Designing for Targeted Responder Models: Exploring Barriers to Respond

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ABSTRACT
Targeted responder model is a recent approach in providing initial treatment to cardiac arrest patients. In this model, a group of trained responders are dispatched via mobile devices to nearby cardiac arrests. While prior work shows that targeted responder programs are successful in reducing average response time, less than a quarter of the responders who receive the notification of a nearby cardiac arrest travel to the scene of event. This study is an attempt to better understand barriers to respond in targeted responder programs. We conducted a weeklong diary study and focus groups with 12 participants. We identified four categories of barriers that emerge and we discussed the design implications of our findings within the broader context of location-based crowdsourcing.

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Location-based crowdsourcing; targeted responder model

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION
Cardiac arrest is an interruption of the heart's electrical activity. It causes the heart to stop beating. Over 250,000 people in US alone are treated for cardiac arrest every year [34]. Roughly one-quarter of cardiac arrests happen due to a particular arrhythmia called Ventricular Fibrillation (VF) [12]. VF is treatable using a lightweight electronic device called Automated External Defibrillator (AED). Up to 74% of the VF patients can survive if they receive immediate defibrillation treatment [36]. However, each passing minute without defibrillation causes the survival rate to drop by 10% [36]. The survival rate for out-of-hospital cardiac arrest in the USA remains at the low figure of 12% [34].

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Developments in mobile technologies enabled a new way to provide early treatment to cardiac arrest patients: Targeted responder model [28]. This model is a form of location-based crowdsourcing [3]. It relies on trained responders to provide cardiopulmonary resuscitation (CPR) and/or AED treatment to cardiac arrest patients. Targeted responders are notified through mobile communication devices in case of a nearby cardiac arrest and travel to the scene of event [42]. In programs that include AED treatment, the responders either carry an AED with them at all times or have access to an AED that is located nearby [33,35].

Previous studies on targeted responder programs show that more than a third of the dispatch calls were not noticed by responders in a timely manner [8,39] and less than a quarter of the received notifications resulted in a responder traveling to the scene of event [8]. Identifying the barriers that hold up responders would make it possible to increase response rates through design interventions and save more lives via early treatment.

This study was conducted as part of an exploration for an anticipated targeted responder program in King County, WA, USA. The goal of the study was to investigate barriers that influence response rates and discuss their implications for design. Through a weeklong diary study and subsequent focus groups, we have surfaced a number of additional barriers that were not discussed in the previous literature. Furthermore, we categorized them into four types, based on temporality: (1) barriers to commitment, (2) barriers to notification, (3) barriers to leave, and (4) barriers to perform. We anticipate the findings in this paper not only to be informative for the design of targeted responder programs, but also for other situated or location-based on-demand crowdsourcing applications [31,42] in various domains, such as disaster response [29], citizen science [29] and citizen journalism [1].

RELATED WORK
Prior work on targeted responder programs has shown that not all alerted responders arrive at the scene of cardiac arrest. Location tracking of targeted responders of a CPR treatment program in Sweden shows more than a third of the calls were not answered by the volunteers [39]. Post-alert surveys with responders of PulsePoint, a targeted responder program for CPR treatment, shows that almost a third of the responders missed the notification, and less than

a quarter who received a notification traveled to the scene of emergency [8].

However, our understanding of factors that may attribute to non-response in this context is limited. Earlier studies on targeted responder programs tend to focus on feasibility of the systems [9,43]. As of date, there is only one study [8] that reports on factors that influence response rates. It lists the major barriers as not hearing the device, being apart from mobile phone, regarding the emergency location too far away and being unavailable to respond. While [8] provides an initial understanding of barriers to respond, there are several reasons why additional research is needed. Firstly, [8] mostly talks about technical aspects (e.g not hearing the alert tones. It overlooks causes of non-response in cases where responders reported "unavailable to respond." Secondly, the findings in [8] are based on a survey that is done with responders who have received alerts within the last 26 months. In other words, some responders have responded to a survey which inquired about an experience they had over two years ago. A study that gathers immediate feedback from responders may offer a more accurate picture of barriers to respond.

More generally, research in *location-based crowdsourcing* domain can provide additional insights on barriers to respond in the targeted responder context. Targeted responder model is a form of location-based crowdsourcing [3], which depend on *mobile on-demand workforce* [17,41] to perform *time-sensitive tasks* [7]. Prior work shows that responders are more likely to accept tasks if they receive them under certain circumstances, such as outside of work hours, during their free time, when they are alone, when they are not in their family time and when the tasks are not time critical [3,41,42]. It is also shown that participants are not likely to accept tasks they receive from inconvenient locations or during suboptimal weather conditions [41].

Nevertheless, research on participation barriers in the location-based crowdsourcing context also has limitations. Previous literature explores factors that influence task acceptance when responders receive task requests. However, participating in these systems can take place over a stretch of time – there are multiple potential barriers spanning from *before* receiving a task request and *actually performing* the task.

Therefore, we argue that barriers to respond extend to a broader temporality than discussed in prior work. In this paper, we sought to offer a more nuanced understanding of barriers to respond that emerge during various stages of the responding process. We then categorize these barriers according to their temporality. By doing so, we provide researchers and designers a framework to identify and investigate barriers that may arise in various stages of the task response process. Identifying these barriers and addressing them through design interventions would increase response rates and number of completed tasks, which are critical for crowdsourcing applications [7,21,26].

METHODS

We used diary study [13] and focus group interviews to explore barriers to respond. Diary study is a method rooted in psychology [25]. In this method participants take notes or record media about their experiences in situ, without needing the researcher to be present to get contextual information. We used diary study mainly as a way to assist participants to contextualize how it would be to receive alerts in various situations and mentally prepare them for the focus groups. We have particularly taken the elicitation approach [11]. Participants captured snippets upon receiving our prompts and these snippets were used as discussion prompts to get more in-depth information [30] in the subsequent focus groups.

For the study, we simulated a mobile dispatch system. The participants were given non-functional AEDs to carry with them for five days. During this period, each participant received 2-3 simulated cardiac arrest notifications per day in the form of SMS. We asked participants to inform us about their availability to travel to the scene upon receiving calls. If the participants reported that they would not be available, they were also inquired about the barriers that would have prevented them to travel to the scene of event.

The simulated dispatch calls (hereinafter referred to as "calls") were randomized and a total of 13 alerts were generated through a span of 5 days. We designed the study to include both weekdays and weekends in order to have diversity in the context messages received. The distribution of the times for simulated calls were: Thursday (16:49, 22:40), Friday (00:55, 12:06), Saturday (4:02, 16:32, 20:23), Sunday (00:37, 11:14, 17:25) and Monday (2:00, 7:04, 20:15). The diary study was followed by 2 hour-long focus groups, where participants discussed their experiences as a responder and the barriers to respond to calls positively. Each session had 4 participants. The participants were compensated with $250 Amazon.com gift cards in return of their weeklong efforts.

Analysis

Upon the completion of the diary study, the responses from participants were sorted to create affinity clusters [19]. The clusters consisted of responses that communicated similar grounds for non-availability. These clusters were used to formulate questions for the focus group interviews.

The recordings of the focus group sessions were transcribed and the first author conducted open coding of the interview data. The results were shared with other researchers who were present in the focus groups and the findings were iteratively analyzed following Miles and Huberman's reduction, display and conclusion approach [24]. Common themes in the transcriptions were identified inductively and emerging themes were verified deductively. The final set of themes were refined until a consensus was reached between the interpretations of researchers on the emerged themes.

Participants

A screener survey was sent to a pool of 40 people, who have received American Heart Association HeartSaver CPR and AED training [20] in an institution which we partnered for recruitment. 14 people responded to the survey. Two of them withdrew before the study started, citing unforeseen scheduling conflicts and workload. Of the 12 people who participated: 4 were firefighters, 2 were emergency medical technicians, 1 was a police officer and 5 were laypeople (4 of the laypeople were responsible for emergency response at their respective workplaces). Gender and age distribution were as follows: Female (3), Male (9); 18-25 (3), 26-25 (1), 36-45 (3), 46-55 (2), 56-65(3).

DIARY STUDY RESULTS

For a total of 156 calls (13 calls * 12 responders), the participants reported *available* in 77 cases (49%), and *not available* in 61 cases (39%). Responses which arrived later than 5 minutes (43 cases) or mentioned a physical distance greater ¼ of a mile from the AED (4 cases) were also classified as *not available*. In 6 cases (4%) participants who work as firefighters reported that they were on duty at the moment, and likely be dispatched to the cardiac arrest as part of their job. There were no responses for 12 calls (8%).

Following are the reasons mentioned for not being able to respond for at least two calls during diary study, sorted by their frequency: Missing the alert during sleep (25), not having cell coverage (8), not noticing the alert until too late (6), not being fit to respond (e.g. intoxication, sleepiness) (6), not willing to give up family or private time (3), not being able to leave work or personal responsibilities (3), forgetting to take the AED (2), having no battery at the time of call (2), not being able to check the phone while driving (2) and not carrying the AED along on purpose, due to the limitations of the activity engaged at the time of call (e.g. running) (2).

Subsequent focus group interviews not only provided a deeper understanding of the barriers which were revealed during the diary study, but they also surfaced additional barriers to respond. These additional barriers and their design implications are discussed in the following sections.

FINDINGS & DISCUSSION: BARRIERS TO RESPOND

Through the analysis of the diary study snippets and focus group interviews, we have identified four categories of barriers in relation to the various stages they emerge during the responding process. These categories are as follows: (1) barriers to commitment, (2) barriers to notification, (3) barriers to leave, and (4) barriers to perform (See Figure 1.) In this section, we elaborate on these barriers by presenting them juxtaposed with quotes from our focus group interviews. We also discuss how the barriers we identified during our diary study map on these categories.

We argue that our categorization offers a more nuanced understanding on the temporality of the barriers to respond. We anticipate this categorization to serve as a framework for designers and researchers to investigate other targeted responder systems and crowdsourcing applications, in order to identify system-specific barriers to respond.

Barriers to commitment

This category is consisted of factors that incite responders to temporarily withdraw their commitment to the system. Barriers to commitment occasionally came up during the diary study (8 cases, 13%.) However, we got in-depth understanding of this phenomenon mainly through the focus group interviews. As participants talked about a number of hypothetical situations they would have temporarily wanted to opt-out, it became evident that a number of barriers associated with notification issues in the diary portion of our study (and perhaps in [8]) were actually barriers that emerged *prior to* the reception of task requests. On surface, it seemed as if responders failed to hear the notifications as they arrived. However, a deeper inquiry shows that in certain cases responders *actively decided* to temporarily withdraw from the system before the calls were sent (e.g. putting the phone in a silent mode before an important meeting.) Our findings also reveal other cases where participants would temporarily want to opt-out, such as when they are physically unfit (e.g. being sick) or when they forget to bring along the necessary equipment to respond (i.e. AED).

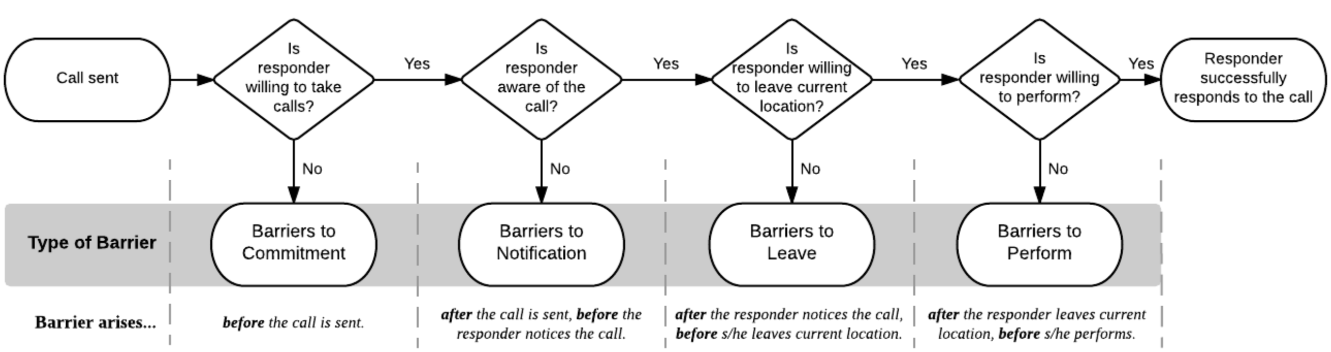

Figure 1. Flowchart of a response process and corresponding "Barriers to Respond", according to their temporality.

In a nutshell, barriers to commitment arise when there are issues that restrain responders' *ability* to respond (e.g. sickness) or when there are circumstances that curb responders' *willingness* to respond (e.g. not wanting to sacrifice family time), a priori to a task request. Several of these situations were related to responders' incapacity due to equipment related issues. They would be involved in an activity such as hiking and their bag would be *"too full to carry both the raincoats and the AED."* Hence, they would not be able to give adequate care to a patient had they received a call. Other reasons were related to the physical capabilities of responders. Participants were not sure if they *"would be the right person"* to respond during a night where they stay at home *"with a broken toe."* Responders referred to a number of moments during the study where they would have wanted to opt-out for the duration of a certain activity, such as during a *"family movie night after working a ton [without] seeing the kids much."* This barrier was particularly relevant for participants with professional response experience, such as firefighters. As people who are "*involved in the business,"* they felt that they have already done their share of helping other people as they "*come back from a 24-hour shift."* In effect the participants could simply ignore the calls they receive during times they do not want to commit, instead of opting out from the system. However, they did not want to receive notifications during periods they did not want to commit, in order to avoid the *"moral dilemma"* of not responding to an alert and thinking that *"somebody might have their life in peril"* because they chose not to respond.

Previous literature on on-demand crowdsourcing discusses *situational* and *temporal* factors as barriers to *task acceptance* [3,41]. However, our findings reveal that many of these barriers are related to issues of commitment, which arise prior to reception of a task request. In other words, the decision to not accept the incoming request may have been made *before* the requests. This new perspective provides a different understanding on how to address the barriers that were deemed situational and/or temporal in prior work. Our findings show that the time periods prior to task requests are also a potential area for design intervention.

Barriers to notification

This category is consisted of factors that prevent responders from being aware of notifications that were sent to them. It is consisted of factors that interfere with responders' availability to *receive* notifications (e.g. being out of cell coverage) and issues that would prevent responders to *notice* the notifications in a timely manner (e.g. not hearing the notification tone).

Barriers to notification were the most frequent type of barriers reported during the diary study (43 cases, 70%) and they also came up regularly during the focus groups. At times participants would be *"ready to roll,"* yet receive the notification *"only after it's too late [because] there was no cell range."* Though less frequently, there were also cases when *"[their] phone would run out of battery*", leading them to miss a call. Another set of barriers under this category are related to responders' *awareness* about the incoming notifications. Our study shows that in more than half of the cases in which participants failed to notice the alert, the problem was related to not hearing the notification tone. This finding is consistent with [8]. Especially during night time, the participants failed to notice almost all notifications because they would *"sleep like a stone [and] the text message noise [would] not wake [them] up"*. Even when they were awake, barriers such as *"[their] phone [being] in silent mode"* or presence of *"loud environment noise"* would prevent them to hear messages. At times, the reported reason for missing a call would be not having a distinct notification for the calls, such as an alert that clearly communicates *"if this is ringing, someone is dead."* This was particularly important while engaged in another activity that requires visual attention (such as driving), since it is impossible to distinguish a dispatch call from a *"candy crush request"* if they have the same tone.

What we classify as *barriers to notification* have been mentioned in the previous literature. However, they were bundled together with the factors we identified as *barriers to leave*, as they both result in participants not traveling to the scene of event [8,39]. The differences between the design implications of these concepts are discussed in detail in the following sections.

Barriers to leave

This category is consisted of factors that prevent responders to leave their current location and travel to the scene of event. Barriers to leave may stem from a *capability* issue that is noticed only after receiving a call (e.g. noticing that the AED is out of battery), from an *availability* issue that makes it inconvenient or impossible to put an end to the current activity (e.g. stepping out of an important meeting), from a *judgement call* regarding whether the responder would perform well in fulfilling the assigned task (e.g. assuming it would take too much time to arrive at the scene of event), or from a *safety issue* regarding the designated task location and/or the time of the call (e.g. not feeling safe to respond to notifications that require travel to certain neighborhoods at night).

Barriers to leave was the second largest collection of issues reported during the diary study (9 cases, 15%). It was also one of the main subjects of discussion during the focus groups. Participants would be ready to leave for the scene of event, only to realize that they don't have their necessary equipment nearby because *"[their] sister borrowed [their] car",* where they usually keep their AED. They would also be in situations where they cannot leave, such as *"a medical appointment where [they get] a mammogram, [therefore] not able to get out of the machine,*" or *"a professional meeting that [they] really could not step away from."* Other times they would not have any external limitations to leave, but after evaluating their own situation, they would find it "*hard to get in a car and drive at 3:00 in the morning after the caipirinhas and all the other drinks.*" This pattern was particularly visible in cases where they think *"it's going to take [them] more than a few minutes to get out of [their] house and [the patient] would have been long dead by the time [they] get there."* Even when participants do not face any of these prior issues, there would still be certain cases where they would want to refrain from responding to a call due to safety concerns. Almost all participants agreed they would be concerned with responding to alerts in areas that they considered unsafe, particularly during night time. *"[They would] not [be] sure that [they] would feel comfortable in the middle of the night, going into a neighborhood that [they] don't know, looking at the GPS by [themselves] and walk into an apartment building that is completely foreign to [them]."*

In previous literature, *barriers to notification* are at times batched together with *barriers to leave*, as factors that prevent responders to travel to the scene of the event [8,39]. We argue that the difference between the two is important particularly due to their design implications. As mentioned in the previous section, the former is a set of *awareness* and *reception* issues that prevent initiation of the task selection process. The latter, on the other hand, consisted of barriers that occur after responders are notified, yet decided not to accept the task.

Barriers to perform

This category is consisted of factors that prevent responders to perform the task. These factors emerge at the very end of the responding process, when responders obtain new information and reassess their intention to respond upon arriving to the scene. Barriers to perform include issues such as concerns of *credibility* (e.g. concerns about having the control of a crowded setting), situations that raise additional questions of *liability* (e.g. confronting a family member against resuscitation), and *lack of mental preparation* to perform a task (e.g. hesitation to give shock treatment to a patient for the first time.)

Barriers to perform did not come up during our diary study, since our simulated system did not include real response situations where participants would perform cardiac arrest treatment. However, during the focus groups, participants talked about a number of hypothetical scenarios where they could travel to the scene of event and *"see the scene is crazy [and decide] not to go in."* A main concern that holds up responders to perform is not feeling confident about performing in a crowded scene, since they think they would not have the necessary "*credibility and validity to what [they] are about to do in the eyes of people.*" Another set of concerns were liability issues that they haven't considered earlier, such as a case where *"[they] show up and [they]'ve got one person who wants this person resuscitated and another family member saying, 'No, they don't want to be resuscitated.'"* Situations like this would be perceived as a *"legal nightmare"* and responders *"would probably choose the safer option [and] prefer not to [perform the task]."* The focus group discussions have also shown that several participants were not quite mentally prepared to perform resuscitation. As the focus group discussions progressed, they expressed *"having a hard time even seeing [themselves] cutting someone's clothes off,"* let alone overcoming *"the fear of using [the AED] because [they] will use it wrong and [they] will kill somebody."*

Factors that influence task completion in location-based crowdsourcing was mentioned in previous literature [2,16]. However, our study yields to a richer set of findings, which were not discussed in prior work. We speculate this outcome is due to the complex nature of cardiac arrest treatment response. This is not to say that the findings are not generalizable to other domains. Barriers to perform due to liability questions are indeed relevant for other location-based crowdsourcing applications, such as citizen journalism or disaster response. However, the intricate nature of our subject matter made these factors more readily apparent during our investigation.

DESIGN IMPLICATIONS

In this section, we discuss the implications of our findings for the design of targeted responder programs and other location-based crowdsourcing applications. Each category in the design implications section maps to the respective category in our findings section.

Addressing concerns of commitment

The issues that fall under *barriers to commitment* in our study lead to design considerations which would be relevant for various on-demand crowdsourcing applications. The challenge here is to design a system which targets responders when they are both *able* and *willing* to receive notifications. An immediate solution that comes to mind is to provide responders with means to temporarily opt-out from the system when they do not want to receive notifications (e.g., a do not disturb button in the notification app). Such general theme of opting out was indeed mentioned in prior literature [21]. However, this solution requires a significant mental effort by the responders. The true challenge here is to get a more profound understanding about why responders want to opt-out in various situations and introduce appropriate design interventions.

For instance, our participants reported a desire to opt-out while they are engaged in activities which they deliberately decide not to bring along their AEDs (e.g. running, attending a fancy dinner event). Our findings show that responders would prefer not to receive any notifications during such activities. A potential design intervention here could be to track not only the responders but also the necessary equipment to perform the task (i.e. AED), and avoid sending notifications if a required device is distanced from the responder at the time of alert. This solution also applies to other location-based on-demand crowdsourcing systems (e.g. a citizen science platform that requires responders to carry a special measurement device [37].) Pairing the tracking information of responders and the necessary response equipment would relieve the responders from the cognitive load of constantly opting-in and opting-out and it would allow them to automatically take part only when they are both able and willing to commit.

Another solution would be to allow responders to set their preferences of commitment as they enter the system. There might be periodic time slots where responders would not want to commit under any circumstances. During sign-up, responders can indicate those time slots and not receive alerts during these predetermined times. Alternatively, the system can synchronize with other systems (e.g. calendars) and make intelligent decisions about alerting responders based on various factors. For instance, a professional responder might be excluded from the potential list of responders after a 24-hour shift. While it is not possible to account for all potential barriers to commitment in advance, such precautions would allow responders to feel less concerned about commitment. These design interventions would also be beneficial from the system point of view; they help depict a more accurate picture regarding responder supply, help make decisions about resource allocation and help distinguish various responder profiles.

Above we discussed various ways to mitigate responders' concerns about commitment. A different approach to address barriers to commitment is to think of ways to increase responders' willingness to commit. One general suggestion here is to make commitment easier for them. For instance, designers can lower the barrier of commitment by making the necessary devices to respond (such as AEDs in targeted responder programs) easier to carry. Thus, responders would be more likely to carry those devices along, increasing their commitment to the program. Designers can also think of solutions that would encourage responders to commit to the cause more strongly. An idea for targeted responder context would be newsletters that share the success stories of the program. Such encouragements would increase responders' willingness to commit more of their time to the program.

Increasing notification awareness

In our findings section, we have shown that *barriers to notification* are rooted in two separate sets of challenges: receiving the calls and noticing the calls. Many mobile on-demand crowdsourcing applications, including the system we studied, rely on external mobile networks for delivery of the notifications. Hence, the barriers of reception are usually not a potential area of design intervention. Therefore, we will discuss the implications of our findings in terms of increasing responders' awareness about the notifications they receive.

A straightforward implication of our findings is that regular smartphone notifications are not suitable as alerts for crowdsourcing applications that push time critical tasks to their users. One potential solution is to implement a loud and distinct special tone akin to AMBER alerts [4], a notification system used in the USA to alert all residents in cases of a nearby child abduction. The design challenge here is to replicate the *unmissable* and *distinct* characteristics of the AMBER alerts in smartphones or other notification devices. This can be achieved through designing a dedicated app, which overrides default smartphone notification settings for the tasks that require immediate attention. Alternatively, the notifications can be delivered simultaneously through multiple channels (e.g. smartphone notifications, e-mails, wearable devices etc.) Thus, the responders would be less likely to miss such notifications. This would be particularly useful for various on-demand crowdsourcing systems with tasks that are infrequent yet time-critical, such as disaster response.

Facilitating responders to leave the scene

There is a variety of *barriers* that prevent responders *to leave* their current location upon receiving a call. This gives way to a number of considerations for designers of location-based crowdsourcing systems.

The first challenge is to reduce the friction for responders to keep the necessary equipment at their vicinity. All location-based crowdsourcing systems rely on responders who carry certain equipment with them in order to receive tasks, perform tasks and/or communicate the outcome. For most systems, all these stages are covered by a smartphone (e.g. a citizen journalist receiving a task through SMS, taking a video with the phone camera and sending the resulting video via the phone's e-mail app.) The prior literature on crowdsourcing talks about design implications for systems that rely on smartphones [3,7]. However, our findings uncover a new set of design challenges that arise due to need of carrying an additional device (i.e. AED.) A solution which designers can consider is to pair the mobility of such dedicated devices with the mobility of other things that responders carry with them on a daily basis. For instance, a scientific measurement device in a crowdsourced citizen science program can double as a keychain or a smartphone case. This eliminates the additional cognitive cost of remembering to carry an extra device around at all times. Of course, if the dedicated device is large in size (as AEDs in our study), a keychain may not be a practical solution. However, the approach of *pairing mobility* still stands. Some responders in our study have addressed this challenge by keeping AEDs in their personal vehicles, which were *"less than a 100 feet away at any given time."* An alternative way to tackle this issue is to track the dedicated devices separately and notify the responders when they go out of a certain range from the device. Such solution would prevent responders to part away from their devices unintentionally.

Another design consideration is to more effectively target the requests. Designers of location-based crowdsourcing applications should explore targeting options that minimize costs to help by directing responders to neighborhoods that are familiar and/or nearby.

The final set of design challenges are related to responders' perceptions of safety, especially while traveling to unfamiliar locations or responding to calls during times generally regarded as unsafe. This challenge was also mentioned in prior location-based crowdsourcing literature [41]. There are two threads that designers can follow here: (1) They can let responders determine the geographical and temporal limits of where they would be willing to take tasks. This approach would likely decrease the number of calls that are sent to responders. However, as our findings point out, such approach would also encourage more responders to sign up, who may not have signed up otherwise. (2) Designers can also encourage responders to travel to scene of event by boosting their actual and/or perceived safety. For instance, a call coming from an area where a responder does not usually travel can include a note, which assures the responder about the safety of the area. Alternatively, designers can envision a system that pair up responders with others (potentially other responders) as needed, which would augment the actual safety for both responders.

Preparing responders to perform tasks

Our findings point out to a rich set of design considerations regarding how to prepare responders, so that they do not refrain from performing the tasks after they arrive at the scene of event. A grand challenge here is to provide responders with adequate training, so that they are prepared about how to act in situations that could potentially prevent them from responding. As one of our participants with professional experience aptly puts *"it's easy to be like, 'here's an AED, put it on.' but once you get on the scene, chaos is there. Everything is different. [You] just need to know how to be able to handle an entire scene."* While this quote is relevant exclusively to cardiac arrest response, many crowdsourcing applications that rely on lay responders should consider the various contextual elements that would prevent responders to perform the tasks. Preemptively training responders to handle potential barriers to perform would be crucial for increasing task completion rates.

A complementary design challenge is to keep the training information fresh. Since the system we studied is a program where responders are rarely expected to receive task requests, they also have limited opportunities to use the skills they attained through training. This is also a challenge for other on-demand crowdsourcing domains, such as disaster response [40], where time-critical tasks happen infrequently. Some of the suggestions that came up during focus groups were drills, periodic meetups and newsletters to refresh responders' knowledge.

One final design challenge is to come up with ways to attain credibility for the responders. Training, again, may partly address this issue by preparing responders about how to control a scene of event. However, several participants in our focus groups suggested that *"[they] would be more comfortable if [they] fill up in a uniform, [because] people [would be] less scared of [them]."* It is indeed shown that professional attire leads to an increase in credibility [5]. Designers of targeted responder systems may consider addressing the challenge of credibility by providing a piece of apparel or an accessory for responders to carry around with them. Such solutions would augment responders' perceived credibility and prevent hesitations that would become a barrier to perform tasks.

LIMITATIONS AND FUTURE WORK

Researchers are encouraged to repeat this study in an active targeted responder program with real calls. This would increase the reports' accuracy. Since we did not have access to an active program, we have used a simulation approach with proxy AEDs. This approach has been used in other studies where access to a real setting or technology is not possible [12]. Also, due to time constrains, the frequency of the calls in our diary study was not realistic. However, the main findings in our paper rely on the focus group interviews, and our principal intention in the diary study was to use it as an opportunity for our participants to establish some sense of how it is to be a targeted responder. Researchers who are focused on more realistic response rates (rather than causal factors that serve as barriers to respond) are strongly advised to replicate the study with a higher number of participants and realistic call frequencies.

CONCLUSION

Early treatment in cardiac arrest is crucial for survival. A recent approach in improving early treatment rates is to launch cardiac arrest response programs that are based on targeted responder models. However, less than a quarter of the calls in targeted responder programs result in a responder traveling to the scene of event. Prior work on factors that influence response rates is limited.

Through a weeklong diary study and in-depth focus groups, we revealed additional barriers to respond that were not discussed in previous literature (i.e. barriers to commitment and barriers to perform). We categorized these barriers to respond based on their temporality: (1) barriers to commitment, (2) barriers to notification, (3) barriers to leave, and (4) barriers to perform. We anticipate this categorization to serve as a framework for designers and researchers to explore and address barriers to respond in targeted responder programs and various other location-based crowdsourcing applications.

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