

A Framework Study of a Central Database of Hypertension Patients Recommended by Wearable Sensors

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ABSTRACT

In most developing countries there are so many barriers to health care delivery and the wellbeing of the citizenry, the two cardinal points of the millennium development goal. Such barriers include; poor road networks, undulating terrain, unacceptable ratio of doctor to patients, poor medical facilities etc. The framework for telenursing hypertension patients was necessitated by the findings that patients are discouraged from checking their blood pressure due to the long distance they have to travel to a medical facility for the check-up. Secondly, they have to wait endlessly before they are attended to thereby adding more stress and increasing the pressure of the blood. In order to mitigate these ordeals, a platform where a patient's blood pressure and other vital signs are regularly checked and reported to a medical personnel like a nursing officer is proposed. The platform has the potential of enhancing uninterrupted access to a patient for prompt health care delivery. The initial cost of setting up such a platform is however prohibitive but the long term benefits outweigh this initial cost. Further study will implement the framework and compare the results with the results obtained in this study.

KEYWORDS

Hypertension; Telenursing; Blood pressure; Diastolic; Systolic.

1. Introduction

One of the cardinal points of the United Nations third sustainable goals is good health and well-being. This goal is greatly hampered by poor access to quality medical care. Going by the World Health Organization (WHO, 2015) reports, the developing countries of the world lag behind in health care facilities; whereas in Europe there are 32.1 medical doctors to its 10,000 population, there are only 2.7 doctors to 10,000 population in Africa. This statistics is made more worrisome by the fact that the developing nations lack access to potable water, the environment is more prone to diseases and the general socio-economic well-being impacts hardship and stress to the populace. Poor road networks and in some cases undulating terrain have also been seen to

hamper access to medical facilities especially in the rural and remote areas. Poor living conditions of most people in the developing countries coupled with excessive workload without adequate rest sometimes result in someone's blood pressure rising beyond the normal threshold. Long queue of people waiting to be attended to by a medical doctor adds more pressure and stress to the patient.

The mortality rate due to cardiovascular diseases seems to be higher in the developing countries than elsewhere. WHO (2016) report shows that cardiovascular diseases (CVDs) are responsible for 17.9 million deaths representing 31% of all deaths in the world. 7.5% of CVDs deaths occur in developing countries while 85% of all CVDs deaths are due to heart attack and strokes. According to American Heart Association (2016a), the major CVDs include coronary heart disease, stroke and hypertension. Hypertension can also lead to kidney failure and other health challenges. Kazem et al (2016) report that half the number of people in Iran who are older than 55 years have hypertension with the country having the fifth in global ranking of hypertension patients. 54% of strokes, 47% of Ischemic heart diseases and 25% of other cardiovascular diseases in Iran are caused by hypertension according to Dasgupta et al (2014). Altun et al (2005) report 31.8% of hypertension in Turkey with 36.1% for women and 27.5% for men.

Although accurate record of hypertension cases cannot be ascertain in Nigeria, the rising increase in sudden death is a concern to the populace and the health practitioners. Telecommunication has helped to get vital information of the health status of neighbourhoods especially when such cases are getting almost out of hand. According to Okafor et al (2016), the teledensity growth of Nigeria rose from 16.7% in 2000 to 91.7% in 2016 and 148.4% in 2018. This success story in telecommunication could be harnessed to improve health care delivery in Nigeria. The delivery of health care services via telecommunication is currently at a nascent stage in Nigeria. One platform that telecommunication could be of immense benefit is telenursing, a tool that enhances the practice of nursing without the barrier of distance. The transfer of expertise's knowledge is paramount in telenursing and it is aimed at discouraging unnecessary travelling of patients. By so doing, nursing services are extended to isolated, geographically dispersed and physically confined patients who are unable to reach a medical facility within a reasonable time and distance, Rao (2001). A wide variety of internal and external examinations can be carried out when the patient is far away from the care giver. This could be done with the use of endoscopic cameras that peer into the interior of the patient located at a distance.

In this study, a framework for telenursing hypertensive patients is presented having studied and identified that the problems of traveling to obtain medical care from a remote location complicates the illness of a patient. The challenges and prospects of practicing telenursing are also presented. In Section 2, reviewed literature is presented, data collected and analysed with the results are presented in Section 3. The framework for telenursing hypertensive patients along with the problems and prospects of practicing telemedicine is presented in Section 4, conclusion of the research is presented in Section 5.

2. Literature

According to Guyton and Hall (2000), many cardiologists consider systolic pressure of 160mmHg and diastolic pressure of 100mmHg (160/100mmHg) to be hypertensive. WHO (2005) reports that individuals whose blood pressure is normal when they are 55 years have 99% lifetime risk of developing hypertension. According to Jarvis (1996), the level of blood pressure is determined by the following factors:

- a. Cardiac Output; if the heart pumps more blood into the vessel, the pressure on the vessel wall increases.
- b. Peripheral Vascular Resistance; this is the resistance to blood flow through the arteries. When the vessel becomes smaller, the pressure needed to push the contents (blood) becomes greater.
- c. Volume of circulating blood; this is how tight the blood is packed into the arteries. Increasing the contents of the vessel increases the pressure.

- d. Viscosity; the thickness of blood is determined by its formed elements; that is the blood cells, when the contents are thick the pressure increases.
- e. Elasticity of the vessel walls; when the vessel walls are stiff and rigid the pressure needed to push the contents increases.

The effect of hypertension are often lethal, these are caused in the following ways:

- a. Excess workload on the heart leads to early heart failure and coronary heart disease, often causing death as a result of heart attack.
- b. The high pressure frequently ruptures a major blood vessel in the brain followed by death of a major portion of the brain; this is called cerebral infarct i.e. stroke depending on which part of the brain is involved.
- c. High pressure almost always causes multiple hemorrhages in the kidneys, producing many areas of renal destruction and eventually kidney failure, uremia and death.

Hypertension is believed to have affected almost 1 billion people worldwide according to Nixon et al (2009). They stated that people whose age ranges from 40-70 years show increment of 20mmHg in systolic and 10mmHG in diastolic pressure doubles the risk of cardiovascular diseases.

Kazem et al (2016) compare the effects of two methods of self monitoring and telenursing on the blood pressure of patients with hypertension. A 3-group-4-stage clinical trial was conducted on 84 patients of 3 groups of self monitoring, telenursing and control containing 28 patients each. The mean of systolic and diastolic blood pressure was measured monthly for the 3 months and for each group. Results show a significant difference between the group with the telenursing group showing a more effective decrease in both systolic and diastolic measures compared to the self monitoring group.

Yildiz and Erci (2016), studied the effects of self-care model on blood pressure levels and self-care agency in hypertensive patients. A pre-test and post test quasi experimental model with a control group was used on 104 patients with 51 in the control group and 53 in the experimental group. T-test was used to compare the pre-test and post-test score means between the experimental group and the control group and their corresponding within group test. It was also used to compare dependent group in terms of the pre and post test intervention.

A statistically significant decrease was observed in the post test systolic blood pressure in the test group compared with the pretest value ($p < 0.01$). A decrease diastolic blood pressure of patients in the control group was also statistically significant ($p < 0.05$). Also observed was a statistically significant difference in blood pressure of the pre intervention and post intervention test ($p < 0.05$ and $p < 0.01$). Pretest self-care agency mean was 93.11 ± 11 in the test group and 94.13 ± 22.33 in the control group.

Okorafor et al (2017) highlighted the problems of telemedicine in Africa to include; ignorance, poverty, dearth of basic infrastructure, poor communication networks and diverse understanding and beliefs about the cause of ailments. They however posited that despite these challenges, telemedicine possesses the potentials of transmitting health information for the diagnosis and treatment of diseases at affordable cost. This is more so with the warm embrace of the mobile communication by majority of the populace. Glinkowski et al (2013) conducted a study to evaluate the knowledge and attitude of nursing students towards telenursing. 308 nursing students from medical universities in Poland were used for the study. Results show that majority of the students had fair knowledge of telenursing and telemedicine and were ready for it to be incorporated in the nursing curriculum.

According to Godstime et al (2010), the benefits of telehealth include; support of health care delivery in distant remote sites and villages, connection of primary care physicians, providers, specialists and patients, offering of improved access to quality health care delivery. There are pilot telemedicine scheme projects supervised by National Space Research and Development Agency in 8 tertiary health institutions in Nigeria. The prospects and challenges of telemedicine in Nigeria are discussed in Ukaoha and Egbokhare (2012). According to them, the inadequate number of medical doctors, the unevenly distribution of these few doctors between rural and urban areas and the bad road networks have made medical health care delivery very expensive and sometime elusive in Nigeria. Telemedicine if properly harnessed could help mitigate these challenges.

Rao (2001) discussed the impacts of integrated health care and telemedicine and its use in fetal medicine, endoscopy, medical education, and pathology. The advantages of telemedicine are enumerated to include that of expansion and export of skills and cost savings. Mayoka et al. (2012) developed a framework for designing sustainable telemedicine information system in developing countries based on Henver et al model. Data collected from two hospitals in Uganda were used and analysed using descriptive statistics and content analysis method. Findings of their research identified speed, ease of use and affordability as the main needs for a sustainable design.

Lockamy and Smith (2009) identified Telemedicine as a process enabler for enhanced healthcare delivery. This was discovered after a field research carried out in 4 health care organisations and a study of existing literature. Some challenges such as cost of implementation, quality of transmission and complexity of equipment were however identified. In order to provide advice on a system that can evaluate the condition of the facial skin and match with appropriate beauty cosmetic products, Hsu (2019) developed a customer-oriented skin detection and care system in a telemedicine platform. Facial skin was recorded with digital images while skin detection was performed using image processing technology. Findings show that normal skin deteriorates with age, oily skin improves with age up to the middle age (20-29 years) and then begins to wear down while dry skin increases with age.

Bidirectional mistrust from both nurses and callers (patients) was identified as a major set back in the national telephone advice nursing project, a Swedish health care direct project. Nurses were also found to be passing the buck to their patients according to Bjorkman and Salzmann (2018) who carried out the online descriptive research. Brownsell (2009) investigated the success of telehealth interventions and listed the following as the indices to success; integration of services, reduction in health inequalities and improved access to health care. Goodwin (2010) investigated the state of telehealth in the United kingdom (UK), his findings revealed key barriers include; lack of robust evidence on cost-effectiveness, interoperability of technology between service actors and implementation for professionals and organizations of changing their established methods of practice. About 1.7 million are beneficiary of telecare services in UK but only 5000 use telehealth

Gagon et al (2006) reviewed several literatures on telehealth and administered questionnaires through telephone to 32 hospitals' administrators to determine which organizational factors influence the adoption of telehealth. From the in-depth study of 9 out of the 32 hospitals and analysis of the questionnaires and the literature it was revealed that telehealth programmes are not isolated but are located within a larger health organizations. Also that healthcare organizations are located in a larger geographical, economical and socio-political environment. Leite et al (2020) discussed the role of telehealth technologies in managing the COVID-19 pandemic. From the observation of telehealth usage it was revealed that it was possible to depend on telehealth technologies to avoid the spread of corona virus by tracking, testing and treating. Based on this, a 3Ts model of Tracking, Testing and Treating was proposed by the authors.

3. Data Collection

Data were collected from 40 patients who check their blood pressure in a medical facility from their residence located few kilometers away. The datasets are presented in Table 1. The analysis of the datasets was carried in MATLAB programming environment and the graphical representations of the analysis are presented in Figure 1 to Figure 4.

Table 1. Datasets of Hypertensive Patients

Sex	Age	Height	Weight	Home SYS	Home DIA	Hosp SYS	Hosp DIA	Distance (km)
Female	38	1.5	41	132	87	130	85	6
Female	39	1.56	103	133	85	125	73	5
Female	40	1.66	62	130	78	131	79	5
Female	40	1.6	68	135	90	138	85	4
Female	43	1.62	73	141	95	148	94	7
Female	43	1.58	62	126	84	120	85	4
Female	47	1.6	82	149	92	142	98	6
Female	42	1.57	87	164	102	131	98	7
Female	54	1.58	77	145	89	143	86	6
Female	45	1.5	53	140	95	145	90	7
Female	45	1.5	60	143	85	140	80	5
Female	48	1.63	65	140	85	148	91	6
Female	62	1.48	62	149	91	145	89	5
Female	65	1.59	58	150	90	153	90	8
Female	46	1.48	59	149	85	150	87	8
Female	48	1.52	63	155	100	160	105	8
Female	50	1.5	65	158	100	160	100	10
Female	51	1.48	75	138	90	143	92	8
Female	44	1.55	73	143	89	150	90	8
Female	47	1.6	74	153	90	160	90	10
Female	38	1.5	41	132	87	130	85	6
Male	47	1.6	63	143	92	143	92	5
Male	50	1.6	65	138	78	135	76	3
Male	58	1.56	71	140	100	138	98	5
Male	63	1.63	75	145	100	140	100	5
Male	61	1.71	68	140	98	138	95	4
Male	55	1.63	70	150	100	148	102	6
Male	48	1.6	62	152	105	150	100	7
Male	50	1.63	67	141	89	145	90	7
Male	60	1.7	70	150	100	150	100	8
Male	45	1.6	70	140	90	145	93	5
Male	53	1.5	73	150	92	155	95	10
Male	52	1.6	75	148	90	150	85	8
Male	49	1.67	68	150	90	155	93	8
Male	53	1.7	68	148	105	155	90	7
Male	58	1.63	73	149	102	153	100	8
Male	61	1.65	76	153	100	160	103	10
Male	63	1.58	74	160	103	160	90	11
Male	43	1.65	69	158	100	165	105	12
Male	49	1.69	74	148	100	153	100	7

4. Analysis and Results

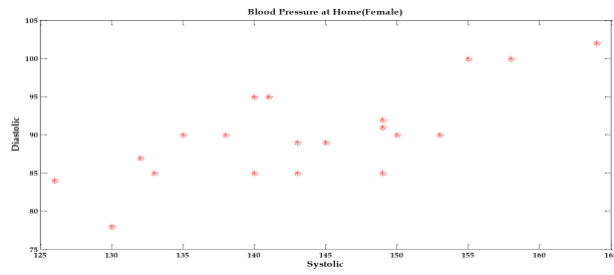


Figure 1. Home diastolic VS Home systolic of female patients

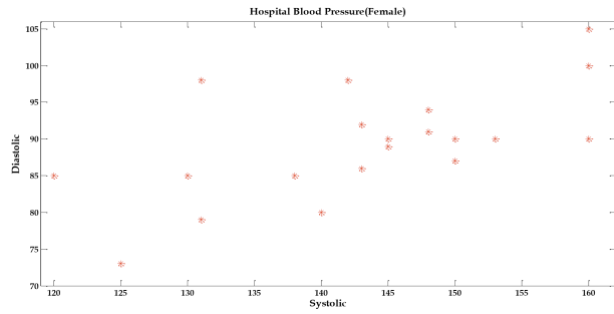


Figure 2. Hospital diastolic VS Hospital systolic of female patients

Figure 2 is the graph of hospital systolic and diastolic blood pressure. Comparing Figure 2 to Figure 1 shows an increase in blood pressure of female patient after moving a reasonable distance to the medical facility for blood pressure check. Only 60% of female patients had an increase in their blood pressure. Therefore, the stress of moving from the house to the medical facility especially if the distance is far has the tendency to cause an increase in blood pressure.

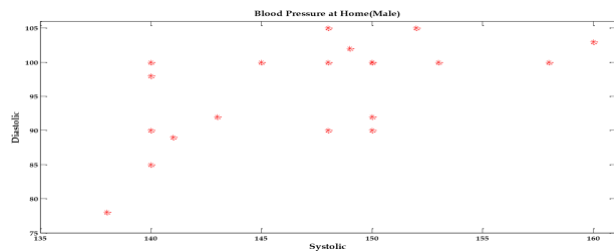


Figure 3. Home diastolic VS Home systolic of male patients

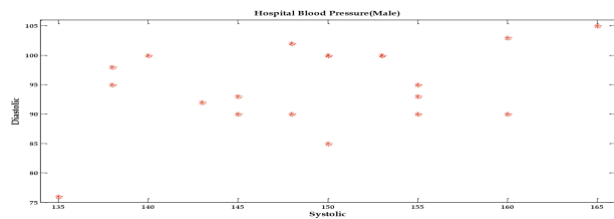


Figure 4. Hospital diastolic VS Hospital systolic of male patients

Figure 4 is the graph of hospital systolic and diastolic blood pressure checks. Comparing Figure 4 to Figure 3 only shows a slight increase in blood pressure of male patient after moving a reasonable distance to the medical facility for blood pressure check. 55% of the male patients showed an increase in blood pressure, 30% showed a slight reduction in blood pressure and the remaining 15% had the same the same blood pressure after getting to the medical facility.

The Framework

Having analyzed the data and the results, it was observed that the farther the distance of a medical facility to a patient's residence to check his/her blood pressure the higher the risk of increasing the blood pressure. It was also noticed that patients were discouraged from checking their blood pressure because of the distance they have to travel for the exercise and the waiting time before they are attended to. To solve this problem, two sets of solutions are proffered. The first is ambulatory checking where a nurse is designated to a locality to go round and check the blood pressure. The second is that of telenursing which the success story of telecommunication in a country like Nigeria could be harnessed. The 75% growth in teledensity, Okafor et al. (2016) in 16years can be harvested to develop a telenursing platform. The architecture of such a platform is depicted in Figure 5. It comprises the patient who wears a device that regularly checks his/her vital signs including the blood pressure. These are sensed by a sensor and captured into a central database. Through the connected router and the GSM, a nurse is alerted of the vital signs parameters which he/she observes and advice the patient on the next line of action whether to see a doctor, rest or continue with his medication.

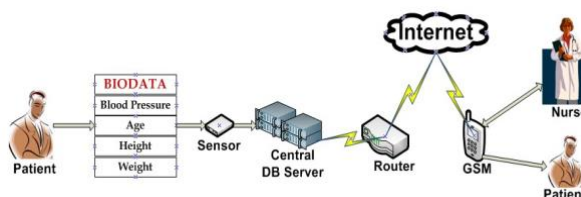


Figure 5. Architecture of a telenursing platform

Prospects of Telenursing

The following constitutes the benefits that can be derived from Telenursing

- Reduced cost of medical care; at the onset the cost of setting up a telenursing platform seems high but the long term effect justifies the cause.
- Reduced stress of accessing medical facilities; patients spend many hours waiting on a queue to see a medical doctor this sometimes lead to complications of the illness and avoidable deaths
- Improved health care delivery; telenursing practice can lead to a great improvement in medical care as it will close the gap existing now between a nurse or any medical personnel and the patient. When such a gap is closed health care can be improved with prompt attention given to the patient.
- High productivity of nurses; currently nurses work under stress due to the high ratio of a nurse to patients in the hospital. This stress causes nurses to be erratic in their behavior and are seen to be rude. This has affected their productivity. Telenursing would assist nurses to carry out their assignment with ease as a click of the mouse could perform a task that takes hours to perform in the present dispensation.

Despite the numerous benefits of telenursing, there are a number of challenges, some of such challenges include the following:

- Absence of enabling legislation; government of different countries are still dragging their feet to legislate on the practice of telehealth, telemedicine, telecare and telenursing.
- Fear of lack of privacy by patients; patients do not have the confidence of a machine in divulging vital information to it with the fear that this could be disclosed to whoever it wills.
- Poor bandwidth; the practice of telenursing will require high bandwidth internet connection. Currently most developing countries still operate at a very poor bandwidth and low internet penetration.
- Illiteracy; a great percentage of the populace are not computer literate so may not appreciate the workings of the system

- Poverty; Lack of basic livelihood may hamper the appreciation of the system that may need regular maintenance of the wearable device.

5. Conclusion

In most developing countries there are so many barriers to health care delivery and the wellbeing of the citizenry, the two cardinal points of the millennium development goal. Such barriers include; poor road networks, undulating terrain, unacceptable ratio of doctor to patients, poor medical facilities etc. The framework for telenursing hypertension patients was necessitated by the findings that patients are discouraged from checking their blood pressure due to the long distance they have to travel to a medical facility for the check-up. Secondly, they have to wait endlessly before they are attended to thereby adding more stress and increasing the pressure of the blood. In order to mitigate these ordeals, a platform where a patient's blood pressure and other vital signs are regularly checked and reported to a medical personnel like a nursing officer is proposed. The platform has the potential of enhancing uninterrupted access to a patient for prompt health care delivery. The initial cost of setting up such a platform is however prohibitive but the long term benefits outweigh this initial cost. Further study will implement the framework and compare the results with the results obtained in this study.

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