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Experimental paper

"Drones are a great idea! What is an AED?" novel insights from a qualitative study on public perception of using drones to deliver automatic external defibrillators

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Abstract

Background: The quickest way to ensure survival in an out-of-hospital cardiac arrest (OHCA) is for a bystander to provide immediate cardiopulmonary resuscitation (CPR) and apply an automated external defibrillator (AED). The urgency of OHCA treatment has led to the proposal of alternative avenues for better access to AEDs, particularly in rural settings. More recently, using unmanned aerial vehicles (or drones) to deliver AEDs to rural OHCA sites has proven promising in improving survival rates.

Objective: A pilot drone AED delivery program is currently being piloted in the community of Caledon, Ontario. The purpose of this study was to develop an understanding of public perception and acceptance of the use of drones for this purpose and to identify tailored community engagement strategies to ensure successful uptake.

Methods: In-depth qualitative descriptive study using interviews and focus group data collection and inductive thematic analysis. Purposive sampling was used to recruit 67 community members (40 interviews; 2 focus groups of 15) at existing community events in the project area. Interview guides were used to ensure consistency across data collection events. Detailed field notes were recorded when audio-recording was not possible.

Results: The central message seen throughout the data was quickly identified as the potential impact of low levels of CPR and AED literacy in the community over anything else including concerns about the drone. The impact of the community's existing relationship with the EMS; the need for bystander CPR & AED promotion prior to the program launch; and the value the community places on transparency and accountability related to the research and the drones were also key findings. In general, the drone concept was found to be acceptable but concerns about providing CPR and using the AED was what created anxieties in the lay public that we underestimated.

Conclusion: Drone-delivered AEDs may be feasible and effective but successful uptake in smaller communities will require a deep understanding of a community's cardiac arrest literacy levels, information needs and readiness for innovation. This work will inform a robust community engagement plan that will be scalable to other locations considering a drone AED program.

Keywords: Out-of-hospital cardiac arrest, Cardiopulmonary resuscitation, Emergency medical services, Drones, Automated external defibrillation, Public perception, Qualitative

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Introduction

Out-of-hospital sudden cardiac arrest (OHCA) accounts for over 400,000 unexpected deaths each year in North America.[1] Sudden cardiac arrest (SCA) is a condition where a person's heart stops beating without warning due to an electrical failure in the heart.[2] Time-to-treatment plays a pivotal role in survival from cardiac arrest which occurs outside the hospital; every minute of delay results in a 10% reduction in survival.[2–4] Unfortunately, the current survival rate in North America range from 8 to 15%.[5]

People who experience OHCA in rural settings are even less likely to survive than those who experience OHCA in urban or densely-populated settings.[6–8] This disparity has been suggested to result from the increased time it can take for Paramedic Services to arrive at the scene in rural settings.[9] While Paramedic response times in urban areas in Ontario are on average 5–6 min, in rural and remote settings response times can be much longer.[10]

The most effective way to optimize survival in an out-of-hospital cardiac arrest is for a lay responder to provide immediate cardiopulmonary resuscitation (CPR) and to apply an automated external defibrillator (AED) to provide a shock to the heart before EMS arrives.[4,8] Survival from OHCA increases significantly when a publicly accessible AED is applied.[11] The urgency of OHCA treatment has led to the proposal of alternative strategies to access AEDs prior to EMS arrival. These include: 1) public access defibrillator programs[4]; 2) community bystander response networks[12]; and 3) drone delivery of AEDs.[8,13–15]

Drones, also referred to as unmanned aerial vehicles (UAV), have experienced rapid expansion in their scope of use in recent years.[16–18] Drones are being used in everything from military strikes to humanitarian aid.[13] Currently, there is a push to integrate drone technology further into commercial endeavours and domestic government operations.[19] In healthcare, drones have been used for public health purposes, disaster relief and humanitarian aid, telemedicine, and medical transport.[13,14,20–22] Specific examples of drone use related to potential health care applications include delivery of vaccinations in Vanuatu, blood transfusion samples in Rwanda, and AEDs in Sweden.[23–26]

There is some evidence to suggest that drone delivery of AEDs in rural settings has the potential to increase survival rates for cardiac arrest by improving time to defibrillation.[15,26] This technology may ultimately prove to be a transformative innovation in the provision of emergency care to people suffering OHCA, especially those who arrest in residential and rural settings. However, as is frequently the case in the earliest stages of technological innovation, there are many unanswered questions related to the feasibility, acceptability, and best avenues for implementation of this technology in different settings. The objectives of this study were to increase our knowledge about public perceptions and acceptance of drone AED delivery and to investigate community information needs related to the implementation of a particular drone AED delivery program in Ontario, Canada.

Methods

"AED on the fly" pilot program

To further our knowledge of the potential for drone delivery of AEDs during OHCA in rural and remote communities, a feasibility study is underway in the Region of Peel, Ontario, Canada, known as "AED on the Fly".[27] The feasibility study is using a phased approach to explore the logistical and practical facilitators and challenges involved in the implementation of AED drone delivery within local EMS systems. Testing for variables such as weather, timing and delivery options, bystander interaction, etc. will ensure the feasibility of drone implementation in the local 911 system at a later date. The results of this work have been published elsewhere.[27] In parallel, we conducted a robust qualitative study in order to get a sense of the public perception and acceptability of a drone AED delivery program within the Town of Caledon where the project will be launched.

Study design

We conducted a qualitative descriptive study of adult residents (18 years and older) of the Town of Caledon in Peel Region, Ontario where the feasibility of drone AED delivery was being tested. Research ethics board approval was obtained from North York General Hospital (REB 19–1012, June 14 2019).

Study setting and sampling

This study was conducted in a town of Caledon in Peel Region, Ontario, Canada. The population of Caledon was 72,900 as of 2018.[28] At the time of our study, the "AED on the Fly" program had not yet been widely advertised and no formal community engagement (CE) had occurred due to the need for confidentiality during initial testing. There are approximately 1300 OHCAs in Peel Region each year and the Peel Regional Paramedic Service provides CPR training through lunch & learn and apartment complex lobby programs and school CPR training programs throughout the year. Business' and other organizations also run CPR training with private companies but overall CPR training of lay residents is not tracked by the region.

Participants were recruited purposively using pre-determined quota sampling techniques to ensure representativeness of the population within the participating community.[29] The research team worked with several stakeholders on participant recruitment strategies for this study: 1) the regional municipal office, 2) the organizers of local programs and events, and 3) individual citizens interested in promoting and organizing data collection opportunities. With the permission of all engaged stakeholders, members of the research team attended preexisting and purposively organized public events at various locations within the region (including a farmer's market, charity run, senior's educational program at a community centre, and town hall meeting) to distribute project information letters and invite eligible community members to participate in this research. Participants were approached both individually and in small groups, depending on the nature of the event. Participants were given time to review the project information letter and gave verbal consent prior to the start of data collection. Only two of the 67 approached individuals declined to participate in this study.

Data collection

In order to generate rich data that included a range of different perspectives on drone delivery of AEDs, we collected data in the form of short semi-structured individual and small group interviews and

focus groups with community members between June and September 2019. These methods were selected to enable the research team to access the thoughts, perceptions, beliefs, and understandings of community members,[30] while providing space for participants to generate their own questions about the topic of study, use their own vocabulary, and pursue their own priorities and interests during the discussion.[31] All data were collected by research team members KND and MBS, both of whom are trained interviewers and group facilitators with qualitative research expertise, with the support of KS, a research assistant who is knowledgeable about the qualitative research process and has experience taking detailed field notes. No members of the research team reside in or were acquainted with the community setting prior to conducting this study. Interviews and focus groups were conducted until the research team felt we had reached thematic saturation and that no new insights would be gleaned from talking with further participants.[32] Our team collaboratively determined that saturation had been achieved through extensive team meetings and transcript review.

Interview and focus group guides were developed by the research team and based on the literature, input of experts in qualitative research, and informed by the objectives of this study (see Appendix 1 and 2). These were designed to provide broad topic areas to guide the discussion and supplemented with extensive field notes documenting the participants' main points, demographic information, and outstanding observations on body language, emotionality, tone, and group dynamics. All data were collected in person. The individual and small group interviews were between 5-10 min in length and the focus groups lasted between 45-80 min each.

Due to the public nature of the interview and focus group spaces, audio recording of some interviews and focus groups was not possible. Therefore, only select interviews and focus groups were audio recorded and transcribed verbatim; the others were recorded using detailed field notes made by the research assistant over the duration of the interview or focus group.

Data analysis and management

In keeping with the iterative process of qualitative methodology, data analysis occurred in conjunction with data collection in order to continuously monitor emerging themes and general areas for further exploration in the interviews and focus groups. Project team members with qualitative methodological expertise led the data analysis process following the constant comparative method,[33,34] an inductive approach geared towards identifying patterns and developing conceptualizations about possible relations in the data, and employing standard thematic analysis techniques.[35]

MBS and KS reviewed and coded the transcripts and field notes independently, and then analyzed the data set through a systematic process of memoeing, theorizing, and writing. First, descriptive codes were attached to segments of the text in each transcript.[36] Second, the codes were grouped into broad topic-oriented categories, and all text segments belonging to the same category were compared.[36] Ultimately, the topic-oriented categories were further refined and formulated into fewer analytic categories through an inductive, iterative process of going back and forth between the data. Any discrepancies in interpretation between the two analysts were resolved through ongoing discussion and noted in the analytic field notes. We also employed several techniques for ensuring analytic rigor and trustworthiness of our analysis, included comparison of coding between analysts, maintaining an audit trail, seeking alternative explanations for the data, and interrogating the coherence of interpretations through deliberations among the analysts and the research team.[37]

Results

Between June 2019 and September 2019, we collected data from 65 participants, all of whom resided in the target region (Table 1). Key themes within the data include the community's initial perception of the drone AED delivery program, the impact of low literacy on CPR and AED use, and a strong desire for community engagement.

Community perception and acceptance of the drone AED delivery program

Many participants were familiar with drone use in a variety of sectors and were not averse to drone technology itself. Participants rarely reacted negatively to the idea of drone technology being used in emergency situations. The overwhelming majority had not heard of the AED on the Fly Program (64/65). While they also had questions about potential logistical issues with regard to the drone program's execution, the fact that a drone was being used was not the root of any major concerns. Participants tended to self-distinguish between drone use for medical and emergency purposes from other categories of drone use such as surveillance or military applications, favoring the former over the latter: *"I don't mind drones for things like [medical emergencies], I don't like them for commercial use . . . " (P24 & P25).* Because the drone program's mandate was explicitly demonstrated to be in the realm of medical emergencies, participants were generally enthusiastic about the concept and largely saw the drone as a useful innovation: *"I think it's pretty ingenious . . . I'm all for trying [it] out!" (P39 & P40).*

This acceptance was primarily informed by the value placed on life-saving interventions; if the drone was framed as a potential saver of lives, any logistical concerns were deemed second priority to its acceptance. Issues with the drone could be worked out after the program introduction, on the condition that it really could save lives.

> *"I think if it saves lives . . . then it's gotta be a good thing" (P24 & P25)*

> *"Anything that can save a life or stabilize a patient before [the paramedic services] arrive is a good thing" (FG1)*

> *"I think if it's gonna get there faster [than the EMS] then it's a great idea" (P27)*

> *"If it results in saving lives then it's needed; if it's just for convenience then don't do it" (P31 & P32)*

However, despite a relative positivity towards drones as a technology, there was still significant wariness and hesitation expressed by participants regarding the drone program as a whole. The source of this wariness and hesitation was rooted in three significant themes, 1) the community's relationship with local paramedic services; 2) low literacy regarding OHCA, AEDs, and EMS procedure; and 3) participants' desire to be engaged throughout the project.

Table 1 – Total number of participants: *n* = 67.

Type of Data	Participant #	Data Collection Site	Gender	Age	Ethnicity
Small group interview	P1,P2	Community Run	M, F	25-35x2	Caucasian
	P3	Community Run	M	45–55	Caucasian
	P4	Community Run	F	35–45	Other
	P5, P6	Community Run	F, F	55+	Caucasian
	P7	Community Run	M	25–35	Caucasian
	P8, P9, P10	Community Run	M,F, M	45-55, 15-25x2	Caucasian
	P11	Community Run	F	55+	Caucasian
	P12, P13, P14	Community Run	F, F, F	15-25; 25–35; 35-45	Caucasian
	P15, 16, 17, 18	Community Run	F, F, M, M	45-55x2, 15-25x2	Caucasian
	P19	Community Run	F	55+	Caucasian
	P20	Farmer's Market	F	15–25	Caucasian
	P21	Farmer's Market	F	35–45	Caucasian
	P22, 23	Farmer's Market	M, F	35-45; 45-55	Other, Caucasian
	P24, 25	Farmer's Market	M, F	25-35; 35-45	Caucasian
	P26	Farmer's Market	F	25–35	Other
	P27	Farmer's Market	F	15–25	Caucasian
	P28	Farmer's Market	M	15–25	Other
	P29	Farmer's Market	F	55+	Caucasian
	P30	Farmer's Market	F	55+	Caucasian
	P31, 32	Farmer's Market	F, F	15-25; 45-55	Other
	P33	Farmer's Market	M	55+	Caucasian
	P34, 35	Farmer's Market	M, F	35-45x2	Caucasian
	P36, 37, 38	Farmer's Market	F, F, F	15-25x3	Caucasian
	P39, 40	Farmer's Market	F, F	25-35x2	Other
Focus groups	FG1 (n = 15)	Senior's Lunch	approx. 6 M, 9 F	Most 55+, one 45-55	Most Caucasian, 1 Other
	FG2 (n = 12)	Town Hall	approx. 8 M, 4 F	Most 55+, one 25-35	All Caucasian

Community's understanding of EMS/Paramedic response

It is important to mention that prior to the beginning of the AED on the Fly project the municipality had undergone a significant change to centralized paramedic services. Participants expressed a general lack of clear communication between local paramedic services and the residents of the region. As a result of this miscommunication, participants felt that there had been cuts in the paramedic services they received, and that rather than genuinely listening to them and hearing their concerns, regional decision makers were offering them the drone program as a "consolation prize":

> *"It seems like we're not supposed to react to the cuts because aren't we lucky we get a drone project . . . " (FG2)*

> *"I don't want to see more ambulances missing because now we have drones . . . this drone project happening right now is a little bit suspect . . . and creates a whole lot of untrust" (FG2)*

Parallel to this, participants seemed to rely heavily on hypothetical access to localized paramedic services. Regardless of whether an emergency was being experienced, the knowledge that fully-staffed paramedic services would be available if there *was* contributed to participants' feelings of safety and security. Consequently, participants expressed a lot of fear and confusion around the possibility of the drone AED delivery program replacing their paramedic services. Multiple participants assumed that the drones would replace paramedics altogether, while a few participants stated that they would "rather support the people [paramedics] than the machines" (P30). The assumption that drones would replace human paramedics was not a positive one. Participants stated angrily, "now we have to do your [paramedics'] job for you" (FG2), expressing feelings of betrayal and a concern that bystanders will not be capable of coping with or managing such an emergency appropriately.

Finally, there seemed to be a limited understanding of EMS procedures and first response, expressed through the surprise participants showed when learning that dispatchers would remain on the phone with them throughout an emergency and talk them through any first aid they would do as a bystander. This limited understanding of EMS procedure underlined any hesitation towards the drone program, connecting to the assumptions that paramedics would be replaced and that the purpose of this program was to put the onus of first response on the community as opposed to paramedic services.

Low literacy in cardiac arrest, CPR and AEDs

The community members also demonstrated a significant lack of literacy in identifying and understanding how to respond to an OHCA and about CPR and AED use. This was both discussed directly and implied in several participants' comments. Some participants openly expressed a lack of trust in their own knowledge, saying, "*How do we as . . . non-medically trained professionals look at that person on the ground and know if that AED is needed or not?" (FG2)*. Many others demonstrated lack of knowledge indirectly, through comments such as, "*how does this [the drone program] help me if I am alone [and experience cardiac arrest]?"* – indicating a critical misunderstanding of the aftermath of a cardiac arrest.

Participants also expressed a lack of knowledge regarding the placement of publicly accessible AEDs in their community and their subsequent operation: *"As a person who's lived there for 26 years I*

have no idea where these [AEDs] are?" (FG2). Much of participants' hesitation in seeing the value in a drone delivery program stemmed from a lack of familiarity with the use and application of AEDs:

> *"Are you sure that people are comfortable using AEDs in the first place?" (P34 & 35)*

> *"I'm more concerned about the intimidation of the unit than the safety of the bystander" (FG2)*

However, parallel to this lack of knowledge, participants also expressed a strong desire to be educated – specifically on first aid and emergency response, and the use and application of AEDs. One participant enthusiastically stated, "*I think we need to do this . . . I'd be willing to partner up with you guys to go . . . everywhere in . . . [the region] to promote that we have AEDs" (FG2).* Others declared that AEDs should be placed in more public places in town and talked about more openly, and that any implementation of the drone program should be coupled with free first aid education.

Engagement needs

Last but not least, participants consistently expressed interest in being made aware of all of the stages of the testing of the drone project. They frequently expressed a desire to receive updates about any research being done on the feasibility of the drone program both within their region and elsewhere in Canada. This was captured in the statement, *"Where are the results in your research to determine what to fly and when to fly? If we can see the research we can help" (FG2).*

Additionally, there were multiple requests for in-person demonstrations of the program to be offered such that community members would be better able to visualize the drone delivery process. Several community members articulated that they would be interested in being part of a citizen committee that would support the implementation process and community engagement initiatives.

Discussion

The findings of this study reveal several vital pieces of information that can be used to frame how the implementation of drone-based AED delivery programs should be handled within a target community. First and foremost, it is apparent that it is largely not issues with the use of drones themselves that pose a barrier to acceptance of a drone AED delivery program, but rather, the nature of the community's understanding of paramedic services and the situation of a cardiac arrest itself. Our understanding of the key perspectives found in our data can be organized into the three themes described above: the community's understanding of Paramedic Service, the community's literacy in first response and associated topics (OHCA and AEDs), and the community's desire to be involved and engaged in new innovations.

Clear and consultative communication with a community in which an organizational change is being made is well documented in the literature as a cornerstone of successful engagement and implementation.[38,39] In the case of the AED on the Fly program, the understanding and potential for acceptance of the innovation seems to be confounded by low levels of literacy on the part of community members about cardiac arrest, CPR and AEDs, and EMS processes in general. Many participants saw the drone simply as a tool to get the AED where it needed to be, and their concerns were more about whether citizens would know what to do with it once it arrived. What participants were expecting of the drone program was not what the explicit mandate of the drone program has been to date. This is especially relevant given that the community engagement literature often states that the meaning of the technology and the way it is introduced in a community impacts its reception and subsequent success and sustainability of its implementation.[40] In this research, we found that drone use was supported if it would come in tandem with activities that addressed more pressing needs (e.g. first response training) and if it was seen to contribute to a good cause – in this case, reducing emergency response times. No remarkable differences were found between participants of varying age or gender during the data analysis.

Community engagement is gaining increasing attention as a dimension of biomedical, public health, and global health research—in particular around technologic innovation.[38,41,42,45,51] However, there has been little agreement about the specific goals of CE and about the best ways to design, conduct, and evaluate it.[43–49] CE places the community at the center of any program implementation in order to 1) ensure relevance of the program, 2) cause minimal disruption in the community, and 3) avoid any risk of exploitation or ethical hazard.[44,50,51] Given the public response to drones in neighborhoods and communities is largely dependent on a community's understanding of the use of drones and the program's overall mandate, projects attempting to introduce drone delivery of AEDs to a rural community must ensure that the target community is not only aware but actively understands the project as part of a larger movement to optimize SCA survival for its citizens.[41] A tailored approach to CE around cardiac arrest survival, including ways to deliver AEDs more efficiently, can provide the framework to successfully implement this and future innovations which are ultimately for the public good.[52] Based on our findings and experience of this study, we would recommend that community consultation and situational analysis be a strong consideration in every drone delivery project.

Conclusion

We know from implementation science literature that uptake of many innovative programs fails due to a lack of in-depth understanding of the actual knowledge and engagement needs of the target population.[53,54] Drone-delivered AEDs may be feasible and effective but successful uptake in smaller communities will require a deep understanding of a community's cardiac arrest literacy levels, information needs and readiness for innovation. This work will inform a robust community engagement plan that will be scalable to other locations considering a drone AED program.

Disclosures

KS, MBS and KND were involved in the conceptualization and design of the study, data collection and analysis and manuscript creation and revision.

IRD and SC were involved in conceptualization of the study, manuscript creation and revision.

KS, MBS, IRD and KND have no conflicts of interest to disclose.

SC is a member of the board at Drone Delivery Canada.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dr. Sheldon Cheskes is a member of the Board of Directors at Drone Delivery Canada. This does not have a direct influence on the research reported in this paper but we felt it important to report.

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