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Implementation of Smart Healthcare system for Cardiovascular Patients in sub-Saharan region

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Abstract

Cardiovascular refers to anything relating to the heart and blood vessels. The flawed current to multiple patients not receiving right care depending with the current health status, leading to critical cases and even death. Tanzania, like other developing countries, is experiencing a higher burden of Cardiovascular diseases. According to recent estimates, approximately 33% of the Tanzanian population is affected by cardiovascular diseases the probability of dying from cardiovascular diseases among adults aged 30 to 70 approximating 16%. Cardiovascular diseases alone are responsible for 13% of Tanzania's total deaths, and adults aged 25–64 years are positively affected. If there are no strategic measures taken, the mortality rates of cardiovascular diseases in Tanzania are expected to rise by 20% in 2022, and this will cause over one million deaths. Therefore, the main of objective of this paper is to develop a smart healthcare system for cardiovascular diseases that will be addressed using machine learning and knowledge discovery techniques to create automated, personalized health recommendations that consider patient characteristics and preferences.

Key words: *Cardiovascular, healthcare, machine learning*

Background

Despite the immense efforts emphasized by Tanzania's government, the increase in cardiovascular disease cases in Tanzania has still been a problem. Cardiovascular disease is a particular abnormal condition that negatively affects all or part of an organism's structure or function, not any immediate external injury [1]. Furthermore, it is abnormal heart or blood vessels [2]. Cardiovascular disease (CVD) is a general term for conditions affecting the heart or blood vessels. It is usually associated with a build-up of fatty deposits inside the arteries and increased blood clots. It can also be associated with damage to arteries in organs

such as the brain, heart, kidneys, and eyes. Cardiovascular diseases develop to be conditions that last one year or more and require ongoing medical attention or limit daily living activities or both

If there are no strategic measures taken, the mortality rates of cardiovascular diseases in Tanzania were expected to rise by 20% in 2020, and this will cause over one million deaths [3] compare:

- *In Nigeria*, The World Health Organization (WHO) in 2016 revealed that non-communicable diseases were estimated to account for 29% of all deaths, of which CVDs contributed 11%. CVDs that are increasing over the past 20 years in Nigeria include hypertension, heart failure, and stroke [4].
- *In South Africa*, CVD is responsible for almost 1 in 6 deaths (17.3%). Two hundred fifteen (215) people die every day from heart disease or strokes. Every hour in South Africa: five people have heart attacks, ten people have strokes, and of those events, ten people will die from it [5].
- *In the North American continent*, cardiovascular disease, including stroke, is the leading cause of illness and death in the United States. An estimated 62 million people with cardiovascular disease and 50 million people with hypertension in this country [6]. About 1 in 12 (or 2.4 million) Canadian adults age 20 and over live with diagnosed heart disease; Every hour, about 12 Canadian adults age 20 and over with diagnosed heart disease die.
- *In Argentina* Cardiovascular disease (CVD) is the leading cause of death and disability in the country. CVD causes approximately 30% of all deaths in the country, and ischemic heart disease is the cardiovascular condition with the highest morbidity and mortality rates [7].
- In 2016, the estimated prevalence of CVDs in India was estimated to be 54.5 million. One in 4 deaths in India is now because of CVDs with ischemic heart disease and stroke responsible for >80% of this burden [8].
- *In Japan*, there were 750,000 estimated cases of CHD, accounting for 38.7% of heart disease cases and 1,668,000 estimated cases of CVD, accounting for 65.8% of cerebrovascular disease cases (2,534,000) [9]

- In UK, More than 30,000 out-of-hospital cardiac arrests in the UK each year, with a survival rate of less than 1 in 10 [10].
- In France, one in three French people presents significant risk factors for cardiovascular disease. Around 120,000 heart attacks occur in France every year; around 10% of the victims die within the hour [11].

In Tanzania's government has created a favorable environment by providing improved and valuable healthcare services to all individuals suffering from cardiovascular diseases. However, despite these efforts, still there has been a higher prevalence of cardiovascular disease cases and their associated risk factors both in men and women. The rise of cardiovascular disease risk factors has been attributed to high costs of healthcare services, untrained health workers, lifestyle modifications, and adverse effects of globalization, urbanization, and migration of rural dwellers to urban areas.

Intermediate risk factors like overweight and obesity, hypertension, diabetes, and hyperlipidemia present in individuals due to poor management of behavioral risk factors. However, they are usually diagnosed at a critical stage, which leads to expensive medical care and specific treatment procedures. However, at critical stages, the treatment and care do not provide a foolproof recovery process for the patient and, in some cases lead to death.

Related work

However, some studies have been done to make sure we get the solution, in Europe and other part of the world has been successful to develop their own healthcare cardiovascular systems.

- ***ADA health*** **-** Ada is a global health company based in Berlin that operates Ada, an end-user self-assessment app. additionally, the company offers enterprise solutions - Assess, Connect, Handover, and COVID-19. The app, developed by Ada Health, uses a medical knowledge database with artificial intelligence technology to help users understand what might be causing their symptoms and provide guidance about what they should do next [12]. Ada's free symptom checker can help one find answers and let the person know if he or she should see a doctor. Ada's AI assesses one’s answers against its medical dictionary of thousands of disorders and medical conditions. Then one will receive a personalized

assessment report that tells what could be wrong and what to do next. [13]. Ada will ask, “Who is the assessment for?” Can choose ‘Someone else,’ and their information will be kept separate from your own. The app also learns from the condition library, written and researched by Ada’s in-house doctors, and their condition library gives a comprehensive understanding of the risks, symptoms, and treatment options for conditions while also offering helpful suggestions for prevention and further reading. No Ada data is stored in your phone, and Ada does not share the data you enter into the app unless you explicitly tell them to do so [14]. In October 2017, when three apps were tested with asthma, shingles, alcohol-related liver disease, and urinary tract infection, Ada performed very well; it asked about the most important symptoms and provided the best diagnoses In October 2019, a German IT security professional claimed that the Ada app sent sensitive user-data (f.e. symptoms, IPs, Android ad IDs) to the Amplitude product analytics service (api.amplitude.com), and some German users' insurance provider to their Facebook Analytics account. In September 2020, Broadband Commission for Sustainable Development issued a report identifying Ada as of the AI solutions that have the "potential to address existing health inequalities and provide medical expertise to clinicians, health workers, and patients alike - all intending to improve the quality, access, and cost of healthcare delivery." [14].

The Ada Health App is a Class I medical device in the European Union. Registration in other markets is pending.

- ***SAMSUNG health-*** Samsung Health (originally S Health) is a free application developed by Samsung that serves to track various aspects of daily life contributing to well-being, such as physical activity, diet, and sleep. Launched on July 2 2012, with the new Samsung smartphone, the Galaxy S3, the application was installed by default only on some smartphones of the brand. It could also be downloaded from the Samsung Galaxy Store [15]. The main boundary objects are the

Samsung Health app (S Health) and SDH's cloud servers. Like Apple's Health Store, app developers can use S Health to store and access all their health data. SDH aims to play an active role also in the service end. Health data stored in S Health are synchronized with SDH's SAMI servers *(www.samsungsami.io).* They can be accessed directly by other service providers using a secure API. SDH claims to provide an open platform at the device end due to their use of the open-source Android OS. Samsung is also involved in developing Simband (www.simband.io), a generic health device. This means both Android Wear-based and Simband-based health and fitness devices can connect to SDH. SDH employs a similar model to Apple regarding its data model. App developers can use an existing data type set and extend this set with their own data types [16].

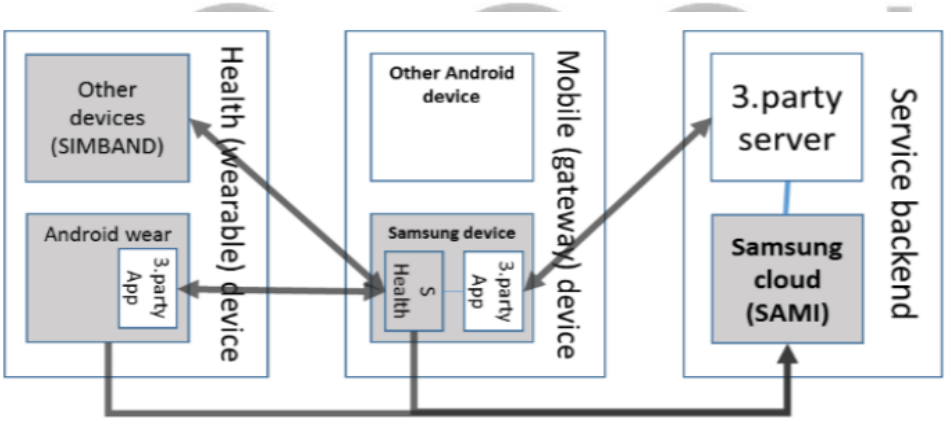

Figure 1: Service architecture for Samsung Health Platform

- **Healthy heart 2 –** This app is a prevention/monitoring app for high blood pressure / high cholesterol patients at risk of heart diseases and their caretakers. It tracks blood pressure, pulse, cholesterol, blood glucose, potassium, medication, and behavioral and environmental factors. This data is invaluable in helping one's doctor pinpoint the cause of the sickness and evaluate the effectiveness of medications. The data can be saved to the ***Ringful online*** service for backup, analytics,

and easy sharing with doctors and family members. Released on May 22, 2010. It currently serves on version 1.2. It is compatible with iPhone, iPod touch, and iPad requires iPhone OS 2.2 or later, iTunes account required [17].

- **Heart pal-** Heart Pal connects with a separate handheld ECG monitor to record one's heart and help one's medical team determine a diagnosis. Users can see the results, historical data, and waveform for analysis and review. The app uses AI technology to determine whether or not there is an arrhythmia [18]. Heart Pal is a helpful tool for patients and doctors to use to monitor their average blood pressure. The app allows one to log information, display it in charts, and share it with the doctor. This is done through a scheduling feature built right into the app. It can also remind one of important dates, such as doctor's appointments, to keep one organized and help maintain healthy blood pressure [19].
- **Withings health companion-** WITHINGS creates devices embedded in easy-to-use everyday objects that connect to a unique app and act as powerful daily health check-ups, as well as tools to help master long-term health goals. Automatically track one's daily activity and workout sessions with in-depth insights, including steps, heart rate, multisport tracking, connected GPS & fitness level assessment. Improve nights with sleep-lab-worthy results (sleep cycles, sleep score, heart rate, snoring & more) and uncover breathing disturbances. Monitor hypertension from the comfort of one's home with medically accurate systolic and diastolic blood pressure results, plus reports one can share with the respective doctor to monitor the efficacy of treatment

Creating neural network model

In addition to the aforementioned diagnostic models, a Neural Network model was created and tuned using the architecture shown below. This neural network classifier has resulted in 0.97 F1 mean scores on cross-validation.

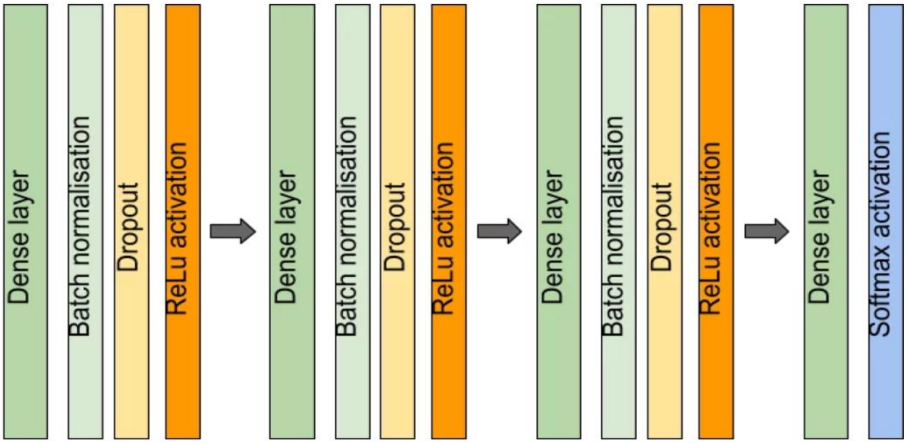

Figure 2: Neural Network Model

Designed and Implementation Smart healthcare system for cardiovascular diseases for sub Saharan region

Individuals also perform self-diagnosis through information from sources like the internet, television programs, literature sources, and experience. Applications like Ada, Aptiv, and Fitplan have been made exclusive for only the European or the American region; therefore, for a country like Tanzania, which is located in Africa in the sub-Saharan region, does not get the precise information basing on the climatic region. Other factors like nature of activities and levels of development play a crucial role in how different diseases take shape to the individuals of that region. Due to those factors, these health apps are not efficient for their clients in the sub-Saharan region and usually provide a disclaimer in their profile to ensure that users understand the consequences of using the app and being out of the supported region. Below is the proposed system for Tanzanian environment.

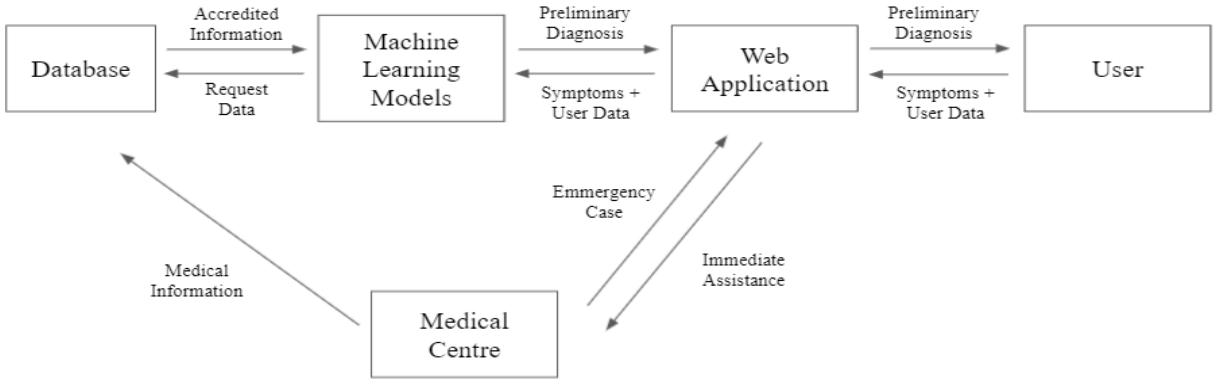

Figure 3: The proposed system for cardiovascular diseases

The suggested system, as shown in figure above is the smart healthcare system for cardiovascular diseases for sub Saharan region (Tanzania). The system will manage all users seeking cardiovascular medical assistance. The medical assistance can inform of medical information of balanced diet that is various nutritious foods which can help improve the user's well-being. The other form of medical assistance can be in the form of recommendation of different behaviors and general conduct of the user, such as daily exercises, self-diagnosis, and level of activities

Testing

After a build iteration has been coded and implemented, it underwent a series of testing procedures to identify and locate any potential bugs or issues that have cropped up. The project underwent a set of test cases to locate shortcomings and train the machine learning models to understand the nature and patterns of data accepted by the user. This process was done to improve the accuracy of the recommendation and give the models the ability to be more intelligent in situations where not enough data is present. At this phase, identification of vulnerabilities of the system might affect confidentiality, integrity, and availability of the patient personal information and health data.

Advantage of proposed system

i. The decrease in the number of cases. Proper management of risk factors prevents worsening of the victim's condition. With proper medical care, the victim has a higher probability of healing completely. Therefore, ensure the national workforce is not depleted.

ii. Improved provision of medical assistance. With the help of machine learning, the system assures precise results and proper recommendations at any user's request. This helps to take off the load that the Ministry in charge of health and social welfare and other organizations were responsible for, disseminating accredited information regarding cardio health matters.

iii. Provision of balanced diet and nutrition knowledge. The system recommendations ensure that each individual depending on his/her intermediate and behavioral characteristics, gets the proper diet, reducing the risk of developing the disease.

iv. Provision of room for further studies and innovation in the health sector. Through further research and the

development of more advanced tools, the system can pave the way for more effective approaches to talking about these kinds of diseases.

Scope and limitation of the project

The study focuses on designing a model that can provide a preliminary diagnosis to the patient depending on the patient's signs. The system will have the following scope:

- Focus on Coronary cardiovascular diseases.
- Platform to access education, recommendations, and assistance on living healthy.
- English, a medium of communication due to its vastness in vocabularies and popularity among different ethnicities on an international scale.
- Web application make the system flexible on multiple devices. They have native features like broadcasting notification channels in mobile systems to handle the notifications from the system and be easily deployable.

The following are the limitations of this project:

- Time. Due to the limited amount of time, it places a massive amount of pressure to finish the project and meet the requirements on time. Thus this hinders further enhances and modification of the project.
- Data Availability. Due to the sensitive nature of the field that the project focuses on, that is the health sector. Data about the disease is confidential, making it very cumbersome for the project as the third party to access it.

Conclusion and recommendation

Conventional digital computers may be capable of running such programs, or we may need to develop new machines that can support the complexity of human thought. Generally, this report has provided all basic information concerning the existence of the problem and the procedures towards solving it. Using these procedures, the system has been designed and realized using machine learning algorithms. Moreover, the system has been tested and appeared to give the expected results. Considering these results obtained after repeated testing, the overall performance of the designed system is good. Therefore, it can be concluded that the designed system is expected to solve the existing problem. Smart healthcare for cardiovascular patients is strongly recommended due to benefits from fine functionalities that allow the project to run

more smoothly without the user acknowledging the background processes. Implementation of this project will completely eliminate possibilities of receiving biased cardio-health information, provide preliminary diagnosis and advise regarding different parameters that an individual will experience in his or her life

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