

FEBRUARY 1, 2018

A LANDSCAPE ANALYSIS OF CHATBOTS FOR HEALTH

APPLICABILITY FOR SUB-SAHARAN AFRICAN CONTEXT

UNIVERSITY OF WASHINGTON STRATEGIC ANALYSIS,
RESEARCH & TRAINING (START) CENTER

REPORT TO THE BILL & MELINDA GATES FOUNDATION

PRODUCED BY: NAUGHTON B., LI KAPPE D., CHEN A., AND DOOLEY E.



**START
CENTER**

STRATEGIC ANALYSIS,
RESEARCH & TRAINING CENTER

Department of Global Health | University of Washington

Executive Summary

The Strategic Analysis, Research and Training (START) team at the University of Washington was tasked with conducting a landscape analysis of chatbots, and assessing their potential in the provision of healthcare in the developing world. A chatbot simulates human conversation, powered by artificial intelligence (AI). According to Juniper Research, it is estimated that chatbots could save organizations \$8 billion annually worldwide by 2022, up from \$20 million in 2017 [1]. However, the vast majority of medical applications today are in customer service in the high-resource regions of the world [1]. The START team surveyed over 200 articles, selected 43 key articles and industry reports to inform the results, contacted 28 experts on the landscape of chatbots in healthcare, and interviewed in-depth seven experts.

The demand for pre-primary care solutions, such as symptom tracking, first-aid assistance, and general medical information has driven the establishment of several prominent chatbot companies. Babylon Health with 120,000 users a month, Your.MD with 230,000, Florence with 2,700 and Praekelt have demonstrated leadership and innovation in this industry [2]. While these pioneering organizations and companies play an important role in the global landscape of health technologies, Gartner [3] and our findings indicate that conversational interfaces are still 5-10 years out, and may have limited potential for impact in the near term.

The trajectory of adoption of mHealth technologies may be instructive in understanding the potential for chatbots. In a 2017 comprehensive review [4] of the adoption of 92 mhealth projects, only 11 scaled to more than 1000 users. The trends of broader mHealth technologies could indicate that the development, adoption, and scale of chatbots will be limited. Chatbots today offer a unique vertical solution that can target very specific aspects of a frontline health worker's care delivery or a patient's interaction with the health system; however, they do not fulfill the need for systematic horizontal integration with healthcare providers, ministries of health, and hospital networks to achieve necessary impact. The key findings are summarized below, as are our recommendations, informed by the literature reviews and expert interviews.

— KEY FINDINGS

- ▶ Over 130 chatbots for health were identified and surveyed in this report. As this is such an early stage in the medical chatbot market, there is limited information on several key impact measures, such as the number of users per month. For Your.MD, HealthTap, and Florence, the number of users reached 230,000, 5 million and 2,700 with fractional use in the sub-Saharan Africa region [2]. In the low-income countries, Totohealth reported 140 registrations per month and Babyl by Babylon Health in Rwanda reached on average 1,700 registrations per day [2].

- ▶ Most of the chatbots surveyed used English exclusively (n=109, 80%), were accessible on smartphones (n=131, 96%), and 79% (n=108) included consultative or educational aspects.
- ▶ There is presently very limited application and utilization of chatbots in the sub-Saharan African region: of 136 chatbots for health surveyed, only 16 were developed or exclusively deployed in the SSA region.
- ▶ The primary uses of the chatbots reviewed were directed at understanding symptoms and accessing care, such as helping to diagnose illness from symptoms, and guiding patients to appropriate services.
- ▶ There is little peer-reviewed literature on the effectiveness of chatbots in providing care. One two-week study of 70 students found that a chatbot was effective in delivering cognitive-behavioral therapy [5].
- ▶ Among the chatbots identified, there is significant heterogeneity in the fee structure varying between fee-for-service, monthly subscription, and free-to-the-end-user in cases of government subsidies and sponsorship. Funding dedicated to the developing chatbot solutions in sub-Saharan African countries appears constricted and minimal.
- ▶ This is a very early-stage technology, near the peak of the Gartner technology hype cycle [3], and real traction is probably 5-10 years out. However, the promise of help in triage and diagnosis for frontline health workers in low-resource settings is appealing.

RECOMMENDATIONS

- ▶ As chatbots are primarily utilized via phones, it is expected that chatbot trends will follow mHealth trends closely. The literature and experts interviews highlight that mHealth shows a positive trend of growth due to a rapid smartphone and internet penetration in sub-Saharan Africa, however, the most significant growth is observed in geographic clusters around Kenya, Nigeria, Democratic Republic of Congo, Tanzania and South Africa. In addition, scarcity of qualified medical professionals and lack of infrastructure continue to prevail, while the need for healthcare chatbots could play an important role in bridging this gap. **To maximize the possibility of effective and widespread uptake of chatbots, we recommend a close study of the adoption facilitators in mHealth.**
- ▶ The scope of this project was to conduct an initial landscape analysis, thus further exploration of barriers and opportunities present throughout the supply chain including end users, frontline health workers, hospitals, and government agencies is highly recommended. **The scalability of chatbots is strongly dependent on political, infrastructural and economic constraints; therefore, we recommend conducting a deeper analysis of the most promising and high priority chatbots presented in our database.**

- ▶ The future of digital health is quickly coalescing around the importance of interoperability: it is expected that the most effective frontline health technologies will be integrated into health systems. **Investments in chatbot development or scale should align with this trend in digital health, focus on improving interoperability, and move beyond standard vertical chatbot systems.**

Table of Contents

Executive Summary.....	1
Introduction.....	5
Trends and Opportunities for Digital Health.....	6
Landscape Analysis of Healthcare Chatbots.....	11
Barriers and Considerations for Chatbots in Sub-Saharan Africa...	22
Conclusion.....	28
Appendices.....	30
References.....	35

Introduction

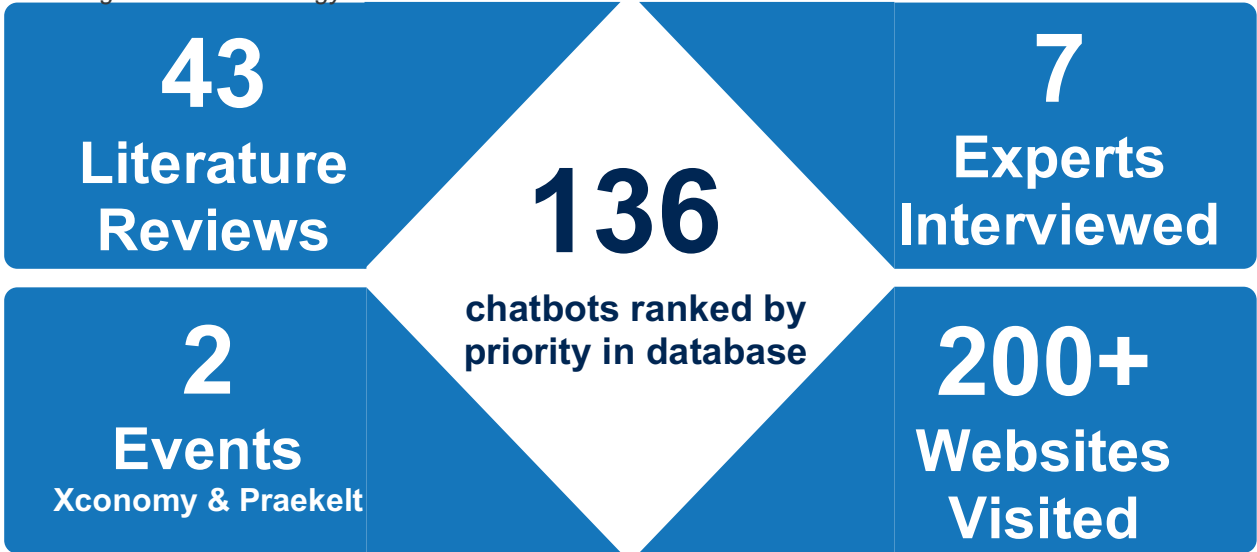
PROJECT OVERVIEW

The Bill & Melinda Gates Foundation invests broadly in digital healthcare and is considering a strategy for chatbot deployment in healthcare in sub-Saharan Africa (SSA). The purpose of this report is to provide a landscape analysis of health chatbot use, and to provide recommendations for the impact of chatbots, focusing on those most applicable to SSA. This report serves as a resource to survey the landscape and to highlight the strengths and limitations of chatbots deployed in SSA.

METHODOLOGY

To accomplish this project, the START team took a multi-faceted approach (Figure 1) starting with a broad assessment of artificial intelligence capabilities in health fields and further focusing on the current landscape of healthcare chatbots. The development of chatbots for health is still in its nascent stages, and information was collected from resources found as a result of grey and white literature reviews, databases including Forrester and Gartner, reaching out to approximately 28 experts, and conducting seven targeted key informant interviews of experts in digital health, artificial intelligence, frontline health workers, and low-resource health systems. The team attended an Xconomy event “Healthcare + AI” to gather insights on the direction of artificial intelligence in healthcare, and a working session with Praekelt at the Foundation. To distill the results, a database was created of 136 chatbots pertaining to the healthcare industry. Each chatbot was analyzed and assigned a priority based on applicability to BMGF’s work in sub-Saharan Africa and relevant healthcare domains for the region.

Figure 1. Methodology



Trends and Opportunities for Chatbots

Chatbots provide an innovative opportunity to incorporate the use of conversational interfaces powered by artificial intelligence to improve the quality and quantity of care provided by frontline health workers and health systems. We found that the demand for pre-primary care solutions, such as symptom tracking, first-aid assistance, and general medical information has driven the establishment of several prominent chatbot companies and organizations addressing healthcare needs. For instance, Babylon Health leveraged the United Kingdom NHS database to provide their users with up-to-date relevant medical information. Coupled with a team of readily available healthcare professionals, Babylon is uniquely positioned to address pre-primary healthcare needs. While these entities play an important role in the global landscape of health technologies, our findings indicate that the chatbot landscape is still in its nascent stage, and there are questions about the expected ability to implement, scale, and achieve impact.

Healthcare Trends

The world population is projected to reach 9.8 billion by 2050; with 2.5 billion in Africa. While the nature of healthcare problems varies, the gap of unmet patient demand prevails across the globe. In high-income countries, despite a relatively high density of physicians, healthcare costs are often prohibitive [6]. With an increasing burden on existing healthcare, in the US alone, the shortage of primary care providers is estimated to be between 40,800 to 104,900 by 2030 [6]. The expectation is that chatbots can be used to alleviate the problem.

In middle- and low-income countries, the scarcity of qualified medical professionals and lack of infrastructure presents an acute healthcare problem. Twenty-four percent of the global burden of disease is observed in sub-Saharan Africa, home to only two percent of the world's doctors [7]. The African health systems are being further strained by increasing rates of non-communicable diseases such as hypertension, diabetes, and coronary heart disease [8]. With such diverse health burdens, innovative developments in digital health have the potential for substantial impact, particularly those that facilitate health at the front line of delivery.

Frontline health workers (FHWs) are often the first and only point of contact for people who seek healthcare services in the low-resource settings. The many challenges faced by FHWs, from the maintenance of skills and knowledge to the complexity of tasks performed in the field, have the

potential to be supported by information and communication technologies. This important frontline interaction between patients and FHCs presents an important opportunity to innovate. There is an increasing interest in the role that digital solutions can play in boosting healthcare delivery and access in SSA [7].

Digital Health

With significant strides in technology and innovation, digital health has become a real possibility within high-, middle- and low-income countries. In 2017, digital health attracted \$6 billion in venture capital funding. Mobile health (mHealth) in particular saw an influx of funding and attention and is increasingly utilized in low-resource settings [9]. With nearly five billion mobile phone users in the world, mobile devices have become a prominent tool in the hands of healthcare providers. mHealth can support the performance of health care workers by the dissemination of clinical updates, learning materials, and reminders, particularly in underserved rural locations in low- and middle-income countries where community health workers deliver Integrated Community Case Management to children affected by diarrhea, pneumonia, and malaria [10]. While many mobile health interventions, particularly in high-resource countries, focus on instantaneous and ubiquitous mobile phone access as a way to target the population and patients directly, in low-resource countries, mobile phones or tablets are often the only electronic tool in the hands of a health worker [11]. The technological features that have been used for interactive and personalized health interventions include text messages (SMS), software applications, and multiple media (such as complementing SMS with photos) [12].

While the adoption curve indicates continuous growth, sustainability of such growth is hindered by economic challenges, low purchasing power, and unevenly distributed quality of infrastructure in the low-resource settings [9]. Furthermore, the distribution of mobile subscriptions is saturated in the four most populated markets in the region – DRC, Ethiopia, Nigeria and Tanzania. These countries will account for nearly half of the 115 million new subscribers expected by 2020 [9, 13]. Another considerable challenge with scaling mHealth is the cost of text messaging. For instance, Praekelt Foundation reported a monthly spending of approximately one hundred thousand US dollars on SMS alone. However, with a rapid entrance of the messaging platforms, healthcare providers and end users can enjoy the benefits of bi-directional communication and creating virtual groups at no cost.

By the end of 2016, there were 420 million unique mobile subscribers in sub-Saharan Africa, equivalent to an estimated penetration rate of 43%, compared to a global penetration rate of 63% [9]. Mobile internet penetration in the region has doubled over the past three years to 26% in 2016. It is forecasted that the region will have more than half a billion unique mobile subscribers by 2020 (Figure 2), with half of the population subscribed to a mobile service. Considering the effectiveness of mHealth solutions with mobile phones specifically, we anticipate that the

forecasted growth in mobile phone and internet penetration will have a positive effect on chatbot growth trends.

Figure 2. Major growth of mobile technology in sub-Saharan Africa [9].

Mobile broadband connections to increase from 33% to total in 216 to

60

by 2020

By 2020, there will be

498M

smartphones growth of 300 million from the end of

Mobile data traffic to grow by a CAGR of

66

over the period 2016 - 2020

Artificial Intelligence

Artificial intelligence (AI) devices perceive their environments and take actions that maximize chances of success at some targeted goal. This type of machine learning is a fast-moving field, particularly with widely varying health applications. The use of artificial intelligence in healthcare ranges from providing simple diagnoses to designing personalized treatment plans and streamlining routine check-ins. With an expected market share of \$6.6 billion by 2021 and a compound annual growth rate of 40%, the health AI market segment is predicted to grow more than tenfold [14]. AI is expected to have a substantial impact in increasing access and lowering costs in basic primary medical care known as “low acuity” care.

Applying artificial intelligence to health challenges can alleviate the shortage of primary care providers by moving prevalent low acuity conditions, such as common cold, flu, urinary tract infections, and sinus issues out of the emergency rooms and replace unnecessary in-person clinic visits with an AI-powered follow-up. In middle- and low-income countries, where the scarcity of qualified medical professionals and lack of infrastructure presents an acute healthcare problem, artificial intelligence can further enhance access to pre-primary care, front-line services such as first-aid advice, self-diagnosis, and vital healthcare information.

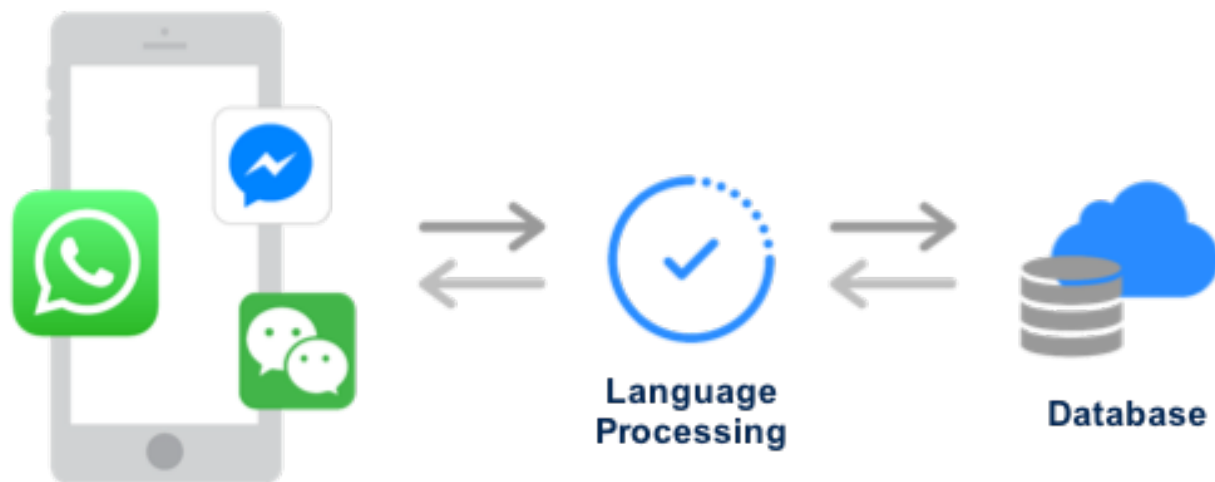
Chatbots

Chatbots are computer programs that conduct conversational interfaces, operating within defined rules and parameters. Chatbots typically include an application layer, a database, and a language processing system (Figure 3). The chatbot-user interface allows the end user to “chat” with the bot. The chat interface can be implemented via various services, such as SMS, web pages, Facebook messenger, Slack, Skype, Kik, and Telegram among others. The user interacts with one of these services, and the chatbot identifies and extracts relevant pieces of information by querying a database. The chatbot can repeatedly pull information from the database in response to user requests, and some chatbots are designed to be able to store information, allowing for conversations to build upon recent history.

There are two types of chatbots: rule-based and AI-based. Rule-based chatbots can only perform simple question and answers sessions with the user, and do not use machine learning algorithms, as AI-based chatbots do. These chatbots are designed to be one-dimensional, performing based on predetermined options and questions within their programmed parameters. These types of chatbots are cheaper and easier to develop than AI-based chatbots, although they lack the deep learning processes that artificially intelligent chatbots possess. Thus, rule-based chatbots have limits to the user experience, and do not learn over time and over conversations with users. An example of a rule-based chatbot is the SophieBot, a Kenya-based chatbot that answers questions about sexual and reproductive health. The users ask simple questions, and the chatbot replies with specific and narrow answers.

The second type of chatbot, those that are AI-based, utilizes Natural Language Processing (NLP). NLP allows the chatbots to gather information, and to understand the intent of questions and human context. These types of bots elevate the technology and user experience from rule-based

Figure 3. Chatbot system overview



chatbots. AI-based chatbots can make real-time decisions and provide detailed information, but are expensive to develop. Popular examples of such chatbots include Babylon, Your.MD and HealthTap. The Babylon Health chatbot is able to analyze hundreds of millions of combinations of symptoms in real time, based on the information in its database. The system takes into account individualized information on the patient's genetics, environment, behavior, and biology and suggests the best course of clinical action.

The opportunities for both types of chatbots for use in frontline health systems vary. Chatbots have an ability to incorporate point-of-care decision support tools with automated AI- or rule-based instructions to help ensure quality of care in task-shifting scenarios by prompting frontline health workers to follow defined guidelines. They also offer a novel channel to deliver content intended to improve patients' knowledge of self-care, medication, diagnoses and other pertinent health information. The following landscape analysis of healthcare chatbots, including though utilized in and applicable to SSA, is detailed in the next section.

Landscape Analysis of Healthcare Chatbots

Database

A database of 136 chatbots was created detailing chatbots that were found relevant to healthcare worldwide. They were prioritized based on the following criteria (Table 1), and the database includes diverse indicators for each chatbot (Table 2).

Table 1. Prioritization criteria of chatbots in database

High Priority	Represents bots currently deployed in Sub-Saharan Africa, or those created for key health domains of family planning, maternal and child health and infectious diseases. Those chatbots require only minor modifications to reach SSA.
Medium Priority	Denotes technology platforms and applications designed for or adaptable to healthcare in low-income settings, such as sub-Saharan Africa. Among medium priority are key health domains that are presently outside of SSA context and adaptation would require major alterations to scale in SSA.
Low Priority	Demarcates chatbots that do not address the needs of low-income settings or have minimal to no available information.

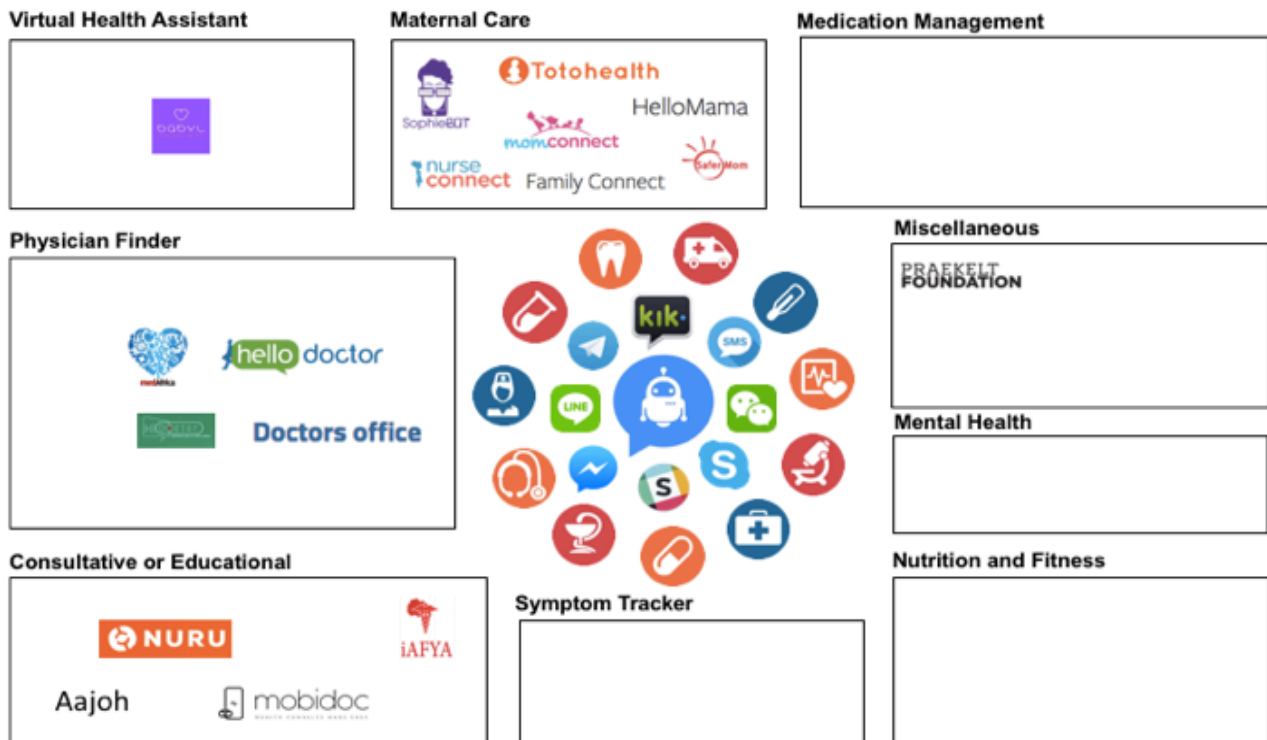
Table 2. Key Database Indicators

Product Description	Provides a narrative summary of the chatbot
Platform	Provides information on portal requirements, such as messaging platform (51%), SMS (13%), voice (32%) or web browser (15%).
Purpose	Illuminates the aim for an individual chatbot. We observed several sub-categories that healthcare chatbots fall into, including self-diagnosis (22%), symptom tracking (8%), consultation or educational (79%), referral to a health professional (7%), medication reminders (10%), prescription management (1%), appointment management (2%) and clinical communication (4%).
Key Health Domain	The main focus of this project was sub-Saharan Africa, thus this highlighted key health domains, which for all chatbots included family planning (21%), maternal and child health (29%), infectious disease (22%), mental health (29%) and non-communicable diseases (31%).
Devices	The chatbots are characterized by type of device required. 96% of chatbots run on smartphones. However, among chatbots that serve SSA, the majority (56%) allow feature phones.
Language Capacity	Language capacity can play a pivotal role in application and scalability, particularly in rural and remote areas of sub-Saharan Africa. Where possible, we captured the information on whether a given chatbot currently exists in or has a potential to expand to other languages. 80% of chatbots are exclusively in English.
Country of Origin	Location where the chatbot development occurred.
Geographies Served	Geographical implementation and utilization of the chatbot.
Fees	Fee information to indicate feasibility and scalability
Company Status	There was limited information specifying the stage in which companies and organizations operate, but were characterized when possible.

Figure 4A. Selected Chatbots Based on Primary Categorization



Figure 4B. Sub-Saharan Chatbots Based on Primary Categorization



REVIEW OF PROMISING CHATBOTS

KEY CHATBOTS IN HIGH-INCOME COUNTRIES

The table in Appendix 1 showcases several prominent chatbots designed in high-income countries such as USA, UK, and Germany. The primary purpose for these chatbots is to provide personalized medical assistance as well as serve as an information source to patients.

There are several advanced chatbots that have been widely used due to their broad applicability. For instance, Your.MD references hundreds of thousands of symptoms in order to inform a patient, and depending on the seriousness of a given condition, suggests that a patient see a medical professional. Another example of an advanced chatbot is Florence, created to imitate basic functions of a nurse who can remind patients to take prescribed medication based on the information programmed earlier.

Individual chatbot funding is often proprietary, and is rarely available, but we have found that some of the chatbots have gathered significant funding from investors and foundations (Figure 5). Babylon Health is the leading company that has raised more than \$85 million in total, where \$65 million was raised in Series B funding in April of 2017 [15]. It is important to note that recent figures indicate the chatbots in general – including those beyond a health focus - have attracted \$24 billion in funding over the past seven years, with the majority of that money going towards bot developer tools and service providers, which has attracted \$20 billion in investment since 2010 [16]. The chatbots in this report reflect a small fraction of the global chatbot funding, and indicate that there is a dearth of investment in health-related chatbots.

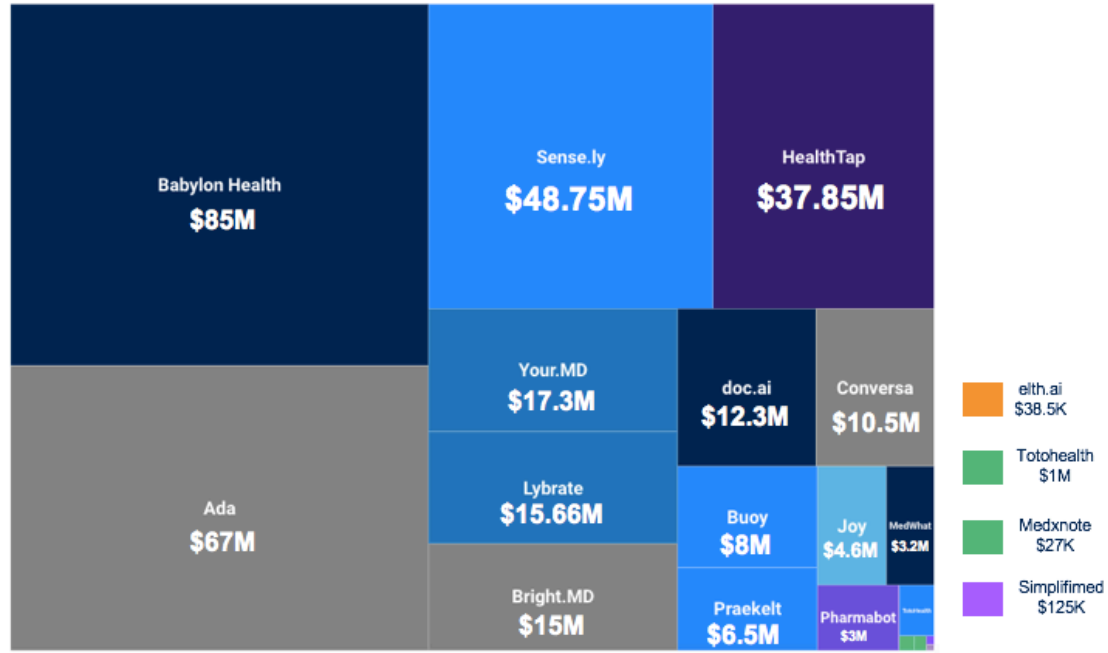
KEY CHATBOTS IN LOW-INCOME COUNTRIES

Of the chatbots surveyed, only 16 healthcare chatbots originated in sub-Saharan Africa or were primarily implemented in SSA (Appendix 2). They are predominantly addressing health issues prevalent in the region, such as maternal and child health, sex education, and diagnoses for communicable or infectious diseases, such as malaria, and HIV. The Praekelt suite of chatbots in South Africa, including MomConnect and NurseConnect, are scaling quickly, while Babylon Health's chatbot Babyl in Rwanda is expanding as well. MedAfrica in Kenya and Hello Doctor in South Africa provide question and answer services to patients seeking health information. Of the funding data available, Totohealth has raised \$1 million in total for venture capital firms, and Praekelt has raised \$6.5 million from various organizations and revenue.

Lastly, we have found that the most successful chatbot companies have partnered with local government agencies. For example, Babylon Health, the most funded company in our list, is working with UK NHS to connect users to their GP more easily. Babylon is mimicking this model

in Rwanda, with its Rwanda-focused service, Babyl, and is partnering closely with the Rwandan Ministry of Health. The success of the Praekelt Foundation’s MomConnect is due in large part to Foundations close partnership with health officials in South Africa.

Figure 5. Selected chatbot funding from SSA and non-SSA chatbots





COMPANY STRATEGY

Babylon uses artificial intelligence to provide a 24/7 symptom checker service, empowering patients with quick clinical reassurance by identifying the appropriate course of action through their mobile phone.

COMPANY DESCRIPTION

- Personalized health guide utilizing the National Health Services database in the UK.
- Allow users to ask simple medical questions via text service, monitor health with tracking system and talk to GP via phone or video call.

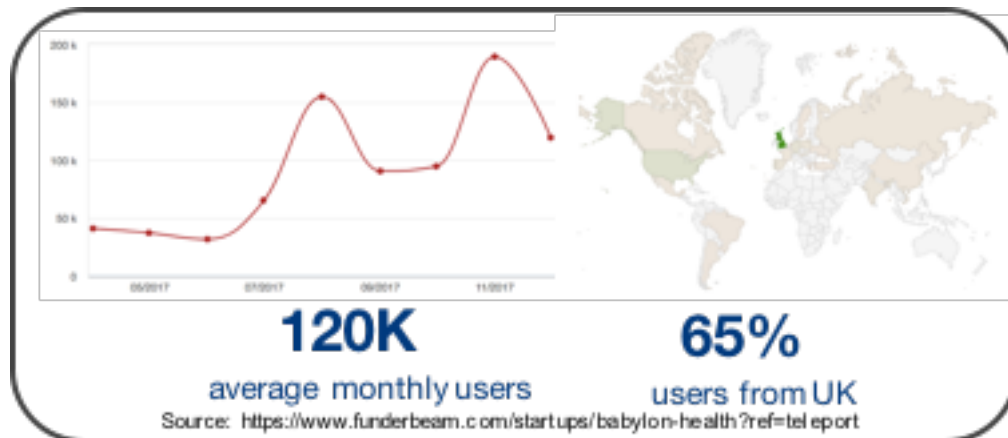
TECHNOLOGY

- The service is available through a downloadable application and via a website.

BUSINESS MODEL AND FUNDING

- \$85 million: \$25 million in Jan 2016, and \$60 million in April 2017. The investment was led by Investment AB Kinnevik, Vostok Nafta Investment Ltd [2].
- Three membership offerings: free users, premium users, and specialists.

Figure 6. Babylon Health Trends





COMPANY STRATEGY

Babyl is Babylon Health's chatbot in Rwanda. The chatbot is utilized for health information, prescriptions, and referrals to physicians [17].

COMPANY DESCRIPTION

- In first year, 750,000 people have been registered and 135,000 appointments have been booked.
- Services are being extended to integrate with the national health insurance system
- Babyl is planning to partner with 30 pharmacies in Rwanda to enhance integration and care delivery.
- 25 clinicians are supported by a team of 20+ back office staff including administration, marketing, communication, software development and technical support amongst many others

TECHNOLOGY

- The service is available through smartphones and chatbot-enabled tablets

BUSINESS MODEL AND FUNDING

- Babyl is funded through Babylon Healthcare and Spring Accelerator



COMPANY STRATEGY

Your.MD uses artificial intelligence to guide users to the most relevant health information in order to improve their health. The users can use Your.MD for free [18].

COMPANY DESCRIPTION

- Created to fill the pre-primary care, and has two platforms: Health Library & OneStop Health.
- Generated 2.1M downloads, and 1M user per month at launch. Benchmark tests have shown medical accuracy at 85%.

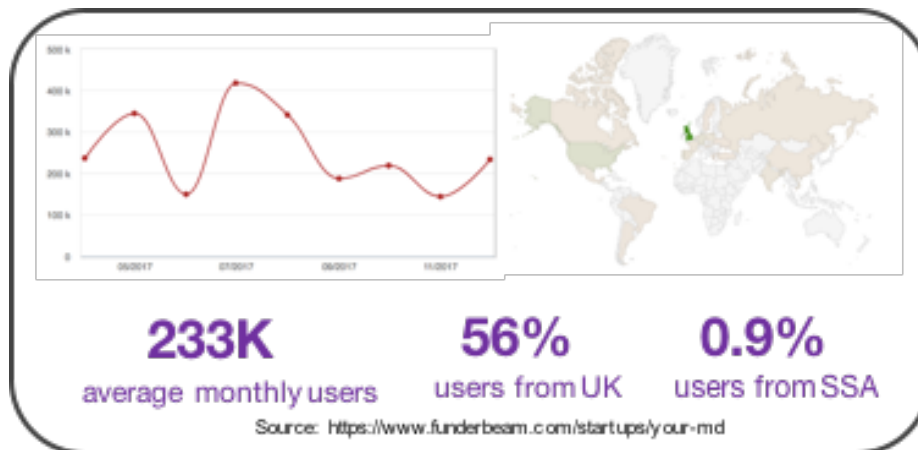
TECHNOLOGY

- Health Library is the database. OneStop Health is the AI-enabled app.
- Available for web, iOS, Facebook Messenger, Android, Skype, Slack and Telegram.

BUSINESS MODEL AND FUNDING

- Your.MD has successfully raised four rounds of funding, totaling \$17.3 million. In the last round, the company has raised \$10 million in June 27th, 2017, which was led by Orkla Ventures [2].
- The app is free to use for all users. It is unclear how the company profit from its services. However, it has a marketplace of trusted health service providers and products. Your.MD also partners with NHS and Samsung Health.

Figure 7. Your.MD Trends



COMPANY STRATEGY



HealthTap uses artificial intelligence to provide answers to people's healthcare questions anytime and anywhere. It connects millions of people with trusted doctors through a network of US-licensed doctors [19].

COMPANY DESCRIPTION

- HealthTap's AI-driven chatbot has answered 6.9B patient questions.
- The company has a network of 108,000 US-licensed doctors. They serve both B2C and B2B customers, and work with insurance companies.

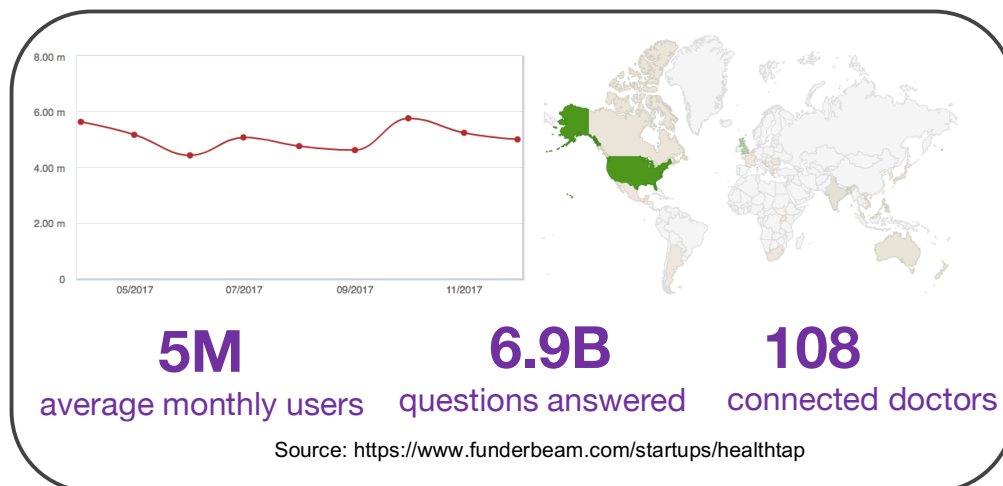
TECHNOLOGY

- Dr. AI is HealthTap's main chatbot that provides answers to health questions
- Available for web, iOS, Facebook Messenger, Android, Skype, Slack and Telegram.

BUSINESS MODEL AND FUNDING

- HealthTap has successfully raised three rounds of funding, totaling \$37.85 million. In the last round, the company has raised \$24 million in 2013, which was led by Asset Management Ventures.
- The chatbot is free to use for all users. HealthTap Prime costs \$99 per month, plus \$10 for every additional family member. HealthTap Concierge connects members with their own doctors and healthcare providers via HD video, voice, and text chat for a \$49 per-consult fee. HealthTap Compass provides healthcare services for corporate employees where insurance company is also involved.

Figure 8. HealthTap Trends





COMPANY STRATEGY

Totohealth is a social enterprise utilizing mobile technology to detect child development abnormalities and improve access to maternal and child health information for the marginalized communities using

mobile technology [20].

COMPANY DESCRIPTION

- The mobile platform aims to provide maternal and child health status of marginalized communities in Kenya.
- The app had more than 3K downloads at launch. However, it only had 140 active users by 2017.

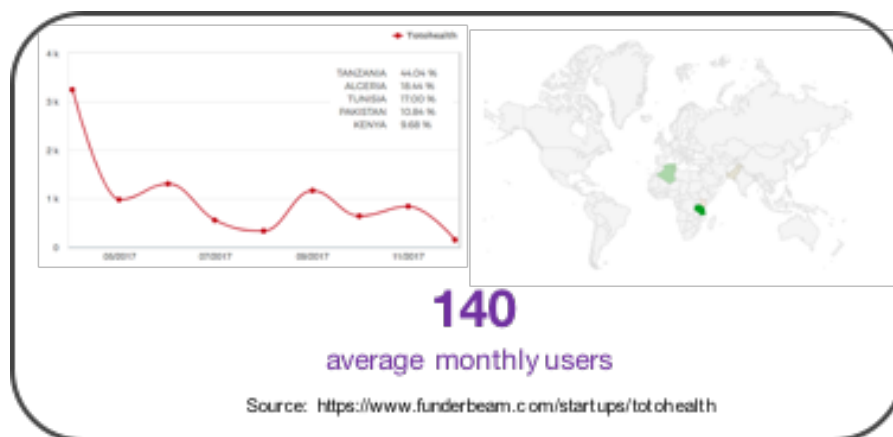
TECHNOLOGY

- SMS-based platform allows parents to receive timely guidance to improve health of the mother and child during and after pregnancy.
- The automated system keeps track of each child's age or mother's stage of pregnancy.

BUSINESS MODEL AND FUNDING

- Totohealth has raised \$1 million funding in December 16th, 2016, led by Safaricom and Streams Capital. However, the company does not have a clearly defined business model [2].

Figure 9. Totohealth Trends



COMPANY STRATEGY

PRAEKELT FOUNDATION

The Praekelt Foundation leverages open source mobile technologies to deliver essential information and vital services to more than 100 million people in over 54 countries [21].

BUSINESS MODEL AND FUNDING

- The F17 financial year saw total revenue of \$6.5 million, which was a 52% increase in revenue, compared to F16, as well as an achievement of a 7.34% surplus. This surplus is used to ensure that a three months' working capital in reserve; any surplus beyond this is used to support research and development within the organization.



MOMCONNECT

A South African National Department of Health (NDOH) initiative that uses mobile technology to improve the health of pregnant women, newborns and infants at national scale. Through the platform, every pregnant women can register to receive free, informative, and stage-based messaging for the first year of a baby's life. It has reached 2M users by the end of 2017.



HELLOMAMA

In Nigeria, the HelloMama program addresses the fact that most women are illiterate and that SMS is seen as a premium service by utilizing voice-based technology for the delivery of stage-based messages. This pilot launched in two states in November 2016 and has registered over 6,000 women and sent over 40,000 voice messages.



FAMILYCONNECT

In Uganda, with most women living in rural areas and the difficulty in accessing clinics that this presents, FamilyConnect is expected to leverage over 10,000 village health workers in communities to sign women up to the service. It is supported by UNICEF and the Ugandan Ministry of Health.

Barriers and Considerations for Chatbots in Sub-Saharan Africa

Barriers and Considerations

Despite the current surge of interest and funding in digital health, the ecosystem is still in the early stage of development and implementation. There is little evidence to suggest how digital health interventions function at scale, and even more of a paucity of evidence to understand how chatbots could be best introduced, scaled, and sustained in SSA [4].

The chatbots highlighted above that are currently in use in SSA, including MomConnect, Babyl, and others have not reached any scale on par with chatbots such as Your.MD or Babylon Health. There is evidence from trends in mHealth that without investments and strategies to mitigate barriers to implementation and scale, the near-term scope of chatbots is uncertain. The research and interviews conducted by the START team found that there are challenges to utilizing chatbots in SSA, including infrastructure constraints, political concerns, transferability issues, need for innovative business models, and a broader push for interoperability. However, chatbots remain a unique and important opportunity for frontline health care workers, often with limited training and resources, to have access to vast databases of medical knowledge that can improve healthcare delivery in rural areas.

The barriers and considerations that follow were informed by the literature reviews and the targeted interviews, and include aspects that are expected to serve as barriers for chatbot growth, and aspects to consider for any future targeted investments in this area.

Infrastructure Constraints

SYSTEM INFRASTRUCTURE

Adequacy of infrastructure to support digital health programs at scale vary by country. Indicators such as smartphone and internet penetration rates suggest that the majority of chatbots will be prevalent in similar geographic clusters around Nigeria, Tanzania, Kenya and South Africa. Reliable electricity in many countries is poor, particularly in rural areas, and access to internet is also highly variable [22].

HARDWARE

A robust support network is required to troubleshoot, repair and replace hardware such as feature phones, smartphones, and tablets and laptops.

SOFTWARE

The rise in interest and demand for open source software is promising, but any proprietary software can be prohibitive to end users in resource-limited settings. Additionally, chatbots developed for iOS or android systems can be difficult to scale.

— CONSIDERATION

Despite an evident increase in smartphone penetration, SMS-based chatbots through feature phones have the most immediate impact. Experts highlighted that the near-term impact with feature phones is more effective, as such phones have a higher penetration rate, and require less on-site training and technical support. Going forward as smartphone penetration scales up, chatbots that require smartphone functionality are most helpful when utilized through a messaging service, such as Facebook or WhatsApp, rather than requiring a unique application that must be downloaded. The smartphones in use have limited space, and patients and health workers are less inclined to take up phone space with a downloaded app. Facebook and WhatsApp are widely in use across the continent, and are the recommended front-end interfaces with health workers and patients.

Political Constraints

According to the experts interviewed, political support is arguably the most vital aspect to establishing and expanding technological solutions such as chatbots. MomConnect, a chatbot developed by Praekelt Foundation is an example of a successful government intervention. The program was established by South African National Department of Health to support maternal and child health. Praekelt's partnership with the National Department of Health resulted in a 95% clinic participation rate, making it widely accessible to mothers in South Africa.

LOCAL STANDARDS AND PROTOCOLS

As with any region, scaling systems that are meant to enhance or bypass local health systems is fraught with political challenges. If a chatbot is developed to assist a frontline health worker, the FHW cadre needs to be trained to use the bot, which requires effort and support from the local governments.

PROTECTIONISM

When adapting chatbots developed in other countries, implementation can be met with resistance from national and local health agencies and councils unless appropriate buy-in at all levels is established.

DATA SECURITY

There is limited information on data security protocols and compliance with national regulations in regards to chatbots. Most countries where these projects are operational may not have any national regulations on data security imposed. Data breaches with chatbots are common, and data security, particularly highly valuable health data, is a serious concern [23].

— CONSIDERATION

Similar to the use case of implementing Babyl in Rwanda, there are several key aspects to consider going forward: close coordination with the Ministries of Health, ensuring that the chatbot follows standards and protocols, and ensuring that the chatbot enhances the health system while not superseding established structures and lines of authority. Companies and funders need to endorse local involvement at all levels of scale, including implementation on a national scale and safeguarding ongoing sustainability. Data cannot be exported from the country without explicit permission from authorities. Finally, as community data are integrated with facility base patient records, high standards of patient security must be followed.

Transferability Constraints

CONTEXT

The majority of digital health tools, including chatbots, are developed by technology experts in North America, Europe, or Asia. Though many widespread chatbots are in English, they often pertain to specific health protocols or standards that may not be generalizable to areas in SSA. For example, to scale a chatbot from Silicon Valley to Kigali, Rwanda, large teams are required to ensure that any medical advice given through the chatbot is in line with Government of Rwanda standards, and is acceptable to the medical staff and patients. Local staff need to also be trained to ensure buy-in and acceptability, and to provide local support.

LANGUAGE

The main challenge for frontline healthcare workers in using many of these chatbots is that they are developed in English, often exclusively (85%), as are the backend databases from which the chatbots pull pertinent information. Large developer teams are required to translate these databases and bots into languages that are applicable for frontline workers, such as Swahili, Zulu, etc.

— CONSIDERATION

Robust investments are required to translate backend chatbots databases to other contexts and languages in order to meet the growing demand in sub-Saharan Africa. While locally designed systems, such as the Maternal Health Platform by Praekelt, are most applicable to specific contexts, targeted investments could allow for scaling of more widely applicable chatbots such as Your.MD to multiple contexts across several geographies of interest. Capacity-building at the national level is needed to provide the local support and understanding needed to build, maintain, and fully utilize digital health systems.

Business Model Constraints

PAYWALLS

As seen with the cost-prohibitive user fees in frontline health care settings, any paywall or payment required for a chatbots is expected to reduce the scalability. The current landscape of chatbots for health has a variety of business models, including payment to download an application or a fee to connect to a clinician upon a bot recommendation. There is evidence that in some cases this can translate to SSA contexts, such as the Babyl chatbot. However, for the greatest impact, additional business models or philanthropy-funded chatbots need to be considered. Communication platforms such as WhatsApp expand the possibility for scaling chatbots. WhatsApp introduces bi-directional communication free of charge. In Praekelt's case, monthly cost of SMS communication results in \$100,000 spending per month, and their recent transition of MomConnect to Messenger platforms is expected to be a significant cost-saving move.

COST-EFFECTIVENESS

Although existing evidence for the cost-effectiveness of mHealth interventions for FHWs looks promising, there is insufficient evidence due to limited research on the topic. There is sparse literature published on chatbots specifically as well as a lack of clear cost categorization. Furthermore, among funding information presented by chatbot entities, research and implementation costs are not disaggregated, making it difficult to consider the sustainability of chatbots.

— CONSIDERATION

For the greatest impact in frontline health in SSA, the costs associated with the chatbots should not be passed onto the user, but rather be absorbed upstream, by governments or philanthropic organizations. There is an acute need for further research on cost-effectiveness, utilization and impact of chatbots prior to the government spending on chatbot support.

Interoperability Constraints

INTEROPERABILITY

A recurring theme in the research and interviews was the importance of interoperability of chatbots – i.e., developing systems that can share information and leverage specific functions to improve efficiencies, such as shared health records and unique individual identifiers. Governments, donors, and implementing organizations are increasingly recognizing the importance of integration and interoperability, which allow for digital programs to transfer and retrieve information across systems [24]. Companies such as Medic Mobile work in this space, interfacing frontline health workers with backend national systems, resulting in “horizontal” systems. Chatbots remain largely vertical with a single stream of chatbots to end user without integration into local systems. While there are tangible benefits to patients using feature phones to inquire about their health, for FHWs who use chatbots to help diagnose a patient, the magnitude of impact is expected to amplify when FHWs can link a diagnosis with an individual patient’s clinical record, allowing ongoing follow-up and health system integration. These interoperable frameworks allow FHW-targeted systems to synchronize on a common platform (such as multiple, interconnected “apps” on a mobile device), as well as contribute to national health information systems like DHIS2 or clinical systems like OpenMRS [4].

— CONSIDERATION

Though some vertical chatbots can yield important impacts, the future of the field of chatbots and digital health is generally moving towards interoperability. Chatbots integrated into horizontal systems appear to offer the greatest impact to frontline health care workers, making targeted strategies toward these horizontal systems crucial going forward. There is increasing interest in supporting and encouraging broader system and platform-level support with a focus on scale, and targeted investments in these horizontal interoperable systems could yield wide-ranging impacts.

Conclusion

Chatbots for health are theoretically a promising technology to improve frontline health care delivery in low-resource settings such as sub-Saharan Africa, but the field is still very early stage, and there are questions about the expected ability to implement, scale, and achieve impact. The promise of help in triage and diagnosis for frontline health workers in low-resource settings is appealing, but to maximize the possibility of effective and widespread uptake we recommend a close study of the adoption facilitators in mHealth. The field of digital health is moving towards strengthening health systems with horizontal, interoperable digital health technologies, and while chatbots provide a unique opportunity for targeted frontline support, innovation and investment in more horizontal systems are expected to have the greatest impact.

The many chatbots for health surveyed here provide a view of the diverse landscape, with chatbots covering many health domains and with various platforms and technologies. There are promising examples with large user bases and with millions in funding, such as Babylon Health and Your.MD, although their ability to scale meaningfully in SSA seems limited due to a diverse set of limitations and barriers. Early-stage chatbots targeting SSA regions are providing unique frontline delivery support, such as those developed by Praekelt, although their ability to scale to additional health systems and countries could be limited. There is evidence from trends in mHealth that without investments and strategies to mitigate barriers to implementation and scale, the near-term scope of chatbots is uncertain. The research and interviews conducted by the START team found that there are challenges to utilizing chatbots in SSA, including infrastructure constraints, political concerns, transferability issues, need for innovative business models, and a broader push for interoperability. Further exploration of these barriers and opportunities present throughout is highly recommended. The scalability of chatbots is strongly dependent on these contextual factors, and therefore, we recommend that a deeper analysis is conducted.

The following recommendations are proposed:

- ▶ As chatbots are primarily utilized via phones, it is expected that chatbot trends will follow mHealth trends closely. The literature and expert interviews highlight that mHealth shows a positive trend of growth due to a rapid smartphone and internet penetration in sub-Saharan Africa, however, the most significant growth is observed in geographic clusters around Kenya, Nigeria, Democratic Republic of Congo, Tanzania and South Africa. In addition, scarcity of qualified medical professionals and lack of infrastructure continue to prevail, while the need for healthcare chatbots can play an important role in bridging this gap. **To maximize the possibility of effective and widespread uptake of chatbots, we recommend a close study of the adoption facilitators in mHealth.**

- ▶ The scope of this project was to conduct an initial landscape analysis, thus further exploration of barriers and opportunities present throughout the supply chain including end users, frontline health workers, hospitals, and government agencies is highly recommended. **The scalability of chatbots is strongly dependent on political, infrastructural and economic constraints; therefore, we recommend conducting a deeper analysis of most promising and high priority chatbots presented in our database.**
- ▶ The future of digital health is quickly coalescing around the importance of interoperability: it is expected that the most effective frontline health technologies will be integrated into health systems. **Investments in chatbot development or scale should align with this trend in digital health, focus on improving interoperability, and move beyond vertical chatbot systems.**

System-level digital systems, such as those implemented by organizations such as Medic Mobile, are escalating impacts in SSA regions, and is in line with the trend toward interoperability. However, chatbots remain a unique and important opportunity for frontline health care workers, often with limited training and resources, to have access to advanced digital technologies that can improve healthcare delivery in rural areas in limited ways. Nonetheless, going forward, the most effective frontline health technologies will likely be those most integrated into national health systems, and most applicable to scale.

APPENDIX 1: PROMISING CHATBOTS IN HIGH-INCOME COUNTRIES

COMPANY	PRODUCT	PLATFORM	GEOGRAPHY	MONTHLY USERS	FEE STRUCTURE
Your.MD	A personalized health guide that gives relevant and trusted health information.	Messaging Platform, App	100 countries	233K	Membership fee, e.g. \$60 per month for adults, \$120 per month for families.
Babylon Health	A personalized healthcare service that gives access to reliable medical advice and GP appointments.	App	UK	120K	Free for medical advice; monthly fee for GP access, e.g. \$5/month for unlimited GP.
Babylon Health UK NHS	Based on partnership with Babylon and NHS, to reduced burden on 111 lines and dispense medical advice.	App, Voice	UK	1.7K (total users)	Free for users.
Health Tap	AI-powered personal physician. Trained by doctors and incorporate content and clinical expertise.	App	USA	5M	Free for basic features; monthly fees for premium services, e.g. \$ 99/month. Also provide corporate health insurance.
WebMD	Provide information on symptoms, treatments, and cause for condition, definition of medical terms.	Alexa Skill	USA	179.5M (total users)	Free for users.
Florence	Remind patients to take medication, keep track of health, and provide disease information.	Messaging Platform	Germany	2.7K	Free for users.
Cardea	Personal medical aid that answers health questions, helps understand symptoms and connects to doctor	Skype	UK	Unclear	Free for users.

APPENDIX 2: PROMISING CHATBOTS IN SUB-SAHARAN AFRICA

COMPANY	PRODUCT	PLATFORM	GEOGRAPHY	MONTHLY USERS	FEE STRUCTURE
Babyl	A personalized healthcare service that gives access to reliable medical advice and appointments with qualified GPs	App, Voice	Rwanda	750K	Per consultation
TotoHealth	Monitors pregnancy and sends reminders; tracks immunizations and child development.	Voice, SMS	Kenya, Tanzania	140	Raised \$1M in funding. Voice/SMS charges, e.g. ~200 Kenya shillings per year.
HelloMama	Adapting Maternal Health Platform to meet the needs of Nigerian mothers in two states.	Voice	Nigeria	6K	Standard voice charges; cost averaged at NGN 2497.86 per pregnant women during trial.
MomConnect	Supports mothers and midwives working in maternal health, child health and family planning.	SMS	South Africa	2M	Standard SMS charges
NurseConnect	Support nurses and midwives working in maternal health, child health and family planning across South Africa.	SMS, App	South Africa	12K	Standard SMS charges
FamilyConnect	Maternal Health platform to address the needs of families as well as mothers in Uganda.	SMS, App	Uganda	Unclear	Unclear
Mobidoc	Real-time doctor to patient chat-based application; and provide health information from doctors.	App	Nigeria	Unclear	Free for users.
SophieBot	Provides information on sexual health	App	Kenya	Unclear	Unclear

APPENDIX 2: CONTINUED

Table 3. Promising chatbots in low-income countries (cont.)

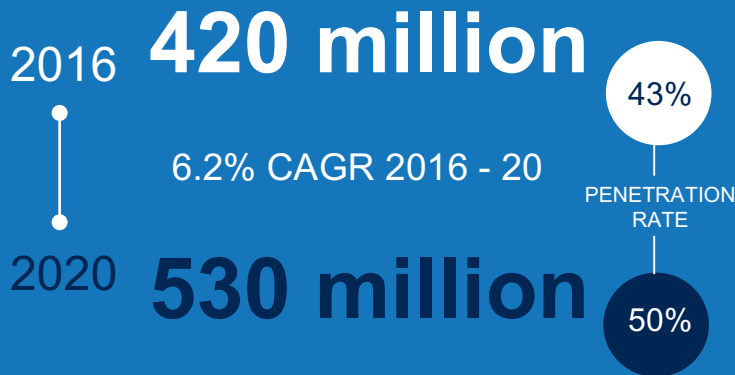
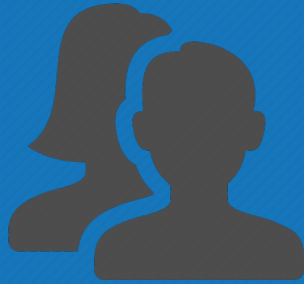
COMPANY	PRODUCT	PLATFORM	GEOGRAPHY	MONTHLY USERS	FEE STRUCTURE
HelloDoctor	Provides people direct and immediate access to Doctors for health advice and information.	App	South Africa	Unclear	R85 per month
MedAfrica	Helps find reputable healthcare providers through a free mobile application.	App	Kenya	Unclear	Free for users.
SaferMom	Delivering personalized health information to keep expectant mothers and Newborns safe.	SMS, Voice, App	Nigeria	Unclear	Unclear
iAFYA	Offers answers to everyday questions on medical conditions, treatment options or basic first aid	SMS, App	East Africa	36K	Unclear
Doctor's Office	Help users find available doctors	App	Unclear	Unclear	Unclear
Hidoctor	Connect patients to doctors	App	Unclear	Unclear	Unclear
Nuru	Agriculture, classified ads, finances, and healthcare	App	Kenya, Ghana	Unclear	Unclear
Aajoh	Allows individuals to input health symptoms via text, audio and photographs to obtain a diagnosis instantly using AI.	SMS, Voice, App	Nigeria	Unclear	Unclear

APPENDIX 3: LIST OF EXPERTS INTERVIEWED

NAME	ORGANIZATION	TITLE	EXPERTISE
Xuchen Yao	Kitt.ai	Founder & CEO	Artificial intelligence and natural language processing
Dykki Settle	PATH	Global Program Leader	Digital health landscape
Isaac Holeman	Medic Mobile	Co-Founder & COO	Frontline mHealth
Will Kearns	University of Washington	PhD Candidate for Biomedical and Health Informatics	Chatbot design and infrastructure
Hao Fang	University of Washington	Alexa Prize Winner, Postdoctoral Fellow	Chatbot design and infrastructure
Dino Rech	Bill and Melinda Gates Foundation	Senior Program Officer	Clinical service delivery
Tim Wood	Bill and Melinda Gates Foundation	Senior Program Officer	Digital health landscape

Appendix 4: MOBILE ECONOMY SUB-SAHARAN AFRICA

Unique
mobile
subscribers



SIM connections



ACCELERATING MOVES TO MOBILE BROADBAND NETWORKS AND SMARTPHONE ADOPTION

Mobile broadband
connections to increase
from 33% to total in 216 to

60%
by 2020

By 2020, there will be

498M

smartphones growth of
300 million from the end of 2016

Mobile data traffic to grow
by a CAGR of

66%

over the period 2016 - 2020

Data growth
driving
revenues and
operator
investments

Operator total revenue



REFERENCES

- [1]. Siwicki, B. (2017, 18 September). "AI chatbots might be the money-savers hospitals are looking for." Available from <http://www.healthcareitnews.com/news/ai-chatbots-might-be-money-savers-hospitals-are-looking>.
- [2]. Babylon Health, Your.MD, HealthTap, Florence, TotoHealth investment page on "funderbeam". Available from <http://www.funderbeam.com>.
- [3]. Kenneth F. Brant, T. A. (2017). "Hype Cycle for Artificial Intelligence, 2017." Gartner.
- [4]. Smisha Agarwal, L. R., Tamara Goldschmidt, Michelle Carras, Neha Goel, Alain B. Labrique (2016). "Mobile Technology in Support of Frontline Health Workers: A comprehensive overview of the landscape, knowledge gaps and future directions." Johns Hopkins University, Global mHealth Initiative.
- [5]. Fitzpatrik, K.K; Darc, A; Vierhile, M. "Delivering Cognitive Behavior Therapy to Young Adults With Symptoms of Depression and Anxiety Using a Fully Automated Conversational Agent (Woebot): A Randomized Controlled Trial", JMIR Ment Health, 2017, Vol. 4, Issue 2.
- [6]. WHO (2017). "Density of Physicians, Global Health Observatory Data." Available from http://www.who.int/gho/health_workforce/physicians_density/en/.
- [7]. Morais, JC. (2017). "Digital technologies can deliver better healthcare to sub-Saharan Africa." Available from <https://www.weforum.org/agenda/2017/10/digital-paths-for-better-healthcare-in-sub-saharan-africa/>.
- [8]. Africa, W. (2017). "The African Regional Health Report: The Health of the People." Available from <http://www.who.int/bulletin/africanhealth/en/>.
- [9]. The GSM Association (2017). "The Mobile Economy 2017." Available from <https://www.gsmainelligence.com/research/?file=9e927fd6896724e7b26f33f61db5b9d5&download>
- [10]. Källander, K. Tibenderana, J. K. Akpogheneta, O. J. Strachan, D. L. Hill, Z. ten Asbroek, A. H. Conteh, L. Kirkwood, B. R. Meek, S. R. "Mobile Health (mHealth) Approaches and Lessons for Increased Performance and Retention of Community Health Workers in Low- and Middle-Income Countries: A Review." J Med Internet Res. 2013. Vol. 5, Iss 1.
- [11]. Labrique, A. B. Vasudevan, L. Kochi, E. Fabricant, R. Mehl, G. "mHealth innovations as health system strengthening tools: 12 common applications and a visual framework." Glob Health Sci Pract. 2013. Vol. 1, Iss 2.

- [12]. Free, C. Phillips, G. Watson, L. Galli, L. Felix, L. Edwards, P. Patel, V. Haines, A. "The effectiveness of mobile-health technologies to improve health care service delivery processes: a systematic review and meta-analysis." PLoS Med. 2013. Vol. 10, Iss 1.
- [13]. Lee, S. Cho, Y. M. Kim, S. Y. "Mapping mHealth (mobile health) and mobile penetrations in sub-Saharan Africa for strategic regional collaboration in mHealth scale-up: an application of exploratory spatial data analysis." Global Health 2017, Vol 13, Iss 1.
- [14]. Accenture, "Artificial Intelligence: Healthcare's New Nervous System". Available from <https://www.accenture.com/us-en/insight-artificial-intelligence-healthcare>
- [15]. Babylon Healthcare Services Limited. "Babylon Health Plan Pricing." Available from <https://www.babylonhealth.com/pricing>.
- [16]. Donal Power, "The Bot Invasion is On, Powered by \$24B in Funding", available from <https://readwrite.com/2017/04/09/the-bots-invasion-is-on-powered-by-24b-in-funding-dl4/>
- [17]. Babylon Health, "Rwanda. Our experience, delivery model and what we learned so far." Available from <https://www.babylonhealth.com/uploads/business/Rwanda-Case-Study.pdf>
- [18]. Your.MD page on techcrunch, available from <https://techcrunch.com/2017/06/27/your-md-raises-10m/>
- [19]. HealthTap. Available from <https://www.healthtap.com/>.
- [20]. TotoHealth. Available from <https://totohealth.org/homepage>
- [21]. Praekelt Foundation, Annual Report 2016. Available from https://static1.squarespace.com/static/579f3fe2cd0f685ac1ca6b9e/t/594d0214f7e0ab535a5822c1/1498219035804/Praekelt_Org_Annual_Report_F17.pdf
- [22]. Joint USAID-African Development Bank Ministerial Meeting. "Investing in Technology and Innovations for Human Development in Africa: Meeting" Morocco. 2014. <http://www.africanstrategies4health.org/>
- [23]. Bhatia, R. (2017). "Is data the only barrier to developing chatbots? Check out the pitfalls to avoid." Available from <https://analyticsindiamag.com/is-data-the-only-barrier-to-developing-chatbots-check-out-the-pitfalls-to-avoid/>.
- [24]. USAID (2016). "Trends in Digital Health in Africa: Lessons from the African Strategies for Health Project." Available from https://www.msh.org/sites/msh.org/files/digital_health_in_depth_review_final.pdf.

RECOMMENDED LITERATURE

[1]. The GSM Association (2017). "The Mobile Economy 2017." Available from <https://www.gsmainelligence.com/research/?file=9e927fd6896724e7b26f33f61db5b9d5&download>

[2]. Kenneth F. Brant, T. A. (2017). "Hype Cycle for Artificial Intelligence, 2017." Gartner.

[3]. Smisha Agarwal, L. R., Tamara Goldschmidt, Michelle Carras, Neha Goel, Alain B. Labrique (2016). "Mobile Technology in Support of Frontline Health Workers: A comprehensive overview of the landscape, knowledge gaps and future directions." Johns Hopkins University, Global mHealth Initiative.

[5]. Labrique, A. B. Vasudevan, L. Kochi, E. Fabricant, R. Mehl, G. "mHealth innovations as health system strengthening tools: 12 common applications and a visual framework." Glob Health Sci Pract. 2013. Vol. 1, Issue 2

[6] USAID (2016). "Trends in Digital Health in Africa: Lessons from the African Strategies for Health Project." Available from https://www.msh.org/sites/msh.org/files/digital_health_in_depth_review_final.pdf.