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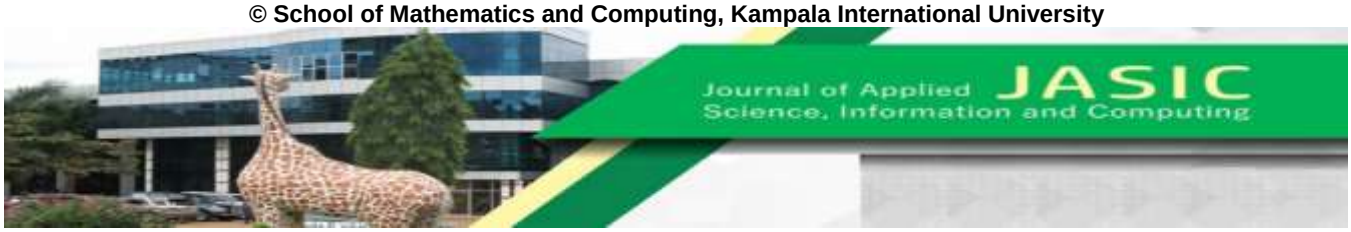

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Interactive Health Information Chatbot for Non-Communicable Diseases in Swahili Language

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Abstract

Current health awareness campaign strategies, efforts, and methods on NCDs have not produced improved outcomes in reducing the burden, spread, and deaths linked to NCDs in Tanzania. To support, compliment, and improve health literacy on NCDs and promote good healthcare, we designed and developed an interactive health Chatbot 'afyaBot' in Swahili language that can respond to user's requests concerning NCDs symptoms, prevention, management, and cure. The Chatbot was designed using Botsociety; a special tool for designing Chatbot prototypes; BotMan framework for coding the Chatbot logic and Google Dialogflow platform that offers high-level Natural Language Processing capabilities. The Chatbot was integrated into the Facebook Messenger platform which offers free public API access that eliminates the cost of the internet from the consumers. The Chatbot was tested for accuracy, usability, user experience, responsiveness, reliability, maintainability, and portability. The results of implementation were satisfactory and provide insights useful to stakeholders in the health sector. The interactive Chatbot was designed to provide real-time information on NCDs, create awareness, and educate users on preventive, control, and treatment measures of NCDs. It will likewise assist healthcare providers to collect accurate timely health data for monitoring, planning, and research purpose.

Keywords: Chatbot; AI; Intelligent Systems; Health Literacy; NCDs, Tanzania

1. Introduction

The global burden of chronic, non-communicable diseases (NCDs) largely heart disease, stroke, cancer, chronic respiratory disease, and diabetes is increasing rapidly and will have significant social, economic, and health consequences unless it is urgently addressed (Islam et al., 2014; Peykari et al., 2017). NCDs are defined as a medical condition that is not capable of being communicated by direct contact and have been primarily associated with four life and social habits: physical inactivity or sedentary lifestyle, unhealthy diets, smoking tobacco and drinking alcohol (increased fat and sodium, with low fruit and vegetable intake). In 2016, NCDs were responsible annually for more than 41 million (71%) of the 56·9 million worldwide deaths and responsible for 16 million premature deaths. The World Health Organization (WHO) estimates that by 2020, NCDs will account for 80 percent of the global burden of disease, causing seven out of every ten deaths in developing countries and about half of the premature deaths under the age of 70. Eighty percent (80%) of these deaths are already occurring in low-and middle-income countries (WHO, 2018).

Existing studies on NCDs in Tanzania were revealing; evidence shows a lack of coordinated efforts and ineffective strategies in communicating information on NCDs in Tanzania. In 2016, NCDs was estimated to have accounted for 33 percent of all deaths in Tanzania, and the proportion of diseases due to NCDs had doubled from 19 percent of the total disability-adjusted life years in 1990 to 35 percent by 2015, with about 50,000 cancer cases been reported each year (Buguzi, 2018; Mbani, 2018). Some of the challenges that hamper the efforts to combat NCDs in Tanzania are observed to be: Lack of specific policy to address NCDs; limited context-relevant information on the epidemiological patterns of NCDs; and inefficient health systems. It is when patients pay a visit to hospitals they become aware of NCDs and most outpatients' information related to NCDs is only available at the hospitals (Metta et al., 2014; Peck et al., 2014). Health information is promoted and disseminated basically through library's websites, organization's websites, mass media, newspapers, meetings, exhibitions, and other information communication materials (Chipungahelo, Haruna, Ndege, & Lujenje,

2015). All these strategies have proven ineffective in reducing the burden of NCDs in Tanzania.

Despite all efforts and interventions by local and international health organizations, existing studies shows that health literacy and healthcare habits about the prevention of NCDs have not improved in many developing countries including Tanzania. The current system and strategy of health awareness have not achieved the desired results. Lack of proper education on NCDs is a hindrance to healthcare delivery. Empirical research suggests that low health literacy is a major barrier to delivering preventive healthcare and that individuals with low health literacy suffer from been able to vigorously engage in socio-economic activities. Therefore, improving health literacy through different strategies could save thousands of lives and eventually contribute to economic growth and development.

In essence, all ideas that could be put in place to improve health literacy, attitudes towards healthcare, combat NCDs and save lives should be explored. The current strategies through which health information are been propagated in Tanzania seem to be ineffective in obtaining adequate, reliable, and accurate information about NCDs. Hence, we propose the introduction of an AI/Machine Learning interactive health Chatbot system to complement current and on-going interventions on health literacy and health education on NCDs. AI and machine learning systems are technologies designed to perform tasks that normally require human intelligence (Nilsson, 2014). Therefore, the key metric in determining the value or effectiveness of the Chatbot in this regard is the extent to which information seekers can interact with it in a natural fashion and by extension exhibiting an avenue to provide informal interactions in such a way that they can be leveraged to support ubiquity and self-directed learning as well as personal development. There are Chatbot offered by many software and internet companies. For example, Apple offers (Siri), Amazon (Alexa), Google (Assistant), Microsoft (Cortana), and Samsung (Bixby) (Borana, 2016; Dale, 2019; Hoy, 2018). However, these Chatbots are not advised to be consulted for medical or health information since they have not been trained to assist patients, thereby lacking rigorous healthcare knowledge. Meanwhile, Chatbots with a health focus, such as Florence (getflorence.co.uk), Molly (sense.ly), Lark (lark.com), Koko (itskoko.com), and various other messaging services, has recently attracted interest with positive feedbacks related to user acceptance and treatment success (Kowatsch et al., 2017).

Besides, in the past couple of years, we have seen major companies invest in Mobile Health (mHealth) applications to engage patients for everything from medication adherence, action plans, vital signs monitoring, self-reporting of symptoms, telemedicine consults, behaviour coaching, etc allowing end-users to play an active role in their healthcare. It has been proved beyond doubt by studies after studies, that we can achieve better results and great savings if patients and healthcare providers simply keep in touch after the patients go home (Kowatsch et al., 2017; Kumar, Keerthana, Madhumitha, Valliammai, & Vinithasri, 2017; Pistorius, 2017). Some best practice often requires a team of clinicians to follow up with patients to make sure that they use the technology solution regularly (Wilson, Daugherty, & Morini-Bianzino, 2017).

In essence, follow up and continue engagement with patients through different mediums has achieved much-improved outcomes and cost-effectiveness in healthcare delivery. Therefore, we believe that an interactive Chatbot that interacts, educates, informs, advises the general public about NCD's with their symptoms, prevention, and control will go a long way in supporting patients and reduce the risks and deaths attributed to NCDs in Tanzania.

1.1. Objectives of the Study

The objective of this study was to design and implement an interactive Chatbot that will provide adequate, timely information about Non-Communicable Diseases NCDs to support the general public with prevention and control. The specific objectives are as follows:

i. To assess the need for the development of an Interactive Chatbot for NCDs in Swahili language.
ii. To design, develop, and populate the Chatbot's knowledge database using Swahili language.
iii. To train the Chatbot using large quantities of conversational data in Swahili language.
iv. To test and implement the Interactive Chatbot for NCDs.

2. Materials and methodologies

2.1. The Need for the Design of an Interactive Chatbot for NCDs

The need for the development of interactive health information Chatbot was informed by the results of the preliminary survey. It is clear from the results of our preliminary findings and review of literature that the current health information dissemination mediums for NCDs in Tanzania are not adequate and there is a need to provide a more direct platform that could be tailored towards solving the problem of NCDs. It is necessary to understand the current health information dissemination strategies in Tanzania to examine if the current strategy is effective and to identify challenges encountered. This knowledge will help us to proffer better solutions going forward and it was observed that the

use of Chatbot as a medium for health information access and retrieval could solve many of the aforementioned challenges. Besides, preliminary findings from this research suggest that the number of people using a mobile messaging app in Tanzania is growing rapidly, and this is where a technology such as Chatbot comes in handy since it offers quick and cheap instant messaging solutions. Instant messaging is a type of online chat which offers real-time text transmission via the internet; the appearance of the smartphone has resulted in the explosion of mobile messaging apps with affordable chat cost or free chat (Pallavi, 2019). Social messaging apps have proven themselves as a cheap alternative to operator-based text messaging via SMS and many messenger apps offer features such as group chats, the exchange of graphics, video, and even audio messages as well as stickers or emoticons stimulating learning and knowledge acquisition (Portal, 2018).

2.2. Design and Development

The interactive Chatbot for NCDs diseases (afyaBot) was designed using the combination of Botsociety, Botman framework, and Google Dialogflow. Botsociety is a special tool for designing prototypes specifically for Chatbots. BotMan framework is an open-source framework developed in PHP language, and it was used to code the Chatbot logic. To create an engaging conversation, the Chatbot utilized the use of Artificial Intelligence through Natural Language processing; this help to understand users' requests and find a match for any corresponding feedback in the database. A conversational platform provided by Google 'Dialogflow' was utilized to facilitate human-computer interaction based on natural language conversation. This platform offers users new ways to interact with Chatbot by building an engaging voice and text-based conversational interfaces powered by AI. It also provides opportunities to connect with users on a website, mobile app, Google Assistant, Amazon Alexa, Facebook Messenger, and other popular platforms and devices. The Chatbot used Machine Learning (ML) which provides better interaction with the user.

Figure 1 shows the architecture that was used to develop the Chatbot.

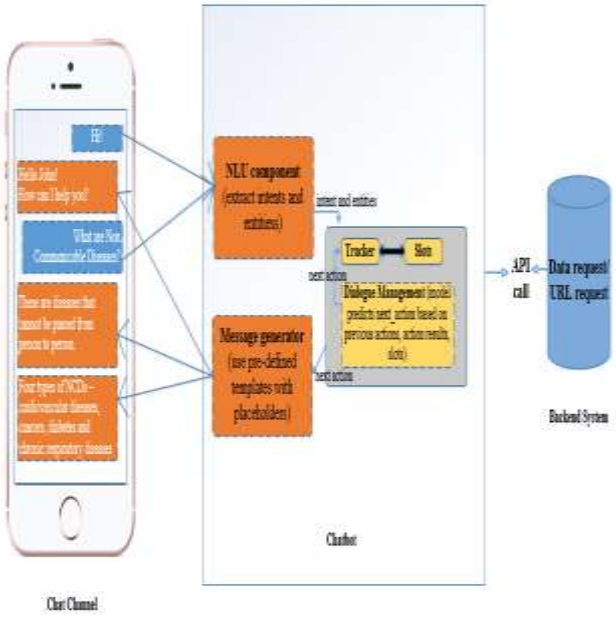

Figure 1: Chatbot Architecture. Adapted from Kompella (2018)

The architecture supports a clear separation between the chat channel, (interaction example: Facebook Messenger), the actual Chatbot logic (intelligence) that deals with providing answers, and with backend systems that offer integration.

The three high-level areas of Chatbot development are described below:

i. Chat Channel: interaction and connectivity with external channels. This part enabled the connectivity with different channels. For instance, it allows the bot to communicate with Facebook Messenger. It is responsible for ensuring the delivery of a message to and from the Chatbot logic.

ii. Chatbot Logic: Intelligence. The intelligence capabilities as described were implemented using Natural Language Processing with a Training Model that enables the bot to learn and to understand a sentence, Context that enables the bot to perform a conversation, and History that enables the bot to learn from previous conversation or experience. The Google Dialogflow makes it possible for the bot to respond to input and requests from users in a smooth fashion as depicted in figure 2. According to the architecture presented in figure 1, the box that represents the NLU component (Natural Language Understanding) helps in extracting the intent and entities from the user request. By using Dialogflow, three important parameters were specified when training the agent:

Intents – This represents a mapping between a user's request and how you wish the system to respond. For example, if a user wants to know about cancer, there are

several natural ways a user might ask: "What is Cancer?", "I want to know about Cancer", or simply someone may just say "Cancer".

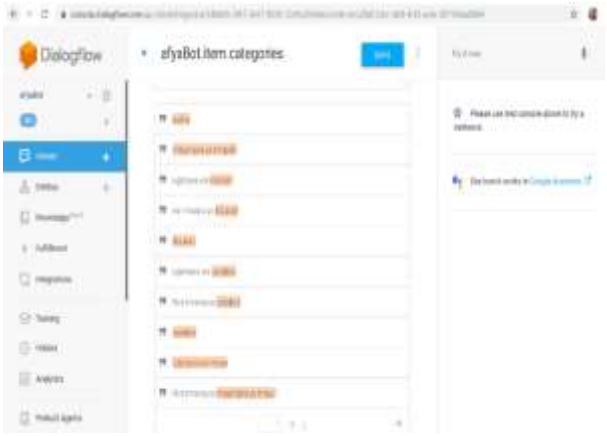

Figure 2: afyaBot Intents Structure

iii. **Entities** – These represent specific intents in the request, which is the categories of subjects that the bot understands. Entities correspond to extracting the information from the user request about diseases, disease categories, location, and age. For example, in afyaBot's case, categories of disease entities for the Chatbot are Cancer, Diabetes, Cardiovascular Diseases, and Respiratory Diseases.

iv. **Context** – These represent knowledge obtained by the bot during the conversation. Since afyaBot is a conversational AI bot, there is a need to keep track of the conversations that happened thus far, to predict an appropriate response for the future. Kompella (2018) indicated a dictionary object that can be presented with information about current intent, current entities, persisted information that user would have provided to bot's previous questions, bot's previous action, results of the API call (if any). This information will constitute input X, the feature vector. The target Y that the dialogue model is going to be trained upon will be 'next_action' (The next_action can simply be a one-hot encoded vector corresponding to each action that is defined in the training data) (Kompella, 2018).

Referring to the architecture, dialogue management keeps the model to be context-aware and check the conversational history to predict the next_action. The process involved in predicting the value of the next_action can be represented as follows:

- Respond to the user with an appropriate message
- Retrieve some data from a database (if any data exist)
- Make an API call and get some results matching the intent.

If it happens to be API call/data retrieval, then the control flow handle will remain within the 'dialogue management' component that will further use/persist this information to predict the next_action, once again. The dialogue manager will update its current state based on this action and retrieve results to make the next prediction. Once the next_action corresponds to responding to the user, then the 'message generator' component takes over.

The message generator component consists of several user-defined templates (templates are nothing but sentences with some placeholders, as appropriate) that map to the action names. So depending on the action predicted by the dialogue manager, the respective template message is invoked. If the template requires some placeholder values to be filled up, those values are also passed by the dialogue manager to the generator. Then the appropriate message is displayed to the user and the bot goes into a wait mode listening for the user input.

i. Backend System: The last part of the Chatbot was the ability to communicate with backend systems. The Chatbot was supported by the excellent integration capabilities with Botman application which was programmed with a knowledge database in such a way that it has preprogrammed questions, terminologies, phrases, and words relevant to non-communicable diseases and how it is to respond.

2.3. Data Collection Methods

Simulated data about non-communicable diseases were created based on information obtained from a group of health providers, the general public, specialist doctors, researchers, and also through observation and document review. We conducted a critical review of the document produced by the World Health Organization (WHO) 2018 report on NCDs. The data collected were grouped using different classification methods. Also, we employed machine learning techniques to train the Chatbot using large quantities of conversational data (translated to Swahili language), which allows it to respond to a wider variety of user input and requests accurately in Swahili.

3. Results

3.1 Testing and Implementation

The afyaBot conversational agent was tested for efficiency and accuracy by integrating it with Facebook Messenger. The Chatbot was implemented using PHP programming language which is integrated with the Dialogflow for Natural Language Processing. The afyaBot was then deployed for implementation in varieties of chat services such as Google assistance

simulator, Facebook messenger, Telegram, and it was also embedded in the Botman PHP framework web application. There are several search criteria available, including voice search and keyboard type-search; custom selection of available options is also possible. The Chatbot is accessible through mobile and web portals. In the design, we considered the requirements of the system, technical constraints, database accessibility, security and privacy, feedback mechanism, and the demand for efficient conversation. The Facebook Messenger user interface for the afyaBot is illustrated in figure 3.

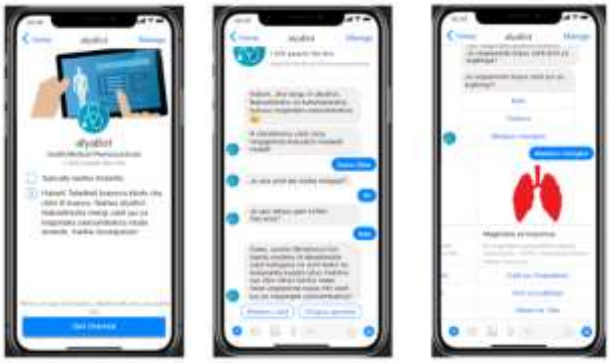

Figure 3: Facebook Messenger user interface for the afyaBot

4. Discussion

This research examined the need and discussed the design and development of an interactive Chatbot to support education on NCDs in Swahili language. This study was motivated by the fact that the current health information medium on NCDs is insufficient and ineffective, and there is an opportunity provided by an intelligent conversation medium to compliment and achieve better results on NCDs prevention and control. The current strategy and medium for disseminating information on NCDs have not to yield meaningful outcomes, therefore, it is pertinent to support the general public with affordable, easy to learn, easy to use technologies that would enable them to receive timely, accurate, on-demand information on all aspects of NCDs. The interactive Chatbot was designed to provide real-time information on NCDs, create awareness, and educate users on preventive, control, and treatment measures of NCDs. Existing research and statistics from international bodies have reported growing internet penetration and narrow digital divide in many developing countries, however, it is not clear whether this growth has resulted in improvement in health literacy, healthcare behavior, and general healthcare wellbeing. As a result, we were motivated to exploit digital expansion in improving health literacy through the design and development of an interactive Chatbot for NCDs in Swahili. It is hoped that this research will spur more effort in applying novel technology to improve and prioritize health literacy. Emerging technologies, novel digital tools, and social media platforms have become an integral part of the daily lives and activities of lots of people and it offers immense opportunities to healthcare organizations, stakeholders, and policymakers in the health sector and healthcare business. These tools have the potentials to overcome certain barriers in disseminating health information. Barriers such as distance, delays, waiting lists, and geographical limitations hinder attendance at face-to-face doctor's appointments. Apart from offering easy solutions to lots of problems in health information dissemination, Chatbot also enables users to play an active role in their health care. Text-based messaging services or Chatbots are cheaper, faster, and are especially popular amongst young people as the most preferred way of communication. This technology has demonstrated the potential to improve customer service since it is not hindered by time-zone or any environmental condition with the ability to offer 24/7 patient support, thereby positively improving customer satisfaction and loyalty (Haan, 2018; Kim & Xie, 2015) (Haan, 2018). Besides the fact that afyaBot provide information on NCDs prevention and control, it will also help healthcare providers collect accurate timely health data from users for analysis, monitoring, planning, and research purpose. Data and information collected from the conversation agent could help to formulate proper and evidence-based policies on health and also promote research and use of Chatbots. The afyaBot promises to support and complement the current strategy and medium of health information retrieval in Tanzania since these diseases are largely preventable and manageable.

5. Conclusions

Artificial Intelligence technologies are assisting with business solutions and convenience across many industries. These technologies are one of the best healthcare software solutions available today. Therefore, healthcare providers, stakeholders, and policymakers in this sector should promote the adoption of these technologies to combat all other diseases and overcome other healthcare challenges. Government and Private sector involvement in the provision of healthcare should invest in AI technologies like Chatbots, and promote the use of Chatbots by the general public. Non-communicable diseases are largely preventable and manageable and mostly require proper awareness and education which is offered by afyaBot. The afyaBot can be extended to be integrated with other messaging services (WhatsApp Messenger, Viber, Skype) as well as voice assistants. A chatbot is never a finished artifact; all Chatbots undergo enhancement, improvement, maintenance, and continuous data training throughout their lifespan and that is the same with afyaBot. Currently, there are a lot of opportunities offered by this Chatbot and there is no question that this technology will have an even deeper reach shortly. We have commenced work on assessing user interaction with the afyaBot and

the chatlogs from the user interaction are currently being used to modify the system.

References

Borana, J. (2016). Applications of Artificial Intelligence & Associated Technologies. In Proceeding of International Conference on Emerging Technologies in Engineering, Biomedical, Management and Science [ETEBMS-2016].

Buguzi, S. (2018). Cancer War, is Tanzania Fighting in the Dark? Dar es Salaam. The Citizen.

Chipungahelo, M. S., Haruna, H., Ndege, J., & Lujenje, S. (2015). Promoting Public Access to Health Information: Experience of the Association for Health Information and Library in Africa, AHILA-Tanzania Chapter. Retrieved from http://creativecommons.org/licenses/by/3.0/

Dale, R. (2019). Industry Watch The return of the chatbots. Natural Language Engineering, 22(5), 811–817. https://doi.org/10.1017/S1351324916000243

Haan, H. de. (2018). Chatbot Personality and Customer Satisfaction. Utrecht University.

Hoy, M. B. (2018). Alexa, Siri, Cortana, and More: An Introduction to Voice Assistants. Medical Reference Services Quarterly, 37(1), 81–88. https://doi.org/10.1080/02763869.2018.1404391

Islam, S. M. S., Purnat, T. D., Phuong, N. T. A., Mwingira, U., Schacht, K., & Fröschl, G. (2014). Non‐Communicable Diseases (NCDs) in developing countries: a symposium report. Globalization and Health, 10(1), 81. https://doi.org/10.1186/s12992-014-0081-9

Kim, H., & Xie, B. (2015). Health literacy and the internet- and mobile app-based health services: A systematic review of the literature. Proceedings of the Association for Information Science and Technology, 52(1), 1–4. https://doi.org/10.1002/pra2.2015.145052010075

Kompella, R. (2018). Conversational AI chat-bot — Architecture overview - Towards Data Science. Retrieved November 20, 2019, from https://towardsdatascience.com/architecture-overview-of-a-conversational-ai-chat-bot-4ef3dfefd52e

Kowatsch, T., Nißen, M., Shih, C.-H. I., Rüegger, D., Volland, D., Filler, A., … Dagmar L'allemand, &. (2017). Text-based Healthcare Chatbots Supporting Patient and Health Professional Teams: Preliminary Results of a Randomized Controlled Trial on Childhood Obesity. In Persuasive Embodied Agents for Behavior Change (PEACH2017) Workshop, co-located with the 17th International Conference on Intelligent Virtual Agents (IVA 2017). Stockholm, Sweden. Retrieved from www.mobile-coach.eu

Kumar, M., Keerthana, A., Madhumitha, M., Valliammai, S., & Vinithasri, V. (2017). Sanative Chatbot For Health Seekers | International Journal of Engineering and Computer Science. International Journal Of Engineering And Computer, 5(3). Retrieved from http://www.ijecs.in/index.php/ijecs/article/view/720

Mbani, M. (2018). Tanzania faces a rise of non-communicable diseases - The Citizen. The Citizen. Retrieved from https://www.thecitizen.co.tz/news/Tanzania-faces-rise-of-non-communicable-diseases/1840340-5122162-22ci2ez/index.html

Metta, E., Msambichaka, B., Mwangome, M., Nyato, D. J., Dieleman, M., Haisma, H., … Geubbels, E. (2014). Public policy, health system, and community actions against illness as platforms for response to NCDs in Tanzania: a narrative review. Global Health Action, 7(1), 23439. https://doi.org/10.3402/gha.v7.23439

Nilsson, N. J. (2014). Principles of Artificial Intelligence eBook: Nils J. Nilsson: Kindle Store (Kindle Edition). Retrieved from https://www.amazon.com/Principles-Artificial-Intelligence-Nils-Nilsson-ebook/dp/B01E548U26

Pallavi. (2019). Global Mobile Messaging Apps Market Size, Status and Forecast 2019 - 2025.

Peck, R., Mghamba, J., Vanobberghen, F., Kavishe, B., Rugarabamu, V., Smeeth, L., … Kapiga, S. (2014). Preparedness of Tanzanian health facilities for outpatient primary care of hypertension and diabetes: A cross-sectional survey. The Lancet Global Health, 2(5). https://doi.org/10.1016/S2214-109X(14)70033-6

Peykari, N., Hashemi, H., Dinarvand, R., Haji-Aghajani, M., Malekzadeh, R., Sadrolsadat, A., … Larijani, B. (2017). National action plan for non-communicable diseases prevention and control in Iran; a response to emerging epidemic. Journal of Diabetes and Metabolic Disorders, 16(1). https://doi.org/10.1186/s40200-017-0288-4

Pistorius, C. (2017). Developments in emerging digital health technologies. Innovation Insight.

Portal, T. S. (2018). Most popular global mobile messenger apps as of October 2018, based on number of monthly active users (in millions). Retrieved from https://www.statista.com/statistics/258749/most-popular-global-mobile-messenger-apps/

WHO. (2018). Noncommunicable diseases. Retrieved from https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases

Wilson, Daugherty, P., & Morini-Bianzino, N. (2017). Chatbots made for Healthcare - Tincture. MITSloan Management Review, 58(4), 14–17. Retrieved from https://tincture.io/chatbots-made-for-healthcare-fec631bc8462