Text-to-9-1-1: Testing CPR Instructions for the Deaf and Hard of Hearing Population in King County, WA

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Abstract

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There are nearly a quarter of a million individuals who are deaf and hard of hearing in Washington State as of 2015 (Raff, 2013). Members of this community face several challenges when communicating with others, particularly with 9-1-1 and emergency services. Despite the size of this population, patterns in communication with EMS within this group remains poorly understood. Though many counties are now rolling out text-to-9-1-1, the efficacy of text-to-9-1-1 has not been comprehensively reviewed. This paper aims to address ways to optimize the delivery of text-to-9-1-1 for the deaf and hard of hearing population in King County, Washington, primarily with critical time-sensitive emergencies, such as cardiac arrest.

A simulation pilot was completed to understand the barriers and facilitators of using text-to-9-1-1 for the deaf and hard of hearing population with the goal of optimizing delivery of T-CPR instructions via text messages. The simulations were a crossover observational evaluation design, testing two formats for the delivery of CPR text instructions. The formats differed by the time between each CPR instruction – format A sends all three text message CPR instructions at once, whereas format B asks for a response from the texter in between instructions.

Ten participants were recruited from the deaf and hard of hearing population in King County. Both a King County call taker and American Sign Language interpreters were provided for the completion of the simulations. Semi-structured survey questions were administered verbally prior to the simulations and once the simulations were completed. After the pre-survey was administered, participants were asked to read a scenario describing an adult man,

represented by a CPR manikin, who was found unresponsive in a building. Using their own phones, the participants were asked to text 9-1-1 using a test number. During the simulations, the participant and call taker exchanged text messages. The call taker provided CPR instructions using the predetermined formats.

All ten participants completed the full simulations and tested both canned message formats. While one format was not heavily preferred over the other, we found that both formats had no obvious problems in delivering CPR instructions for the deaf and hard of hearing participants. These simulations helped identify ways King County can best optimize the delivery of CPR instructions by including simplified language and asking texters about their CPR knowledge. Additionally, these simulations point to the need of effective text-to-9-1-1 campaigning within this population to educate members on the application of text-to-9-1-1.

The deaf and hard of hearing population face unique barriers when communicating with 9-1-1, such as language differences. There is a need for additional explanatory studies using a larger and more representative sample of members from the deaf and hard of hearing population. These simulations indicate the significant opportunity to standardize and improve the delivery of text-to-9-1-1 CPR instructions.

Introduction

Deaf/Hard of Hearing in US:

Out of every 1,000 children born in the United States, around two to three are born with a detectable level of hearing loss. Furthermore, approximately 15% of adults aged 18 or older report some level of hearing loss. The prevalence is much higher in adults ages 65 – 74 where nearly 25% are diagnosed with disabling hearing loss. Many of those who identify as a part of the community with hearing loss use American Sign Language (ASL) as a common way to

communicate with others. In the United States, nearly one million people use ASL as their primary language (Quick Statistics About Hearing, 2018; Statistics, n.d.; Access to 911 Emergency Services, 2019).

At a local level, there are nearly a quarter of a million individuals who are deaf and hard of hearing in Washington State as of 2015 (Raff, 2013). Members of this community face several challenges when communicating with others, particularly with 9-1-1 and emergency services. Emergency services are highly dependent on clear and prompt communication but the current modes of communicating with these services for the deaf and hard of hearing population is time consuming, which can result in life lost. Despite the size of this population, patterns in communication with EMS within this group remains poorly understood. This paper aims to address ways to optimize the delivery of text-to-9-1-1 for the deaf and hard of hearing population in King County, Washington, primarily with critical time-sensitive emergencies, such as cardiac arrest.

Communication Methods for the Deaf and Hard of Hearing Population: History and Current Methods

To make communicating easier for the deaf and hard of hearing population, a teletypewriter (TTY) was developed in the 1960s. In 1990, The Americans with Disabilities Act (ADA) mandated nationwide relay services to be available 24/7 throughout the country for all telephone and Internet companies. These services connect TTY relay calls with their receiving line using a communications assistant who communicates with both parties using two options: (1) voice carry-over, where a person with a hearing impairment can speak to the other party to

which the communication assistant will type the response back or (2) hearing carry-over, where a person with a speech impairment can hear the other party and relays a typed response to the other party using the communication assistant (TTY and TTY Relay Services, 2017; Telecommunications Relay Services, 2018). As of recent, this community has several other communication methods including Voice Carry Over (VCO) for people who are deaf or hard of hearing but communicate by speaking, Non-English language relay, Video Relay Service for people with videophones or video equipment to communicate using American Sign Language via Internet services, in addition to many other Internet and non-Internet based service (Relay Services, n.d).

With the advancement of technology, many TTY users have switched to other forms of communication to access telephone networks, such as Internet-based relay services. However, TTY is still widely used by the deaf and hard of hearing population who may not have access to broadband or reliable Internet. Additionally, TTY plays a very important role by providing the deaf and hard of hearing population direct access to 9-1-1 (Cochlear Implants, n.d).

The current 9-1-1 system in the United States is based on telephone technology that accepts voice and TTY calls (Cochlear Implants, n.d). But, the options for the deaf and hard of hearing population are limited to using TTY or relay services, which can be time consuming. 9-1-1 is a vital life-saving program that should be equally accessible to all, and with its current delivery practices, it is not (Access to 911 Emergency Services, 2019).

Importance of Equitable Access to Emergency Medical Services

In times of a medical emergency, the lack of effective communication between Emergency Medical Services (EMS) and those involved in the health emergency can be catastrophic, particularly for life-threatening emergencies such as a cardiac arrest. The first link

in the chain of survival during a cardiac arrest is the immediate recognition of cardiac arrest and the activation of the emergency response system (Access to 911 Emergency Services, 2019). The role of EMS is to provide quality prehospital care, but EMS providers rely on accurate and timely information to ensure they arrive swiftly, are able to assess the situation, and make decisions quickly (Tate, 2015). As such, EMS cannot be delivered without the effective communication between bystanders and 9-1-1 call takers. Prompt response to a crisis is critical, especially in urgent medical emergencies like cardiac arrest, where lay bystander response is a vital factor in increasing chances of survival (Sasson, Rogers, Dahl, & Kellermann, 2010).

In the United States, approximately 300,000 people experience an out-of-hospital cardiac arrest (OHCA) which has about an 8% survival rate, making it the nation's leading cause of death (McNally et al., 2011; Sutter, 2015). Nearly half of cardiac arrests are witnessed by someone, thus, efforts to increase bystander cardiopulmonary resuscitation (CPR) and effective communication with EMS is essential (McNally et al., 2011). Studies indicate the likelihood of survival of OHCA is much higher in those victims that received CPR from a bystander or an EMS provider, however, bystander CPR is only performed in less than half of OHCAs (Sasson, Rogers, Dahl, & Kellermann, 2010; Sutter, 2015). It can take up to seven minutes before Advanced Life Support (ALS) arrives from the time of the 9-1-1 call, or much longer in rural settings, advising the most apt time for action is between those seven minutes (Meischke et al., 2016). In order to assist bystanders, 9-1-1 call takers provide over-the-phone CPR, or telephone-CPR (T-CPR) instructions. But, identification of cardiac arrest and completing the CPR instructions is reliant on the communication between the call taker and bystander. When seconds count, pre-arrival instructions can be the difference between survival and fatality. Yet, the need for prompt and accurate assessment of the emergency can be a large barrier for many

populations, such as the deaf and hard of hearing community (Sasson, Rogers, Dahl, & Kellermann, 2010).

Text-to-9-1-1

Public safety answering points (PSAPs) nationwide are upgrading from analog to a digital or Internet Protocol (IP)-based 9-1-1 system – this is known as Next Generation 911 (NG911). NG911 will allow emergency number services to have faster systems that allow for communication between 9-1-1 and the public to come in various forms, including voice, photos, text messages and videos (Next Generation 911, n.d.).

Text-to-9-1-1 sends carrier native Short Message Service (SMS) texts to 9-1-1 call takers using a mobile phone. Carrier native SMS are messages sent through phone carriers and not a third party application. The sender can text directly to 9-1-1, and 9-1-1 will reply with a request to send the location of the emergency in the initial text message. However, text-to-9-1-1 is not available nationwide. If a message is sent to 9-1-1 in an area where this service is not available, the Federal Communications Commission requires all wireless carrier providers to send an automatic "bounce-back" message that advises the sender to contact emergency services through a different method (Interim Text-to-911, 2014; Text to 911, 2019).

As of now, this service can only receive SMS texts in English character set and cannot accept photos, videos, or phone location which are supported through Multimedia Messaging Service (MMS) messages or any characters other than alphabetical text. There is also no way of translating messages sent in character sets of different languages (Interim Text-to-911, 2014; Text to 911, 2019).

Implementation of text-to-9-1-1: King County, Washington

In late 2018, King County Emergency Medical Services in Washington State joined Snohomish, Kitsap, Thurston and Pierce Counties in accepting text messages. The counties have begun marketing efforts to the public on how to send 9-1-1 messages, which includes: keeping texts concise, using only English with no abbreviations, sending the location of the emergency and type of assistance needed (medical, police, fire) in the first message and to be prepared to answer follow-up questions if needed. They also ask that this service should be used only by those who are unable to call 9-1-1, such as members of the deaf and hard of hearing population or those who are in unsafe conditions (King County, 2019). Though many counties are now rolling out text-to-9-1-1, the efficacy of text-to-9-1-1 has not been comprehensively reviewed nationwide. An assessment of text-to-9-1-1 could prove vital in identifying the best delivery practices of CPR instructions to ensure there is applicable communication between EMS and the deaf and hard of hearing population. In King County, there is currently no standard procedure for how to deliver text messages that require CPR instructions, so call takers use their best judgment in how to communicate CPR instructions via text. To address this knowledge gap, the E-9-1-1 office has developed a set of canned T-CPR instructions for dissemination during a texting communication. As aforementioned, there is currently no information on how to best deliver these instructions using this new medium.

The primary objectives of this project were: 1) to explore the best delivery practices to ensure effective communication between 9-1-1 and the deaf and hard of hearing community via text messaging and 2) to assess the barriers of contacting and communicating with 9-1-1 for the deaf and hard of hearing population

Research Questions

- At a systems level, what are the barriers for the deaf and hard of hearing community-related to use of text-to-9-1-1 when needing instructions for CPR?
- By exploring the barriers, how can texting instructions be best delivered for life-saving pre-arrivals, such as CPR?

The project includes a simulation approach where the information gained from these simulations will be used to better inform the delivery of CPR instructions for the King County E-911 office.

Methods

Simulation Pilot

A simulation pilot was completed to understand the barriers and facilitators of using text-to-9-1-1 for the deaf and hard of hearing population with the goal of optimizing delivery of T-CPR instructions via text messages. The simulations were a crossover observational evaluation design, testing two formats for the delivery of CPR text instructions. The formats had been pre-determined and vetted through King County EMS, King County E-911, and members of the deaf and hard of hearing population (see appendix A with the two formats, A and B). The formats differed in the timing of delivery of CPR instructions – format A sends all three text message CPR instructions at once, whereas format B asks for an acknowledgement that the message was received from the texter in between instructions. These messages are referred to as canned responses, which are programmed responses to common questions where the call taker can insert the canned response through a drop-down menu rather than typing the full response.

This test was IRB exempt as the pilot focused on optimizing a King County specific texting program adopted by the 9-1-1 call centers and the intent was not to generate generalizable knowledge related on emergency communications.

Mock Trial

Prior to conducting the simulations with the targeted population, a mock trial was completed using two University of Washington students (friends of the investigator) to test the questions and instructions. Neither participant identified as a member of the deaf and hard of hearing population and both had recent (within the past three years) CPR training.

The mock trial was very similar to the simulations, where each participant completed the simulations individually. The participants were asked the same set of pre and post survey questions, were given the same scenario of an adult man who was found non-responsive, and were asked to use their respective phones to communicate with 9-1-1. For the mock trial, the investigator acted as the 9-1-1-call taker.

The purpose of the mock trial was to test the questions asked in the pre and post survey and to ensure the flow of the simulation was efficient. The participants both recognized no problems with the simulations/surveys; thus, no major changes were made to the final simulation tests.

Recruitment

Purposive sampling was used to ensure the participating volunteers were part of the deaf or hard of hearing population that lived or spent the majority of their time in King County, WA. Recruitment flyers were created and disseminated using Facebook groups specifically for the deaf and hard of hearing population in Western Washington and by connections through staff at the E-911 office. Interested volunteers emailed the investigator and scheduled for a one-hour time slot. The investigator collected cell phone numbers of the participants and their mobile

phone model and carrier. This information was used to input the phone number in the E-911 training technology to ensure the equipment would be able to receive texts from the participants. The participants' self- identified as a member of the targeted community. Participants needed to be over the age of 18 and owned a phone that could both receive and send text messages.

Participants

Ten participants were recruited using the aforementioned channels. Other demographic information, such as age, race, or ethnicity was not taken. Participants were compensated with a $25 gift card for their time.

Simulations

The simulations were conducted over the course of two weekends, with five participants each day and each participant conducting the simulations individually. They took place at the King County E-911 office in Kent, Washington. A 9-1-1 call-taker was provided to communicate with the participants in a simulation of an emergency using training technology similar to that used in 911 call centers. This ensured an accurate depiction of how the delivery and collection of text message exchanges would be in a real-life situation. ASL interpreters were present and provided by the King County E-911 office.

Prior to beginning, the participants were informed of the simulation purpose, data collection methods, and personal information privacy methods. Additionally, they could withdraw from the simulation or skip any questions at any time without penalty. Each participant was then asked to sign a consent form.

Semi-structured survey questions were administered verbally prior to the simulations and once the simulations were completed. The pre-survey questions explored the current modes of communication with both family and friends and emergency services, comfort levels in texting,

and comfort levels with CPR. Post-survey questions aimed to understand the acceptability of the canned format instructions and the feasibility of completing the simulations (see Appendix B for pre and post survey questions). After the pre-survey was administered, participants were asked to read a scenario describing an adult man, represented by a CPR manikin, who was found unresponsive in a building. Using their own phones, the participants were asked to text 9-1-1 using a test number, engaging in behavior similar to how they would in a real emergency. They were told not to ask any clarifying questions to the investigator. Participants were supplied with the following scenario:

You walk into a building in Kent (address: **20811 84th AVE S KENT WA 98032)** and see a collapsed stranger who is not breathing normally. The stranger is a male, and looks like he's in his mid 30s and doesn't respond when you tap them. There is no one else around and you are unable to use TTY or relay services. Please text 911 using this number: 91911. Please follow the instructions as you would authentically do so in a real emergency situation.

During the simulations, the participant and call taker exchanged text messages. The call taker provided CPR instructions using the predetermined formats. Each participant conducted the simulations twice, testing both formats that were given in a randomized order.

The investigator observed the participants as they completed the tasks and simulation, while specifically looking for the completion of pertinent CPR instructions (see Appendix C for observation checklist). Additionally, the investigator timed two points of the simulations: (1) the time of the entire simulation (measured from when the participant picked up their phone to text the test 9-1-1 number until they began compressions) and (2) the time it took the participant to start the CPR instructions on the manikin after reading the scenario. Once the participant partook in both formats, the post-survey questions were administered. After all procedures were

completed, the investigator demonstrated to the best practice for performing CPR on a manikin and the participants were briefed on King County's text-to-9-1-1 program.

Findings

Nine of the ten participants utilized the ASL interpreters, while one participant was able to lip-read. Additionally, one participant identified as both deaf and blind, but was able to understand the simulation instructions through ASL. Table 1 shows the result of the pre-survey.

Table 1. Answers to the Pre-Survey Questions

Day 1: Pre-Survey Questions				
Participant	**Current mode of communication with friends and family not in a face to face setting**	**Comfort Levels with Texting**	**Prior Knowledge of Text-to-9-1-1**	**Comfort Levels with CPR/Current or Previous CPR certification**
1 – Deaf, ASL	• Facebook • Video Relay • Texting	Very comfortable	Heard of the idea a few weeks prior to the study, but isn't sure what it entails	Previous training about four decades ago – no current trainings

2 – Deaf, ASL	• Text • Video Relay	Comfortable	Heard of text-to-9-1-1 but isn't sure how it works or if it's deaf friendly	Not confident in performing CPR – has had trainings in the past
3 – Deaf, ASL	• Text • Email	Very comfortable	Has heard about it but is not sure what it entails	No certified training, knows basics through videos
4 – Hard of Hearing, Lip-read	• Text	Very comfortable	Very familiar, worked on a similar project in a different country	Previous trainings 20 years ago
5 – Deaf blind, ASL	• Email • Text • Video relay	Very comfortable	Heard of it but isn't sure what it entails	Certified in CPR and First Aid in the past

Day 2: Pre Survey Questions

Participant	**Current mode of communication with friends and family not in a face to face setting**	**Comfort Levels with Texting**	**Prior Knowledge of Text-to-9-1-1**	**Comfort Levels with CPR/Current or Previous CPR certification**
1 – Deaf, **ASL**	• Text • Email	Very comfortable	Understands text-to-9-1-1, didn't know King County established it	CPR certified within the past year

2 – Deaf, **ASL**	• Video Phone • Video Relay	Very comfortable	Hasn't used it but knows a lot about it	Authorized provider and trainer for CPR and First Aid for deaf people
3 – Deaf, **ASL**	• Text • Email • Video Relay	Very comfortable	Knows a lot about it – worked with King County to help create marketing for the deaf and hard of hearing population	Previously certified
4 – Deaf, **ASL**	• Texting • Video Relay Services	Very comfortable	Previously worked for AT&T relay services in a different state, knows a little about E-911	Currently certified
5 – Deaf, **ASL**	• Texting • Video Relay Services	Very comfortable	Has heard of it but doesn't know what it entails	Previously certified

All participants identified as heavy users of text and included texting as one of their main modes of communication when contacting others who are not in a face-to-face setting. In addition to texting, majority of participants used email, video relay services, or videophone. Each participant noted that TTY is outdated and have not used it recently. Nine out of ten of the participants had been formally CPR trained in the past, however, only three participants were currently CPR certified at the time of the simulations. One of the three was a CPR instructor for members of the deaf and hard of hearing community. Two of the ten participants were aware that King County has rolled out text-to-9-1-1. All participants had heard of text-to-9-1-1, but six had extensive knowledge of how it worked.

Table 2 shows the time it took the participant to start the CPR instructions on the manikin after reading the scenario, the total time of the text message exchange, a brief description of the

information that was included to the first text message to 9-1-1 and any key observations made from the investigator.

Table 2. Simulation

Day 1: Simulation	Format A				Format B			
Participant **Format order**	**Time before initial contact**	**Total Time**	**First text message sent to 9-1-1**	**Investigator Observations of CPR performance**	**Time before initial contact**	**Total Time**	**First text message sent to 9-1-1**	**Investigator Observations of CPR performance**
1 – Deaf, ASL **A then B**	2:38	2:15	Included address of emergency; briefly described emergency	Turned manikin over before texting 9-1-1, slow compressions	1:36	1:33	Included address of emergency; briefly described emergency	Slow compressions
2 – Deaf, ASL **A then B**	N/A	2:16	Included address of emergency; briefly described emergency	Fingers not interlocked	N/A	1:51	Included address of emergency; briefly described emergency	Slow compressions, fingers not interlocked
3 – Deaf, ASL **B then A**	3:06	2:09	Briefly described emergency	Compressions were not in the middle of the body	3:58	4:19	Briefly described emergency	Compressions were not in the middle of the body
4 – Hard of Hearing, Lip-read **B then A**	1:30	1:36	Included location of emergency	Didn't use palm of hand to push	N/A	2:17	Included location of emergency	Did not interlock fingers or place palms in the middle of the chest
5 – Deaf blind, ASL **A then B**	N/A	5:13	Briefly described the emergency	Compressions were not deep	N/A	6:03	Briefly described the emergency	Stopped to look at phone in between compressions

Simulation								
Participant **Format order**	**Time before initial contact**	**Total Time**	**First text message sent to 9-1-1**	**Investigator Observations of CPR performance**	**Time before initial contact**	**Total Time**	**First text message sent to 9-1-1**	**Investigator Observations of CPR performance**
1 – Deaf, ASL **A then B**	N/A	2:39	Briefly described the emergency	Kept phone in hand during compressions	2:17	2:44	Briefly described the emergency	Good compressions
2 – Deaf, ASL **B then A**	1:25	4:05	Greeting with name of the participant	Good compressions	1:30	4:33	Stated there is an emergency	Good compressions
3 – Deaf, ASL **A then B**	3:40	1:56	Included location of emergency; briefly described emergency	Good impressions	2:58	2:49	Included location of emergency	Fingers not interlocked
4 – Deaf, ASL **B then A**	N/A	0:57	Briefly described emergency	Good compressions	N/A	7:31	Briefly described emergency	Good compressions
5 – Deaf, ASL **A then B**	2:01	0:46	Included participants name; Included location of emergency; described emergency	Didn't put manikin on floor	1:30	1:12	Included participants name; Included location of emergency; described emergency	Stopped compressions to respond back to text from call taker

*N/A: An accurate measure of the time was not taken due to various circumstances during the simulation, such as technical difficulties with mobile devices.

All ten participants completed the full simulations and tested both canned message formats. Using the CPR checklist, the observer identified each task being complete and ended the simulation once the participant had done four compressions on the manikin. The number of four compressions was chosen to ensure the participant completed the CPR instructions from the call taker, not to evaluate their actual CPR performance. Of the times that were recorded, it took

about two minutes and twenty seconds, on average, for participants to start the CPR instructions once beginning the simulation, indicated by the time the participant would touch the manikin after a text message exchange. Simulations were considered to begin once the participant put down the scenario worksheet and began initiating a text message to the call taker. The time in which CPR action is taken is crucial – this measurement served as a proxy in how quickly bystander response could begin. However, due to logistic issues during some of the simulations, not all participant times could be measured for this time slot. Thus, it is difficult to interpret any differences between the formats.

Time to complete the entire simulation varied considerably between participants, varying from between two minutes after the initial contact with the manikin, to up to six minutes. However, similar to the initial contact with the manikin, consistent times were not taken for each participant due to various circumstances occurring during the simulations. Thus, in place of this measurement, a detailed log of the time from the first text message sent to the test 9-1-1 number and the last message in the text exchange was extracted. On average, the time between the first and last text message was 2:17 for format A and 3:29 for format B. Technical difficulties with reception ensued primarily when participating in format B, consequently, some of the times can be considered to be outliers.

Four participants experienced technical difficulties, which included spotty reception that delayed texts or receipt of duplicate text messages. Four participants were unable to use their own phones due to some unknown technical difficulty that was not allowing for a text message exchange to the text 9-1-1 number. A spare smartphone was available for those whose phones were not initially working.

Below is a text message exchange between a participant who faced reception issues and was not retrieving the messages from the call taker at the time it was sent. Because of the reception issues, the call taker was unable to get the address for approximately three minutes after the initial text and the full text message exchange took more than seven minutes.

Date/Time	Value
03/16/2019 13:14:16.410	Rx : There is a collapsed man not breathing normally
03/16/2019 13:14:19.003	Rx : There is a collapsed man not breathing normally
03/16/2019 13:14:21.987	Tx : Where is the emergency?
03/16/2019 13:15:38.673	Tx : I need the address where this man is
03/16/2019 13:16:06.213	Rx : He's a male around 30s
03/16/2019 13:16:12.717	Rx : He's laying down
03/16/2019 13:16:18.883	Tx : What is the address of your location? Where is he?
03/16/2019 13:17:14.723	Rx : 20811 84 th ave s Kent wa
03/16/2019 13:17:23.823	Rx : Should I move him ?
03/16/2019 13:17:28.837	Tx : Thank you. I will get help started as soon as possible.
03/16/2019 13:17:34.953	Tx : I am going to send you instructions for doing CPR. Once I send you the third instruction, continue doing CPR until help arrives.
03/16/2019 13:17:41.497	Tx : -ADULT CPR-3 instructions-
03/16/2019 13:17:45.497	Tx : 1. Get them on their back on the floor and kneel by their side.
03/16/2019 13:17:51.690	Tx : Let me know when you have done this.
03/16/2019 13:19:45.233	Rx : Address
03/16/2019 13:19:45.433	Rx : Address
03/16/2019 13:19:48.837	Rx : 20811 84 th ave s Kent wa

03/16/2019 13:19:49.537	Rx : Giving him CPR now
03/16/2019 13:20:11.947	Tx : I have the address, help will be there as soon as possible. Do you have him on his back on the ground?
03/16/2019 13:21:01.627	Tx : I'm going to send you the next instruction.
03/16/2019 13:21:06.783	Tx : 2. Put your hand on the center of the chest, right between the nipples and put your other hand on top of that.
03/16/2019 13:21:11.173	Tx : Let me know when you have done this.
03/16/2019 13:22:02.347	Rx : He's on his back
03/16/2019 13:22:03.647	Rx : He's on his back
03/16/2019 13:22:05.147	Rx : He's on his back
03/16/2019 13:22:06.347	Rx : Ok
03/16/2019 13:22:08.747	Rx : Yes I do
03/16/2019 13:22:13.873	Tx : 3. With straight arms push down as hard as you can just like you're pumping the chest and don't stop.

Five of the participants included the address and type of emergency in the initial text sent to the test 9-1-1 number. An additional two participants only sent the address of the emergency but no information regarding the type of emergency in the first message. The remaining three identified needing help but did not indicate the type of emergency or the address of the emergency. Failure of not including the address of the emergency leads to additional time before appropriate help can be initiated. This can be seen clearly in the text exchange example above.

Table 3 shows the results of the post-survey.

Table 3. Post Survey Answers

Day 1: Post-Survey	Format A			Format B		
Participant	**Pros of format/instructions**	**Cons of format/ instructions**	**Other comments**	**Pros of format/instructions**	**Cons of format/ instructions**	**Other comments**
1 – Deaf, ASL	Clear instructions	Felt robotic, instructions came in all at once	Was unclear if the call taker was still on standby after the CPR instructions were given	Appreciated having to respond "yes" to the instructions – felt like someone was on standby	N/A	Would have been helpful if the instructions were broken up into more text messages
2 – Deaf, ASL	Clear instructions	Came all at once which caused some panic	Recommends changing some language and grammar to be more ASL focused	Felt more comfortable after responding to the call taker	Waiting for a response could take a while	Felt messages were too bulky, recommends bullets
3 – Deaf, ASL	Overall, clear instructions	Location of where to push felt unclear	Instructions of where to put hands should be listed first	Felt it had more information on CPR instructions	Felt nervous waiting for a response Responding to call taker was difficult	N/A
4 – Hard of Hearing, Lip-read	Quick with all the messages coming at once	Can be overwhelming to people who need step by step instructions	Recommends call taker to ask texter their CPR comfort ability levels	Step by step instructions can help people feel less overwhelmed	Responses took a long time	
5 – Deaf blind, ASL	Clear instructions	Messages came too quick, as someone who has their phone on accessibility mode, participant had to spend lots of time scrolling	Suggests simplifying words	Appreciated getting instructions in chunks – best for deaf/blind people	N/A	Suggests simplifying words and instructions

Day 2: Post-Survey	Format A			Format B		
Participant	**Pros of format/instructions**	**Cons of format/ instructions**	**Other comments**	**Pros of format/instructions**	**Cons of format/ instructions**	**Other comments**
1 – Deaf, ASL	Liked that all CPR instructions were given at once	N/A		Clear instructions	Takes time to receive a response	Felt that the first question from the call taker should have asked if they were familiar with CPR
2 – Deaf, ASL	Liked that all CPR instructions were given at once	N/A	Suggested using simple language	Helpful to tell call taker once steps were completed	Takes time to receive messages	N/A
3 – Deaf, ASL	Liked that all CPR instructions were given at once	Bulky messages	Suggested using simple language	Some people may appreciate having step by step instructions	Had to continuously pick up the phone to reply back during CPR instructions	2nd and 3rd instruction should have been combined
4 – Deaf, ASL	Clear instructions, liked that all CPR instructions were given at once	N/A	N/A	Clear instructions	Too time consuming	N/A
5 – Deaf, ASL	Liked that all CPR instructions were given at once	N/A	N/A	Clear instructions	Waiting for a response is too time consuming, especially when reception may not be working	

After the simulations, each participant participated in the post-survey questions. Overall, all participants felt the instructions were easy to understand and did not feel confused by any particular wording or instruction. They each identified the benefits of text-to-9-1-1 and would prefer to text 9-1-1 in the future compared to the current methods of either TTY or relay services.

Five out of the ten participants preferred format A, while the other five preferred format B. The following summarizes the pros and cons of each format:

Format A:

While some participants liked that the CPR instructions all came at once, others felt that this method made the text message conversation seem too robotic. Additionally, participants felt that they wasted time by having to scroll their screens back to the first CPR instruction. The participant who identified as deaf and blind experienced unique challenges as the phone was set to accessibility mode, which increases the size of the text. Due to this, the participant felt as if each sentence took up their entire display screen and thus, they needed to scroll back much farther to reach the first CPR instruction.

Format B:

Some participants felt that this channel was more personable, as they knew someone was on the other end on standby in case of any questions. However, on the contrary, other participants felt that the time between getting an answer from the call taker took longer and added challenges when reception was not reliable.

There was a relationship between those who preferred format A over B - those who have had recent CPR instruction/training knew what to expect and did not need to refer to the call taker's instructions as often and preferred format A.

While all participants were able to understand the messages, they identified ways to improve the verbiage of the instructions for members of the community who may not be familiar with CPR and to keep the language very simple and plain. Some suggestions were to change the word "instructions" to steps, "pumping" to pushing, "help is on the way" to an ambulance is coming, and "third" to 3rd. Additionally, three participants noted that having to respond back to the call taker between steps two and three in Format B was very awkward and time consuming. They recommend sending those instructions one after the other without a response back to the call taker and only asking for a response back after step one. Four participants, including those who had recent CPR training, recommended adding whether or not the person texting 9-1-1 knew CPR, as this could save time for those who do know how to perform it. Participants who did not have recent CPR training also noted that the CPR instructions given were very limited and wondered if they should have been checking for a pulse or performing any mouth to mouth resuscitation. While this did not delay CPR, this marks the need to describe the CPR instructions as "simplified CPR" in the text messages.

When reception problems occurred, the call taker was unsure if the participant wasn't responding to a particular question on purpose so the call taker sent duplicate messages. This points to the need for marketing and education to the target population regarding the information the first text message needs to include. Instructions of the initial text message need to center around the importance of including the address of the emergency and type of emergency. This

can help reduce problems that may come with reception complications, as the call taker will already have the pertinent information to send assistance.

Discussion

Each participant was able to successfully finish the simulations and tested both formats. While one format was not heavily preferred over the other, we found that both formats had no obvious problems in delivering CPR instructions for the deaf and hard of hearing participants. All participants mentioned they are happy King County EMS is now accepting text messages and will utilize this service in the future if needed over other current modes of communication.

These simulations helped identify ways King County can best optimize the delivery of CPR instructions. The participants had varying levels of CPR training and this may make a difference in how to communicate CPR instructions. Those who were currently CPR certified or had recent training were able to perform CPR with minimal help from the call taker's instructions; however, those who did not have recent CPR training or any formal training at all read the full text message instructions. This suggests the possible benefit of identifying if the person texting 9-1-1 is familiar with CPR. Furthermore, as mentioned above, the CPR instructions should be identified as "simplified CPR" as a few participants noticed instructions such as checking for a pulse was missing.

One of the biggest takeaways from this pilot is that counties and emergency medical systems need to assess any text message instructions via simulations. Both of the formats had been previously vetted through various knowledgeable sources, yet, once they were tested with members from the target community, some suggestions and observations had been brought up. One of which was the need to simplify language as communication barriers contribute to the marginalization of deaf and hard of hearing people. The participants of these tests were confident

in their ability to understand the English instructions, but felt that other members of the community would not be able to comprehend as clearly. ASL has its own language structure and syntax, which is very different than English (McKee, Winters, Sen, Zazove, & Fiscella, 2015; Smith, Kushalnagar, & Hauser, 2015). Keeping the language clear and as simple as possible will be the most beneficial for the community.

The participants identified themselves as active members of the deaf and hard of hearing population and while nearly all of the participants had heard of text-to-9-1-1, very few knew it was established in King County. Moreover, a limited number knew the information that should be provided in the first initial text message to 9-1-1. Recommendations to King County E-911 and EMS would be to market and advertise the implementation of text-to-9-1-1 and the importance of learning how to text 9-1-1 through channels used by members of the deaf and hard of hearing population – such as social media, e-mail, and respective organizations.

Limitations

Due to feasibility and budget, one of the largest limitations to this test was the relatively small sample size. The participants were all familiar with CPR and medical terminology, thus, they were able to complete the tasks easily. They remarked their prior knowledge created ease in performing the simulations with limited questions – however, they noted many "grassroots" people, or those who might not have prior CPR training or extensive medical knowledge, may have a harder time completing and understanding the instructions. Studies show the deaf and hard of hearing population have relatively low health literacy rates (Pollard & Barnett, 2009). Therefore, future tests should include a more representative sample of the deaf and hard of hearing community, focusing on members who may not be as well informed.

There were also several technical difficulties caused by the test 9-1-1 number. Participants' phone numbers were inputted into the system prior to arrival, but even still, several participants were unable to send messages to the text number. To alleviate this concern, a backup smartphone was available for participants to use. However, this phone system and texting keyboard was unfamiliar to them, which caused for extra time delay. In times of bad reception, the deaf and hard of hearing population should use the original relay services.

Additionally, it was difficult for the key investigator to observe and record the timing of each critical point of the simulation (when the participant first initiated CPR with the manikin, the time it took to complete the full tasks, etc.). In future pilots, two members of the team should administer the simulations to evenly split up observations. Despite these limitations, this dataset provides the first opportunity to explore the barriers in texting 9-1-1 for the deaf and hard of hearing population.

Conclusions

The deaf and hard of hearing population face unique barriers when communicating with 9-1-1, such as language differences. There is a need for additional explanatory studies using a larger and more representative sample of members from the deaf and hard of hearing population. These simulations indicate the significant opportunity to standardize and improve the delivery of text-to-9-1-1 CPR instructions.

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Appendix A

Pre:

- What is your main mode of communication with family and friends that are not in a face-to-face setting?
- How comfortable are you with texting?
- Have you already learned about text-to 911/what is your prior knowledge with text-to-911?
    - If they have not heard of it – how do you assume text-to-911 works?
    - If you have used it – how did it go?
- In what situations would text-to-911 be helpful for you? What situations would it be helpful for the general population?
- How comfortable are you with CPR? Are you currently CPR certified or have been in the past?

Post:

- Did you feel the instructions were clear in the texts?
- Were you able to easily follow all the questions asked by the call taker?
- Were there any points of confusion when communicating with the call taker? Feel free to check through your texts if needed.
- What did you like about the instructions or format of text-to-911?
    - Asking specifically for each format
- Was it difficult to look at your phone while performing CPR?
- Is there anything you would change about the instructions from your first format? What about your second format?
- Would you use text-to-911 over other modes of communication, such as TTY or relay?
- Any last comments?
- Optional: If they used emojis/pictures/videos: ask if they thought emoji/pictures would go through

Appendix B

A:

ADULT CPR-3 instructions
1. Get them on their back on the floor and kneel by their side.

2. Put your hand on the center of the chest right between the nipples and put your other hand on top of that.

3. With straight arms push down hard and fast like you're pumping the chest and don't stop.

B:

I am going to send you instructions for doing CPR. Once I send you the third instruction continue doing CPR until help arrives.
1.Get them on their back on the floor and kneel by their side.
Let me know when you have done this. (or something similar)

2. Put your hand on the center of the chest right between the nipples and put your other hand on top of that.
Let me know when you have done this. (or something similar)

3. With straight arms push down hard and fast like you're pumping the chest and don't stop.

Appendix C

Format: A or B
Participant:

Text Message	Observations	Completed?	Notes
Get them on their back on the floor and kneel by their side.	Get them on their back: · Lay them down · On the ground · Face Up		
	Kneel by their side: · Get down on the floor · Next to/close to/near them		
Put your hand on the center of the chest right between the nipples and put your other hand on top of that.	· Middle of the chest · Between the breasts · Use palm/heel/bottom of the hand		
Arms push down hard and fast like you're pumping the chest and don't stop	· Push this fast · Pump/push up and down · On the chest		

Time Start: _____ Time End: _____