Rapid Development of Public Health Education Systems in Low-Literacy Multilingual Environments: Combating Ebola Through Voice Messaging

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Abstract

One of the main challenges in combating the spread of the Ebola outbreak in West Africa is a lack of effective public health education among affected populations in Guinea, Sierra Leone, and Liberia. Difficulties include resistance to official sources of information, mistrust of government, cultural norms, linguistic barriers, and illiteracy. In this paper we describe the development and initial deployment of a voice-based, multilingual mobile phone application to spread reliable public health information about Ebola via peer-to-peer sharing. Our hypothesis is that we can overcome mistrust and disseminate important health information via the power of social learning and suggestion from friends, family, and local communities. In collaboration with partners on the ground in Conakry, Guinea, we have launched two parallel mobile phone services known as Polly Game and Polly Health to enable message sharing in several Guinean languages. We discuss a variety of strategies we have tried to encourage the spread of the application and data on uptake to date.

1. Introduction

It has been widely reported that some of the factors exacerbating the spread of Ebola Virus Disease (EVD) in West Africa are human behaviors and social conventions [1] such as funeral practices [2][3], cultural norms involving bodily contact such as hand-shaking [4][5], the consumption of contaminated bushmeat [2][6][7][8], and a general fear and mistrust of national governments and foreign health workers [9][10][11][12][13][14][15]. Public health education and mass messaging have thus become crucial aspects of the Ebola containment campaign [16][17][18]. However, the efficacy of typical modes of information dissemination such as signs and billboards, radio broadcasts, robo-calls sand SMS blasts are dubious in this case because the perceived credibility of information is ostensibly one of the major barriers to public trust [19]. Furthermore, West Africa is a diverse multilingual environment (with over 40 languages spoken in Guinea alone [20][21]) with high rates of illiteracy, particularly among rural and impoverished populations [22][23].

Our work concerns an effort to address some of these shortcomings in public health education communication in Guinea. According to the Centers for Disease Control and Prevention (CDC) [24], the World Health Organization (WHO) [25][5] and the U.S. Agency for International Development (USAID) [26], concerted efforts must be made to provide information about Ebola in a variety of local languages besides French and English [27][28]. Furthermore, there is significant evidence to suggest that social learning and peer-to-peer sharing of information are effective means of disseminating correct information about Ebola as well as accelerating the rejection of popular myths [19]. To accomplish both of these objectives, we have first taken a series of seventeen question-answer style messages prepared by the WHO (currently used as educational flipcharts and memory aids for Ebola Surveillance Committees in Guinea [29]) and translated them into the seven most common local Guinean languages. Next, as a delivery mechanism we have adapted an application developed at Carnegie Mellon University in 2010 in collaboration with Lahore University of Management Sciences (LUMS) in Lahore, Pakistan called *Polly* which leveraged virally spread telephone-based, speech-based entertainment services to disseminate development information to low-literate users in Pakistan and India [30][31][32][33][34].

Polly is an IVR tool relying on a simple callback mechanism to allow users to avoid cellular charges. Users register callbacks from the system via "flashing" or "beeping" (ringing once and hanging up) and then follow a series of interactive prompts which enable the recording and forwarding of messages to any freely-provided phone numbers. Recipients of delivered messages can then reply and/or forward messages to others. Users can also record feedback and questions regarding Ebola or Polly in general. Our current system allows the forwarding of WHO messages in nine recorded languages (including French and English), as well as a light-hearted voice-based game to motivate users to continue using the application.

Each design aspect of Polly is intended to address a specific problem in message dissemination. Although radio technology has greater overall penetration in West Africa, GSM technology is indisputably the most ubiquitous medium for two-way communication, and, crucially, Polly makes no assumptions about the sophistication of user devices.

Furthermore, multilingual voice-based information typically has greater reach and expressive capacity than written information, especially among low-literate populations speaking languages rich in oral traditions, (e.g. the use of griots and town criers), which are often unwritten.

Finally, social messaging is arguably a universal form of information dissemination, while fun and entertainment are among the most effective known motivators for the use of a given product or service. Together, we leverage these design aspects to produce a public health education tool which has numerous advantages over conventional communication media.

2. Operation in Guinea

We are currently working in collaboration with the United States Embassy in Conakry, the language and training staff from

Peace Corps Guinea, and indirectly through these partners with the CDC. This has provided us an invaluable set of responsive, on-the-ground partners with local connections and the essential blessing of the Government of Guinea. They are also an authoritative source of news and up-to-date information on the current status of the Ebola epidemic, and much of our system design feedback has come from them. Polly is currently deployed and supported via a GSM Gateway at the US Embassy which communicates with our servers in Pittsburgh Pennsylvania, USA.

The user interface of Polly is recorded in Guinean French, and consists of mostly simple language pertaining to button menus and browsing/forwarding features. We expect that these rudimentary instructions are understandable to the majority of the adult population in Guinea, though this might not be a reliable assumption in all cases, as French is typically a second or third language for most of the Guinean population [21].

It is for this reason that the WHO question-answer flipchart recordings have been recorded in French as well as seven Guinean languages including (in order of their prevalence in Guinea) Fulani (a.k.a. Peul, or Pular), Malinké, Susu, Kissi, Toma (a.k.a. Guerze), Kpelle, and Manon [20]. The Peace Corps Guinea language and training staff have been our primary resource for these languages, as they have many language tutors and maintain strong positive connections with local communities throughout the country.

2.1. Localized Challenges

A key challenge for information dissemination (particularly in West Africa) is the rich multilingualism and varied literacy of the local population. Content messages printed on billboards or transmitted via SMS are often rendered ineffective by illiteracy. Likewise, radio spots and voice messages recorded only in French may not be understood, particularly in rural and remote areas such as the Forest Region which was the epicenter of the original outbreak of Ebola in early 2014 [2][11].

One of the primary utilities of the Polly Health system is the ability for users to pick the language in which they want to hear the WHO messages as well as the language in which to forward on to others. This allows messages to be chosen for a particular individual selected by their friends and families. Polly is thus highly adaptive to the multilingual environment of Guinea.

At the same time, opening the door to so many languages creates difficulties in the task of responding to user feedback and questions. Polly features a feedback mechanism which enables users to record questions and comments in the language of their choice. This has led us to rely on our partners in Peace Corps Guinea to not only detect which languages are being spoken, but to develop accurate and culturally appropriate translations of potentially technical answers from health authorities such as the WHO, CDC, and the Guinean Ministry of Health.

Formulating responses in low-resource languages regarding Ebola is often a sensitive task, furthermore. Translations need to be both respectful of local customs and culture as well as true to the intended meaning of medical authorities.

2.2. Current Status of Ebola

As of this writing the Ebola outbreak appears to have shifted somewhat to the Conakry region [35], which speaks primarily Susu [21]. We have thus begun an effort to translate and record our entire UI in Susu to meet the needs of the non-French-speaking population. In this task we face additional challenges as our system is currently slightly biased towards French grammar. Many languages in Guinea have different syntactic structures and this becomes complicated, for instance, when we try to parameterize button press instructions where the verb follows or precedes the object.

The US Embassy in Conakry currently employs several thousand community health workers whose job is to travel to various communities and educate people using the WHO flipcharts. The Polly Health system has been branched for this purpose and we have developed a specific sub-application called Polly/Browse which allows community health workers to easily browse messages for reference or to use as examples. It can also serve as an aid for workers who may not speak the most appropriate language in which to communicate their message to a given community.

3. Polly Telephone System

Polly was designed to deliver information to an audience by way of the endorsement of their personal connections. It features a game system that will attract new users and motivate them via entertainment to interact with the system long enough to forward it on to others and discover our secondary systems.

These secondary systems are designed to disseminate information, and are available as transfer menu options within the Polly/Game system.

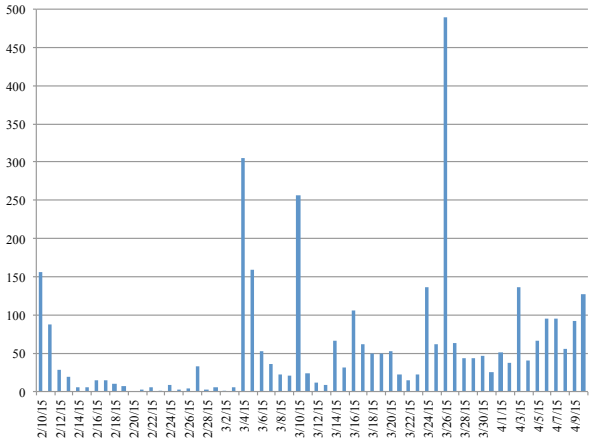

Figure 1: Number of Calls Answered By Polly Users Since February 10, 2015

3.1. Polly/Game

Polly/Game was designed to provide entertainment, and has been used for previous deployments in other countries in addition to our current efforts in West Africa. The game features a lighthearted interaction which prompts users to record and modify their voices with funny modulation and sound effects, which they can send on to others.

Recipients of these recordings can then choose to forward them again to other people, respond to the sender with their own recording, or send a new recording to someone else.

3.2. Previous Polly Deployments

Polly has previously been deployed to Pakistan and India, going on to achieve exponential growth in both of these countries. In Pakistan, Polly reached 165,000 users after a year of operation.

Both of these deployments were aimed to reach low literate workers and deliver to them job ads. This allowed people who

might not have been able to read job listings instead use their mobile phones to find employment opportunities.

3.3. Deployments in West Africa

Our current work concerns the dissemination of Ebola-related public health information in Guinea. The deployed systems also have the ability to forward messages and spread independently without the help of the Polly/Game system. Polly/Game was nevertheless deployed alongside these systems to aid the overall spread and to seed new users. Contrary to previous experiences in which Polly/Game was used as a viral mechanism to spread job-ads, in Guinea we have also experienced our Polly Health systems feeding users to Polly/Game. All three of these systems have different phone numbers which users can call and access.

3.3.1. Polly/Spread

Polly/Spread will play Ebola messages one at a time, and intentionally stop after each message to urge users to forward on to others. By design it will wait until the user has provided of a delivery recipient before moving on to subsequent messages, though this can also be bypassed in the menu. This was intended to get members of the general public to spread Ebola messages as many times to as many people as possible. Polly/Game has the option of transferring users over to this system as well.

3.3.2. Polly/Browse

In contrast to Polly/Spread, Polly/Browse allows easy browsing of Ebola messages. This was aimed towards community health workers working door to door or traveling to remote areas. This audience might already be familiar with the content of the provided messages, but might need reminders and the reassurance of hearing a second opinion from an authoritative source.

A selected message in this system can be forwarded on to others just like in Polly/Spread, but it is left as a passive option that the user will not be specifically urged to use.

4. Seeding Techniques

To encourage usage of the different Polly systems, several different 'seeding' events were held. These can be characterized as either In-Person Demonstrations or Cold Seeding, in which the users have no prior knowledge of Polly and have not received a personal introduction to the system. So far, seeding events have generally resulted in a short-lived spike in traffic to Polly before dying down in subsequent days.

4.1. In-Person Demonstrations

As the primary method for seeding Polly/Game, personal demonstrations were held to small groups of people. A small group of 20 to 30 people would be brought into a room and be taught how to use and interact with the system, encouraging them to call and send messages to others before they leave.

Even with limited initial numbers of people, these were volunteers from around the US Embassy, and would be motivated enough to spread Polly to hundred of others.

4.1.1. Nzérékoré Schools

A demonstration event that derived the most sustained activity occurred at the schools in Nzérékoré, in the Forest Region of Guinea. Workers from the US Embassy visited several primary schools and demonstrated Polly/Game to groups of children, who seemed to respond favorably, continuing to call in even after several days.

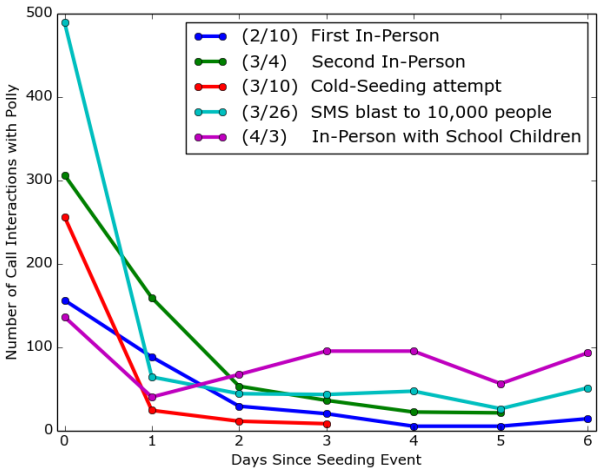

Figure 2: Usage of Polly after different seeding events. Each plot is drawn up to a week or up to the start of another event.

4.2. Cold Seeding & SMS Blasts

A limitation to personal endorsement and demonstration seeding is the effort and time required to find and train initial groups of users. As an alternative approach, random phone numbers were contacted with unsolicited calls from Polly.

After dialing 160 phone numbers with Polly/Browse, about 70 people called back into the system. While some of these users interacted with Polly, most did not forward to others, and there was a sharp decline in user activity after the first day.

On a separate day, the Embassy used an SMS broadcast system to advertise Polly/Browse to 10,000 people. Of these, almost 500 people responded and interacted with Polly on the first day, and then declined afterwards.

4.3. Radio Spots

Working with the US Embassy, a 1-minute radio advertisement was produced for Polly/Spread, and played once every other day during an Internews Guinea nightly broadcast about Ebola which was then repeated by local radio stations around the country. However, after two weeks, no notable increase in traffic has occurred.

5. User Behavior

For each seeding attempt and method of user introduction, there was typically a spike in activity which died down in subsequent days. So far, a very low baseline number of users interact with the Polly systems on a day-to-day basis.

The typical behavior we have observed has been a constant increase in the number of daily users with very few repeat users. In the first week after the deployment of each separate application, roughly 78.4% of users each day were new. This may be a misleading figure however, because cellular phone users in Guinea often use SIM cards from a variety of carriers and multi-SIM mobile phones are popular.

In Figure 1 we display the overall number of answered calls in each day of our deployment since February 10th, 2015. We

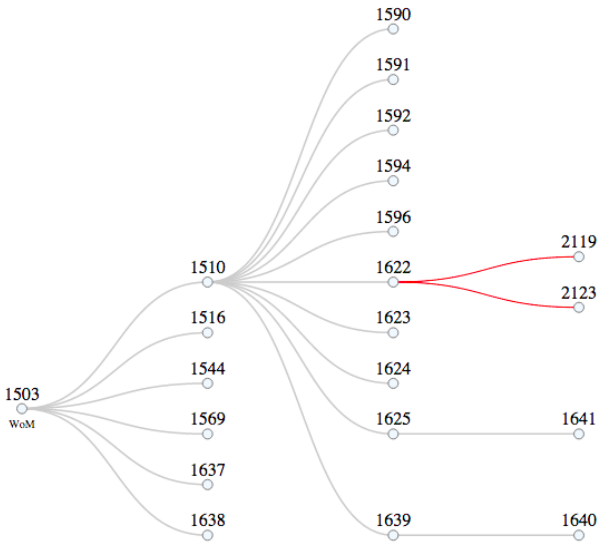

Figure 3: Example of Organic Spread Between Users

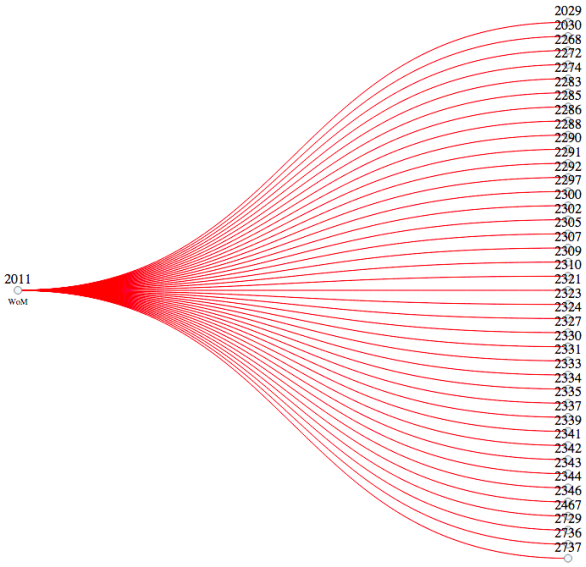

Figure 4: Example of Single User 'Super' Spreading

have observed a steady increase in sustained activity with each new seeding attempt, and as of the week of April 10th, 2015, we have observed four days with 90+ answered calls, which is the highest overall period of sustained activity since our initial deployment.

5.1. Organic Dissemination

While the majority of Polly users have only interacted with the system once, we have also observed many instances of sustained organic spread between successive users. In 3 we have displayed a tree representation of several users who received delivery messages from an initial Polly user and then forwarded messages onto their friends and family.

The red colored edges in the tree are successful forwarding attempts which were made via the Polly/Spread application, and the grey edges are users of Polly/Game. This behavior occurred as a result of a user transferring to the Polly Health application through a menu option provided in Polly/Game. There are many such instances of this behavior in our records.

Another rare but not uncommon type of behavior we observed were 'Super-Spreaders', which is a term for users who took it upon themselves to forward messages to a very large number of people. Particularly with the Polly/Spread application, we observed a large number of such users.

The delivery graph for one such user is shown in Fig 4. This user successfully delivered messages to 39 new people. An increase in the number of such users would likely result in the Polly system growing virally or exponentially, as was observed by Raza et al. in Pakistan and India in 2012 and 2013 [30][32].

5.1.1. Emergence of Word-of-Mouth Users

The most common type of user introduction appears to be word of mouth spreading. We observe far more new users who call the system without being introduced by existing Polly users through message forwarding. We have observed behavior from certain users which seems consistent with this pattern. The most avid Polly users play messages in a variety of languages and interact with the system many times over the course of a given day, sometimes for several hours at a time. This behavior suggests that they are introducing people to the application in person, after which time people call the application themselves.

5.1.2. Most Popular Messages

The messages available through the Polly/Spread and Browse systems are always introduced in order, so it is no surprise that the first message pertaining to the symptoms of Ebola is the most 'popular' message in the system. In Fig 5 we list the messages in our system by their relatively popularity as per their subject matter.

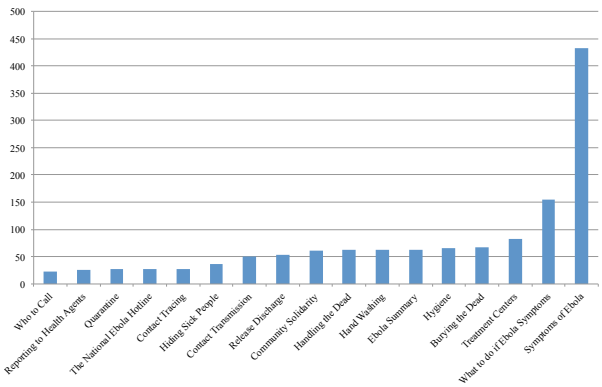

Figure 5: Content vs. Number of Times Message Played

The most commonly listened to messages after the first message pertain to what to do if one experiences symptoms of Ebola, how to find Treatment Centers, and the technical aspects of buying the dead.

5.1.3. Multilingual Aspects

Table 1 shows the number of messages listened to in each message language compared with the number of times messages were forwarded in each message language. The relative frequency of message languages chosen by users seems roughly consistent, in fact, with the percentages of the population speaking each language.

Table 1: *Messages Played in Each Language*

Language	Messages Played	Messages Forwarded
French	973	133
Pular	150	81
English	87	5
Susu	58	36
Malinké	23	16
Kissi	21	5
Kpele	12	6
Manon	1	1
Toma	1	0

6. Future Work

As ongoing work, we hope increase Polly's appeal to Guineans and potentially expand to other countries in West Africa. We need to investigate shortcomings in our current design such that users will stay and interact with the system longer, call in again after the first day, and send messages to more people. This could be done by listening and implementing feedback submitted by users, changing the introduction that is first heard when called, and changing the types of health messages available.

In addition, we imagine Polly is not limited to Ebola or only health-related applications. As a platform that relies on peer-to-peer endorsements to spread information, messages could be sent regarding development and reconstruction after the epidemic is over, or potentially civic education, political awareness, and economic literacy.

7. Conclusions

The available Ebola messages in Polly were sent in many different local languages, which supports the assertions of many local and international observers [26][5] that addressing multilingualism is a critical aspect of public health messaging systems.

We have identified challenges associated with public health outreach in a multilingual low literacy environment, and we have introduced a telephone system intended to address these challenges. After a variety of different seeding events and strategies, Polly currently enjoys a small but slowly growing stream of regular and new users.

8. Acknowledgements

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