia} = 78; \text{Pulse} = 69$$

So the blood pressure for the patient 'A' on 30/04/11 is

$$\text{Blood Pressure} = \frac{\text{Sys}}{\text{Dia}} = \frac{117}{78} \text{ and the pulse rate is } 69$$

The mean blood pressure and pulse rate of the patient 'A' over a period of one week is shown in the table below:

Table 4.8: Mean Blood Pressure and Pulse Rate of Patient ‘A’

Date	Systolic	Diastolic	Pulse	Suggestions
4/24/11	121	83	74	Pre-hypertension
4/25/11	106	77	75	Desirable
4/26/11	105	75	83	Desirable
4/27/11	127	83	80	Pre-hypertension
4/28/11	122	80	79	Pre-hypertension
4/29/11	113	79	78	Desirable
4/30/11	117	78	69	Desirable

From the readings obtained in the table above, it can be seen that the patient has pre-hypertension in some of the days and has a desirable blood pressure in some of the days. It is now left for the doctor to determine the best advice or treatment to :

give to the patient for optimal result. However, the pulse rate is normal for all the days since the pulse rate is less than 100 in all the days.

The figures obtained in the table above can be used to draw the charts below

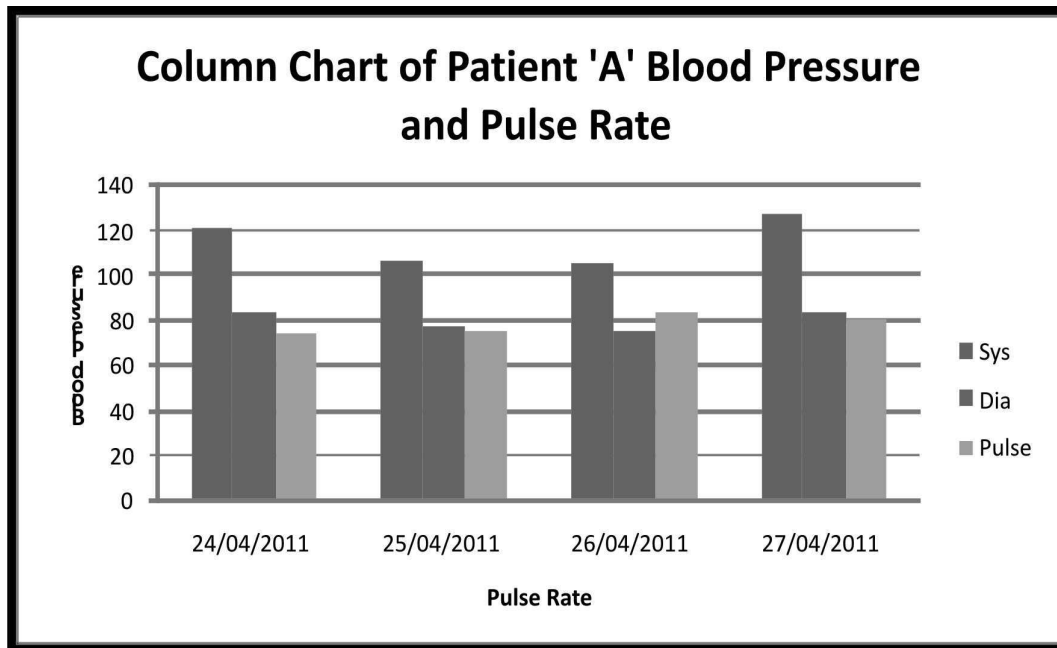


Fig. 3.8 Sample bar chart of blood pressure and Pulse Rate

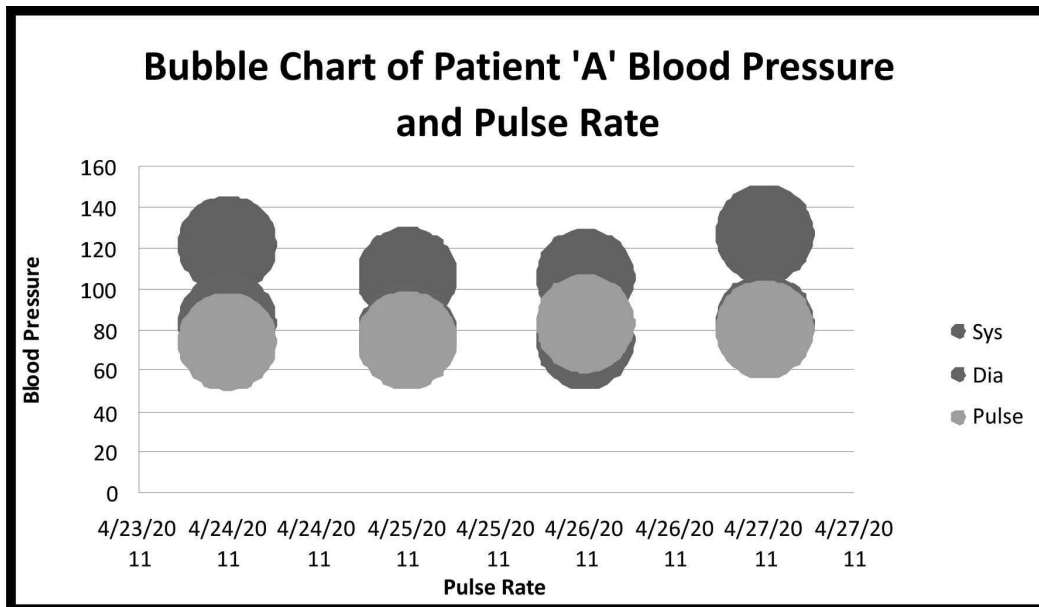


Fig. 3.9 Buble Chart of Patient A Blood Pressure and Pulse Rate

The doctor can quickly glance through the charts to understand the trend the patient's reading is taking and give his expert advice.

5.0 Conclusion:

A blood pressure alert system has been designed and presented. It has been shown that a patient can be at home and check his blood pressure and pulse rate using the Omron 790IT blood pressure monitor, after which he sends it to the hospital where the nurse uses the blood pressure

loader to automatically upload the patient's readings to the hospital server. The nurse can also send an alert to the doctor's phone when there is an abnormal reading. The doctor in turn can check the hospital database to see the detailed readings of the patient's blood pressure and pulse rate and proffers a solution. By so doing, more wards will be available for other patients and the doctors can take accurate and timely decisions which are capable of saving lives.

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