CROWD-SOURCING DISEASE SURVEILLANCE: AN EXPLORATION OF ATTITUDES AND BEHAVIORS TO INFORM THE DEVELOPMENT OF A PARTICIPATORY MHEALTH SURVEILLANCE SYSTEM IN GHANA, WEST AFRICA.

by

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(Under the Direction of Tamora Callands)

ABSTRACT

Ghana experiences struggles with high rates of morbidity and mortality attributable to both communicable and non-communicable diseases. Efforts to address the health inequalities and concerns – beginning with the country's disease surveillance procedures – have produced mixed results due to a lack of innovative approaches and the necessary infrastructure to support creative solutions. Modern technological advancements have produced many commonplace items such as the mobile phone. With a national mobile phone subscription rate of 134.32 phones per 100 people, Ghana is uniquely poised to host ingenious advances in the arena of disease surveillance by utilizing mobile health (mHealth) technology. This study examined mobile device usage behavior among key informants in the Greater Accra region of Ghana, and also explored their willingness to adopt a mobile phone-based participatory surveillance system. Additionally, this study investigated the desired features and characteristics of such an mHealth surveillance system through individual interviews which probed topics such: as attitudes towards transmitting health information via the Internet, differences in sources of health information, and the community's desire to actively participate in disease surveillance. The approach for developing interview questions and topic themes was guided by the Unified Theory of

Acceptance and Use of Technology (UTAUT) to ensure a systematic approach to this study. Individual interviews were supplemented with standardized and structured surveys distributed to all study participants. Results from this study indicate that key informants ascribe a high level of importance to processes that have potential to influence their health. As such, they are willing to share health-related information via a mobile app system as long as their information remains private and they are explicitly made aware of the potential benefits of using the app. This study concludes with recommendations for developing a participatory mHealth surveillance system as well as recommendations for future research.

INDEX WORDS: mHealth; mobile health; mobile phones; disease surveillance; data collection; health information; information sharing; Ghana; West Africa; key informant interviews; qualitative, behavior theory; UTAUT; Diffusion of Innovations; Individual Innovativeness Scale; features.

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CHAPTER 1

INTRODUCTION

Mobile Health (mHealth)

Around the year 2000, when the popularity of mobile phones really began to take off, the United States had 109.4 million active mobile phone subscriptions in a country of 282.1 million people, making a mobile subscription rate of 38.9% ((ITU), 2020; "United States | Data," 2017). Similar subscription rates were observed in developed countries around the world. During the same time period developing countries also experienced mobile phone penetration, although at a slower rate. As an example, the mobile subscription rate in Ghana, West Africa was approximately 0.7%; there were 130,000 mobile service subscriptions in a country of 18.9 million people at the time ((ITU), 2020; "Ghana | Data," 2017). As of the International Telecommunication Union's last analysis in 2019, Ghana had a mobile phone subscription rate per 100 inhabitants that rivals or far exceeds that of most Western countries and other African countries. In 2019, Ghana had a mobile subscription rate of 134.32 per 100 people ((ITU), 2020). For comparison, that same year the number of mobile subscriptions (per 100 inhabitants) was 91.85 in Nigeria, 165.60 in South Africa, 119.90 in the United Kingdom, 91.86 in Canada, 110.61 in France, and 134.46 in the United States ((ITU), 2020). Resulting from the worldwide proliferation of mobile telephones and mobile devices, health workers and providers around the world have begun exploring novel applications of mobile technologies in the arenas of health research and healthcare service provision (Ali, 2016; Brinkel, Kramer, Krumkamp, May, & Fobil, 2014; Raifman, Lanthorn, Rokicki, & Fink, 2014; Surka et al., 2014; Wakadha et al., 2013). Mobile health—or mHealth—is the delivery of healthcare services and health information through mobile phones and other wireless telecommunication devices (Pande et al., 2017).

mHealth in Ghana

Ghana is a country located on the western coast of Africa, with a population of approximately 32 million people ("The World Factbook: GHANA," 2021). With the distinction as the first sub-Saharan African (SSA) country to regain independence from European colonial rule (in 1957), Ghana continues to lead the region when comparing health and social indicators. For example, in 2015 the average life expectancy at birth for the total Ghanaian population was 61.5 years and the infant mortality rate (IMR) was 42.8 per 1,000 live births, compared to the total life expectancy for the SSA region of 58.9 years and total IMR of 56.4 per 1,000 live births ("Ghana | Data," 2017). Additionally, Ghana has achieved a total adult literacy rate of 76.6% (compared to 60.9% in SSA) and a total youth literacy rate of 90.6% (compared to 71.4% in SSA) through diligent legislative and social messaging efforts ("Ghana | Data," 2017).

Across SSA, health workers are consistent in their complaints regarding the deficiencies of their health systems (Mitchell et al., 2012). Information leading to accurate counts of disease and illness are often reported to be incomplete (Joos et al., 2016; Mitchell et al., 2012; Simonyan, Gagnon, Duchesne, & Roos-Weil, 2013). Added time taken to complete paper forms and the lack of completed forms are some of the main complaints reported by health workers (K. Johnston, 2004; Joos et al., 2016). Other concerns are the underdeveloped healthcare infrastructure in SSA countries. For example, in Tanzania volunteer health workers (VHWs), reported frequently needing to write a letter—to be delivered in person—when needing to notify the necessary parties about emergency health situations (Madon, Amaguru, Malecela, &

Michael, 2014). They further elaborated that there were times when this time-consuming process did not produce any action on the health issue until it was too late (Madon et al., 2014).

In Ghana and around Africa, explorative studies have determined that mHealth tools are successful at collecting viable health information and aiding in providing quick responses to health concerns (Aranda-Jan, Mohutsiwa-Dibe, & Loukanova, 2014; Chin et al., 2013; K. Johnston, 2004; Mash et al., 2007; Mwabukusi, Karimuribo, Rweyemamu, & Beda, 2014; Quan, Hulth, Kok, & Blumberg, 2014). Research studies and review articles examining numerous mHealth initiatives in Africa conclude that collecting data using mHealth tools is feasible for delivering information in real-time and helping reduce data loss and reporting errors, addressing some of the previously identified issues plaguing disease surveillance and data collection in Africa (Aranda-Jan et al., 2014; Ndayizigamiye & Maharaj, 2016; Zargaran et al., 2014).

Significance of Proposed Research

This research project seeks to increase overall completeness of disease surveillance activities in the Greater Accra Region of Ghana by taking advantage of mobile telecommunication tools which are ubiquitous within the Ghanaian community, and have been shown to produce more complete and valid surveillance information ((ITU), 2020; Aranda-Jan et al., 2014; Chin et al., 2013; “Ghana | Data,” 2017; M. Johnston, Mobasheri, King, & Darzi, 2015; Mash et al., 2007; Mwabukusi et al., 2014; Quan et al., 2014; Simonyan et al., 2013). This research project provides foundation for further work to explore using mobile technology to improve the amount of time required to collect, transmit, analyze, and interpret health surveillance data within the local Ghanaian community (Aranda-Jan et al., 2014; Ndayizigamiye & Maharaj, 2016; Zargaran et al., 2014).

Study Aims

This research project highlights the importance of exploring and scaling up participatory surveillance systems in developing regions of the world, with Ghana as an example by assessing the following aims among working Ghanaian adults:

Aim 1: To understand the general community's use of, attitudes towards, and willingness to adopt mobile device usage for health-related information sharing.

Aim 2: To determine the desired features and characteristics that could promote self-reporting of health-related information and health behaviors to a mobile health surveillance system.

Contribution and Innovation

There are four main areas of innovation that this study intends to contribute to the field of mHealth surveillance and data collection. Successful completion of this research project will allow the scientific community—as well as technology developers—to gain a better understanding of the potential for lay community-member participation in the healthcare surveillance process, essentially through crowdsourcing surveillance data. This research project's goal is to expand the scope of mHealth work that utilizes lay community members as active participants in the disease surveillance process. The use of lay community members as the sources of data input and the population-focus under study is a strategy that has seldom been used in mHealth surveillance research among populations in developing countries. Second, the attempt to approach disease surveillance via "crowd-sourcing" has not been explored within mHealth data collection and disease surveillance among populations in developing countries. Third, implementing a syndromic surveillance system on such a large scale for the purposes of continued surveillance is an approach that is not represented in the mHealth surveillance literature, especially when focusing on developing countries. If successful, this approach may chart a path for exploring real-world applications of large-scale syndromic surveillance systems. Finally, taking a health behavior theory-based approach to the formative stage of developing this research tool is a strategy that is almost nonexistent within the mHealth surveillance literature (Brinkel et al., 2014; Goyal et al., 2016; Hussain et al., 2015).

CHAPTER 2

LITERATURE REVIEW

mHealth

mHealth refers to the delivery of healthcare services and health information through mobile phones and other wireless telecommunication devices (Pande et al., 2017). mHealth tools offer the promise of delivering health interventions aimed at reducing morbidity and mortality, as well as improving the quality of life in resource-constrained settings (Forrest et al., 2015). There are also examples of mHealth tools enabling health authorities to respond to cases of disease or to conduct follow-up in a quicker time frame, enabling providers to conduct more complete disease screenings, and enabling patients to improve adherence to medication (Forrest et al., 2015; Mash et al., 2007; Mwabukusi et al., 2014).

mHealth in Ghana

Although mHealth applications have demonstrated the potential to make a substantial difference in the health systems frameworks of countries across Africa, government entities have been slow to dedicate policies and investments to the development of mHealth tools (Barkman & Weinehall, 2017). In the private sector, companies such as Apple and Google devote immense resources not only to the development of such innovations as mHealth, but also to continued improvement based on implementation feedback (Barkman & Weinehall, 2017). On the other hand, many African governments struggle with histories of lost financial investments resulting from poorly designed or poorly implemented information technology (IT) solutions (Barkman &

Weinehall, 2017). However, growing evidence supporting the potential for mHealth solutions and a fear of missing the Millennium Development Goals by the year 2015 led the Ghanaian Ministry of Health (MoH) to adopt a National e-Health Strategy in 2010 (Barkman & Weinehall, 2017; Ministry of Health, 2010). This strategy was aimed at:

1) Streamlining the regulatory framework for health data and information management,
2) Building sector capacity for wider applications of e-health solutions in the health sector,
3) Increasing access and bridging the equity gap in the health sector through the use of Information and Communication Technology,
4) Moving the sector towards a paperless records and reporting system (Barkman & Weinehall, 2017).

Efforts at achieving the aims of this e-health strategy have encountered challenges, chief of which relates to finances. Funding for implementing technological innovations at healthcare facilities comes from a combination of government funds and internally generated funds (Ministry of Health, 2010). Due to shifting political priorities and an already constrained national budget, government funding for innovative projects is often unpredictable. (Ministry of Health, 2010). Thus, the inability to rely on government funding with any form of regularity serves as an excellent illustration of the financial challenges associated with mHealth implementation in the Ghanaian context. The scarcity and unpredictability of government funds combined with the typical slim profit margins of internally generated funds presents a major barrier to the systematic and standardized development of mHealth tools across the country.

The existing information and communications technology (ICT) infrastructure in the country has not been integrated and networked in a manner sufficient to support the data collection, storage, analysis, and communication demands of an entire nation’s healthcare system (Ministry of Health, 2010). Achieving such a level of integration and connectivity will require concerted efforts from ICT professionals to program and develop the necessary software and to maintain the system on an ongoing basis (Ministry of Health, 2010). This issue of mHealth system sustainability is ever present in the wake of the numerous pilot studies that have been conducted in Africa. Pilot studies are often the primary funders of exploratory mHealth systems (and in some cases, the only funders solely), with financing coming primarily from the study’s funding mechanism and lasting only through the study’s completion (Ministry of Health, 2010; Mtema et al., 2016). Study communities are frequently left with the inability to financially support and maintain the successful systems following study completion (Ministry of Health, 2010; Mtema et al., 2016). This has been identified as the leading cause of mHealth project failures in Ghana (Ministry of Health, 2010).

Funding proves to be a challenge in beginning mHealth initiatives because the setup costs have the potential to be high. This is especially true for studies requiring high-tech equipment, as setup costs for some mHealth initiatives involving specialized technology is known to be very high. A study of teleconsultations between patients in remote areas of Cameroon and physicians in central locations reported initial planning costs for study equipment to be approximately €9,000 (or roughly $10,700) at each study facility (Bigna, Noubiap, Kouanfack, Plottel, & Koulla-Shiro, 2014). Additionally, it cost about €900 (roughly $1,070) per month for broadband Internet subscription to support data transfer in times of network lapses, bringing the total first year cost for implementing this study to about €20,000 (approximately $23,800) (Zachariah et al., 2012). Another study of teleophthalmology consultations between patients in South Africa and physicians in the United Kingdom reported setup costs for the appropriate camera equipment of between about €13,400 and €13,900—roughly between $15,900 and $16,500 (Githinji et al., 2014).

Though these reported setup costs look daunting and discouraging to the implementation of mHealth initiatives, it seems that high setup costs are associated with very specialized and specific mHealth tools such as special camera equipment and audio equipment (Bigna et al., 2014; Githinji et al., 2014; Zachariah et al., 2012). Other studies that involved using existing infrastructure and equipment—i.e. existing mobile phones and the existing cellular network—have reported manageable costs associated with their programs. In a teleconsultation study conducted in rural Cameroon, text messages sent as part of the study were reported to cost between 50 Central African CFA Francs (CFA) and 100 CFA depending on the length of the message sent—which is approximately between $0.01 and $0.18 per text message sent (Bigna et al., 2014). Another study using mobile phones to track drug safety and adverse events associated with taking malaria medication in Ghana reported costs associated with phone calls made. Phone calls inquiring about adverse events lasted between 16 seconds—with an associated cost of 0.26 Cedis or $0.20—and 53 minutes—with an associated cost of 279 Cedis or $27 (Kukula et al., 2015). Though the average phone call lasted 3 minutes and 51 seconds and cost 2.70 Cedis ($0.77), most phone calls lasted 5 minutes and cost 13.50 Cedis or about $3.86 (Kukula et al., 2015).

The lack of a standardized mHealth architecture and framework is another identified challenge in the development and adoption of mHealth tools for the Ghanaian context (Ministry of Health, 2010). As a result of nonexistent standard framework for development, majority of the mHealth tools currently present were developed and exist in silos with each tool collecting different data points in different formats using different operating software platforms (Ministry of Health, 2010). Adding to the lack of standardization within the health system is the fact that, while the International Classification of Diseases (ICD) codification system is occasionally used in developing these innovative software, country-specific classifications are often used in order to ensure successful case identification (Ministry of Health, 2010). Utilizing knowledge from these studies would lead one to conclude that the best approach to introducing mHealth innovations in a resource limited setting such as Ghana would be to take advantage of existing resources. Within the arena of mHealth, it is widely known that the rapid adoption of mobile phones has promoted the ability to conduct remote communication of voice and limited data flow at a low cost (Chin et al., 2013).

Facilitators and Barriers to mHealth in Ghana

Following a number of disease outbreaks in the 1990s (such as yellow fever, meningococcal meningitis, and Ebola and Marburg hemorrhagic fevers), various country ministries of health (MoH) sought the services of the World Health Organization (WHO) regional officer for Africa and other stakeholder partners to help develop appropriate strategies for early detection, confirmation, and adequate response to disease outbreaks and emergencies (Adokiya, Awoonor-Williams, Beiersmann, & Müller, 2015). After working on this initiative, member states adopted the Integrated Disease Surveillance and Response (IDSR) strategy in September 1998 at a regional committee meeting in Harare, Zimbabwe (Adokiya et al., 2015; Kaboré, McDonnell, & Perkins, 2001; World Health Organization, 2010). Surveillance was selected as a focus for the approach to disease control because the WHO member countries understood that without adequate disease detection mechanisms, governments could never know the true scope of work needed to control disease spread. Additionally, many of the diseases that plague African communities have well-known prevention and control methods associated with them, indicating that future cases can be prevented if health workers and health authorities have an accurate picture of the disease burden (Kaboré et al., 2001; World Health Organization, 2010).

Ghana adopted the IDSR strategy for disease surveillance and control in 2002 and has seen the number of reportable diseases to the system increase from 23 in 2002 to 43 in 2011 (Kaboré et al., 2001). Similar to other countries in the region, one of Ghana's motivations for adopting the IDSR was a desire to integrate disease surveillance activities. Prior to adopting the IDSR, the country had multiple existing independent surveillance systems – one for each disease or condition being monitored (Adokiya et al., 2015; Kaboré et al., 2001; Nsubuga et al., 2010). This strategy required skilled workers at each level of surveillance for every system in existence, which taxed an already scarce pool of skilled personnel and overburdened an already shaky surveillance infrastructure. The implementation strategy for IDSR is focused on integrating surveillance activities at the district level, where these streamlined surveillance activities can be used to collect information from any level of the health system (Kaboré et al., 2001).

The development of a detailed surveillance framework with a strict set of guidelines serves as a major facilitator for disease surveillance in Ghana. The IDSR aims to reduce the number of people required to conduct adequate disease surveillance across the country in addition to reducing the amount of time it takes to respond to a disease emergency or outbreak. Under the IDSR procedures, disease surveillance in Ghana begins once a person presents to a hospital, healthcare facility, or other location for medical attention. During this visit, information about the patient's condition (e.g. date of onset, date of presentation at facility, symptoms exhibited, etc.) and demographic information (e.g. age, gender, area of residence, etc.) are collected and entered into a register on a daily basis (Kaboré et al., 2001). Due to financial challenges and infrastructure shortcomings in many parts of the country, these patient registers are often paper forms or physical notebooks (Kaboré et al., 2001). Data collection and analysis via paper-based systems is very common in developing countries, and is known to take a long time to complete in addition to often generating inconsistent and unreliable data (Ndayizigamiye & Maharaj, 2016). If a patient presents to the health facility with an illness that requires surveillance reporting, the condition is immediately reported to appropriate personnel at the local facility who then relays this information via paper forms to the appropriate authority at the district level (Kaboré et al., 2001). Otherwise hospital staff compiles summary information for each routinely reported condition periodically (typically weekly or monthly) and sends the summary to the district (Kaboré et al., 2001). Every month, relevant data for each of the IDSR conditions are compiled and analyzed at the district level before being sent to the regional or central level, where geographic plots of surveillance trends and a log of all suspected outbreaks are produced (Kaboré et al., 2001).

Although the process underlying the IDSR system is theoretically sound, previously mentioned infrastructure issues that exist in most parts of Ghana create challenges for the disease surveillance process to work at optimum performance. These infrastructure issues are very similar across all the countries in SSA, and though they are not reflected in the disease surveillance literature specifically for Ghana, they are well documented in numerous studies of multiple SSA countries (Dil, Strachan, Cairncross, Korkor, & Hill, 2012; Madon et al., 2014; Stevens & Pfeiffer, 2015). Since the IDSR requires information to be filled out at a health facility, the disease surveillance process is reliant on a patient presenting to his or her local healthcare facility.

A major barrier to hospital visitations in rural areas is the cost of hospital services. Patients who cannot afford needed medical services are not likely to seek medical care, precluding them from inclusion in the surveillance report. Outside of the few cities with passable roads and functional transportation, many patients across the country are likely to encounter problems with accessing a healthcare facility. Results of a study conducted by Dil et al. (2012) captured the major challenges faced in data collection in SSA. Poor—and sometimes nonexistent—roads and extreme travel conditions often mean that members of the community do not seek medical care until their condition is advanced. A similar observation was made in a study of cholera surveillance in Bangladesh, which illustrated that passive and clinic-based surveillance activities end up ultimately capturing only severe cases of illness that have the ability to access healthcare services (Azman et al., 2015). Comparable results were demonstrated in Ethiopia, where more than half the patients who were diagnosed with pulmonary tuberculosis did not present to a public health facility for at least 30 days (Rajput et al., 2012). Even more concerning, they further point out that many patients who have specific medical conditions never get diagnosed because they rarely interact with the healthcare system (Rajput et al., 2012). As an alternative to requiring patients to travel to healthcare facilities, communities in Africa have adopted the model of utilizing the services of community health workers (CHWs) to conduct surveillance through home and community visits. While CHWs can lessen the burden of traveling to a healthcare facility from the patient, it does not address the actual burden of treacherous road conditions. Qualitative interviews conducted by Dil et al. (2012) revealed that community-based surveillance volunteers in northern Ghana frequently encountered problems securing transportation to conduct surveillance in remote communities (Dil et al., 2012).

In addition to infrastructure challenges, surveillance activities tend to suffer from other identified challenges such as a lack of adequate incentives for health workers, corrupt practices and resulting stigma, and an endemic lack of motivation for collecting health data among health workers (Madon et al., 2014). For example, Tanzanian health officials in a study interview complained about infrequent updates of village registers to the facility level because clinicians attached little importance to the recommended format for reporting information during their rounds (Madon et al., 2014). Another study in Nigeria investigating the country's integrated Community Case Management (iCCM) system identified poor clinical worker adherence to iCCM guidelines as a major shortcoming of the paper-based system (Heavin & O'Connor, 2016). This lack of strict adherence has been associated with misdiagnoses and mistreatment of seriously ill children in the health system (Heavin & O'Connor, 2016). The challenge of motivation comes up again on behalf of community health workers and volunteers, who reported a lack of motivation resulting from shortage of necessary equipment, paucity of adequate incentives for work-related tasks and travels, and periodic struggles with losing financial compensation to other corrupt health workers who help themselves to district funds meant for incentives and reimbursements (Dil et al., 2012). In the case of community volunteers, negative stigma from some corrupt government worker practices precedes them, leading to mistrust and poor cooperation from community members (Dil et al., 2012).

Examples of mHealth across sub-Saharan Africa

An example of mHealth used to increase healthcare service utilization is a study that explored children's participation in the Pesinet program and changes in healthcare services utilization (Simonyan et al., 2013). In this study, children ages 5 years and younger were separated into a telehealth group—who were enrolled in the Pesinet program—and the control group—who received usual care (Simonyan et al., 2013). The Pesinet program entailed weekly or bi-weekly home visits from weighing agents who collected information on the child's health status, such as body weight, body temperature, breast-feeding, vomiting, stools, coughs, health concerns, and any emergency indicators (Simonyan et al., 2013). These data were collected using the weighing agents' mobile phone and information was transmitted to a central network via the available mobile network (Simonyan et al., 2013). Information sent to the nearest participating community health center was analyzed and automatically flagged for abnormalities when necessary (Simonyan et al., 2013). Abnormalities were examined by a general practitioner, and if a health problem was identified, the weighing agent returned to the patient's home and presented them with an emergency ticket for a same-day consultation which was provided free of charge to children enrolled in the Pesinet program (Simonyan et al., 2013). Enrollment in Pesinet also provided reduced pricing on prescribed medications (Simonyan et al., 2013). Results of their study indicated that enrollment in the Pesinet program resulted in a higher utilization of healthcare services compared to children not enrolled (Simonyan et al., 2013).

In another study conducted in rural Zambia, mobile phone technology was used to improve clinical processes such as the delivery of clinical guidance, data collection, and patient services (Brinkel et al., 2014). Researchers in this study created electronic versions of clinical data forms, which were able to share follow-up schedules and other patient information with a central server (Brinkel et al., 2014). Patient information could then be transmitted to community health workers' mobile phones to prompt timely follow-up (Brinkel et al., 2014). This mHealth initiative proved successful in enabling CHWs to conduct more thorough follow-up with patients who indicated the need for more attention (Brinkel et al., 2014). This study illustrates that equipping CHWs with mHealth technologies has the potential to increase health service outreach, to facilitate better quality interactions between the community and health centers/clinics, and to enhance health data collection in Zambia (Brinkel et al., 2014).

Most studies conducted in the region have determined that mHealth is indeed a viable option to collect and transmit useful health information, thereby decreasing the amount of time clinicians devote to data entry/paperwork and freeing up more time to actually attend to patients' needs (Zargaran et al., 2014). In addition to the initiatives highlighted above, mHealth tools have been used to explore the formation of peer support groups for illness treatment and recovery support in Cameroon, Nigeria, South Africa, and even war-torn regions of Somalia (Bigna et al., 2014; K. Johnston, 2004; Rotheram-Borus et al., 2012). So far, the literature in mHealth surveillance demonstrates overwhelming success in proving that mobile technologies, in the hands of properly trained users, are capable of delivering more complete health information in near-real time with minimal reporting errors (Aranda-Jan et al., 2014; Brinkel, May, et al., 2017; Déglise, Suggs, & Odermatt, 2012). The studies that mentioned challenges in implementing mHealth tools referenced issues such as technical problems with the devices, financial problems in maintaining smooth flow of mHealth processes, and infrastructural difficulties (Brinkel, May, et al., 2017). The only known study where mHealth tools proved to be a failure was a pilot teleophthalmology trial located in rural Malawi. Researchers in this study aimed to enroll HIV-infected patients who presented at the district health clinic and had eye manifestations of disease (Perez, Swart, Munyenyembe, & Saranchuk, 2014). However this study ultimately remained unsuccessful because of an extreme underestimation of the number of staff required to support study activities (Perez et al., 2014). In fact, there were not enough trained health personnel in the entire region where the study was conducted (Perez et al., 2014). Researchers use this study as an opportunity to underscore the importance of involving local authorities and representatives from local Ministries of Health from the beginning of project design (Perez et al., 2014). Continued communication with local players in the health arena will prove very valuable in my research objectives to ensure that the research project has a good understanding of the specific challenges and barriers that may accompany the project.

In the midst of investigating the capabilities and potential for mHealth on the continent, West Africa experienced the largest and deadliest outbreak of Ebola hemorrhagic fever to date (Centers for Disease Control and Prevention, n.d.; Sacks et al., 2015). What made this outbreak different from typical disease outbreaks was the quick and deadly nature of the Ebola virus. Ebola quickly transitions its victims through symptoms of fever, fatigue, muscle pain, severe headache, diarrhea, vomiting, unexplained bleeding, and often causing death within an average of 2 – 21 days (Centers for Disease Control and Prevention, n.d.). With the quick progressing nature of this disease and the manner in which it is spread, parties involved in the response to the outbreak needed to be very quick and very accurate in identifying potential cases as well as conducting contact-tracing. Majority of the population in West Africa resides in rural and often-remote locations and are highly mobile, making the prolonged contact tracing required by Ebola very difficult (Sacks et al., 2015). Additionally, the contact tracing processes at the time this outbreak began were paper-based, often taking a minimum of two to three days for information to be compiled, processed, and made actionable (Sacks et al., 2015).

Understanding that this situation required creative solutions, health professionals deployed innovative approaches to obstacles, such as the real-time information system for contact tracing activities in Guinea (Sacks et al., 2015). Using existing protocols from CDC, the World Health Organization, and the United Nations, the research team in this study developed an application called CommCare via a combination of Open Data Kit (ODK) for data collection and Tableau software for data analysis and display (Sacks et al., 2015). This mobile application contained a responsive decision-tree algorithm that suggested action steps to the contact tracer based on the information previously entered (Sacks et al., 2015). The application also allowed users (i.e. contact tracers and appropriate health authorities) to visualize longitudinal representations of a person's contact tracing (Sacks et al., 2015). The collected information was immediately available in the system to the appropriate authorities who could make important and potentially lifesaving decisions in the timely manner requisite of the response to a disease such as Ebola (Sacks et al., 2015). While the developers of CommCare recognize the immense challenges that come with developing such an innovative application during an emergency outbreak response, they acknowledge the immense potential for bridging wide health gaps in the region—especially in relation to data collection and disease surveillance (Sacks et al., 2015).

Key Technology Adoption Theories

Recognizing that mHealth research in SSA seems to be stuck in a cycle of pilot studies without much follow up, researchers point out that involved stakeholders will be hindered from building larger datasets and information systems for use in the region unless they are able to move past this stagnated period of “pilotitis” in mHealth, (Bigna et al., 2014; Mtema et al., 2016). Studies have presented technical issues, financial issues, infrastructure challenges, data security issues, challenges with cultural understanding, and the scarce availability of diagnostic tools as barriers to effective research conduct and progress in the field (Aranda-Jan et al., 2014; Brinkel et al., 2014; Rotheram-Borus et al., 2012). Regardless of these challenges, the low-cost, ease of use, and widespread availability of mobile phones and mobile devices continues to drive exploration and implementation in the region (Aranda-Jan et al., 2014). Perhaps the most important reason for the lack of progress from pilot studies to more widespread and sustainable models was presented in systematic reviews by Brinkel et al. (2014), Hussain et al. (2015), and Goyal et al. (2016), in which the authors observe that although mHealth studies report acceptance of mobile technologies within health worker groups and the local community, there is no mention of theoretical bases or theoretical influences for designing the mHealth surveillance tools or for conducting mHealth surveillance activities (Brinkel et al., 2014; Goyal et al., 2016; Hussain et al., 2015). Without consulting health behavior and adoption theories in designing the mHealth tools for research studies, investigators cannot make confident statements about the likelihood that their innovative systems will gain permanent adoption among the local communities and health systems. As a result of the absence of theoretical framework to guide the creation of mHealth tools and applications, coupled with the increasingly rapid advancement of mobile technology, pilot studies conducted as recently as five years ago may have limited applicability today (Forrest et al., 2015; M. Johnston et al., 2015).

In contrast to mobile disease surveillance and data collection, the field of health behavior has taken the lead in applying theoretical models to the design, development, and implementation of their mobile health tools and interventions. A review article by Riley et al.

(2011) found that health behavior interventions designed for computer and web use have frequently utilized the most applicable of the following: Theory of Planned Behavior, Theory of Reasoned Action, Health Belief Model, Social Cognitive Theory, the Transtheoretical Model, and Self-Determination Theory (Bandura, 2001; Becker, 1974; Godin & Kok, 1996; Prochaska & Velicer, 1997; Riley et al., 2011; Ryan & Deci, 2000). Another review noticed that health applications designed using the Social Cognitive Theory (SCT) (Bandura, 2001) have demonstrated positive behavior change, improved compliance, and improved health outcomes in randomized trials (Bandura, 2001; Goyal et al., 2016). Being that majority of these theories were developed in the context of psychological behavior change, technology researchers realized the need to devise theoretical frameworks more specific to technology adoption. Through continuous work and adaptation of existing behavior change theories, the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003) and the Diffusion of Innovations Theory (Rogers, 1983; Rogers, 2003) have emerged as leading frameworks for technology development and research (Davis, 1989; Rogers, 1983; Venkatesh, Morris, Davis, & Davis, 2003).

UTAUT is a combination of several health behavior theories, and is based on four constructs, namely performance expectancy, effort expectancy, social influence, and facilitating conditions (Ndayizigamiye & Maharaj, 2016; Venkatesh, Morris, Davis, & Davis, 2003). Performance expectancy refers to the degree to which a person believes that using an information system will contribute to gaining some desired benefits related to performing a job (Ndayizigamiye & Maharaj, 2016; Venkatesh, Morris, Davis, & Davis, 2003). Effort expectancy is an expression of how easy an information system is to use (Ndayizigamiye & Maharaj, 2016; Venkatesh, Morris, Davis, & Davis, 2003). Social influence refers to how much a person feels that influential people believe he or she should use a new information system; and facilitating conditions are defined as the extent to which a person believes that the technical and organizational support needed to effectively use an information system exist (Ndayizigamiye & Maharaj, 2016; Venkatesh, Morris, Davis, & Davis, 2003). Researchers in this study also examined Attitudes Towards Using Technology, Self-Efficacy, and Anxiety as possible constructs of UTAUT, however, these proposed constructs were not significant in predicting intension to use a new information system (Venkatesh, Morris, Davis, & Davis, 2003).Venkatesh, Morris, Davis, & Davis (2003) further proposed that age, gender, experience, and a person's voluntariness of using an information system are variables that moderate the behavioral intention to use the information system (Ndayizigamiye & Maharaj, 2016; Venkatesh, Morris, Davis, & Davis, 2003)(***Figure 1***).

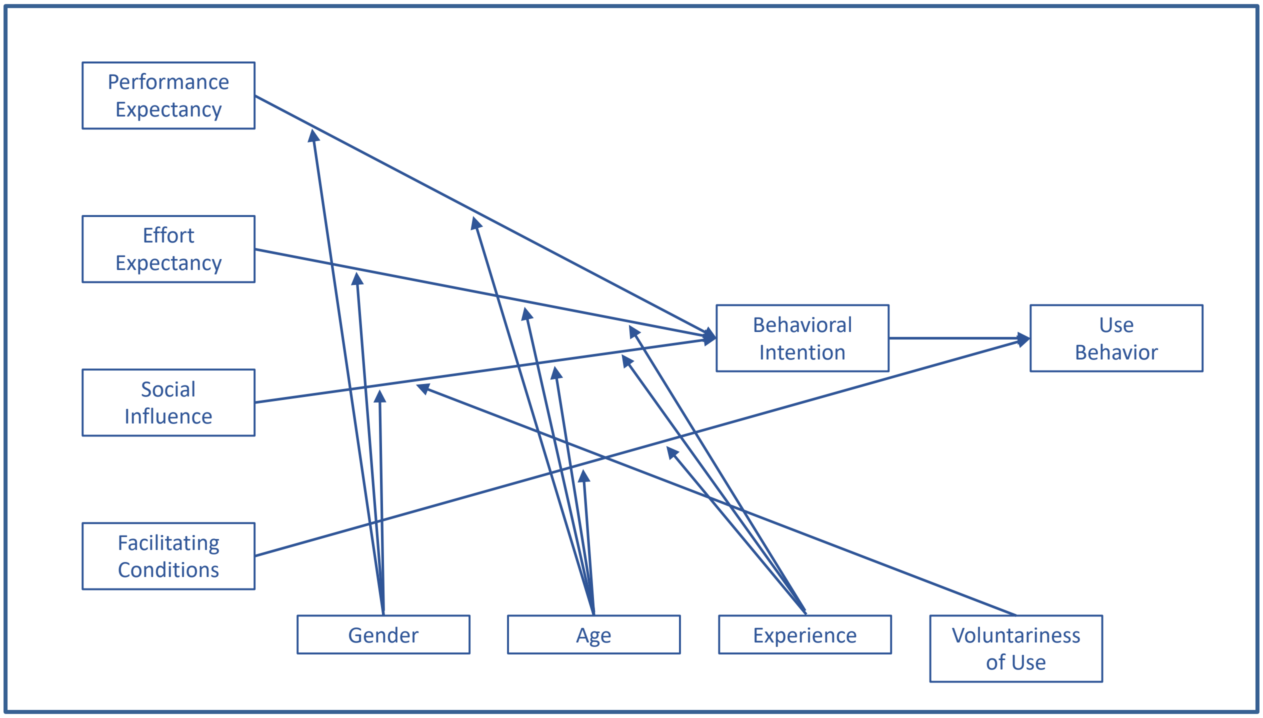

Figure 1: Unified Theory of Acceptance and Use of Technology (UTAUT) model from Venkatesh, Morris, Davis, & Davis. (2003).

An important study in Burundi investigated the factors that have potential to influence health workers' acceptance and adoption of mHealth technology for healthcare service delivery by utilizing a questionnaire adapted to the constructs of UTAUT to determine whether any correlations or associations existed between UTAUT constructs and "mobile health capabilities acceptance"—the dependent variable in this study (Ndayizigamiye & Maharaj, 2016). After conducting Principal Components Analysis (PCA) as well as regression analysis, researchers determined that confidentiality of information (80.2%) was the most agreed-upon facilitating condition considered before adopting a piece of mHealth technology, followed by the reliability of mobile technology infrastructure (61.4%) (Ndayizigamiye & Maharaj, 2016). Further examination of the data revealed that designing mHealth content and messaging in local languages other than English was another important facilitating condition identified through this study (Ndayizigamiye & Maharaj, 2016). To further illustrate this specific finding, the authors reference a Nigerian study of mHealth use in cancer care where 72.5% of study participants—mostly cancer patients—preferred speaking in the local language as they felt it allowed them to better and more clearly describe their health challenges (Ndayizigamiye & Maharaj, 2016; Odigie et al., 2012). Study results also indicated cost factors as facilitating conditions for healthcare professionals in Burundi to adopt mHealth technology (Ndayizigamiye & Maharaj, 2016).

Pertaining to the remaining UTAUT constructs investigated, ease of use of mobile device (83.7%) was the effort expectancy factor most agreed upon for consideration before adopting an mHealth technology, followed by ease of use of mobile health application (77.0%) (Ndayizigamiye & Maharaj, 2016). With regard to performance expectancy, convenience (80.9%) was the factor most agreed-upon before adoption of an mHealth technology, followed by expansion of healthcare access (70.0%) (Ndayizigamiye & Maharaj, 2016). Results of this study indicated that the UTAUT constructs investigated in this study—facilitating conditions, performance expectancy, and effort expectancy—have a positive correlation with mHealth capabilities acceptance (Ndayizigamiye & Maharaj, 2016). Additionally, effort expectancy exhibited a positive correlation with facilitating conditions and performance expectancy, while performance expectancy exhibited a positive correlation with facilitating conditions (Ndayizigamiye & Maharaj, 2016). In the regression analyses, the model with all three variables was not significant, however the model with effort expectancy as a single variable was able to predict mHealth capabilities acceptance in a significant model (Ndayizigamiye & Maharaj, 2016). While this study presents very important results to guide further theoretical explorations and mHealth technology development, it is not without shortcomings. Most notable of these was that the selection of primary healthcare centers to participate in this study, which was based on the healthcare center personnel's availability for study participation, as well as their ability to access passable roads (Ndayizigamiye & Maharaj, 2016). This participant selection strategy threatens the ability to generalize this study's results to other settings. However, based on the fact that this is one of a few of studies exploring theoretical constructs in disease surveillance and data collection in the SSA context, research in this region must build on the results of studies such as this one on the journey to establishing a solid theoretical framework for developing mHealth surveillance tools.

In order to further explore UTAUT, a group of researchers undertook a study aimed at examining user's requirements for using mobile phone-based interactive voice response (IVR) systems for their healthcare seeking needs (Brinkel, Dako-Gyeke, Krämer, May, & Fobil, 2017). The described study was part of a larger project that developed a mobile phone-based electronic health information and surveillance system (eHISS) for collecting child illness symptom information as well as supporting parents and caregivers of ill children (Brinkel, Dako-Gyeke, et al., 2017). Qualitative data from four semi-structured focus group discussions (FGD) were collected from four study sites in southern Ghana: the Accra Metropolitan and Tema Metropolitan areas—both urban centers—and the Shai Osudoku Municipal and Ga West Municipal areas—both rural communities (Brinkel, Dako-Gyeke, et al., 2017). Selecting participants from these locations involved a mixed sampling technique made up of different random stratified steps (Brinkel, Dako-Gyeke, et al., 2017). The final study participant sample was a group of 40 individuals (21 women and 19 men) aged 18 to 59 years (median age was 35 years for women and 37 years for men) who all provided care to at least one child between 0 and 10 years of age (Brinkel, Dako-Gyeke, et al., 2017). Majority of the study participants (26 out of 40) were married and living together with their partner, and half of the study participants (20 out of 40) required assistance filling out the questionnaire on account of low literacy levels (Brinkel, Dako-Gyeke, et al., 2017). Prior to the FGD sessions, participants filled out standardized questionnaires aimed at gathering information on demographics and mobile device ownership and usage (Brinkel, Dako-Gyeke, et al., 2017). FGDs were held at central locations within each community, and were conducted in Twi—one of the local languages—with simultaneous English translation (Brinkel, Dako-Gyeke, et al., 2017). All discussions and interviews were audio recorded and transcribed using the software f4, and later analyzed using a qualitative content analysis in accordance with Mayring's approach—a stepwise analytical approach for constructing coding categories (Brinkel, Dako-Gyeke, et al., 2017).

All study participants reported "very positive" or "positive" experiences with mobile phones, and all but one participant reported daily use of their mobile phone—the lone participant reported weekly use of the mobile phone (Brinkel, Dako-Gyeke, et al., 2017). Daily mobile phone use was reported for a variety of reasons, including social networking, education, employment, leisure time, security, emergency situations, and business purposes (Brinkel, Dako-Gyeke, et al., 2017). Interestingly, 40% (n = 16) of participants reported receiving public health messaging on their mobile phones such as brief health messages and daily health advice (Brinkel, Dako-Gyeke, et al., 2017). Another variable influencing study participants' intention to use the IVR was the ease of use associated with the IVR (Brinkel, Dako-Gyeke, et al., 2017). Falling in line with results reported by other studies, participants reported saved time, improved access to health information, and reduced cost for travel and medical advice as the individual advantages they perceived from using the IVR system to receive health information (Brinkel, Dako-Gyeke, et al., 2017; Brinkel et al., 2014; Datta, Ranganathan, & Sivakumar, 2014; Forrest et al., 2015; Miah, Gammack, & Hasan, 2017; Mtema et al., 2016). Social influence demonstrated its importance in the intention to use the system when participants reported a high level of importance for having the IVR in the voice of a familiar community member, stating that this would boost their trust in information presented through the system (Brinkel, Dako-Gyeke, et al., 2017). The importance of having the system operate in the local languages was also underscored, with one FGD participant suggesting the use of those languages that are commonly used in AM/FM radio communication (Brinkel, Dako-Gyeke, et al., 2017). A notable barrier to using the IVR was the lack of a human interaction using the system, leading to fear that the presenting health problems may be too complex to be adequately handled by an automated system (Brinkel, Dako-Gyeke, et al., 2017). However perhaps the most anticipated barrier was the lack of organizational and technical infrastructure indicated by participant reports of periodic network unavailability and power outages in the country (Brinkel, Dako-Gyeke, et al., 2017).

These were discussed as “moderate” or “extreme” barriers during the FGDs, and are problems which become more pronounced in situations requiring a sustained continued network connection (Brinkel, Dako-Gyeke, et al., 2017; Perez et al., 2014).

While it was not an expected result at the outset of this study, constructs from known technology acceptance models emerged during stepwise analysis of the FGD coding and text material (Brinkel, Dako-Gyeke, et al., 2017). All four determinants of UTAUT—performance expectancy, effort expectancy, social influence, and facilitating conditions—were independently mentioned and discussed during the FGDs (Brinkel, Dako-Gyeke, et al., 2017; Venkatesh, Morris, Davis, & Davis, 2003). In drawing conclusions from their study, Brinkel et al. (2017) suggest that UTAUT is a useful model for predicting and explaining the intention of adopting IVR systems for seeking healthcare information among residents of the Greater Accra region, in Ghana; but as a specific theoretical perspective was not the intention of this study (Brinkel, Dako-Gyeke, et al., 2017). Researchers did not correlate UTAUT constructs with sociodemographic variables or measure determinants of behavioral intention (Brinkel, Dako-Gyeke, et al., 2017).

Mobile devices have long been considered innovations, but as they become increasingly more common around the world their innovativeness becomes tied with the device’s use. Everett Rogers (1983) defines innovation as an idea, object, or practice that is perceived to be new by the population it is introduced to (Rogers, 1983). At the same time, something does not necessarily have to be new in order to be considered an innovation; the device—or its application—simply needs to be novel among that particular group or subgroup (Rogers, 1983, 2003). In this regard, the proposed mHealth tool would not be an innovation based on the involvement of the mobile phone per se, but in the use of mobile phones to collect and transmit this specific type of health and behavioral information directly from community members. Innovative advances in a society are thought to diffuse in a predictable pattern and through established social systems (DiClemente, Salazar, & Crosby, 2019). In order to better understand the potential for widespread adoption of the proposed innovation, Diffusion of Innovations Theory (DOI) will be explored during this study (Rogers, 1983, 2003).

Rogers (1983) proposed DOI as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Glanz & Rimer, 1997; Rogers, 1983, 2003). DOI is comprised of four elements, namely the innovation, communication channels, time, and social system (DiClemente et al., 2019; Rogers, 1983, 2003). An innovation is defined in DOI as an idea, object, or practice that is new—or thought to be new—to a person or community (Glanz & Rimer, 1997; Rogers, 1983, 2003). Communication channels are the ways that the new product or idea is spread from one person to the next (DiClemente et al., 2019; Rogers, 1983, 2003). An innovation is diffused either through formal channels such as media—including television, radio, or internet—or informal channels such as interpersonal relationships (DiClemente et al., 2019; Rogers, 1983, 2003). The time element of DOI relates to how long it takes an innovation to spread across a given population; and the social system refers to the informal communication structures that are present in the population group of interest (DiClemente et al., 2019; Rogers, 1983, 2003).

The concept of time within DOI is of extreme importance because an innovation that takes a long time to gain acceptance and adoption runs the risk of never gaining enough interest and attention (DiClemente et al., 2019; Rogers, 1983, 2003). Rogers identified the *Innovation Decision Process*, which characterizes the time element of DOI and was described to have five (5) discrete stages: Knowledge, persuasion, decision, implementation, and confirmation

(DiClemente et al., 2019; Rogers, 1983, 2003). Knowledge is essential to the adoption of an innovation, as one simply cannot adopt something of which he or she has no knowledge; and this knowledge can take place in three forms: Awareness knowledge—usually by coming in contact with people who are aware of the innovation, acquisition knowledge—knowledge on the use the innovation, and principles knowledge—an understanding of the principles underlying the innovation (DiClemente et al., 2019; Rogers, 2003).

The persuasion stage in the *Innovation Decision Process* is concerned with forming a favorable attitude towards the innovation, to which peer influence is thought to be of particular importance (DiClemente et al., 2019; Rogers, 1983, 2003). During the decision stage the person has decided to adopt or reject the innovation, which is similar to "intending" to use the innovation and is NOT the same as "trying" or "implementing" the innovation (DiClemente et al., 2019; Rogers, 2003). During the decision stage, people are more likely to arrive at a favorable decision to adopt the innovation if they are able to try it without any commitment or cost beforehand (DiClemente et al., 2019; Rogers, 1983, 2003). Following an affirmative decision to adopt the innovation, a person goes through the implementation stage where there is an actual trial or adoption of the innovation (DiClemente et al., 2019; Rogers, 2003). It is important to note that trying an innovation is not equivalent to sustained use of the innovation (DiClemente et al., 2019; Rogers, 2003). The final stage of the *Innovation Decision Process* is the confirmation stage, when people decision to make a long-term commitment to the innovation (DiClemente et al., 2019; Rogers, 1983, 2003).

Upon adopting an innovation, a person is able to share information about the process/product to people within his or her social environment (DiClemente et al., 2019; Rogers, 1983, 2003). The amount of time it takes to adopt an innovation is an important factor in determining the category of innovation adopters that a person falls within: Innovators, early adopters, early majority, late majority, and laggards (DiClemente et al., 2019; Rogers, 1983, 2003). Innovators are the first category of people to adopt a new breakthrough and they tend to have a proclivity for experimentation. This population typically makes up about 2.5% of all eventual adopters (DiClemente et al., 2019; Rogers, 1983, 2003). The next group of people to adopt an innovation are early adopters, who tend to have access to a variety of media in addition to connections with people likely to introduce them to the innovation. Early adopters typically make up about 13.5% of all eventual adopters (DiClemente et al., 2019; Rogers, 1983, 2003). The next category of people to adopt an innovation are called the early majority, and people in this category usually take relatively longer to go through the *Innovation Decision Process* as compared to innovators and early adopters. The early majority typically makes up about 34% of all eventual adopters (DiClemente et al., 2019; Rogers, 1983, 2003). Following the early majority is the category of people termed the late majority, who may require lengthy periods of time to pass through the *Innovation Decision Process* though they may be surrounded by people who have successfully adopted the innovation. This population typically makes up 34% of all eventual innovation adopters (DiClemente et al., 2019; Rogers, 1983, 2003). The final category of innovation adopters are laggards, who are extremely resistant to adopting the innovation (DiClemente et al., 2019; Rogers, 1983, 2003). This category also includes those who never adopt the specified innovation (DiClemente et al., 2019; Rogers, 1983, 2003).

The mHealth literature focusing on projects in sub-Saharan Africa has a large number of studies utilizing DOI in exploring mobile phone use, with the mobile device being the innovation of focus. However, there are no studies present that utilize DOI in the context of adopting a mobile phone-based procedure as the innovation of interest. Perhaps the investigators in those studies believe that adoption of the mobile device in a community will translate to adoption of a mobile application or process. Still, other studies seek to explore characteristics of mobile devices that would make them easily adopted. The present study will examine members of the Greater Accra community according to the category of innovation adopter that most fits their personality. This will be achieved by administering the *Individual Innovativeness Scale* developed by H. Thomas Hurt, Katherine Joseph, and Chester Cook (Hurt, Joseph, & Cook, 1977) (2013).

Purpose of the study

This research study sough to understand typical uses of mobile phones in the local Accra community, the attitudes held about sharing health information via mobile phone, and the likelihood of adopting a mobile app system for community-based disease surveillance. Completion of this task was guided by the following study aims:

> AIM 1: To examine the general community's use of, attitudes towards, and willingness to adopt mobile device usage for health-related information sharing.
>
> > 1a. What are attitudes towards using mobile devices for health-related behavior and information?
> >
> > 1b. What activities/tasks does the average adult perform on his/her mobile phone most often?
> >
> > 1c. What are the facilitators and barriers to accessing and using mobile devices for health-related behavior and information as well as for general use?
> >
> > 1d. What health behaviors would the average adult be willing to share via a mobile phone reporting system?

1e. Which of the five categories of Innovation Adopters—from Diffusion of Innovations Theory—do study participants fall in based on their personality and behavior?

Achieving this aim required exploring patterns of mobile device use among working adults in the Ghanaian community—specifically those in the Greater Accra Region—through semi-structured individual interviews and structured surveys. This study sought to recruit between 15 and 20 adult community members for individual interviews, explored topics including attitudes towards transmitting health information via the Internet, differences in health information acquisition sources, mHealth and mHealth surveillance, as well as participatory surveillance. Qualitative data collection during individual interviews allowed participants to provide detailed and nuanced information that could be missed using predefined measures or questionnaires. This project also sought to describe study participants according to the category of innovation adopter (innovators, early adopters, early majority, late majority, or laggards) that most describes their propensity for taking up innovations according to DOI. To describe their proclivity for adopting innovations, participants completed the *Individual Innovativeness* Scale (2013) (***Appendix A***).

AIM 2: To determine the desired features and characteristics that could promote self-reporting of health-related information and behavior to a mobile health surveillance system.

2a. Identify desirable features to promote frequent and repeated use of a mobile phone-based surveillance system.

2b. How often would adults like to receive feedback and communication from the mobile phone-based surveillance system?

Achieving this aim followed the same methodology as aim one, through conducting individual interviews and structured surveys. Participants completed surveys on demographic information, qualitative information about their mobile phone usage, and surveillance system expectations, as well as a measure that assessed their propensity to accept new technology (UTAUT Scale) (***Appendix B***) and a measure that described their proclivity for adopting new innovations (*Individual Innovativeness Scale*) *(****Appendix A***).

Results from this study highlight the importance of using theoretical approaches in designing mHealth tools meant for community use. Results from this study will inform the design of a functioning, relevant, and useful participatory surveillance system. Appropriately designed participatory surveillance systems will enable health systems to receive data of interest in the fastest possible time and may have the residual effect of keeping community members alert for health issues and poor health conditions in their living environment.

CHAPTER 3

METHODOLOGY

Study Design

The main goal of this study was to gather information about mobile phone-use patterns among Ghanaian adults—i.e., what do people most often use their mobile phones for and the reasons for the described behaviors—as well as their likelihood to accept and adopt mHealth tools for health surveillance purposes. Results from this study will lay the foundation for the larger goal of this effort, which is to develop a working mHealth application that will alert health officials of changes in population health indicators in a timely manner.

Data for this study was collected using questionnaires for quantitative data and individual interviews for qualitative data. Collecting quantitative data through questionnaires enabled us to gather general information from the study participants, such as demographics and health behaviors. Utilizing questionnaires also enabled us to administer the two standardized measurement scales that are grounded in health behavior theory. The measurement scales of interest relate to the Unified Theory of Acceptance and Use of Technology (UTAUT) (***Appendix B***) and the Diffusion of Innovations Theory (DOI) (***Appendix A***) (DiClemente et al., 2019; Rogers, 1983; Venkatesh & Davis, 2003).

The qualitative data collection phase of this study consisted of semi-structured individual interviews with lay adult members of the Ghanaian community in Accra. Individual interviews allowed for direct and detailed examination of individual perspectives about mobile phone use and possible adoption of new mobile technological innovations. The ability to gather such additional nuanced information from participants is one of the main benefits of individual interviews and qualitative data collection during research.

In preparation for this research study, ethical approval was received from the University of Georgia's Institutional Review Board in the winter of 2019 and from the Ghana Health Service Ethics Review Committee (GHS ERC) on March 12, 2020. Immediately following approval from GHS ERC, the world encountered the Coronavirus Disease 2019 (COVID-19) global pandemic. As such, GHS ERC required additional ethical assurances in compliance with all guidance relating to COVID-19. All study measures and questionnaires were converted to internet-based surveys using Qualtrics software, Version [February 2020] of Qualtrics (Qualtrics, 2020). Copyright © [2020] Qualtrics. Qualtrics and all other Qualtrics product or service names are registered trademarks or trademarks of Qualtrics, Provo, UT, USA. https://www.qualtrics.com. Since individual interviews could not be conducted in person, WhatsApp mobile communication software was employed for interview communication. Participants were offered an incentive in the amount of 15Cedis (approximately $3) for study participation. All requirements were met and the final approval letter was received from GHS ERC on May 22, 2020.

Study Procedures

Recruitment and Screening

Due to COVID traveling and gathering restrictions, all recruitment and data collection activities during this study were conducted remotely using convenience snowball sampling techniques. Snowball sampling for this study began with a roster of community members from which the first person was contacted. This potential participant then referred the researchers to other suitable people within his social network for recruitment.

As participants concluded their involvement in the research, they were reminded of study inclusion criteria (adults living in Accra, aged 21 and older, who are employed). Once a person fitting the criteria was identified and expressed interest in the study, their contact information was shared with the study researcher. The potential study participant was then contacted to confirm interest in the study, provided with additional information about study procedures, and had their eligibility for the study confirmed.

Participant Eligibility

In contrast to the overwhelming majority of mHealth surveillance research studies in the literature, the proposed study explored mHealth use from the perspective of lay adult community members. While most published studies research mobile device usage for generating and collecting usable health/medical data, these mHealth tools are used by a health professional (a doctor, nurse, hospital administrator, or community health worker) to streamline hospital data or to make collection of patient data easier. **Inclusion criteria** for the proposed study were as follows: (1) adult members of the general community in the Greater Accra Region aged 21 year and older—the age for inclusion was chosen to be 21 because that is the age a person is considered an adult in Ghana and can drive, consume alcohol, buy cigarettes, etc.; (2) adults who are employed and earn money for a living; (3) adults who own—or have access to—a mobile phone for regular use; and (4) adults who consistently keep at least 45Cedis – 90Cedis ($9.25 – $18.50) worth of credits loaded on the phone for use per month. **Exclusion criteria** include: (1) adults who are not working or unable to describe a place of employment; (2) adults who do not have access to a mobile phone for regular use or have difficulty obtaining one; and (3) adults who are unable to maintain adequate amount of mobile phone credits on their phone. Individuals who met the inclusion criteria were asked to schedule a time block of about 90 minutes (one hour and 30 minutes) for the interview and questionnaires. Participant recruitment followed the described screening process until 15 individuals had been identified and interviewed.

Enrollment and Data Collection

Participant interviews were conducted between May and September 2020. To begin each individual interview, participants were reminded of the study procedures and were read the study consent form. Participants were asked if they had any questions about the consent form or study procedures. The researcher asked participants if the interview could be recorded. All participants agreed to have their interviews audio recorded.

Individual Interviews

The interviews were scheduled for 90-minute sessions with the last 20 – 25 minutes reserved for completing the quantitative participant surveys. Although an interview guide was employed, these interviews followed a conversational format that allowed the participants to feel comfortable discussing various topics and elaborating on any points that required further clarification (***Appendix C***). The interview topics included: mobile phone use patterns, attitudes towards mobile information exchange, mobile phones for collecting health information, and desired features for an mHealth surveillance system. Participants were probed when necessary.

Measures

For this study, DOI and UTAUT were examined under the hypothetical scenario that the participant was sharing personal or health information via a mobile device application. Once all topics and questions of interest had been explored, participants were asked a concluding question that allowed them to express any additional information about mobile device use for health surveillance. At the conclusion of the interview, participants were shown a demonstration of a prototype mobile phone application that was developed for this study. This prototype application demonstration served as the basis for responses to the UTAUT questionnaire (***Appendix B***).

Following the application demonstration, participants were provided with the study survey link to complete the demographics questionnaire as well as the Individual Innovativeness measure (***Appendix A***) and the UTAUT measure (***Appendix B***). Involvement in the study was concluded by thanking participants for their time.

One major factor that distinguishes this study from other studies previously conducted in this region of the world is the attention paid to theoretical frameworks in shaping this formative exploration into building a mobile health surveillance system. Health behavior theories were selected to help promote and/or explain the population's propensity for accepting and adopting the mHealth system as the behavior change of choice. DOI and the UTAUT are the selected theories of interest for this study, and were assessed using survey questionnaires (Rogers, 1983; Rogers, 2003; Venkatesh & Davis, 2000; Venkatesh, Morris, Davis, & Davis, 2003).

Diffusion of Innovations (DOI)

In exploring DOI, this study's primary concern was determining the category of innovation adapter that each participant falls within (i.e. innovators, early adopters, early majority, late majority, or laggards) (Rogers, 1983, 2003). Innovation adapter category was assessed in the quantitative portion of the study using the *Individual Innovativeness Scale* (2013) developed by Hurt, Joseph, and Cook (Hurt et al., 1977). The *Individual Innovativeness Scale*. (2013) is a twenty-item questionnaire that assesses the ways in which people respond and interact with their environment, and is presented in ***Appendix A*** below. Respondents are asked to indicate how much they agree with each of the twenty statements. Response choices ranged from Strongly disagree (1) to strongly agree (5). Respondents with scores above 80 are classified as Innovators. Respondents with scores between 69 and 80 are classified as Early Adopters. Those with scores between 57 and 68 are classified as the Early Majority, while those with scores between 46 and 56 are classified as the Late Majority. Finally, respondents with scores below 46 are classified as laggards. Results from the *Individual Innovativeness Scale* (2013) considers participants who score higher than 68 to be highly innovative, while participants who score below 64 are considered to be low in innovativeness.

Unified Theory of Acceptance and Use of Technology (UTAUT)

In addition to DOI, the Unified Theory of Acceptance and Use of Technology (UTAUT) will be used to assess the population's attitudes towards adopting a mobile health surveillance system (Venkatesh, Morris, Davis, & Davis, 2003). UTAUT is a theory that combines several other health behavior theories (such as the Social Cognitive Theory, Technology Acceptance Model, and the Theory of Planned Behavior) (Ndayizigamiye & Maharaj, 2016; Venkatesh & Davis, 2003). The UTAUT measurement scale aims to describe the respondent's feelings and attitudes towards adopting a technological system. This scale consists of eight subscales: performance expectancy, effort expectancy, social influence, facilitating conditions, attitude toward using technology, self-efficacy, anxiety, and behavioral intention to use the system.

There are no previous studies where the standardized UTAUT questionnaire from Venkatesh and Davis (2000) has been adapted for estimating acceptance and adoption of technology within this population (Venkatesh & Davis, 2000). As such, this study has taken liberties based on scientific education, deduction, and familiarity with the Ghanaian population to adapt the measurement scale for use in this study. Adapting this measurement scale for this specific context produced a 21-item questionnaire scale that addresses all original constructs proposed by UTAUT. The resulting questionnaire is referenced in ***Appendix B***. In order to further support the study participants' ease of completing the scale, response choices were revised from a 5-point Likert-type scale (1=strongly disagree, 5=strongly agree) to yes/no responses (no=0, yes=1). Total mean scores were computed by assigning a point for each item of the particular subscale that was answered “yes” and computing the mean values for each subscale.

A high or positive level of Performance Expectancy means that participants expect their use of the described system to result in the desired benefits associated with using the system. An example question for this subscale is, “I would find the mobile phone system useful in reporting a health condition.” A high or positive level of Effort Expectancy indicates that participants expect their use of the described mHealth system to be relatively easy. An example question for this subscale is, “My interaction with the system would be clear and understandable.” A high score on the Social Influence subscale indicates that participants feel that the influential people in their lives would approve of them using the described mHealth system. An example question for this subscale is, “People who are important to me think that I should use the system.” A high score on the Facilitating Conditions subscale indicates that participants have a generally positive view about the existence of tools to help them use the system. An example question for this subscale is, “There is a specific person (or group) ready to help if I have problems with the system.” A high score on the Attitude Towards Using Technology subscale indicates that participants hold favorable attitudes towards using the described mHealth system. An example question for this subscale is, “I like working with the system.” A high score on the Self-Efficacy subscale indicates that participants have a positive perception of being able to use the described mHealth system by themselves. An example question for this subscale is, “I could report a health condition using the system even when there is no one around to tell me what to do as I go.” Questions posed by the Anxiety subscale have a negative connotation and were reverse coded so that increasingly positive values correspond to less anxiety and a better feeling about using the system. An example question for this subscale is, “I feel some fears about using the system.” Finally, a high score on the Behavioral Intention to Use the System subscale indicates a positive intention to use the described mHealth system in the next six months. An example question for this subscale is, “I intend to use the system in the next 6 months.”

Data Analysis

Qualitative Analysis

This study sought out to gather information about Ghanaian’s mobile device use and the likelihood of the general community to adopt mHealth tools for transmitting personal health information. More specifically, this study aimed to explore the kinds of activities that the average adult performs most frequently using a mobile phone, adults’ attitudes towards sharing health-related information through mHealth tools, and any existing facilitators or barriers to mHealth use for health information sharing. Additionally, this study probed participants for any features or interface characteristics that would be desired in an mHealth tool designed to fit the described purpose. It was expected that adequately responding to these questions would require nuance and detail. As such, qualitative analysis was selected as the method of choice. Qualitative data for this study were contained in the audio recordings and notes made during the individual interviews.

Audio recordings were transcribed verbatim directly into Microsoft Word. Prior to thematic coding, the researchers built familiarity with the interview data as is best practice in qualitative analysis (Gale, Heath, Cameron, Rashid, & Redwood, 2013). We also gained familiarity during the process of interview transcription, since the audio recordings were listened to multiple times in order to accurately capture interview conversations. After transcribing and perusing each interview, a coding scheme was developed based on the topics that emerged most commonly from the interview discussion. The next step in data analysis was to manually code the data, which entailed reading the discussion transcripts line by line and color-coding specific sentences and passages based on the study's coding scheme.

Thematic analysis in this study was guided by the Framework method, a method of analysis that is not aligned with any particular epistemological, philosophical, or theoretical approach (Gale et al., 2013). The inductive process of framework analysis is done without any predefined themes, and the researcher instead allows themes to emerge in an open context (Gale et al., 2013). Since this study used inductive analysis, initial stages of coding involved coding all concepts that seemed important from a range of perspectives (e.g. description of attitudes, health behaviors, household phone usage, etc.). In this process, it was important to remain open to unexpected content and unexpected codes, taking care not to code in a purely descriptive way that would allow important concepts to escape the researcher's focus (Gale et al., 2013). After coding the first few transcripts, there was a basis for grouping and defining early code definitions and assignments, and this process was performed in a continuous manner until no new codes emerged from the transcripts (Gale et al., 2013). One full cycle of transcript analysis was required in order to develop the study's coding scheme. Each transcript was coded by three different student researchers who later met to code each transcript to 100% agreement. Analysis for this study employed the services of NVivo qualitative analytic software (*QSR International Pty Ltd.*, 2020).

Quantitative Analysis

Using the study by Brinkel et al. (2017) as a guide, the following sociodemographic variables were collected in this study: age, education, ethnic group, gender, marital status, and number of children aged 0 – 15 years (Brinkel, May, et al., 2017). We performed descriptive analyses on participant's sociodemographic information as well as responses to the *Individual Innovativeness Scale* (2013) and the *UTAUT* scale. *Individual Innovativeness Scale* (2013) followed conventional scoring, with response choices ranging from 1=Strongly Disagree to 5=Strongly Agree. However, since the response choices for the UTAUT scale were revised to yes/no responses with no=0 and yes=1, the UTAUT scale is scored to indicate whether respondents exhibit high (close to all "yes" responses for that subscale) or low (close to all "no" responses for that subscale) levels of the constructs theorized to influence their intension to use the described system. The anxiety subscale of the UTAUT measure (items 17, 18, and 19) were reverse coded during quantitative analysis in order to maintain the positive interpretation of increasing values in that subscale. IBM SPSS Statistics for Macintosh, Version 27.0 was used to perform all statistical analysis in this research study.

CHAPTER 4

FINDINGS

This chapter presents the findings from 15 individual interviews conducted with lay adult community members in Accra, Ghana. After carefully reviewing the interview transcripts, response themes were grouped and matched to this study's aims.

Sample Size and Demographics

A total of fifteen community members participated in this study, all of whom were Ghanaian adults living and working in Accra. Study participants were comprised of five men and ten women. There were three participants in the 18 – 24-years old age range, seven participants in the 25 – 34-years old age range, one participant in the 35 – 44-years old age range, one participant in the 45 – 54-years old age range, two participants in the 55 – 64-years old age range, and one participant in the 65+ years old age range. Ten participants self-identified with the Ga-Adangbe (or simply, Ga) ethnic group, which is the native ethnic group to the Accra area. The next most represented ethnic group in the participant population was Akan, with three people. One participant identified as Ewe, and one participant identified as other. Seven participants were never married, and six participants were married / living together. There was one participant who was divorced / separated and one participant who was widowed. All participants had received a formal education, with two participants having a "Jr. Secondary School (JSS) or Higher" level of education and thirteen participants having a "Senior Secondary School (SSS) or Higher" level of education.

Table 1.

Sociodemographic characteristics of study participants.		
Variable	N	%
Gender		
Male	5	33.33
Female	10	66.7
Age		
18 – 24 years	3	20
25 – 34 years	7	46.7
35 – 44 years	1	6.7
45 – 54 years	1	6.7
55 – 64 years	2	13.3
65+ years	1	6.7
Ethnic Group		
Akan	3	20
Ga-Adangbe	10	66.7
Ewe	1	6.7
Other (Ga & Guan Mix)	1	6.7
Marital Status		
Married / Living together	6	40
Divorced / Separated	1	6.7
Widowed	1	6.7
Never Married	7	46.7
Highest Education Completed		
None	/	/
Primary School	/	/
Jr. Secondary School (JSS)	2	13.3
Sr. Secondary School (SSS) or Higher	13	86.7
Children aged 0 – 15 years living in your home		
0	7	46.7
1	3	20.0
2	3	20.0
3	1	6.7
4	/	/
5 or more	1	6.7

Table 1: Sociodemographic characteristics of study participants.

Qualitative Results

Attitudes towards using mobile devices for health-related behavior and information.

General Information Sharing

When discussing information sharing via mobile devices, our participants pointed out different views between sharing general personal information (e.g., age, height, weight, etc.) and sharing health-related information (e.g., disease history, sexual history, etc.). Participants view health-related information as personal and private. There was a mild sense of apprehension when discussing general information sharing via mobile app or mobile device, but not as much as with health-related information.

Eleven of the fifteen study participants mentioned being concerned about the privacy of information they enter into a mobile app. One female participant described feelings of annoyance when entering any personal information into a mobile app. She expressed not wanting to provide information into an app but was able to recognize the potential benefits from using such apps, and wanted to experience the benefits.

> *"It feels like I'm giving up private information about myself to people who, under normal circumstances I won't give that information about me. But then again, I want to use the app for something that I think could be beneficial to me, so I'm kind of forced to give out that information on that I wouldn't give out on a regular day.*" (KI 1, Female, 25-34y/o).

Another participant shared similar feelings of apprehension when entering personal information into a mobile app.

> "*I've always been a little weird about my personal information being out there in public which is probably why I'm not too into even like social media and stuff like that. So, it's always been a little "ugh" for me. But, because I need…well, I don't need it. But, like, it helps me. And I feel like it's not that deep.*" (KI 4, Female, 25 – 34y/o).

One male participant was very succinct in his response to entering personal information into a mobile app.

> "*Actually, if you ask too many questions, like for my personal details, I usually stop the process or stop using the app.*" (KI 7, Male, 18-24y/o).

Further discussion during the interviews enabled a few participants to vocalize how their attitude towards entering personal information into a mobile app have evolved over time.

> "*Well, previously, like way, way, way, way back, sometimes I wouldn't want to enter my information. But now it looks like it's sort of a requirement for every app, so I've done it so many times that when I download a new app and I'm entering my information, it doesn't seem like a big deal.*" (KI 6, Female, 18 – 24y/o).

However, even with this apprehension, all study participants were able to articulate benefits of entering one's personal information into a mobile app.

> "*I would say all that info is used to provide personalized service—whatever services that I need. So, I guess it's necessary.*" (KI 1, Female, 25 – 34y/o).

Another female participant was able to identify a potential benefit of entering one's personal information into a mobile app and was able to articulate some examples.

> "*Oh, I guess then it can streamline things for you. So, it can give you…what's the expression? Like, personalized…it can give you personalized information, and…yeah. And for like…for example, for my…I'm going to use those two apps—so, my period tracker and then my health app. Like, it can check my weight, tell me if I'm losing weight, if I'm doing enough exercise, if I need to, you know do some more, if I'm eating enough. Depending on how much information I want to put in there, I can put in my meals, I guess, and all that. So, it can tell me. And it helps. And for my…my period tracker, I actually don't use like half of the stuff [laughs] on there. But, if I did, like, for people…I guess, trying to get pregnant and all that, like there's all this… there's a diary, you can*

> *add your symptoms, umm…they…you can check your temperature so they can tell you like, even the best time in the day when you're ovulating to have sex and all of that. So, like, it's really helpful and it…the more information you give it, the more it can streamline things for your personally and help you. But, because I don't put…I put in like the minimum…the barest minimum information I need to put in so that I track my period and that's it. So, I don't think I'm getting the most from it, but it is beneficial for a lot of people when they put in all that information because it generates charts and stuff for you. Like, it does the most. I just don't use it to the fullest of, you know…its capacity.*" (KI 4, Female, 25 – 34y/o).

Health-related Information Sharing

Two of the fifteen participants indicated that they currently use of mobile apps to store health-related information. Both participants were female, and both utilized a mobile app to track their monthly menstrual cycle. No other participants discussed actively using mobile apps for health-information. Despite not having experience with health-related information sharing via mobile apps, all study participants were able to clearly express their feelings on the topic.

> "*If it's going to help me, why not? As much as I don't like it, let me be…should I say selfish? If it will help me, I'm definitely on board.*" (KI 1, Female, 25 – 34y/o).

> "*To me, like I said earlier on, if it's…once it's a medical app, I don't think anyone should have a problem holding back. 'Cause it's like having a problem and then sitting down on it and then not letting anyone know about it and it's eating you up. You get it?*" (KI 5, Male, 25 – 34y/o).

> *I wouldn't have any problem with it. Because it's for my benefit and like, I trust that, because it's a healthcare something, they will ensure confidentiality too. Yeah, I wouldn't have any problem with it.*" (KI 6, Female, 18 – 24y/o).

> "*As for that one, I wouldn't hesitate. I would readily give it out. I would readily give it out. If it has to do with my health, I would do it without even thinking.*" (KI 14, Female, 45 – 54y/o).

> "*With health, I find it like, I normally don't debate too much when doing something because, as for that one, it's about health. It's about someone's life and stuff. That one, I normally don't debate about anything. But, to enter it, maybe I'll make sure that I know the person that I'm going to talk to very well to be sure that the person I'm talking to, I can trust the person or something like that.*" (KI 15, Female, 25 – 34y/o).

Responses suggest that, although participants are generally hesitant to enter personal information into a mobile app, they are willing to overlook any apprehensions they have when sharing health-related information. Participants recognized the potential for personal ramifications in the event of data leaks, and stated that the potential for personal benefit was a driving factor in their willingness to use a mobile device or mobile app for health-related information sharing.

Activities/tasks that adults perform on their mobile phone most often.

All study participants discussed using their mobile phones for multiple purposes, including social interactions, academic work, and professional tasks. By far, the most stated use of the mobile phone was for getting in touch with family and friends. To that end, the WhatsApp social communication mobile application was specifically mentioned by all fifteen interview participants.

> "*I think now it's all mixed up, because like everybody communicates using the phone. So work, social purposes, school purposes, everything.*" (KI 6, Female, 18 – 24y/o).

> "*And then with WhatsApp, it's mainly for getting in touch with my friends and my colleagues, so... Okay, At this point, it's usually my junior colleagues at that's work, so they need something, they prefer to WhatsApp me and ask me how to figure something out as opposed to voice calls.*" (KI 1, Female, 25 – 34y/o).

> "*I go there because I'll be…I get a lot of communication from friends. Friends and family. So I check what messages people have sent me, and then I answer back.*" (KI 2, Female, 55 – 64y/o).

The next most popular response for activities performed on one's mobile phone was for locating different types of information—mentioned by six participants—followed by for educational purposes—mentioned by three people.

> "*Yeah, just 'cause it keeps me informed on the go, about the world. So, I can have a lot of information within a short time.*" (KI 3, Male, 25 – 34y/o).

> "Okay. I just like the fact that anything I want is readily available. I can just go and search for it and it's quite simple. There's a feed that maybe I can find information." (KI 7, Male, 18 – 24y/o).

> "*So mostly I am reading, so, like, most of my books are on there. So, I'm mostly just reading. But, I do do a bit of editing. Like, if I scan documents or whatever, then I will edit them or combine the documents on my phone. But, essentially, it's mostly just to read and sort through my papers that I have. And my books.*" (KI 4, Female, 25 – 34y/o).

> "*So I have apps on herbal medicine because I'm into herbal medicine now. I'm learning herbal medicine. So, solutions to ailments, cure to ailments and stuff like that.*" (KI 11, Male, 25 – 34y/o).

Less popular mobile phone-related behavior among study participants included shopping (one participant), intellectual games and puzzles (one participant), and working with pictures/videos (one participant). The word cloud in ***Figure 2*** depicts participants' responses to the question about the activities most often performed on their mobile phones.

> "*I go there to learn a lot. Like this baking. Every day, they are coming up with new things. So I go there to check exactly what's new. And then I learn a lot of things there. I mean, apart from cakes, religious things as well. You know, what pastors think about other things. Then I have somebody there—a guru there [on YouTube] who I follow to do yoga and telling me about yoga, things I didn't know, things the average Christian doesn't know about yoga.*" (KI 10, Female, 65+ y/o).

> "*And I also have this app that I actually…it gives me questions and I answer them. So it gives me marks [scores] on everything. On maths, on general questions, and other things. Sometimes it's just a brain teaser. Asking you general questions, you find answers to them, and that gives you how many correct answers you got, how many wrongs you got.*

Words. Apps that I learn new words from. Basically those are apps that I'm really into." (KI 11, Male, 25 – 34y/o).

"*The gallery. Yes. Because that one you can use it to store up your pictures. You can store up your pictures, your videos. So as for that one dierr [expression of specificity], it's very important.*" (KI 12, Female, 25 – 34y/o).

Figure 2.

Figure 2: Word cloud of participants' responses about activities most often performed on the mobile phone.

Facilitators and barriers to accessing and using mobile devices for health-related behavior and information as well as for general use.

Facilitators

We asked community members about factors that would promote their use of a mobile device or mobile app for health-related information sharing. Responses to this question included laws/standards to govern the app's use of user information, familiarity with the entities behind the app, an explanation of the app's specific purpose, and the ability for users to submit information anonymously. Thirteen of the fifteen study participants explicitly stated needing to be assured of governing standards and data protection within the app in order to feel comfortable sharing their information.

> "*Yeah, so it's basically about how safe and secure the network is. And then what are the governing data…what are the governing laws surrounding data protection within that framework.*" (KI 3, Male, 25 – 34y/o).

> "*So, for me, if I'm going to use an app and input any kind of personal information in there, I need to know that the app in itself is secure. … But my concern has always been how to protect. Like, what are the data protection laws that make sure that this information doesn't get into the wrong hands.*" (KI 4, Female, 25 – 34y/o).

> "*I wouldn't have any problem with it. Because it's for my benefit and like, I trust that, because it's a healthcare something, they will ensure confidentiality too. Yeah, I wouldn't have any problem with it.*" (KI 6, Female, 18 – 24y/o).

> "*Well, first of all, I would check the…who is coming for that information or who is in charge and I would ask questions on the goal and all of that. And maybe possibly or probably read the…like, what am I getting into? The terms and conditions. Apart from that, if it's fine with me [if everything checks out], I don't see a problem.*" (KI 7, Male, 18 – 24y/o).

In addition to needing assurance of governing standards, participants also mentioned needing an explicit explanation of the purpose of the app and the intended use of their collected information in order to feel comfortable providing health-related information.

> "*Well, if they're doing the survey to find out something that will benefit the society here [in Ghana], that one is for the benefit of all, so that's okay. I wouldn't mind at all. But they would have to tell me that, "We are doing this survey for 1, 2, 3." If I see that it will benefit the society, why not? I will cooperate.*" (KI 10, Female, 65+ y/o).

> "*So before, I download the app, If I have that assurance that whilst using the app, whatever I put there is secure or private…sort of. Or…within the app itself, after downloading it, there's a section that lets me know that, ok, we are bound by 'a, b, c, d, e.' That would work for me.*" (KI 1, Female, 25 – 34y/o).

> "*Like, what are the data protection laws that make sure that this information doesn't get into the wrong hands. But yeah, again, if it's a service provider that I can be confident in, and I'm sure that the information is protected, I would be very happy to use that service. And to have my patients use it as well.*" (KI 4, Female, 25 – 34y/o).

Participants stated that their level of comfort and participation with mobile information sharing would increase if there was a sense of familiarity with the entity they were communicating with via the mobile application. Either a sense of familiarity or knowledge about the professionals working with their information behind the scenes would greatly increase their likelihood of participation.

> "*So I have no issues giving it out. For instance, if I speak to you, if I give you some information, I know, 'okay, I've spoken to Kevin. Kevin is bound to keep my info private.' So if it gets out there, I know who I'm holding responsible.*" (KI 1, Female, 25 – 34y/o).

> "*Yeah. When it comes to…like I said, when it comes to health, I don't…'cause, let's say, if I'm diabetic, I won't mind letting my physician know, 'cause I know he's professional. He's not going to sit somewhere and say, "Oh, [redacted] is diabetic." Or, "[redacted] has this. [redacted] has this." You know? They've professionally bound them to be professional about most things. So, when it comes to a physician or a doctor, I think I'll be more than comfortable to talk to the person. Or, like, to give all that app my information. You get it? Yeah, so…with that, I don't think I have a limit with that.*" (KI 5, Male, 25 – 34y/o).

> "*Who exactly it's being shared with, and what exactly is being shared. And I would like to give consent that even though I know downloading or using this app exposes me to my information being shared, I'll still to agree with it.*" (KI 9, Female, 55 – 64y/o).

Another facilitator for using mobile phones for health-related behavior and information sharing was anonymity. Participants expressed a strong interest in contributing health information for the imagined purpose as long as their information was kept anonymous and unidentifiable. As mentioned in the findings under Aim 1a, eleven of the fifteen study participants explicitly mentioned concerns about the privacy of any information they enter into a mobile app. In addition to this, seven study participants stated that they would gladly share their health-related information via a mobile app as long as their information was rendered unidentifiable.

> "*Or at least info that cannot identify me as an individual. So, with most of the apps I think a lot of the information they collect make it very easy to, you know, track down somebody as an...Okay…this is this person exactly. But I don't know if you get what I'm saying. Like if I have to do, Okay, African female, adult, and then end it there, I prefer it to name, age, location, activity, preferences, all those things.*" (KI 1, Female, 25 – 34y/o).

> "*Yeah. Like, things that can be generalized. Not necessarily so intimate. But, stuff like that dierr [general expression], I don't have a problem with that.*" (KI 5, Male, 25 – 34y/o).

> "*If it's all anonymous I don't think I'll have a problem. Like, I whatever information I give can't be just like…like, somebody can't just pick it and trace it back to me just like that, then I don't think it really matters.*" (KI 6, Female, 18 – 24y/o).

> "*Maybe I should have said something from the beginning: if they start from the beginning saying, for example, "don't write your name." [it's anonymous] As for that, I can tell you everything. But the moment my name becomes linked with it, even though I've said I don't mind, I'll be thinking about what happens if someone sees my name and knows me.*

> *Right? So, if it doesn't require my name but just indicating whether you're male or female and then age, I would be prepared to do that truthfully. But the moment my name gets attached, I'll think, "Wait a minute!" That will make me not say all the things I should say, because I would be thinking of the fact that my name is linked to it.*" (KI 10, Female, 65+y/o).

Barriers

We asked community members to think about any factors that would hinder or discourage their use of a mobile device or mobile app for health-related information sharing. Responses to this question included the general feeling of distrust/fears of information leaks, possible language barriers, unreliable network data connectivity, and stigma. Participants seemed to still harbor a sense of distrust for entering one's information into a mobile application. One participant mentioned doing his best to control the kind of information he provides.

> "*Because, I know the information I'm giving. I'll only give information that won't really harm me in any way. Any information, like I said, things pertaining to my financial status and all that, that one I won't give it out.*" (KI 11, Male, 25 – 34y/o).

A different participant expressed that her apprehension with sharing information on mobile device depended on the kind of information that was being shared and the potential impact of an information breach.

> "*…but if it's just my height and weight, that one I don't care. If you know my height and weight, it doesn't kill me. But if you can get my bank account number and go and cash my money, that would worry me. Or you can use my credit card to buy your stuff, that would worry me.*" (KI 2, Female, 55 – 64y/o).

Another barrier that came up was concern about access to the app. Six of the fifteen participants spoke about the need for people who aren't fluent or comfortable with the English language to still be able to use the mobile device or mobile app for its intended purpose.

> "*So if it's in our local dialect, those who do not understand the English will be able to express themselves freely.*" (KI 14, Female, 45 – 54y/o).

> "*At work, there is a lot of complaints of, 'mo ka brofo dodo. Me nte asee. ['you guys speak too much English. I don't understand.'] So they feel alienated. So if there's an app that's too much speaking of English or too much having to read in this part of the world, I think it wouldn't go over too well as in….you have those of us who are comfortable with it who can use it. But majority of the people wouldn't be able to use it like you want it to be used, because unfortunately they wouldn't get what the whole thing is about.*"
> (KI 1, Female, 25 – 34y/o).

> "*Yeah. Because there are a lot of illiterates out there who are holding phones. And the only language on the phone is English. Everything that they network with are English. So if there's another language like Ewe, Hausa, Twi, and those things [and others]…you'll see the way people will be going into those [apps] more than this English English thing [English everywhere you turn].*" (KI 8, Female, 35 – 44y/o).

> "*Okay, I think it should be more interactive. It should come with a whole lot of pictures. Because, maybe it's not everybody who is…if you ask in Accra, right now in Accra the literacy rate is getting better. But there are a lot of people who can't really read. But*

> *when they see pictures, they can really relate to the pictures and know that, "Oh, okay. This is the condition" or something. So if it comes with more pictures, it's more interactive, and with text.*" (KI 11, Male, 25 – 34y/o).

Even with the shared understanding that the proposed mobile process should work for people with differing levels of English proficiency, there were multiple thoughts as to how this population may be reached.

> "*I think it will be important if there is an audio bit to it, 'cause I don't know how many people can read Twi when it's typed or read GA when it's typed. Like, the normal…the average Ghanaian, I don't know if they can read…yeah, they might be able to read. But if it's an audio, they can listen in another language and understand. But, for the stuff to be typed, I don't know how much it's going to help. I don't think it's going to help as much.*" (KI 6, Female, 18 – 24y/o).

Data connectivity issues were reported by three participants as a barrier to health information sharing via a mobile device, although they are a constant occurrence throughout the country. In conducting this research study, there were 17 instances of data connectivity issues that either caused interruptions to the interviews or caused the voice call to drop completely.

> "*If it's an app that works offline as well as online, it would be really really good for us here, because of uhh…expensive data issues. And even when you have the data, there's still times it cuts out with no explanation whatsoever. So, when I'm home like today, we have…our home plan is quite a lot of data we have so I'm not worried when I'm home. But, when I step out, like when I'm going to work, my cellular data plan is very expensive so when it runs out it's a huge headache. And then even when it hasn't run out, there's*

> *times where the connectivity just goes off. And so, I prefer the apps I have that work online as well as offline to those that are solely online.*" (KI 1, Female, 25 – 34y/o).

> "*And then also because, uhh…we have internet issues, data issues….yeah. So, uh…yes. And then I'm thinking maybe it may be extreme, but if it's for like some emergency something, so if you have like, chest pain or something, this is how…it would probably not be the best to use an app, 'cause then like, 'cause it's…and you don't want people to be reporting chest pains on app.*" (KI 3, Male, 25 – 34y/o).

Finally, the most discussed barrier to using mobile devices for health information sharing was the possibility for stigma from others in the community. Participants' fears about having their name being associated with any health information they share or fears about their health information being leaked are all related to the fear of stigmatization.

> "*But to put it on the open market, it's difficult for…because we Africans, Africans are a bit…like, if somebody even hears that you have cancer, it means you're dying. They're going to tell the whole world that you're going to die tomorrow because you have cancer. Merely the person hearing that. And when they tell one person, oh, within 2 days everybody will hear that you're dying because you have cancer. Even though that may not even be the cancer that will kill you. And that one is even dangerous, because uhh…the fear. The way people will start running away from you will even scare you yourself. Eh hehn [affirmative sound]. It becomes a stigma, which shouldn't be. So, like this COVID-19 here. They are not mentioning anybody's name. It becomes a stigma. If somebody knows that you have COVID in this house, if you're not even careful, people won't pass in front of your gate. So it becomes…unless it is one of the everyday diseases*

that we have here. Like if they say 'you have malaria.' That one is not a problem. People have malaria everyday. If you have…eh hehn…those common diseases, it's ok. But the deadly diseases, any disease that is attached to death, it becomes so scary that people…it becomes a stigma for you. So it depends on how open that app will be to the outside world. If it's only a specific people who I am ok with that will see it, I don't have a problem. But if it's going to be somewhere that anybody can open and see, that one I won't do. Because, when it's affecting you, it's not just only you. It will affect you and your children. They'll say, 'Ei, this one has COVID.' 'This one's father, COVID baby.' There were calling one woman…she had the COVID, and her children were calling…they were calling her children 'COVID babies.'" (KI 2, Female, 55 – 64y/o).

"*Maybe if you are sick…for example right now with the COVID. For some strange reasons, when they identify the people who have COVID, they are stigmatized. So, if they are doing something like this and they are asking if you've ever had COVID and someone would be able to find out that I had it before, that would bother me. That's an example. You get it? So, it will make me feel confident especially if they are able to assure me that nobody will know. Because you live in the society, so if someone knows someone and they can tell them that "this person has coronavirus," you'll see that you'll feel like the society will ostracize you. Because, some people who had COVID, when they went home [from the hospital], nobody comes to buy stuff from their shop. When folks see their kids, they point them out and say "this is the COVID baby." Meanwhile the child never even had the COVID; it was the mother who had it [laughs].*" (KI 10, Female, 65+ y/o).

> "*Because of how, afterwards, after you've told people or you've told a physician about it, they feel life won't be the same again. Like they will be stereotyped, they will be seen in a way [that] people will now begin to keep an arm's length, not get close to them, and all that. So, there are certain diseases, naturally, that one without any app, people would like not to really share information on them. Just so that they can live normal life with people. But, immediately they share anything and it gets to the wrong people or people who don't really have good information on those things, the people will now not get closer to them, stereotype them, feel some way, talk to people in a negative way about them, and maybe I think they wouldn't really like it.*" (KI 11, Male, 25 – 34y/o).

> "*Like, when you wanted to count…like the amount of disease like malaria that we have in an area, at times when they want to put the information maybe on the net [internet], like people will be saying that, "This area here, they have this and so so so so malaria." Like, it's a disadvantage. People will be saying…like, let's say it is HIV, they will be saying that, "Like in Osu here, this area there are a lot of people there who have HIV there." So it's like…it's a disa…I don't know how to say it, but it's a disadvantage. They'll be saying that…you'll see like people might not want to come there or something.*" (KI 12, Female, 25 – 34y/o).

In response to being asked some reasons why he may not enter personal health information into a mobile app, one participant said, "*Stigmatization. And, like, attacks. Or people knowing that this person has a disease or this person is in a particular category or anything.*" (KI 7, Male, 18 – 24y/o).

Health behaviors that adults would be willing to share via a mobile phone reporting system.

When asked about the pieces of information they would be willing to share via a mobile app or mobile device, eight of the fifteen participants specifically mentioned being comfortable with providing surface level and demographic information such as gender, height, weight, hair color, and general area of location.

> "*I won't mind putting my height. I won't mind putting my age. Umm…I won't mind…if my name is there. I mean those basic ones. Those basic ones I won't mind. So it depends on how open that app will be to the outside world. If it's only a specific people who I am ok with that will see it, I don't have a problem.*" (KI 2, Female, 55 – 64y/o).

> "*Oh, my name, I don't mind sharing my name. My age, my sex, uhh…the basic demographic. But, I think maybe name, sex, gender…those are the three things. Maybe email address, because, yeah. Fine.*" (KI 3, Male, 25 – 34y/o).

> "*My height, I won't mind. My weight, my color, my date of birth, umm…my favorite food, my favorite footballer…Yeah. Like, things that can be generalized. Not necessarily so intimate. But, stuff like that dierr [general expression], I don't have a problem with that.*" (KI 5, Male, 25 – 34y/o).

> "*Maybe I'd rather be okay giving like a general location rather than the exact address. Maybe, 'Which vicinity do you live in?' And it's just maybe a general…maybe, 'East Legon'*" (KI 6, Female, 18 – 24y/o).

A few study participants open to sharing any necessary information for health purposes as long as their identity was protected. The one thing they were adamant about not disclosing was information related to their money or finances.

> "*Well, I'm very hesitant on entering maybe bank details or credit card details. So, yeah.*" (KI 7, Male, 18 – 24y/o).

> "*Any other information, like if it's about health issues and you tell me that I should give certain information, I know that it's something that will benefit me. So, with that one, it depends on what you're asking. But, I mean, what extent of information are you going to ask [in order to make me uncomfortable]? Anything apart from things related to my money, I'll be able to tell you.*" (KI 10, Female, 65+ y/o).
>
> "*So, aside that, aside my finances, I think I won't have problem with any other information that I'm supposed to put down.*" (KI 11, Male, 24 – 35y/o).

Study participants generally reported feeling guarded about sharing any personal information except anonymized information about their health. They deem health to be of utmost importance and feel it is important to do whatever necessary to secure one's good health.

> "*I think I'll feel more than comfortable. Once it's something like my health, I don't really have a problem. At least they can monitor me and all that.*" (KI 5, Male, 24 – 35y/o).

> Asked if there was any health information she would not share via a mobile app. "*For health, I don't think so. Because I think that's more important than anything else.*" (KI 9, Female, 55 – 64y/o).

> "*Okay, as for that one, I will feel comfortable because I have to be open so that I will get a good health for myself. I have to be very open.*" (KI 12, Female, 25 – 34y/o).

> "*As for that one, I wouldn't hesitate. I would readily give it out. I would readily give it out. If it has to do with my health, I would do it without even thinking. If it has to do with my health, I'll just put every information needed. If it has to do with my health. I would just volunteer every information I need to.*" (KI 14, Female, 45 – 55y/o).

> "*With health, I find it like, I normally don't debate too much when doing something because, as for that one, it's about health. It's about someone's life and stuff. That one, I normally don't debate about anything.*" (KI 15, Female, 25 – 34y/o).

Participants were then asked about any health behaviors or information they were unwilling to share via a mobile app. Fourteen of the fifteen participants stated that they would be willing to provide any necessary health or medical information as long as their information was anonymized, or their identity was protected. The one participant who stated that they would be unwilling to share health-related information reported that she would not want to share her personal medical history via a mobile app.

> "*So, umm… 'give me your medical history or you're not allowed to use my app.' Ok, fine. I will not use the app. I think it's too much.*" (KI 1, Female, 25 – 34y/o).

Identify desirable features to promote frequent and repeated use of a mobile phone-based surveillance system.

When asked about the features and characteristics they would like to see in an mHealth surveillance system that was open to public participation, study participants had a wide variety of ideas that would create a very robust system. The most important issue to the study participants was the privacy and security of the user's information. All fifteen participants made specific mention of this issue during this portion of the interview. The next most mentioned feature of a potential mobile phone-based surveillance system was the ability to communicate—either written or verbally—in one or a few of the more popular local languages. Eleven of the fifteen participants' responses talked about interacting in Ga or Twi, and most responses referred to the segment of the population without a formal education who may be more comfortable communicating or describing illness symptoms in their local dialect. Having pictures or good visual appeal was a feature that was brought up by nine participants. Reasons for this being an important feature ranged from bringing vibrance to the app's appearance to helping potential users with literacy issues. Desired characteristics of a mobile phone-based surveillance system have been listed and presented with sample quotes from the participant interviews in ***Table 2***.

Table 2.

Desired Feature	Participants (N)	Quote(s)
Privacy and Security	15	“*So the most important issues would be how the app is delivered to the end user, the security of the app, and then how secure whatever information the end user is putting in is.*” K.I.01 (Female, 25 – 34y/0) “*Because of the fear of privacy. There’s only so much [information] you can throw there, especially if it’s the beginning and you don’t know how the thing operates. But if you know how the thing operates and you know that nobody is sharing your information…your identity out there.*” K.I.02 (Female, 55 – 64y/o) “*Yeah. Uhh…I’d be happy about it. But the thing about internet and everything is data protection and then security. So, even though I know it's a good thing, I’d probably only subscribe to if I know that it's…my medical information is safe and secure within that app or within that ehhh…network.*” K.I.03 (Male, 25 – 34y/o) “*Once my information is going to be secure, I don’t think that will be a problem*” K.I.05 (Male, 25 – 34y/o) “*So, most of the times, in the terms and conditions, you know it’s a long list and people don’t read that. So, an assurance. Let’s say, maybe a line or two on…okay, maybe not a line or two [laughs], but let’s say something that is very clear and simple one, ‘Yeah, okay, your information blah blah blah blah.’*” K.I.07 (Male, 18 – 24y/o) “*It should be private.*” K.I.08 (Female, 35 – 44y/o) *“Who exactly it’s being shared with, and what exactly is being shared. And I would like to give consent that even though I know downloading or using this app exposes me to my information being shared, I’ll still to agree with it.” K.I.09 (Female, 55 – 64y/o)*
Audio Chat / Audio Messaging	2	“*Verbally talk to somebody. If I can verbally talk to somebody. Because, communication…that brings the communication part that WhatsApp has. And, it supersedes the other…you know, because it’s about my health. So, if it’s such that ok, if it’s that serious, I can hit somebody and chat with somebody.*” K.I.02 (Female, 55 – 64y/o) “*I think it will be important if there is an audio bit to it, ‘cause I don’t know how many people can read Twi when it’s typed or read Ga when it’s typed. Like, the normal…the average Ghanaian, I don’t know if they can read…yeah, they might be able to read. But if it’s an audio, they can listen in another language and understand. But, for the stuff to be typed, I don’t know how much it’s going to help. I don’t think it’s going to help as much.*” K.I.06 (Female 18 – 24y/o)
Advice / Recommendations Section	1	“*So, yes. So, then I’d want the app to advise that ‘based on this and this and that, we recommend this.’ But then I have the choice to, based on the information, decide that okay, this is how I want. So that there is more personal responsibility as well. You know?*” K.I.03 (Male, 25 – 34y/o)
Forum / Community Feature	1	“*Yeah, yeah. So, yeah. There can be a forum. I think there actually should be a forum where people can ask questions and they can get feedback from, like, people who have gone through. But the risk there is that you may have people giving wrong advice. Yes. So, it, it depends. You can have a forum where they talk about their experience and everything. But, when it comes to the disease itself, an expert is the one that gives*

		the reply. People can share their experiences per se. But then when it comes to an absolute medical or technical question, you have an expert actually answering on the…so, yeah. I think a forum usually helps just for people to share their thoughts and experiences. Yeah." K.I.03 (Male, 25 – 34y/o)
Reminders	1	"*There are times where you might forget [to enter or check your information], but once it comes on then yeah, it's a nice reminder for you..*" K.I.04 (Female, 25 – 34y/o)
Education Section	5	"*So maybe the app educating me on items within the surveillance to help me…eh hehn [affirmative sound], exactly. So, yeah…like, if it's surveillance for hypertension or something, then there are articles or there are videos or there are educating on the biggest aspects of hypertension. Like, regularly checking your blood pressure, doing this dieting, like exercise, those things. So, like, it's informing me as well instead of I'm just putting in my info.*" K.I.03 (Male, 25 – 34y/o) "*Because it depends on the level of education. So, for malaria, because everybody knows what malaria is, you don't need much education to get people's ideas or knowledge, attitudes, practices in relation to malaria because they already know what malaria is. But, when you say heart disease or when you say kidney disease even, people have all kinds of weird understanding of what that is. And so you need to start from the baseline of…like for me, if I get a client, I now have to start from telling them what a kidney is. Whereas in other parts of the world, you just say, 'Oh, well, your kidney is not functioning well.' But for me, I have to start from like, 'This is what a kidney is. It's in this part of the body. This is what it does.' And a lot of people, even for that, can't really grasp the concept. So like, I have to use all kinds of analogies and things like that and it can be very, very frustrating. But…and that's for like, sometimes even people who HAVE been to school. I'm not even…I've not even gotten to like illiterates yet. I'm talking about people who are university graduates, but just didn't study science*" K.I.04 (Female, 25 – 34y/o) "*At least, something…for now, for me, in this current COVID situation we are in now, something educative would be better if that…something educative. Something about this COVID…education on this COVID would be…that would be the best for now.*" K.I.08 (Female, 35 – 44y/o) "*I think, if the app has a section that is supposed to educate people on diseases and things like that, I think that would be important and necessary.*" K.I.09 (Female 55 – 64y/o "*Like maybe a daily this thing [fact] to be aware about. If it's this COVID, maybe one day it will say, 'today wash your hands' or something. Then the next day it will say…[something else].*" K.I.15 (Female, 25 – 34y/o)
Quick Chat Feature	1	"*Maybe if I have the means to communicate with my physician once in a while. Like, let's say I could text back. Or, maybe he or she could ask me questions. And then, let's say, when it comes to the notifications, depending on whatever feedback she's giving me, I could ask her a question I don't understand or something like that. Like, text very fast. Maybe if it's a pre-auto something that is there.*" K.I.05 (Male, 25 – 34y/o)
Search Feature	1	"*Okay, I like that I can search for things that I'm interested in.*" K.I.06 (Female, 18 – 24y/o)
Pictures / Visual Appeal	9	"*Like, you see, when you open up the gallery, we have where videos are, where pictures are, where messages are. So I think, with this app when they do it that way, you know that when you open the app, this is where the videos are, this is where the pictures are, and this is where the messages are. That would be very easy.*" K.I.12 (Female, 25 – 34y/o)

		"*At the end of the day, I think a lot more imagery than written stuff. And then maybe some audios would go over better.*" K.I.01 (Female, 25 – 34y/o) "*Yeah, but I think, maybe uhh…pictures. Images. Videos. So, yeah. I think that's something that my app could do. So maybe if it's an education…if it's a tip or something, I'd rather see it. Like, it would be easier to see it. Maybe a 30 second video where somebody is saying…you know those kinds of things instead of just reading reading. I mean, it should be both, but there should be visuals as well. Because visuals communicate.*" K.I.03 (Male, 25 – 34y/o) "*Yes, the ease of use is important, the more pictures so people can understand.*" K.I.04 (Female, 25 – 34y/o) "*I think the pictures will do. Because, you know, I don't know. You've been in Ghana for some time and you notice that even everything that we do, it's either through music, dancing, or pictures. So, it's something that is going to be like, very easy to…you know, most of the actors in Ghana that people really hear about and stuff like that…if you're going to be all intellectual about it like reading reading reading…let's take this COVID for instance. Currently, we have a place that the president [of Ghana] addresses us, okay? And then when I go to town and I interact with some of them [the people], they tell me that they don't understand anything the president is saying, because the English is…[too much]. Yeah, they don't! So, they…to them, they believe COVID is not even in Ghana. They think it's just a setup. Exactly. Simply because they don't like to listen. They don't listen. All they want to do is, if like, it was like a cartoon kind of way or something like very funny and then it's in an educative way, they'll be more attracted to it. You get it? So, I think pictures. And [laughing] I think dancing too will also be an addition. The pictures should dance. You get it? [laughs] Yeah, it should be something that is going to be…supposed to be music-like. Because, even now, we have musicians doing things about COVID. [singing current popular jingle] 'COVID is real. COVID is real.' Then people will be dancing. Then people will be like, 'Ei! This is real!' So, it sticks to them. It sticks to them better.*" K.I.05 (Male, 25 – 34y/o) "*I think it should be…do I say colorful? I don't know, but it should…is vibrant the word? And, maybe not so much text. Like, maybe one…let's say a particular question at a time. So maybe you just have to swipe for the next. Not like everything on one interface, and…yeah.*" K.I.07 (Male, 18 – 24y/o) "*And more pictures. Not just pictures, but pictures with text. Or, with words in it. So if you can read, then fine. It's add-on information. But if you can hardly read, then the pictures will give you a fair idea of what you're suffering from or the condition, then you'll know how to go about it.*" K.I.11 (Male, 25 – 34y/o) "*More pictures would do. And then more illustrations is very helpful.*" K.I.14 (Female, 45 – 54y/o) "*Okay. As for me, I like…to me, I'm normally into pictures a lot, because sometimes the pictures can say a lot. Sometimes you can just see the picture and you know like, you know, it's telling 'this' it's telling 'that.' And I'm that kind of person who likes to see pictures more than going through words and interacting with someone and stuff.*" K.I.15 (Female, 25 – 34y/o)
Pictures (sharing condition)	4	"*In the comfort of my home or wherever I'll be. That would also be very good. With the mobile phone, it would be very easy for me to be able to show him pictures. And then freely [comfortably], without thinking, oh maybe I have to get up…in terms of consultation, if maybe there are a lot of people in line waiting to see the doctor. But*

		with this I don't see any people so I feel I have him personally to myself." K.I.14 (Female, 45 – 54y/o) "*I was saying that it depends. Because, [the yogi] for example, he's showing you postures. You see? Postures that you will do, so that [video] us appropriate for his own. Because, there are a lot of us who when they show us postures, we don't know exactly how to do it properly. But if he has a visual with it, the pictures [and videos] are appropriate. But it might not be appropriate for other things. Or it might not be necessary. For the example that I gave you [yoga], it's really necessary for the person to see exactly what to do.*" K.I.10 (Female 65+ y/o) "*Umm…if like, maybe you can even at the same time snap pictures there, it would be very nice.*" K.I.12 (Female, 25 – 34y/o) "*Yes. I think it would be better to put on like a video something. Like WhatsApp Video Call. Or something like a video call. So, calling the doctor, the doctor would be able to see you, you'll be able to see the doctor, and as for that one, you know that this is the doctor. I can tell that this is the doctor. You know that, as for this person, I've seen the person's face and stuff [the doctor]. So, I think that one will help you to trust in it more. So I think the video call would be okay.*" K.I.15 (Female, 25 – 34y/o)
Information for Emergencies	1	"*So maybe if you're diabetic you should have something on you in case you lose consciousness that tells anybody, you know…I would love to have something on me or store somewhere for…worst case scenario, say I…something happens to me in town. So whoever health personnel gets to me should be able to know when I can't speak for myself that, ok there's blah blah blah…so at the end of the day they know exactly what to do to save me, basically.*" K.I.01 (Female, 25 – 34y/o)
Local Languages	11	*"For me, English alone is fine. In actual fact, I understand the local languages…reading them is very difficult for me. So, I'm fine with English. But there's, like I said, a lot of people who would be more comfortable with the local languages.*" K.I.01 (Female, 25 – 34y/o) "*I think that it should be in a language of choice for the person. The local dialect is a bit difficult 'cause it's difficult to read. Exactly. So, like, those people that know Twi and Ga and everything, they can understand when you speak to them, but they can't read the local dialect. Eh hehn [affirmative sound] exactly, so that would be a bit dicey on that side.*" K.I.03 (Male, 25 – 34y/o) "*That would be epic. Like, because unfortunately there's all these people with smart phones and a lot of them…because we are in Ghana, our primary language isn't English. I mean it is the country language but it's not our primary language, and there's more people who aren't fluent in it but are forced to try and use it. And more often than not, explaining what is wrong with you—especially if it's a health app—explaining what is wrong with you in your own language is much simpler and usually more efficient than explaining it in another language because then you have gaps and you have missing information; especially if you can't really find the words. But if it's in your language, you can find the words.*" K.I.04 (Female, 25 – 34y/o) "*If it's going to be like for the masses, it should definitely be in a local dialect too. Yeah, that would really help. The local…I think the local dialect would actually sell. 'Cause, in Ghana, people are perceived if, like…like me. If I'm a young boy and I'm driving and I'm speaking English, they make it look as if 'you dey see your body.' [you're arrogant] 'You're some 'Dada B'.' [you're spoiled] You know? They want to know you some way [pre-formed perceptions of you]. But, the moment you start speaking their local dialect, it makes them feel like you're one of them.*" K.I.05 (Male, 25 – 34y/o)

		“*I think it will be important if there is an audio bit to it, ‘cause I don’t know how many people can read Twi when it’s typed or read GA when it’s typed. Like, the normal…the average Ghanaian, I don’t know if they can read…yeah, they might be able to read. But if it’s an audio, they can listen in another language and understand. But, for the stuff to be typed, I don’t know how much it’s going to help. I don’t think it’s going to help as much.*” K.I.06 (Female, 18 – 24y/o) “*I think it will…it has to do with reach. Like, being able to reach a lot of people. Because, maybe not everyone is okay [comfortable] with English. So when you say other languages, you mean local languages? Yeah, I think it would be very helpful. More people will…even people who are not really conversant with technology will say, ‘Okay, it’s in Ga so I could at least try and then use it.’*” K.I.07 (Male, 18 – 24y/o) “*Yeah. Because there are a lot of illiterates out there who are holding phones. And the only language on the phone is English. Everything that they network with are English. So if there’s another language like Ewe, Hausa, Twi, and those things [and others]…you’ll see the way people will be going into those [apps] more than this English English thing [English everywhere you turn].*” K.I.08 (Female, 35 – 44y/o)
Online / Offline Capabilities	2	“*If it's an app that works offline as well as online, it would be really, really good for us here, because of uhh…expensive data issues. And even when you have the data, there’s still times it cuts out with no explanation whatsoever.*” K.I.01 (Female, 25 – 34y/o) “*I think you’ve put it correctly. And then also because, uhh…we have internet issues, data issues….yeah. So, uh…yes.*” K.I.03 (Male, 25 – 34y/o)
Interactive Interface	3	“*I mean, the symptoms might not be malaria. So the back-and-forth will…can help to…I’m not a doctor. So if I say I’m having malaria, who told me that it is malaria? So, maybe it is the back-and-forth that will let us all know whether it is malaria or not.*” K.I.02 (Female, 55 – 64y/o) “*I’d want it to be user-friendly. So it’s easier if I’m not typing a lot. I would want a back-and-forth manner, but…like, there’s some data which won’t change. So, then I don’t expect you to be inputting that kind of data like every time. Ah ha…exactly. So, for those ones, yeah. Once…one-time input and then that’s it. But the parameters that would be used for the surveillance, yes. It should be interactive, where I come in and give updates more or less.*” K.I.03 (Male, 25 – 34y/o) “*Okay, I think it should be more interactive.*” K.I.11 (Male, 25 – 34y/o)

Table 2: Study participants’ desired characteristics to promote frequent and repeated use of an mHealth surveillance system shown with number of participants who mentioned, as well as sample quotes.

How often adults would like to receive feedback and communication from the mobile phone-based surveillance system.

An important feature of a mobile application is how it interacts with the user. Most often, this interaction takes place in the form of a notification—e.g., a sound, a buzz, a pop-up message, or an icon badge that prompts the user to enter the app for a message or to complete a task. Users tend to have varying attitudes towards mobile app notifications. There are those who consider them to be beneficial reminders and then there are those who deem them to be annoyances they could live without. Below is a table summary (***Table 3***) with quotes representing study participants' desired feedback frequency when interacting with the described mobile phone-based system.

Table 3.

Desired Feedback Frequency	**Participants (N)**	**Sample Quote(s)**
Daily (or more frequently)	5	"*Oh, once a day.*" K.I.08 (Female, 35 – 44y/o) "*Okay, umm…not too many notifications. Just enough. [laughs] Umm…not too much text, but then informative text as well. Well, the app should be…I don't need to think too much to be able to get…to understand how to use it. Or else I won't use it. …Maybe…well, the important ones [feedback/information] I wouldn't mind multiple times a day. That should be fine. And I think with the apps, you get to choose how often you receive [feedback] and stuff like that, so…yeah.*" K.I.09 (Female, 55 – 64y/o) "*I think if it comes only once in a day it's okay.*" K.I.12 (Female, 25 – 34y/o) "*On a daily basis.*" K.I.13 (Male, 18 – 24y/o) "*Normally it's daily. But, because mine [current mobile apps] it's not like important and stuff, I normally don't pay attention to it. But with something like this, I know it's about my health and stuff so…I prefer daily.*" K.I.15 (Female, 25 – 34y/o)
Weekly	3	"*For me I'd say maybe weekly.*" K.I.01 (Female, 25 – 34y/o) "*I think once a week is fine.*" K.I.06 (Female, 18 – 24y/o) "Maybe once a week would be fine." K.I.10 (Female, 65+ y/o)
Every 2 Weeks	1	"I'd say two weeks. Every two weeks. Usually when you receive so many mails from a particular source, you don't even open them anymore because it's like they're just bombarding you. Most of these…I have apps that I don't even open the emails anymore.

		They just appear in the notifications. I don't think that's okay for a health app, so it shouldn't be too frequent." K.I.07 (Male, 18 – 24y/o)
Personalized	2	"*I would want an interactive app. But then, I would want the option to determine the level of interaction I want. Yeah, exactly. So, so that…maybe I don't want like daily reminders. Or maybe I want weekly reminders, I want monthly reminders, I want quarterly reminders. So, I would want to be able to determine the level of interaction that I want with the app.*" K.I.03 (Male, 25 – 34y/o) "*Okay, I think it should be an individual preference because there are people that frequent pop-ups irritate them. So I think there should be option that the person should choose. If the person wants feedback more frequently or less frequently, maybe each day, weekly, twice a day. So you choose based on your preference. But I would like to have it maybe twice a day or maybe once a day. Somebody might choose to have it maybe more frequently depending on the severity of the condition. So there should be option to choose based on your preference.*" K.I.11 (Male, 25 – 34y/o)
No Feedback	2	"*So, personally [laughs] I don't like notifications. So, it's like when I need you, I'll come to you.*" K.I.03 (Male, 25 – 34y/o) "*I want feedback to be there when I go to it, but I don't want the app to harass me [laughs]. I don't know if that makes sense. You know there are some apps that you'll be getting like, a million…you know, for like my health app, if I don't go to the app I don't know how many steps I've taken. But, like, once I go there I can see like, '10,000 steps.' But it's not going to be beeping.*" K.I.04 (Female, 25 – 34y/o)
Unspecified / Don't Care	2	"*But, come on…medical too is also important. So, let's say…umm…let's say not too much, not too little. Let's say "medium." But, as frequent as possible. If you understand what I'm saying.*" K.I.05 (Male, 25 – 34y/o) "*If it will benefit me, I wouldn't mind. If it is something that will be coming in every other minute or every other hour, I'll just mute it. In my free time, then [just go and check]. As for the frequency, I wouldn't have a problem because I have my phone. I can mute. It doesn't become irritating. In my free time I just go back to it and address what I need to address. Every information I have to soak in, I just soak it in. If I know it will benefit me in a way, I'll just leave it. I can get what number of notifications, I wouldn't mind. In my free time, I'll just go to it and see through everything.*" K.I.14 (Female, 45 – 55y/o)

Table 3: Study participants' desired feedback frequency from an mHealth surveillance system shown with number of participants who mentioned, as well as sample quotes.

Quantitative Results

Individual Innovativeness Scale

Participants' category of innovation adopter—from Diffusion of Innovation Theory.

Data collection for this research study included the Individual Innovativeness Scale, which places respondents into categories based on their propensity to adopt an innovation. All study participants completed the Individual Innovativeness questionnaire by themselves and submitted it via mobile Qualtrics (Qualtrics, 2020). Results indicate that three participants are categorized as “Innovators,” six participants fell in the “Early Adopters” category, four participants were categorized as “Early Majority,” and there was one participant each in the “Late Majority” and “Laggards/Traditionalists” categories. The Individual Innovativeness measure also allows respondents to be classified as being High, Neutral, or Low in innovativeness. Participant responses indicated that five study participants are low in innovativeness, one participant is in the neutral range, and nine participants were rated as high in innovativeness. The above information is contained in ***Table 4** and **Table 5***.

Table 4.

Descriptive Statistics of Participants’ Innovativeness Category		
Innovativeness Category	**N**	**%**
Innovators	3	20.0
Early Adopters	6	40.0
Early Majority	4	26.6
Late Majority	1	6.7
Laggards/Traditionalists	1	6.7
Total	**15**	**100.0**

Table 4: Participant Innovativeness Category based on Individual Innovativeness Scale.

Table 5.

Descriptive Statistics of Participants’ Innovativeness Level		
Level of Innovativeness	**N**	**%**
Low Innovativeness	5	33.3
Neutral	1	6.7
High Innovativeness	9	60.o
Total	**15**	**100.0**

Table 5: Participant Innovativeness Level based on Individual Innovativeness Scale.

UTAUT Scale

In addition to the descriptive analysis performed on study participants’ sociodemographic variables and the *Individual Innovativeness Scale* (2013), we report results from descriptive analysis performed on the UTAUT questionnaire measure. Study participants were asked questions from the UTAUT questionnaire after viewing a short demonstration of a prototype health data collection app. Questions from the UTAUT questionnaire are presented in ***Table 6*** below along with the percentages of participants who responded "yes" or "no" to each question. More than 80% of study participants responded positively ("yes") to 15 of the 21 questions. Two questions had more than 70% of participants responding "yes". There was one question from the Facilitating Conditions subscale that had 66.7% of participants who responded "yes". The Anxiety subscale had the questions with the fewest participants responding in a positive manner ("yes"). The question, "I feel some fears about using the system" had 33% of participants answering "yes" and 66.7% responding "no." The question, "It scares me to think that I could lose a lot of information using the system by hitting the wrong key" had 46.7% of participants answering "yes" and 53.3% of participants answering "no." The question, "Sometimes I may decide not to use the system because I fear making mistakes I cannot correct" had 53.3% of participants answering "yes" and 46.7% of participants answering "no."

Table 6.

UTAUT Subscale	**Questions**	**Participant Responding (%)**	
		Yes	**No**
Performance Expectancy	1. I would find the mobile phone system useful in reporting a health condition.	100	/
	2. Using the system allows me to alert a provider about my health condition more quickly.	100	/
Effort Expectancy	3. My interaction with the system would be clear and understandable.	93.3	6.7
	4. I would find the system easy to use.	86.7	13.3
	5. Learning to operate the system is easy for me.	80.0	20.0
Social Influence	6. People who influence my behavior think that I should use the system.	71.4	28.6
	7. People who are important to me think that I should use the system.	85.7	14.3
	8. In general, doctors or other health providers support my using the system.	93.3	6.7
Facilitating Conditions	9. I have everything I need to be able to use the system properly.	80.0	20.0
	10. I know everything I need to know about how to use the system.	66.7	33.3

	11. There is a specific person (or group) ready to help if I have problems with the system.	86.7	13.3
Attitude Toward Using Technology	12. Using the system is a bad/good idea.	93.3	6.7
	13. Using the system is fun.	80.0	20.0
	14. I like working with the system.	100	
Self-Efficacy	15. I could report a health condition using the system even when there is no one around to tell me what to do as I go.	93.3	6.7
	16. I could report a health condition using the system if I could call someone for help if I got stuck.	100	/
Anxiety	17. I feel some fears about using the system.	33.3	66.7
	18. It scares me to think that I could lose a lot of information using the system by hitting the wrong key.	46.7	53.3
	19. Sometimes I may decide not to use the system because I fear making mistakes I cannot correct.	53.3	46.7
Behavioral Intention to Use the System	20. I intend to use the system in the next 6 months.	80.0	20.0
	21. I will use the system in the next 6 months.	78.6	21.4

Table 6: Percentage of participants answering “yes” and “no” to each question.

Using the research study conducted by Brinkel et al. (2017) as a guide, this study sought to determine whether topics explored during community member interviews were direct matches to the UTAUT constructs (Brinkel, Dako-Gyeke, et al., 2017). Using the codes developed for this study’s coding scheme, interview quotes were matched to the construct they most closely related to. Each identified quote was then re-examined in the context of the UTAUT construct to ensure there was still congruence between topics. Similar to the results of research by Brinkel et al. (2017), there were quotes directly speaking to topics of the UTAUT constructs that are most significant in predicting behavioral intention. UTAUT constructs and relating quotes from the individual interviews are presented below in ***Table 7***.

Table 7.

Questions	UTAUT Subscale	Related Quotes
1. I would find the mobile phone system useful in reporting a health condition. 2. Using the system allows me to alert a provider about my health condition more quickly.	Performance Expectancy	"*If I have the means to communicate with my physician once in a while. Like, let's say I could text back. Or, maybe he or she could ask me questions. And then, let's say, when it comes to the notifications, depending on whatever feedback she's giving me, I could ask her a question I don't understand or something like that. Like, text very fast.*" (KI 5, Male, 24 – 25y/o). *"It's not like you are now going to take car, walk, and all that before going to the doctor and see and tell him your problem and all that. But you'll just do it in an easy way where you can be in your house at the same time talking to the doctor. I think it's one advantage. Because you don't have to take car. If the place is even far, that means you have to take car, pay transport, and all that before reaching to the doctor.*" (KI 12, Female, 25 – 34y/o). "*Yes. For instance, if I'm not able to get to the health center, at least somebody could call or give the exact information I need to be able to treat myself properly. I would really appreciate that. I would feel that every minute counts.*" (KI 14, Female, 45 – 54y/o) "*For instance, thinking of this pandemic that we're dealing with now in the...I would think if there was an app like that, that you could put in maybe symptoms or whatever, and would help identify infected people more easily, and in the long run prevent the asymptomatic people from unknowingly infecting others.*" (KI 1, Female, 25 – 34y/o).
3. My interaction with the system would be clear and understandable. 4. I would find the system easy to use. 5. Learning to operate the system is easy for me.	Effort Expectancy	"*I have always thought that the idea was cool because it makes sense and it's simpler because all your information is in one place and then you can just share it, because as a doctor, like it can be very frustrating when sometimes patients don't really know their own history, or they can't give it to you the way you need it, or they can only give it to you from their point of view, which isn't always the point of view you need to hear it from.*" (KI 4, Female, 25 – 34y/o). "*In the comfort of my home or wherever I'll be. That would also be very good. With the mobile phone, it would be very easy for me to be able to show him pictures. And then freely [comfortably], without thinking, oh maybe I have to get up…in terms of consultation, if maybe there are a lot of people in line waiting to see the doctor. But with this I don't see any people so I feel I have him personally to myself.*" (KI 14, Female, 45 – 54y/o). "*Okay, so let's assume it's the COVID. You know how the COVID, people like to criticize and stuff if they realize that you have the COVID, and they like to call you by the name and stuff [call you a COVID-related name]. So like, as I said earlier on, I won't want anyone to know. I [would] like to call doctor to inform the doctor about it. So, if that's the way that it's going to be, then I think I would prefer that more than going to the hospital, people to*

		recognize me, going to hospital and tests and stuff, and [people] knowing it [about your condition]. So, I think that one would rather be better than me going to the hospital to be telling the doctor or whoever I'm going to talk to." (KI 15, Female, 25 – 34y/o).
6. People who influence my behavior think that I should use the system. 7. People who are important to me think that I should use the system. 8. In general, doctors or other health providers support my using the system.	Social Influence	"*Yeah, if I know who I'm giving it to. Definitely if I know I'm giving it to my doctor, it's easy because if I'm sitting in front of him, I'll tell him the same thing. Or if he says, "Okay, tell me exactly what it is so I can write a prescription for you or I can send a prescription to the pharmacy so that you go and pick it." Then it would be easy for you to tell. If you know who you're dealing with.*" (KI 2, Female, 55 – 64y/o). "*If my physician or my healthcare provider is cool with it, then fine. She is the expert in that regard. So I'll seek the person's advice. If she says she's cool with it and there's no problem, then fine. But upon advice from my healthcare giver or my personal doctor or something, like they tell me it's not a cool thing, I don't think I would do it. Yeah, so all would be based on what my healthcare provider—my doctor or my nurse—advises because that's their field, so, yeah.*" (KI 11, Male, 25 – 34y/o).
9. I have everything I need to be able to use the system properly. 10. I know everything I need to know about how to use the system. 11. There is a specific person (or group) ready to help if I have problems with the system.	Facilitating Conditions	"*So before, I download the app, If I have that assurance that whilst using the app, whatever I put there is secure or private…sort of. Or…within the app itself, after downloading it, there's a section that lets me know that, ok, we are bound by "a, b, c, d, e." That would work for me. I mean, I don't know about you but I have certain health information about me that I wouldn't want out there. Stuff that, if I didn't have to, I wouldn't even tell my healthcare provider. So if I'm using an app to access healthcare, then I would want to know that whoever is running the app…whoever is developing the app is bound by the same rules that my doctor is bound by.*" (KI 1, Female, 25 – 34y/o).
12. Using the system is a bad/good idea. 13. Using the system is fun. 14. I like working with the system.	Attitude Toward Using Technology	"*People filter more in person. Yeah, yeah. So, the app or the interface would be better 'cause then it's like you're not really seeing anybody directly. You know?*" (KI 3, Male, 25 – 34y/o) "*Oh, I think I'd prefer the app. Okay, so for me, it's based on my background. Like, I'm into tech and all that. I just think we need to grow or develop and move away from all these manual stuff. So I just feel…it has ummm…yeah. The other aspect…the other side is maybe not wanting someone to see you or the person will be able to put a face to whatever information you're providing. But I don't think it's more of that.*" (KI 7, Male, 18 – 24y/o). "*But then if there's an app where you have your information on it, you can readily check it and then you'll be more informed. So I think that's also one benefit. Because the patients themselves, they will know more about their health status because they have easy access to it now. Their medications that they are on, their allergies, their, you know?*" (KI 3, Male, 25 – 34y/o). "*They've professionally bound them to be professional about most things. So, when it comes to a physician or a doctor, I think I'll be more than comfortable to talk to the person. Or, like, to give all*

		that app my information. You get it? Yeah, so…with that, I don't think I have a limit with that." (KI 5, Male, 25 – 34y/o). "*I wouldn't have any problem with it. Because it's for my benefit and like, I trust that, because it's a healthcare something, they will ensure confidentiality too. Yeah, I wouldn't have any problem with it.*" (KI 6, Female, 18 – 24y/o).
15. I could report a health condition using the system even when there is no one around to tell me what to do as I go. 16. I could report a health condition using the system if I could call someone for help if I got stuck.	Self-Efficacy	"*So…but with the app, I know I can just go to the app and then, I know a doctor is there who is going to help me. And even if I'm having symptoms, he's going to tell me whether it's this or it's that. And as for that one, he's going to be specific whether I have it or not. So, with that one I can trust the doctor very well.*" (KI 15, Female, 25 – 34y/o).
17. I feel some fears about using the system. 18. It scares me to think that I could lose a lot of information using the system by hitting the wrong key. 19. Sometimes I may decide not to use the system because I fear making mistakes I cannot correct.	Anxiety	"*And then you'll be too dependent…if you're too dependent on it and the phone goes bad, it means you're losing everything.*" (KI 2, Female, 55 – 64y/o).
20. I intend to use the system in the next 6 months. 21. I will use the system in the next 6 months.	Behavioral Intention to Use the System	

Table 7: Individual Interview quotes matched to specific UTAUT Subscales.

Summary of Findings

This chapter presented the results of this study based on the analysis of the community member individual interviews and survey questionnaires administered to each study participant. Results from the interview content were presented as responses to the study's specific aims. Results from the survey questionnaires are also presented visually in Tables 1, 4, 5, and Table 6. Chapter 5 discusses the most salient points from the project findings and makes recommendations for developing a participatory mHealth surveillance system.

CHAPTER 5

DISCUSSION

Summary

This study was developed to explore the possibility of creating a participatory mHealth surveillance system that would gain acceptance and uptake within the adult population in Accra, Ghana. Before beginning the process of system development and dissemination, it is important to understand the needs of the local community and to meet them where they are as much as possible. For the purposes of the described participatory mHealth surveillance system, meeting the population where they are requires an understanding of their current attitude towards mHealth tools as well as their current mobile phone use habits. Research for this study was conducted through individual interviews with community members from the general adult population in Accra. This chapter reviews and discusses findings from the interviews conducted in this study, and concludes with recommendations for designing and developing a participatory mHealth surveillance system. Work for this study was guided by the following specific aims:

1. To examine the general community's use of, attitudes towards, and willingness to adopt mobile device usage for health-related information sharing.
    a. What are attitudes towards using mobile devices for health-related behavior and information?
    b. What activities does the average adult perform on his/her mobile phone most often?
    c. What are the facilitators and barriers to accessing and using mobile devices for health-related behavior and information as well as for general use?

    d. What health behaviors would the average adult be willing to share via mobile phone reporting system?
    e. Which of the five categories of Innovation Adopters—from Diffusion of Innovations Theory—do participants fall in based on their personality and behavior?

2. To determine the desired features and characteristics that could promote self-reporting of health-related information and behavior to a mobile health surveillance system.
    a. To identify desirable features that would promote frequent and repeated use of a mobile phone-based surveillance system.
    b. How often would adults like to receive feedback and communication from the mobile phone-based surveillance system?

Prevalent Themes

Attitudes towards using mobile devices for health-related behavior and information.

This study helps broaden the knowledge base on Ghanaian adults' attitudes about health-related information sharing using mHealth tools. Community members who were interviewed for this study reported feeling extremely guarded and cautious when sharing any personal information over mobile devices. They specified this personal information as anything that can identify or locate them personally, such as their home address or employment details. Study participants also classified their personal financial information as personal and private details that they were extremely hesitant to share via mobile devices and applications. These findings are consistent with findings previous studies that found confidentiality to be a major factor influencing the adoption or use of mHealth tools (Nachega et al., 2016; Ndayizigamiye & Maharaj, 2016; Sacks et al., 2015; Skinner, Rivette, & Bloomberg, 2007). Previous experiences of theft and fraudulent activity are strong influences on their extreme reluctance to disclose personal private information via mobile devices and apps. In contrast, participants were very open to the idea of sharing health-related information via a mobile application. They all vocalized the high level of importance they place on their health and health-related information. The unanimous sentiment was that if sharing health information via a mobile device or application was going to aid in preserving or improving their health in any way, participants were more than willing to participate. Study participants had a low level of experience with apps that required health information sharing. However, all participants stated that they would need to be assured of the privacy and security of their health information before agreeing to take part in this system. Similar to results from previous work on the feasibility of mHealth use in a South African community-based study, our community members understand the potential benefits of sharing health-related information for a specified purpose via a mobile application (Nachega et al., 2016; Odigie et al., 2012). However, the weight of these benefits was not enough to outweigh their fears that any shared health information could be traced back to the individual.

Activities/tasks that adults perform on their mobile phone most often.

Participants in this study described using their mobile phones for multiple activities daily. Frequent or daily mobile phone use and using mobile phones for social communication among other mainly social tasks are consistent with findings from the literature of mHealth endeavors in SSA (Brinkel, Dako-Gyeke, et al., 2017; Nachega et al., 2016). Activities discussed in this study included yoga studies, baking tutorials, maintaining mental sharpness, and listening to music. Activities that the community members had in common were communicating with friends and family, interacting with social media, and completing professional and academic work. Communicating with friends and family was the most commonly discussed mobile phone activity, and WhatsApp was explicitly mentioned by every community member during the interviews. Social media was the next most discussed activity on the mobile phone, and users mentioned Twitter and Instagram the most. Discussions about completing professional and academic work often mentioned Google or a Google-related app by name. This is a more comprehensive list of daily mobile phone activities than is represented by a single in the mHealth literature in SSA. In describing their frequently completed tasks with the mobile phone and mobile apps, participants described their phone use with ease and high levels of proficiency. They also intimated that their mobile phones were often handy and available for use when needed. For the apps that they deemed important, participants did not describe any hesitance or issues related to repeated—or even daily—interactions with these apps. With comparable results to previous mHealth work in SSA, this study indicates that participants would not have an issue disclosing health-related information as long as their information was kept private or made anonymous; and that participants do not seem to be averse to frequently interacting with a certain mobile phone app as long as they perceive some personal benefit from their use of the app (Nachega et al., 2016; Ndayizigamiye & Maharaj, 2016; Odigie et al., 2012; Sacks et al., 2015).

Facilitators and barriers to accessing and using mobile devices for health-related behavior and information as well as for general use.

Facilitators

When discussing facilitators to using mobile devices for health-related information sharing, our participants were focused on their previously mentioned need for privacy and security. Study participants were adamant about their need to be assured of the privacy and security of their health information. Each participant expressed how important their health and wellbeing is, and multiple participants discussed the perceived benefits of utilizing such a health-based app as was described for this study. However, even after discussing the perceived benefits of using such an app, participants stated that they would not be willing to participate in an app or a system that did not have measures in place to secure and protect the privacy of the user's information. This finding is consistent with the results of multiple mHealth studies conducted in SSA, but especially with the findings of a study by Ndayizigamiye & Maharaj (2016) who determined that confidentiality of information was the most agreed upon facilitator for adopting mHealth (Brinkel, Dako-Gyeke, et al., 2017; Nachega et al., 2016; Ndayizigamiye & Maharaj, 2016; Sacks et al., 2015; Skinner et al., 2007). In addition to securing the user's privacy, participants felt they would need to know that the processes and information shared within the app adhered to a set of acceptable governing standards or data protection laws. Faced with a situation where data privacy laws were unclear, Sacks et al. (2015) reported making sure that all shared data were mostly limited to aggregate indictors (Sacks et al., 2015). This is an approach that can be utilized in other settings and can help form the basis of data privacy laws in the region.

Knowledge was brought up again as a facilitator when participants discussed wanting to know or be familiar with the entities they were communicating with through the mobile app. Study results indicate that participants would feel more comfortable and confident in using a mobile app for health information sharing if they either know the party with whom they are sharing their information or if they are familiar with—and have a favorable opinion of—the entity that has access to their health data. The final facilitator for using a mobile app for health information sharing was the anonymity of the user. Community members in our study were aware of the difference between keeping a person's information private and providing information anonymously. If the described mHealth system is unable to ensure privacy and security of the user's information, study participants felt that the only other way to facilitate use of the system would be to collect information anonymously. Anonymous information would not be traceable back to the original user even in the event of a hack or data breach. With the fear of stigma being a major barrier to participating in such a mobile system, maintaining the user's anonymity would go a long way in easing the worries of the target population. As one community member stated, "if they start from the beginning saying, for example, 'don't write your name.' As for that one, I can tell you everything. But the moment my name becomes linked with it, even though I've said I don't mind, I'll be thinking about what happens if someone sees my name and knows me."

Barriers

The fear of stigma was the most frequently mentioned barrier to using the described mHealth system. The fear of stigma or previous instances of stigma has been mentioned as a direct barrier to adopting mHealth tools in previous sub-Saharan African studies (Asgary et al., 2019; Rubagumya et al., 2020; Smillie et al., 2014). Participants in our study described previous instances of people within the community being ostracized, shunned, or stigmatized especially within the context of having a contagious illness. Study results indicate that tough privacy and security measures or an anonymous mHealth system would play an immense role in relieving potential users' fears of stigma. The second most discussed barrier to using a mobile device for health information sharing was a shared general feeling of discomfort and distrust when using internet-based technology that can be hacked. Previous personal experiences with information hacking and financial fraud as well as widespread reports of hacking and fraud within the community have made a lasting impression on community members. Reports of discomfort and distrust within the community are consistent with findings from previous mHealth work in SSA (Asgary et al., 2019; Smillie et al., 2014). Participants in our study acknowledged that they would only participate in an mHealth information sharing system because they deem their personal health to be of utmost importance. In the presence of measures to help maintain the privacy or anonymity of their health information, they would be able to move past their feelings of distrust and discomfort. As was expected, access to mobile phones was not mentioned as a barrier to using such an mHealth system. Participants did mention the lack of a consistent cellular data network connection as a barrier to the optimal function of such an mHealth system. This is another barrier that frequently appears in the mHealth literature, specifically in SSA (Brinkel, May, et al., 2017; Harris et al., 2010; Ndayizigamiye & Maharaj, 2016; Odigie et al., 2012; Sacks et al., 2015; Smillie et al., 2014). Individual interviews experienced these network connectivity issues numerous times during the course of this research study. Though this presented a very annoying problem, previous technological work in low-resource settings has established processes for storing necessary information locally on a mobile device and then transmitting to the destination once a network signal becomes available (Sacks et al., 2015). Development of the described mHealth system would greatly benefit from incorporating such processes to combat network connectivity issues. The final barrier mentioned in our participant interviews was the ability for individuals with low literacy levels to access and use the described mHealth system. As with results from other studies conducted in the region, there was concern for people with low literacy levels who often find it difficult to read or can hardly read at all (Brinkel, Dako-Gyeke, et al., 2017; Brinkel, May, et al., 2017; Odigie et al., 2012; Sacks et al., 2015; Smillie et al., 2014). Community members expect that such people in the target population would reject such an app if there are no efforts made to help bridge the literacy gap. To that end, multiple participants described utilizing pictures and images as well as having the capability for users to interact with the app in their spoken local language as possible ways of overcoming the literacy/language barrier.

Health behaviors that adults would be willing to share via a mobile phone reporting system.

Our study participants were very hesitant about sharing any personal information over a mobile device. When asked about the information they would be willing to share via a mobile phone system, participants mentioned surface level information such as age, gender, height, weight, foods, and general residence area. When asked about detailed pieces of information and health-related information, participants expressed a strong desire to know the purpose and intended use of their collected information. Having an understanding of how their information would be utilized and explicit knowledge about the purpose of collecting information would help participants feel better about providing their information to an mHealth system. Community members in this study placed a very high level of importance on their health status and reported an increased willingness to share requested pieces of information if it was going to provide a benefit to their personal health status. But even with this increased willingness to share health information, participants were still very concerned about the possibility of their information getting into the wrong hands. As with other mHealth studies in the region, participants once again expressed the extreme importance of information privacy (Brinkel, Dako-Gyeke, et al., 2017; Nachega et al., 2016; Ndayizigamiye & Maharaj, 2016; Sacks et al., 2015; Skinner et al., 2007). Participants stated that they would need to be assured that their health information would be kept private and secure or that their health information would be collected anonymously in order to fully feel comfortable sharing health information. Anyone working with this population will benefit from remembering that trust and privacy are very important factors, especially when discussing a person's health and wellbeing. Without an explanation of why certain information is sought and how it will be utilized, participants would find it extremely difficult to trust and relinquish certain personal pieces of information.

Identify desirable features to promote frequent and repeated use of a mobile phone-based surveillance system.

Although participants in this study described a variety of features they would like to see in an mHealth surveillance system, there were four features that were discussed the most, namely privacy and security features, a section for educational information, strong visuals, and access to communication in some local languages. In line with previous responses during the interviews, privacy and security features were of paramount important to each participant. It bears repeating that our study participants ascribe a very high level of importance to their personal health information. Without assurances of privacy or anonymity, participants stated that they would be unlikely to use the app. While disease surveillance is an activity that may sometimes require a person's identity or location for follow-up, developers in this area may went to start with conditions that do not require much personally identifiable information so as to build trust within the community. The second most mentioned feature was the ability to interact with the described mHealth system in the main local languages spoken in Accra. Study participants described scenarios where the ability to use a local language within the mHealth app would serve as a benefit. For example, participants describe situations where a person who can articulate his or her condition in the local language may be a bit tongue-tied trying to describe the symptom or condition in English. A person in this situation may be able to continue using the app by either typing or creating an audio recording of their symptom description in the local language. Study participants were also cognizant of the fact that there are some adults in the community with low levels of literacy and would not be able to utilize the described mHealth system in an optimal manner. Participants also discussed the fact that entities that communicate in the local languages within the community tend to be ascribed a level of trust not necessarily afforded to entities that are strictly English speaking. Gaining trust with the availability of communication in the local languages would serve as another avenue to build trust in the mHealth system within the local community and hopefully gain acceptance. The next most mentioned feature for the described mHealth surveillance app was the use of pictures and engaging visuals. Participants identified pictures and imagery as easier than text to interface with. They recognize that an app that is easy to interact with is an app that they are likely to use repeatedly. Additionally, our participants identified pictures and imagery as a good way to reach members of the local community who have low literacy levels and would have difficulties trying to read information from the app or type information into the app. The final feature that was mentioned five or more times during our interviews was a section for educational information. Study participants mentioned not wanting to have an app that would solely collect and aggregate their health information, but an app that would also provide some educational materials on health topics that were of interest to them. To bolster this point, multiple community members drew a parallel to the current climate surrounding COVID-19 and how a health app with a section of educational materials would be of immense use as we navigate a global society dealing with this pandemic. Study participants' input to this aim is extremely valuable since there is a dearth of studies examining community members' desired features for mHealth initiatives. Nurses and community health workers in SSA mainly reported the desire for mHealth innovations with visually pleasing elements and multimedia capabilities, while analysis of public app ratings in the United States indicate that community members appreciate the following features of apps they have downloaded: Usability and easy layout, ability to save time, ability to export their health data, and lack of advertisements—which usually comes with paid apps (Chang et al., 2013; Mendiola, Kalnicki, & Lindenauer, 2015).

How often adults would like to receive feedback and communication from the mobile phone-based surveillance system.

Mobile phone users have varying feelings towards feedback and notifications from apps. Although our study participants could articulate the importance of mobile app notifications, there were only a few participants who mentioned keeping their app notifications on and successfully being prompted by the app notifications. Most of our study participants explained that they often turn their app notifications off because of how annoying they tend to become after some time. This feature which is meant to be a gentle reminder to complete a task within the app can easily become a source of irritation as reminders may become more frequent and intrusive. When asked how much feedback they would like to receive from an mHealth surveillance app, the most frequent response was daily and the second most frequent response was weekly. The desire for weekly prompts/notifications is more in line with the mHealth literature, in which weekly notifications seems to be the most represented consensus among lay community members (Endehabtu et al., 2018; Hirsch-Moverman et al., 2017; Kazi et al., 2017; Nachega et al., 2016). As much as there was a likelihood for notifications to become annoying, study participants, once again, discussed the level of import they place on their health. With regard to a health app, participants were more open to receiving feedback on a more frequent basis as they would not want to miss any important updates, information, or prompts. But even with the understanding of the importance of health information, community members cautioned that the notifications should not be too frequent. There was only one participant who mentioned being okay with multiple notifications a day, and that was solely because the topic was a health-related mobile app. The next most suggested notification frequency was weekly, and these suggestions came from community members who described easily getting annoyed with their app notifications. A few participants also discussed having the capability to personalize notification frequency based on the individual user's preferences, an idea that is only beginning to gain traction in the mHealth literature (Hirsch-Moverman et al., 2017). stating that the app could offer recommendations for notification frequency based on the conditions or symptoms being surveilled. This may be the best approach in order to meet each user where they are without requiring a drastic change in behavior.

Participants' category of innovation adopter—from Diffusion of Innovation Theory.

Results from the *Individual Innovativeness Scale* (2013) indicate that our study participant population comprises of mostly Innovators (three participants) and Early Adopters (six participants). Further classifying our study participants based on their level of innovativeness, five of our study participants are classified as having "low" levels of innovativeness while nine participants are classified as having "high" levels of innovativeness. There was one participant who fell in the range between "high" and "low" innovativeness and was thus classified as having a "neutral" level of innovativeness. While understanding where members of the general population in Accra fall along the scale of innovativeness is extremely important in guiding the development of an mHealth system, it may be even more important in directing the dissemination of such a system. Without many studies categorizing SSA community members according to their innovativeness level, this study is left to extrapolate findings from other regions. Studies in other parts of the world have found that participants who are described as "innovators" are the first ones—and sometimes the only ones—to adopt an mHealth innovation (Greenhalgh et al., 2019; Molfenter, Brown, O'Neill, Kopetsky, & Toy, 2018; Zhang, Yu, Yan, & Ton A M Spil, 2015). Assuming that the development stage of the described mHealth system has followed guidance from the target population, it is important to have the appropriate users to buy into the system first and help disseminate it throughout their communities over time. A population with strong numbers of Innovators and Early Adopters—such as is represented by the community members in this study—is optimal in helping an innovation to gain traction and eventually become accepted within a society. With 60% of participants self-identifying as having high levels of innovativeness, findings from this study indicate that the general adult population in Accra may be well setup for the introduction of a robust mHealth innovation. Given optimal function, responsive interface design, and enough time, we expect that this population is well-suited to attempt a participatory mHealth surveillance system.

UTAUT Scale

The UTAUT scale is meant to provide nuance to a population's readiness for acceptance and use of a mobile technological innovation. Results from this study are very encouraging as participants discussed topics that could be matched directly to each UTAUT scale except Behavioral Intention to Use the System. One possible explanation for the lack of quotes matching directly to this subscale is that the individual interviews did not specifically ask participants whether they intend to use the demonstrated mHealth system in the next six months. Participants were asked about their feelings towards such a system and about the things that would pique and sustain their interest in using a system similar to the one that was demonstrated for them. Although there is no anecdotal data to indicate that participants intend to use the system that was demonstrated for them, we cannot take the lack of specific mention during the interviews to mean that participants do not intend to use the demonstrated system.

We looked at participant responses to the individual questions in the UTAUT questionnaire to determine the percentage of participants who answered "yes" and "no" to each question. Both questions that make up the Performance Expectancy subscale had 100% of participants responding “yes”, meaning that all participants thought the demonstrated application would be useful in helping them complete the described health-related app. The three questions making up the Effort Expectancy subscale all had over 80% of participants responding “yes”, indicating that majority of community members in our study expected the demonstrated system to be easy to learn and use. The three questions comprising the Social Influence subscale all had at least 70% of participants responding “yes” (71.4%, 85.7%, and 93.3% respectively). This indicates that majority of community members in our study perceive a strong level of influence for using the app from members of their social circles. More than 80% of study participants responded yes to two of the three questions from the Facilitating Conditions subscale (80.0, and 86.7 respectively). For the question, “I know everything I need to know about how to use the system” there were only 66.7% of participants who responded “yes.” It is expected that there would not be a high percentage of participants who feel they know all they need to know to use the system. As such, 66.7% of participants responding “yes” is a little higher than expected. The three questions making up the Anxiety subscale had the most balance between “yes” and “no” responses. One third of study participants (33.3%) responded “yes” to feeling some fears about using the system, 46.7% of participants expressed being scared about the potential of losing information contained in the system, and 53.3% of participants said they may decide not to use the system for fear of making permanent mistakes. These responses are in accordance with the data gathered during the qualitative phase of this study. Participants expressed apprehensions about using the described mHealth system because of information privacy and data security reasons. We expect that significantly more participants would respond “yes” to the questions from the Anxiety subscale if shown the demonstration of an app with explicit displays of strong data security and information privacy features.

Implications

The following section presents recommendations for app development as well as recommendations for future research in this area. Intervention and app developers who are interested in developing such an app for mHealth information and participatory disease surveillance should build on the valuable information presented by the community members who participated in this research study. Future researchers working in this arena would also benefit from building upon the knowledge garnered from this study just as this study sought to build on the work of preceding researchers.

Recommendations for Developing a System for mHealth Participatory Surveillance

1. Engage members of the target population from the earliest stages of system design possible. The adult population in Accra is very unique based on multiple influences from American and European countries as well as civilizations from Asia and even some within the African continent itself. At the same time, there are still numerous cultural and local norms which permeate the social landscape enough to require approaches that are very different from those used in non-African countries.
2. Prioritize protecting the privacy and security of user information once entered into the mobile surveillance system. Privacy of one's health information is of utmost importance to members of the target population, and any lapse in information protection is likely to become a lasting deterrent to using this app. If user information cannot be kept secure or private, there must be accommodations made to anonymize the user's information so that no information can be traced back to the submitting user.

3. Educate members of the target population on the purpose of the mobile surveillance system and why it is important to provide truthful information when using the system. Highlight the potential individual and community benefits of participating in the system. Members of the target population will also benefit from education on how information is used upon submission to the mobile system.
4. Ensure that there is an entity responsible for overseeing the practices and information security protocols contained within the app. Publicizing any governing laws or regulatory oversight will confer more community trust in the system.
5. Commit to making the system versatile with regard to the ways users can interact and input information. A society whose members are as varied in their education and literacy levels as the study population does not benefit from tools with a one-size-fits-all approach. Pictures and images are the most recommended means of modifying the system interface to reach the largest audience.
6. Incorporate aspects of the local culture or local languages into the system to increase the population who can access and use the system appropriately. The ability to capture user input in the local languages will help build trust in the system among the local community. This capability will also allow potential users to still engage with the app if they have low literacy levels or if they simply cannot describe their symptom or condition as well in English as they can in a local language.
7. Demonstrate how the system functions as well as the ways it can prove useful to the local community. Demonstrations should showcase different features and sections of the system. Members of the target population should also be taught best practices for entering information into the app for one's self or close loved ones.

8. Be open to community feedback. No system is perfect after initial development. The best recommendations for improvement and enhancement will come from the user who interacts with the system on a frequent basis under real life conditions. It is only after the system is deployed and in use by the intended population that certain potential enhancements can truly be perceived.

Recommendations for Future Research

Findings from this research study can be used to inform the design of a participatory mHealth surveillance system. Findings from this study indicate that there are multiple factors influencing community members' intention to use a participatory mHealth surveillance system. Theoretical frameworks were applied in the formation of this research study with the aim of being able to definitively describe our target population based on their proclivity for adopting innovations as well as their likelihood of accepting new technologies. Future research studies should aim to apply robust theoretical frameworks to a sample size much larger than was gathered for this study. Conducting similar research with strong theoretical basis and a larger sample size will allow researchers to be able to make more direct conclusions and may even aid in predicting the likelihood of technology acceptance and adoption within this community. This study found the Unified Theory of Acceptance and Use of Technology (UTAUT) to be useful with our target population and deems it to have great potential for describing the likelihood of technology acceptance among adults living in Accra, Ghana. Similar to the researchers in a 2017 study conducted in Accra, we were able to match our participants' interview quotes to specific constructs of the UTAUT theory (***Table 7***) (Brinkel, Dako-Gyeke, et al., 2017). Researchers from this study are very encouraged by this development and believe that UTAUT should continue to be explored with larger population sizes in this setting. Administering this tool to a larger pool of the adult population in Accra has the potential to be very instructive in determining how and through whom a new innovation should be introduced to provide a better chance of acceptance and adoption. Future research on surveillance processes should also endeavor to capture the views and recommendations of clinicians and health professionals actively involved in the healthcare and administrative aspect of disease surveillance activities in Accra.

Limitations

The findings reported by this research study are limited by a number of factors. The primary limitation of this study is being conducted in the year 2020, during the global Coronavirus Disease pandemic. Travel and in-person research activities were prohibited during the data collection phase of this study. As such, all interviews and interpersonal communication was conducted using mobile cellular voice and video calls. Secondly, this study was completed with a sample size of 15. Having such a small sample size was sufficient for qualitative research and individual interviews. However, the sample size did not allow for a full and thorough interpretation of the UTAUT scale and did not allow for any complicated statistical analyses such as regressions. The small sample size of this study was also a factor that informed the adaptation and modification of the UTAUT scale and response options. Further exploration of this study’s aims with a large enough population to provide strong statistical power and a full administration of UTAUT scale responses will allow predictive inferences to be made regarding the community as a whole and the probability of successfully adopting a technological innovation.

Conclusions

The insights shared by the community members in this research study offer a very unique view of how the average adult in Accra views health information sharing. Study participants reported placing a high value on their health and any processes that are meant to be beneficial to their health. However, the fear of stigmatization from community members makes information privacy and security an area of intense focus for any mHealth system seeking to collect personal health information. As long as users can be shown the potential benefits of using such a system and can be assured of their privacy (or anonymity), a participatory mHealth surveillance system is an innovation that will be met with copious amounts of interest and enthusiasm.

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APPENDIX A

Individual Innovativeness Scale

Directions: People respond to their environment in different ways. The statements below refer to some of the ways people can respond. Please indicate the degree to which each statement applies to you by marking whether you: *Strongly Disagree = 1; Disagree = 2; are Neutral = 3; Agree = 4; Strongly Disagree =5.*

Please work quickly, there are no right or wrong answers, just record your first impression.

1. My peers often ask me for advice or information.
2. I enjoy trying new ideas.
3. I seek out new ways to do things.
4. I am generally cautious about accepting new ideas.
5. I frequently improvise methods for solving a problem when an answer is not apparent.
6. I am suspicious of new inventions and new ways of thinking.
7. I rarely trust new ideas until I can see whether the vast majority of people around me accept them.
8. I feel that I am an influential member of my peer group.
9. I consider myself to be creative and original in my thinking and behavior.
10. I am aware that I am usually one of the last people in my group to accept something new.
11. I am an inventive kind of person.
12. I enjoy taking part in the leadership responsibilities of the group I belong to.
13. I am reluctant about adopting new ways of doing things until I see them working for people around me.
14. I find it stimulating to be original in my thinking and behavior.
15. I tend to feel that the old way of living and doing things is the best way.
16. I am challenged by ambiguities and unsolved problems.
17. I must see other people using new innovations before I consider them.
18. I am receptive to new ideas.
19. I am challenged by unanswered questions.
20. I often find myself skeptical of new ideas.

APPENDIX B

Unified theory of Acceptance and Use of Technology (UTAUT)

1. I would find the mobile phone system useful in reporting a health condition.
2. Using the system allows me to alert a provider about my health condition more quickly.
3. My interaction with the system would be clear and understandable.
4. I would find the system easy to use.
5. Learning to operate the system is easy for me.
6. People who influence my behavior think that I should use the system.
7. People who are important to me think that I should use the system.
8. In general, doctors or other health providers support my using the system.
9. I have everything I need to be able to use the system properly.
10. I know everything I need to know about how to use the system.
11. There is a specific person (or group) ready to help if I have problems with the system.
12. Using the system is a bad/good idea.
13. Using the system is fun.
14. I like working with the system.
15. I could report a health condition using the system even when there is no one around to tell me what to do as I go.
16. I could report a health condition using the system if I could call someone for help if I got stuck.
17. I feel some fears about using the system.
18. It scares me to think that I could lose a lot of information using the system by hitting the wrong key.
19. Sometimes I may decide not to use the system because I fear making mistakes I cannot correct.
20. I intend to use the system in the next 6 months.
21. I will use the system in the next 6 months.

APPENDIX C

KEY INFORMANT: INTERVIEW GUIDE

Guiding questions

Mobile phone use patterns.

- Think of your favorite mobile app. What is this app, and what do you like most about it?
- How often do you use this app on your phone?
- Thinking about mobile phone use in general, about how much time do you use your phone each day?
- Does anyone use any apps that are in other languages (such as Ga, Twi, or Hausa)?

Attitudes towards mobile information exchange.

- Does anyone use apps where you enter some information about yourself into the app?
- What may be some of the benefits of entering your personal information into a specific mobile phone app?
- What may be some of the negative effects of entering your personal information into a mobile phone app?
- What do you think/how do you feel about the apps that ask you to put in some personal information in order to get the best results from the app?
- What kind of personal information do you/would you readily enter into a mobile app even if it meant you do not/would not get the best performance from the app?
- Are there any types of information that you do not/would not enter into an app if it asked for it? What kind of information?

Mobile phones for health information.

- How would you feel about entering your personal information into an app that was connected to your health services to help provide you with better health services?
- Does anyone have any experience with such an application (or a website) where you provided information for health purposes?
- Thinking of the concept of disease surveillance, how would you feel about entering personal information into an app that would help the health system to carry out more complete disease surveillance in a timelier manner?

- After discussing the benefits of high-quality surveillance and the problems presented by low quality surveillance, does anyone feel differently about entering personal information into an app that would help improve disease surveillance?
- Can you think of any benefits that could come from transmitting your health information over a mobile phone app system?
- Is there any kind of information that you would not want to provide through an app, even if it would help provide better disease surveillance?
- Would you feel differently about providing this information to a health professional in person or over the phone?

Desired features and characteristics.

- If we were to design a mobile app for disease surveillance for use in your home and around your neighborhood, what are some things you would like to see (or would not like to see) about it?
- What kind of information would you consider to be “too much” or “too invasive?”
- Would you prefer a system where you only have to enter your information one time or would you prefer an app that is interactive, where you can enter multiple pieces of information in a back-and-forth manner?
- Would you rather enter your information by selecting one choice from a set of options, or would you like to enter your information in an open field as you would like to (i.e. open text field)?
- Do you/would you have any concerns about how your information is handled or processed from the time you enter it to the time it is used for its specified purpose?
- What kind of feedback would you like to receive from the app, and at what frequency?
- What are some benefits of being able to receive feedback based on your personal health information?
- What are some potential concerns about receiving feedback based on your personal health information?
- What are some things you like about your favorite app that you would like to see in such a surveillance app?
- How important would it be for you to be able to use this app in a language other than English (e.g. Ga or Twi)?
- What other characteristics would you like to see in such an app?

Concluding Question.

- What would you say are the most important issues expressed about today’s topic?

❖ Interview guide created with input from *Updated Guidelines for Evaluating Public Health Surveillance Systems* (Centers for Disease Control and Prevention, 2001).

APPENDIX D

Demographics Questionnaire

Demographics Questionnaire

Please provide an answer to each of the following questions to the best of your ability.

Please indicate your gender below:

☐ Male ☐ Female

Please indicate your age from the age ranges below:

☐ 18 – 24 years ☐ 25 – 34 years ☐ 35 – 44 years

☐ 45 – 54 years ☐ 55 – 64 years ☐ 65+ years

Please indicate the highest level of schooling you have completed:

☐ None ☐ Primary Sch. ☐ Jr. Secondary (JSS) ☐ Sr. Secondary (SSS) or higher

Please indicate your ethnic group:

☐ Akan ☐ Ga-Adangbe ☐ Ewe ☐ Other (please specify below)

Ethnic group specified: ____

Please indicate your marital status:

☐ Married/Living together ☐ Divorced/Separated ☐ Widowed ☐ Never marrie

Please indicate the number of children aged between 0 and 15 years living in your home:

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 or more

APPENDIX E

Recruitment Questionnaire

Recruitment Questionnaire

Please provide an answer to each of the following questions to the best of your ability.

Are you at least 21 years of age or older?

☐ Yes ☐ No

Do you have access to a mobile phone for regular use?

☐ Yes ☐ No

Do you keep at least 45 Cedis – 90 Cedis worth of credits leaded on your mobile phone regularly?

☐ Yes ☐ No

For use by Study Staff only:

Recruitment Score:

☐/ 3

APPENDIX F

UNIVERSITY OF GEORGIA

CONSENT FORM

Theory-based mHealth Participatory Surveillance System Development

You are being asked to take part in a research study. The information in this form will help you decide if you want to be in the study. Please ask the researcher(s) below if there is anything that is not clear or if you need more information.

Project Leader: *Name: Kevin B. Dumolga, MPH*
Department of Study: Health Promotion and Behavior | College of Public Health
University of Georgia
Contact Information:
e-mail: kdumolga@uga.edu
Phone: 678-468-7470

In this research study we want to learn about how adults in Accra use their mobile phones and how we may be able to create a disease surveillance system that can fit in with the ways people currently use their mobile phones. After completing this project, we hope to use your information and feedback to develop a mobile phone-based tool that members of the community can use to share information about their health and the health of members of their household. More specifically, we want to:

1. Understand the attitudes that adults in Accra have about using mobile phones for sharing health information, and how willing these adults are to adopt a mobile phone system that involves sharing health information.
2. Determine what features and characteristics we could incorporate into such a mobile phone health information system that would promote continued use.
3. Explore the things that are working well and things that are not working as well for disease surveillance activities in the Greater Accra region.

You are being invited to be in this research study because you:

1. Are an adult living in Accra who is aged 21 years or older.
2. Own or have access to a mobile phone for regular use.

3. Consistently keep at least 45Cedis – 90Cedis worth of credits loaded on your phone for use each month.

If you agree to participate in this study:

- We will discuss topics about your mobile phone use behavior in general, and as it relates to your health information.
- We will ask you to attend an individual discussion session – taking place via telephone or video conference – to talk about the topics referenced above and complete some related questionnaires. It will take about 120 minutes for all study activities.
- We will only collect your signature to document that you attended the focus group and to document that you received a copy of this consent document.
- We will provide compensation for your time and your opinions in the amount of about $3 (15 cedis).

Participation in this study is voluntary. You can refuse to take part or stop at any time without penalty. If you decide to stop or withdraw from the study, or if the investigator terminates your participation (resulting from poor telephone or internet connection), the information/data collected from or about you up to the point of your withdrawal will be kept as part of the study and may continue to be analyzed.

Your decision to participate in this study (or stop participating in this study) will not impact your work status or your ability to participate in any future mobile phone or health research studies. There may be questions that make you uncomfortable or that you may feel are private. You can skip these questions if you do not wish to answer them. Your responses may help us understand the best approach to take in designing a system that will support and strengthen the ways that disease surveillance is conducted in Ghana.

We will take steps to protect your privacy, but there is a small risk that your information could be accidentally disclosed to people not connected to the research. To make sure we are capturing your responses correctly for our study notes, we will be audio recording our interview. This is very important in helping us keep the best notes and collect the best information from our discussion. If you do not wish to be recorded, we will rely on extensive notes taken during our interview to represent your data for this study. In order to protect your privacy, we will allow you to select a nickname or alias to be used during all of today's discussions if you would like. Information you provide for this study will not be used or distributed to any other researchers for future research. Audio recordings will be transcribed and destroyed at the conclusion of this research project. Data transcriptions will be kept for at least three (3) years after the completion of this study.

You will receive compensation for your time and participation in our study. This compensation will be in the form of a cash payment of 15Cedis. You will be asked to complete a receipt form for this incentive, including your name and telephone number. This information may be shared with the investigator's department business office to make sure that we are conducting this research properly.

Please feel free to ask questions about this research at any time. You can contact the Principal Investigator, Kevin Dumolga (678-468-7470, email: kdumolga@uga.edu) or dissertation research committee chair, Dr. Tamora Callands (706-542-1722, email: tamcall@uga.edu). If you have any complaints or questions about research participant rights, please feel free to contact the University of Georgia Institutional Review Board (IRB) at 706-542-3199 or by email at IRB@uga.edu. You may also contact the Ghana Health Service Ethics Review Committee Administrator for questions or clarification on ethical issues at: 233-302-682709, email: ghserc@gmail.com, postal address:

The ERC Administrator
Research and Development Division
Ghana Health Service
P.O. Box MB190
Accra

If you agree to participate in this research study, please sign below:

Name of Researcher	Signature	Date
Name of Participant	Signature	Date

I agree for the researchers to audio record my participation in this focus group discussion.

Yes ☐ No ☐

Please keep one copy and return the signed copy to the researcher.