

Sharing 9-1-1 Video Call Information with Firefighters During Emergency Situations

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ABSTRACT

In North America, people can phone the number 9-1-1 to obtain emergency services. In the near future, such services will begin to incorporate new communication modalities such as video calling where callers can show visuals of the emergency to 9-1-1 call takers. This information can then be shared with first responders such as firefighters. We conducted an exploratory study with firefighters to understand how 9-1-1 video call information should be shared with them by dispatchers while they were enroute to an emergency and what benefits and challenges it would create. Our results show that video call information can help firefighters gain more accurate information about an emergency, provide location specifics, pre-plan strategies, and mentally prepare for the situation while traveling to it. Yet the mobile phone camera work performed by 9-1-1 callers could be challenging and firefighters require lightweight systems to view and share this information on firetrucks. There exist further design opportunities to support the mental well-being of firefighters who often view potentially traumatic footage, as well as opportunities to integrate other camera technologies (e.g., drones) with video from 9-1-1 callers.

CCS CONCEPTS

Group and Organization Interfaces → Computer Supported Cooperative Work

KEYWORDS

Emergency calling; firefighters; dispatch; video call; video conferencing

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1 Introduction

In North America, people experiencing an emergency situation can phone the number 9-1-1 and be connected with an emergency call centre. They share information about their situation with a call taker and a dispatcher relays the information to a first responder (e.g., fire, police, ambulance) who attends to the scene. In the coming years, emergency calling services in Canada will

begin to move towards Next Generation 9-1-1 (NG911) and include support for text messaging, video calling, and the sharing of photos or videos between callers and 9-1-1 call centres [14,15,46]. In turn, this will involve new ways of sharing information between 9-1-1 dispatchers and first responders. Studies have looked at 9-1-1 video calling between call centres and call takers [45,53]; however, there has yet to be any research that explores how systems should be designed to support NG911 information viewing by first responders after it is shared with them by dispatchers. There is a variety of research that explores media sharing between firefighters and dispatch/call centres [8,37]. This work focuses on ongoing information exchange about a situation while first responders are working, where media is often captured by professionals, such as the first responders themselves (e.g., fire commanders) [8]. Thus, there is a research gap when it comes to understanding how media shared by citizens with 9-1-1 call centres can then be further shared with and viewed by first responders, such as firefighters.

In this paper, we focus on the needs of firefighters who are responding to ‘everyday’ emergency situations and receiving information from a 9-1-1 dispatcher. By everyday emergency situations, we are referring to what are typically small-scale emergencies called into a 9-1-1 call centre on a daily basis, such as car accidents or small house fires. This contrasts emergency response in crisis situations that are typically less frequent and often require large units of first responders over a prolonged period of time [45]. Our emphasis is on the future exchange of video call information between dispatchers and firefighters while they are enroute to an emergency and the 9-1-1 caller is still connected with the call centre/dispatcher and providing visual information of the scene. We focus on video calling because it offers rich visual information about a situation. For example, one could imagine a future where a person makes a call to 9-1-1 to report an emergency and uses a video call, somewhat akin to a Skype or FaceTime call, to communicate with the call taker. When the dispatcher shares information with firefighters about the emergency situation so they can attend to it, the dispatcher is able to send live video, video clips, or images from the caller, in addition to their current practice of sharing text-based information. Thus, the media being shared has been captured by a citizen who may not have much experience in doing so.

We conducted an exploratory study with firefighters as a form of requirements analysis for the design of systems that can allow

firefighters to view and understand 9-1-1 video call information. Our goal was to understand: the challenges that firefighters currently experience, if any, with the information they receive from dispatch centres; what benefits and challenges 9-1-1 video call information might introduce to their practices; and how video information systems should be designed for firefighters to view and receive 9-1-1 video call information from dispatchers. We conducted interviews with firefighters where we focused on four major contexts: fires, motor vehicle incidents (MVIs), medical emergencies, and hazardous materials (HAZMAT) response. Our study emphasizes information exchange while firefighters are enroute to an emergency as we have found that for everyday emergencies, this is the most critical time for information exchange with 9-1-1 call centres. It is also the time period in which a call centre in our region would typically keep the caller on the line and continue to receive video call information from them.

Our results show that video call information from 9-1-1 callers could be very valuable for firefighters in order to understand an emergency, pre-plan tasks, and mentally prepare oneself while they are enroute to the emergency. Yet there are design opportunities for exploring lightweight interactions for video review while traveling in the firetruck; ways to mitigate potential trauma from seeing challenging situations; and, methods to integrate the use of other camera technologies such as drones, in addition to video captured by 9-1-1 callers who may not have the experience to capture ‘good’ video of emergency situations.

2 Related Work

2.1 Video Calling and Streaming

Many people rely on video calling to support both personal and work communication [4,11,32,35]. This involves using video for supporting conversations as well as viewing activities or objects in a remote environment [11,12,32,35,47]. Video has also been found to be valuable as ‘data’ where it can provide valuable contextual information about an activity (e.g., neurosurgery) [41]. Despite the benefits of video calling and video conferencing, people face technical challenges such as connectivity issues [4,35] as well as social challenges related to privacy [10]. Typical privacy concerns include showing oneself on camera in unflattering ways [12,23,34,43] or streaming video of bystanders in public settings [54]. Video calls using mobile devices have been found to require careful camera work in order to adequately show the remote viewer a scene [30,40,47,48]. By camera work, we are referring to the continual reorienting of the camera’s direction and zoom levels to provide an ideal view of the scene to remote viewers [27,31,49]. This act is often difficult for people to do because they are trying to think about what the remote person would most like to see [27,30,49]. In turn, remote users often want more control over their own view and to be able to gesture at things in the scene [30]. There is also a desire for better spatial context [30,34]. To overcome these challenges, design work has focused on combining or providing multiple camera views [44], 360-degree cameras to shift the focus of the camera work to the remote viewer [56], and drones to provide an aerial view of a scene [31].

Researchers have also explored the live streaming of events by amateurs, including performances, social events, and ‘sudden situations’ [33,57]. Again, camera work was shown to be a challenge along with differences between the goals of amateur video streamers and remote viewers [21,22,50]. Here multiple camera views were again suggested as possible solutions along with designs to aid camera work [21,22,50]. Our work is similar in that we explore how everyday people share video of a scene with remote users. We explore topics of camera work and mobile video views as it relates to firefighters receiving video call information that is captured by 9-1-1 callers. We return to these topics in our discussion section for a comparison of our findings to the broader research around mobile video calling and streaming.

2.2 Emergency Call Centres and Dispatch

When people phone 9-1-1, a call taker asks them a series of questions [24,38,61] and records this information in a Computer-Aided Dispatch (CAD) system [45,60]. This is then dispatched to a first responder [45]. Dispatch information is not always accurate and highly dependent on what a caller tells the call taker [24]. Call taking can be a challenging endeavor as call takers must acquire information from frantic callers [5,62] as well as those with language barriers [2,25]. Given these problems, call takers try to take control of the call in order to gather information in a systematic way, through a series of predetermined questions [45,55]. Call takers sometimes hear about traumatic situations in calls that are not easy to forget [2,7,39,52]. A study of 9-1-1 call takers showed that video calls would be valuable for seeing injuries and location details, yet call takers were sometimes concerned about seeing traumatic situations [45]. Call takers also wanted to be able to direct the camera work of the caller, in order to capture specific things in the scene [45]. A complementary study of 9-1-1 callers found that they would be willing to give up control of what to capture on video providing they had given consent [53]. Research on the use of video calls between ambulances and hospitals found that video would be valuable in order to alert hospitals as to the types of situations they were about to have to deal with [6]. Hospitals have also been found to desire more visual information about patients during transportation to the hospital [63].

2.3 Firefighting and First Response

There has been a large amount of research on firefighting practices, primarily focused on procedures at the scene of an emergency. The role of firefighters has changed over the years from responding to just fire emergencies to include a broader set of first response work such as attending to motor vehicle accidents or injuries (e.g., heart attacks, falls) [24]. Firefighters’ work practices are highly structured and roles are hierarchical [13,17,29,59]. When arriving at a scene, firefighters first survey the scene to size it up [29]. High ranked commanders and officers relay instructions of what to do to subordinate firefighters in person or over a shared radio communication channel [13,29,59]. Radio communication involves a shared vocabulary amongst firefighters and firefighters must actively listen to see what

information is important for them to know [17,59]. This is part of maintaining situation awareness, a moment-to-moment understanding of what is happening and how this information should be acted upon [2,17,20,59]. This includes knowing who is doing what, when, and with what equipment, as well as the state of the situation [17,29]. When fighting fires in the front line, situation awareness can be challenging to maintain because radios are difficult to use while wearing fire gear [18]. Background chatter on radios can also be distracting, firefighters can draw conclusions too quickly based on what they hear, and there can be temporal misunderstandings about what is being done [26]. Researchers have investigated new designs and systems to help improve firefighting work while actively fighting fires. For example, designs have focused on virtual reality training for fighting fires [36,58], simulation games [58], clothing to measure physiological data and assist firefighting tasks [16,51], head-worn depth and thermal cameras for seeing in buildings [1], and large displays for task assignment and management [29].

More closely related to our focus, there is research on media-sharing between firefighters and emergency dispatch centres. For example, Ludwig et al. [37] report on the needs of fire and police officers for information sharing with a control centre while emergency situations are ongoing. This contrasts with our focus on travel to the emergency by firefighters. There is also an emphasis on crisis management, rather than our focus on ‘everyday’ emergencies. First responders found value in seeing a situation for themselves [37], though we do not learn about specific details around what would be relevant to show in photos/videos or how it should be recorded (e.g., camera location, camera work). Media from citizens was seen as valuable yet there were concerns around information overload from first responders receiving too much media. Bergstrand and Landgren [8] report on the study and design of a mobile application for incident commanders to share live video from an emergency with control centres. Videos were typically short (less than a minute) and provided valuable contextual information. Videos depicted the physical context and audio narratives described the actions being undertaken by the response team. While valuable, this research again focuses on the ongoing response to a situation, rather than our focus of traveling to an emergency. Moreover, media is captured by firefighters themselves, rather than everyday people calling 9-1-1. Lastly, Betz and Wulf [9] explore the design of EmergencyMessenger, a mobile application that supports text-only communication between firefighters during an emergency. The system was beneficial because it provided a history of messages and predefined responses made communication efficient. Again, it focused on ongoing communication during emergency response.

As can be seen, there has been little focus on understanding the routines and needs of firefighters from the point at which they are notified of a call to the point at which they arrive on scene. This time period is very short, only a few minutes sometimes; however, it is pivotal to the work practices of firefighters as it involves receiving information about the situation that they are traveling to and navigating to the location. Our research explores this time

period with a focus on viewing 9-1-1 video call information captured by amateurs—everyday people calling 9-1-1—as opposed to first responders.

3 USER STUDY

The goal of our study was to understand the challenges that firefighters currently experience, if any, with the information they receive from dispatch centres; what benefits and challenges 9-1-1 video call information might introduce to their practices; and how video information systems should be designed for firefighters to view and receive 9-1-1 video call information from dispatchers. Our study was approved by our university research ethics board.

3.1 Participants

We recruited participants through word-of-mouth by talking with firefighters in our university’s city location. This built on connections we had with local firefighters through past work. Twelve males agreed to participate in the study. All were from the same suburb of a major metropolitan city in Canada. The large number of male participants reflects the high proportion of male firefighters in the city. In 2016, the estimated population of the suburb was 525,000 people distributed over a geographical area measuring 342 km². The city’s fire service has 15 fire halls strategically located throughout the city and a department size of 400+ firefighters. Participants in our study were stationed at both urban and rural fire stations within the city.

All participants had responded to fires, motor vehicle incidents (MVIs), and medical emergencies, as well as, in special cases, hazardous materials response (HAZMAT). Six of the participants were of rank ‘firefighter,’ the lowest rank in the fire service. Two participants were drivers, a special type of the firefighter rank, and drove fire trucks to and from incidents. Two participants were ‘officers,’ a senior rank that includes supervisory work during an emergency call. Within the officer rank, there are additional ranks, such as Lieutenant and Captain, based on experience. The final two participants were retired and had taken on all three of the aforementioned roles throughout their career. The two retired officers we interviewed had 30-36 years of service experience and at least ten of those years of service were in the position of an officer. The retired officers had retired within the last ten years. Participants’ experience ranged from 6 months to 36 years of service and ages ranged from 25-75 years of age. All participants had at least some experience in making video calls in their personal lives using software such as Skype.

3.2 Method

Semi-structured interviews were conducted at the firehall before / after participants’ shifts had finished in order to tie interview questions to the context of work as much as possible. Interviews lasted 60 to 90 minutes. We were unable to conduct interviews *during* work time given a high unpredictability of people’s availability and the emergency nature of the work. Interviews were done individually away from other firefighters in private so that each participant could openly express their opinion. Several

participants requested to be interviewed at their home or a local coffee shop for additional privacy. Interview questions focused on two areas:

1. **Existing Practices:** We asked about current work practices from the moment a call came in to the fire hall until the completion of the emergency response. We probed participants with questions about the common types of emergency situations they encountered, how people on the crew communicated, and what their duties included. We also asked about what types of information they received from dispatch and needed for medical emergencies, motor vehicle incidents, and fires and what worked well and not so well about the receipt of this information. We purposely tried to ground all questions in actual situations that the participants experienced. For example, we asked, “Tell us about the last call you were involved in. What information did you receive about it? What happened?”

2. **Future Situations:** We probed about future technology usage where we asked questions about the possibility of using video calling for 9-1-1 calls where a dispatcher at a 9-1-1 call centre could share video or images of a scene with the firefighters directly. Here we explained that the 9-1-1 call taker/dispatcher would be interacting with the 9-1-1 caller through a video call and information would then be relayed to firefighters by the dispatcher. Firefighters would not directly communicate with 9-1-1 callers, as per present practices. We told them that they could imagine that 9-1-1 callers would be using a system something like Skype or FaceTime on their mobile phone where they would engage in a video-based phone call with a 9-1-1 call taker. We described the caller’s system in this way as our prior work suggests that this is how 9-1-1 video calling systems will likely initially be designed [45].

When it came to the system that firefighters would use to view the video call information themselves, we did not provide any description. Instead, we asked firefighters what they felt the system should be like. We wanted participants to tell us what they felt would be most appropriate for such a system, including things like how video information would be presented to them and in what form, e.g., live video, video clips, images captured as still frames of the video call. We asked participants about the benefits they thought that video call information might bring, the disadvantages of video call information, what kinds of camera views they felt would be best/worst, where they would want to see video call information in their existing software/hardware, possible privacy concerns, etc. Because participants were largely speculating about a technology that was not yet available to them, we ground their thoughts in specific cases of 9-1-1 calls. For example, we asked, “Tell me about a recent fire you went to. If you were able to receive video or images from dispatch, what would you want to see beforehand? Why? What would you not want to see? Why? How would you want information to be relayed to you? How would video/images benefit you, if at all? What challenges do you foresee for both first responders and the public?” We repeated these questions for the different types of emergencies that participants dealt with (e.g., fire, MVIs,

HAZMAT). Throughout this interview stage, we also probed participants about other possible sources that might provide video information of an emergency beyond the 9-1-1 caller. For example, several participants brought up the idea of video footage from drones.

Overall, our study emphasis was largely on the second phase of the interview, where we probed about future situations and 9-1-1 video calls. For this reason, we did not conduct observations of firefighting practices as part of our first interview stage. Prior work has documented such practices in detail (e.g., [50,59]) and our own observations of them would likely have produced very little in terms of new findings. Instead, we used the first stage of our interview to help ground our discussions with the firefighters for the second interview stage. Given that our second stage involved speculation, rather than actual practice, we did not conduct any observations as a part of this stage. Instead, our second interview stage was conducted in a form that is similar to a speculative enactment [19] where participants are prompted about future design possibilities (with a prototype or scenarios showing future technologies) and asked to reflect and discuss them as part of an interview-style conversation. This type of approach has been found to be useful in situations where future technology does not yet exist, but it is valuable to understand participants’ reactions to such technologies in order to help guide their design. It has been similarly used in studies of 9-1-1 video calling [45,53] as well as other areas of technology design [19]. In our case, we did not have a specific prototype as a prompt, but instead used conversations about real 9-1-1 calls to explore and talk about futuristic design ideas.

3.2 Data Collection and Analysis

All interviews were audio recorded and fully transcribed. We used coding techniques coming from Grounded Theory to analyze our data, though we did not use Grounded Theory as an overarching research methodology. Our coding included iterative review of our interview transcripts and open, axial, and selective coding stages. We produced four main categories of findings focused on general work practices, behaviors during the receipt of call information presently, uses for video within dispatch information, and viewing and sharing video information. The former two groups focused on current work practices and the latter two groups focused on future practices with video dispatch information. Within current routines, our codes included subgroups such as private information (known only by the officer), public information (known by all firefighters on the crew), information accuracy, planning, dynamic information, and emotional responses. For future needs, our codes included subgroups such as camera work/views, safety concerns, privacy concerns, private information, public information, information accuracy, and access control. Selective coding revealed main themes around contextual understanding, camera work, safety and privacy, information viewing and sharing, and inaccurate and conflicting information. We focus on these in our results sections.

Throughout our results we report quotes from participants with a participant number (P#). We have also enumerated how many participants shared particular views, when the data was available. We caution, however, that given the style of interviews conducted, even though some participants may not have commented on particular thoughts, it may be because the interview did not go in this specific direction, given their semi-structured nature.

4 RECEIVING INCIDENT INFORMATION

When a person calls 9-1-1, the call taker at the emergency call centre asks a series of questions and records the information about the incident in their CAD system. Once the caller can provide no new information, they are let go by the call taker. A dispatcher sees the incident's information in their own CAD system at the call centre and radios a particular fire station. In the fire halls of our participants, a tone goes off alerting the firefighters that they have an incoming call and basic information is relayed over a loudspeaker that all the hall's firefighters can hear. This includes a basic classification of the call so firefighters know if it is a fire, motor vehicle incident (MVI), an injured or trapped person, or HAZMAT. Firefighters quickly grab the necessary equipment for the type of call and then board the fire truck. For example, for fire calls, they will don their fire protective clothes, but for injury-related calls they will typically not.

So, the initial dispatch is usually very kind of general, so the initial dispatch, you know when it first comes over the loudspeaker at the hall, or over the radio, will just be something simple like 'a rescue.' – P9

In our participants' fire halls, firefighters typically worked in teams of four per truck. This included one driver, one officer who sat next to the driver in the truck, and two firefighters who rode in the back of the truck. The exception was rescue trucks that were stationed in busy parts of the city to respond to medical calls and act as backup resources. These trucks contained only a driver and an officer. On the trucks, the driver and officer decide on the best route to get to the incident. The front passenger seat of the truck has a laptop next to it. Officers look at the CAD system running on the computer periodically while driving to the incident. It will continually update with new text information as the call taker adds information during the call with the 9-1-1 caller. For example, in the case of injuries, this might include the patient's age, gender, and specifics of the injury. Thus, information that is sent from the call centre to the officers in the firetruck is done so mostly automatically as the call taker types it out and it appears in the call taker's CAD system as well as the firetruck's. The decision of what to type is made by the call taker who tries to select key details that can help first responders understand the situation best. Other details that might be heard in the call such as background information about what was happening at the time of the incident (e.g., family picnic) or how panicked the person would often not be recorded.

Information that the officer thinks is pertinent for the other firefighters on the truck to know about will be spoken over the

radio to them while they are driving, e.g., injury type, type of fire. Officers will also relay strategy to the firefighters that is specific to the call's incident. Information may also be shared over the radio from the dispatcher, which all fire fighters on the truck can hear. This often involves repeating information that has already been typed into the CAD system, but saying it verbally in case the officer did not have time to read it. The officer can ask the dispatcher additional questions if needed.

When the crew arrives at the scene, the driver finds an appropriate place to park. The officer performs a size-up of the scene and gives orders to the firefighters of what to do. A size-up is defined as an overview of a situation including hazards, number of people involved, and severity of the incident. Sometimes multiple trucks go to a scene. In this case, the first truck arriving would be responsible for the size-up.

This entire process of traveling to the scene and acquiring an initial understanding of the situation happens very quickly. For severe fire calls or MVIs, depending on the location, it can take a fire truck as little as two minutes to arrive on scene. For less severe incidents, participants said that they usually arrived within eight minutes because they did not need to travel with lights and sirens. This allowed them to travel more safely and avoid additional accidents. Thus, the time period where information was received from dispatch was very small when traveling to an incident, but extremely important. We found this was also the only time period in which the 9-1-1 caller was on the call with the call centre. Thus, it was generally the only period of time in which new information was shared by a caller, since callers were let go by call takers once the first responders arrived.

Our participants talked about several challenges that they experienced in relation to gaining and understanding information about the scene while enroute. We describe these challenges next where we detail how video calling might benefit the situation.

4.1 Information Inaccuracies

First and foremost, nine participants talked about the accuracy of the information they received from dispatch. They explained that when they would arrive at a scene, the nature of the injury or what was happening was not always what was described in the CAD system and by dispatch. Like prior work found, this was because some callers had a hard time describing the situation, were frantic, or faced language challenges [5,24,62]. Accurate information was very important as it helped judge the seriousness of the call and how fast they needed to respond. The same participants felt that video clips could help because it could show the situation to provide actual details and allow them to assess the situation on their own. This was similarly found in cases of crisis management when media was shared with first responders [37].

Several participants talked about information being highly dynamic, which meant details could quickly become inaccurate. Even though the time needed to get on scene is a matter of minutes, this time period is long enough for fires to escalate from small kitchen fires to large house fires. In the case of MVIs, the

amount of change was seen as being less dynamic, however, changes to injuries could also change largely (e.g., amount of bleeding). Participants felt that live video would be valuable for such situations as opposed to still video clips or images that had been forwarded by the dispatcher. They felt that live video could even help them understand the origins of fires, which would help better fight the fire in its present situation. Several participants also talked about wanting to be able to move forward or backward in a video feed to see the progress of the incident (e.g., look at the origin of the fire and how it grew).

A lot of the times we do get inaccurate information on patients...A lot of the times the information we get isn't necessarily ... its not live information. Its a little bit delayed in that ambulance gets it, then it goes to our dispatch. – P4

Two participants talked about how it would be valuable for them to have access to the full video of what was happening because they, and not necessarily the dispatcher, would have the training to know what to look for in the video to properly understand the situation. This is similar to findings around media sharing during crisis management [37].

4.2 Location Details

Firefighters received location details including the address of the emergency, yet five participants commented they often wanted more details. This included the type of building, the side of the street when it was a complex street situation, and details about the specific location within a property. This information was not always sent to them.

Usually if it's at a house, we know that it's going to be inside the house, but if it's a patient down for instance, it's nice to know where is the patient? Is he in the middle of a field? Is he in the middle of a busy street? Is he up a tree? You never know, just a patient down, you don't know where he is. – P8

Participants said they wanted to know site-specific details that would help them know where and how to park upon arrival. For example, they wanted to know the location of fire hydrants so that they could park the fire truck within a necessary distance from them. Participants felt that knowing these details ahead of time could help them to strategize what direction to come into on a street. This could seemingly save only a short amount of time (e.g., seconds or minutes), but this time was often critical. Three participants also talked about complex streets that contained medians and large volumes of traffic traveling in each direction. They felt that video or pictures of a location could provide valuable information to help plan their approach, providing that such media was recently captured or 'live.' This information was currently not provided by the dispatchers and would be difficult to relay via text or verbal descriptions.

4.3 Task Preparation

Eight participants talked about challenges with task preparation while they traveled to the emergency. They told us that they

would often preplan in their head as to what they might do, or recite what the particular emergency steps were for the given situation. Many were highly familiar with processes such as CPR or steps to treat specific injuries, yet they wanted to mentally recite them as a way to focus.

I typically will just go through my first aid protocol in my head. It's just a way of getting everything clear in my head which way I'm going to go. – P3

Other tasks were sometimes more demanding and, even though they contained routine actions, the firefighters would have to apply their training to the specific context of the call. For example, participants talked a lot about MVIs and how to rescue people from cars. However, the locations of where the cars were and how accessible the people were within the car were often very different across emergency calls. Participants felt that video or images of the actual scene could help them to figure out how they might rescue a person in the given situation. In the case of fire, they felt that they could begin to judge distances between areas around a building and within a building itself. Videos showing specific injuries were felt to be valuable so that the firefighters could think of what equipment they would need ahead of time (e.g., stabilization board).

There's all kinds of things that could come into play. If they're wedged upside down in a ditch, your first thing might be breaking the back window and going through there. Or if you can't do that, you might need a shovel, just start digging the sides of the bank away...if you knew ahead of time, what you had, you have time to think of these things and what your Plan A, Plan B, Plan C is before you get there. So that would be good. – P1

4.4 Psychological Preparation

Psychological preparation was critical for many of the firefighters in our study. Seven participants talked about wanting to know ahead of time what type of situation they were getting into as they traveled to a scene so that they would not be shocked when they arrived. The information they received from the call centre described what they were about to encounter, yet the specifics of the incident could still vary quite heavily (e.g., how gory the scene was). They were used to seeing very traumatic situations, however, many felt they could be in a better state of mind if they knew more details ahead of time such as exactly what they would see. Several participants in our study had calming rituals that they would do enroute to an emergency situation. Video information was seen by many as a means to help such preparations. Of course, this presupposes that the caller is able to acquire such information. Prior work has found that callers may feel uncomfortable capturing details that might be considered gory or hard to look at [53].

Rather than being shocked, especially at two in the morning. A lot of these calls come at two in the morning when you're half asleep. If I had a little bit of pre-warning, as to what I'm going to see and what we're going to be doing when we get there, I think that'd be a

little better on my mental and my physical health, too.
– P12

In contrast, there were five participants who did not want to see traumatic visuals from dispatch. They thought they were already seeing too much when it came to traumatic situations on scene and gory video information should be limited to avoid further challenges with post-traumatic stress disorder. This is similar to findings of emergency call centres where not all call takers/dispatchers wanted to see visuals of a scene [45].

If there was a fatality, I don't know if I'd want to see that on video and then now I'm knowing I'm going there... It's never good seeing that, but you kind of want to react when you're there. I don't think I'd want to see a burning building with people entrapped in it and seeing video of that. – P5

4.5 Scene Size-Up and Hazards

When arriving at a scene, participants described the first activity as scene-size up. Participants talked about video call information being valuable for sizing up the scene while they were enroute to it, as well as identifying any obvious hazards that they may need to pay attention to. Such hazards could affect their route to the specific location of the incident (e.g., down power lines) and if they had the right amount of vehicles, or the right crew (e.g., HAZMAT) and equipment (e.g., 'jaws of life'). They felt that dispatchers may not be trained to notice or understand such specifics within a 9-1-1 video call, but their additional firefighting training would allow them to do so. Of course, this presupposes that the person shooting or recording the video for the 9-1-1 call centre would be capturing such details on video, which may not be the case when calls are made by everyday people.

5 CHALLENGES WITH VIDEO INFORMATION

We probed participants about the various ways that video call information from 9-1-1 callers might be shared with them as they thought about and discussed their past emergency calls. Within these conversations, several themes emerged around how video call information would need to be shared, how systems would need to be designed, and what challenges would need to be overcome. These points relate to the ways in which the aforementioned benefits of video call information would need to be realized and the complexities around citizens capturing such information when calling 9-1-1. We describe these details next.

5.1 Information Viewing and Sharing

Participants made it very clear that 9-1-1 video call information that was relayed by the dispatcher to them would need to be viewed exclusively while on the truck and traveling to a situation. The time spent in the fire hall before leaving was too short, and, once arriving at the scene, participants all said that video information provided little extra value because they were focused on the situation at hand. Yet the driving context raised issues around the ability to actually look at a video screen in a moving vehicle. Participants noted that the truck was often moving very

quickly and, given its large size, was prone to bouncing. This meant that it could be hard to look at a small screen. Currently, the laptop screens onboard in the cab were considered to be relatively small (e.g., a 15 inch display) for viewing and participants said they would have to look closely to inspect the screen and see what was happening in a video or image.

Our screens are just little, I don't know what they are, probably 15 inch screens...And you are in a moving vehicle, so nothing's very stable. You're bouncing on a seat and you're on route, so you gotta take that into consideration. You're not just sitting in an EZ Boy looking at TV. It's gotta be pretty clear for you to make decisions. That's one consideration. – P1

There were mixed reactions over who should be able to see the video on the fire truck. The two drivers in our study very adamantly did not want to have access to view video call information, nor did they think they needed to. They said that their focus was solely on driving and they did not want to be distracted for safety reasons. The six participants who rode in the back of the truck all said that they wanted to see video call information during the drive. It was seen as a valuable resource to understand the scene and mentally prepare, both psychologically and task-specifically. Yet they were cautious that they did not want to be overloaded with information during such a short time span. There were also concerns about getting tunnel vision and overly fixating on what they saw in the video information. Thus, in some cases, they felt like getting information filtered by an officer could help.

I think it would be helpful for everybody to have a view on it. Ultimately, I do like having the captain's input on it into what he's deciding on his wall. I think it would be beneficial for everybody to see the information opposed to just one guy being able to see it. I think it would be good for everybody to see it. – P3

The four participants who were currently officers or had taken on this role in the past said that their role in the front of the truck was to help the driver navigate, read information on the laptop's CAD system, and relay pertinent information to the other fire fighters on the truck over the radio. They cautioned that they did not want to be too distracted by a video feed such that it might take them away from their ability to help the driver navigate. This meant that they would have to be able to quickly glance at a display screen and acquire the necessary information. Two participants expressed hesitation about having the rest of the firefighters on the truck see the call information. The officer's role was described as being very purposeful: he needed to figure out what was pertinent for his crewmembers to know, and then relay it in a calm manner. Thus, the officer acted as an information filter that would help direct his crew in the right manner, rather than have them come up with their own plan about how to handle a call.

The guys in the back basically do what I tell them and so, for them to have information is irrelevant...I want them to do what I want them to do. We go to a fire and I'm lookin' at a screen and I see what I want...I've seen

notes for so many years, that I can read between the lines. And it would be the same with video...For someone, say, it's their first month on the job and they see some video footage, they might be panicking, 'cause it's not enough information for them, or whatever, or they think it's worse than it is. It might just create anxiety for someone that's new to the job. – P1

5.2 Camera Work

Participants talked in detail with us about the types of camera views and camera work that they felt would create the best information for them. Two participants said that callers should pan around a scene with their mobile phones to provide an overview, or that CAD systems might be able to stitch together video from multiple callers' phones to create a 360-degree view. This would help with scene size-up while enroute. Five participants talked prominently about the high value that they would get from seeing elevated views of an area, including 360-degree views of an entire scene. These participants talked about having drones fly above a scene to capture such aerial views.

If you had a drone do a 360 around it or something, or multiple videos so that you can see all the way around the incident before you get there, it would just help us identify more hazards ahead of time, and potential problems, and potential victims, and potential solutions to those problems. – P9

Nine participants talked about close-up views, in particular, to see injuries or vehicles in order to see if somebody was trapped inside. Several said that it could be difficult to acquire such close-up footage if the situation was spread across an area, like a multi-vehicle car accident.

Seeing a nice a close up of just the arm would help...because we could see that he's got a big dog bite on his arm, but you can also see maybe he's got, like I said, puncture wounds on his abdomen or both arms are bit. Or, maybe he's got half his chin missing, but he doesn't even know, so it would be good to see the whole, yeah, the whole patient I guess. – P8

There were also concerns raised by three participants about whether a 9-1-1 caller would have the necessary camera work skills when using their mobile phones in order to capture the aforementioned details, e.g., the ability to frame the video, zoom in and out, etc. This could be the case because people do not frequently call 9-1-1 so it may be a new experience for them and they would not have built up training in capturing such video on their mobile phones. Participants also felt that a 9-1-1 caller may be less familiar with technology. For example, one participant said that older adults may not know how to use a video call on a mobile phone. Many participants talked about the value of 'good' camera work and commented that they did not want to see a lot of irrelevant information since they had such little time already when traveling to the incident. This could cause information overload and make it hard to assess what is relevant. For example, one participant talked about not wanting to see 'a lot of sky' or other features of the scene not related to what was actually

happening because callers did a poor job of orienting their phone's camera. This could slow down their ability to acquire the necessary information from video clips or live video. Video shot during the night time on a mobile phone was noted by one participant as being particularly challenging to decipher even if it did focus on relevant information. There were also concerns by two participants that a person calling 9-1-1 may not be comfortable getting up close to somebody who was injured and capturing possibly gory information.

I guess what I wouldn't want to see is something that is not related to the incident. They're showing water flooding out of the basement or something. I don't care about that. I'd rather see what's going on at the incident. So, non-pertinent information, I guess. – P7

5.3 Safety and Privacy

Seven participants talked about serious safety concerns related to the person shooting the video and providing it to the 9-1-1 call centre. There was a general sense that this person could be putting themselves in harm's way by trying to get good footage or footage that was requested of them by the 9-1-1 call taker. They did not want to have additional emergencies to take care of at the scene because the caller became injured as well. Participants said this could be difficult for the caller to know, or even the 9-1-1 call taker to alert the caller about, because hazardous materials can be hard to spot and identify. Fires can also easily and quickly escalate. There was even a question of which was more helpful, providing video to 9-1-1 call centers or physically helping an injured person (e.g., giving CPR).

There's a lot of things that you can't see necessarily through a screen that could potentially get that guy into trouble or he could become part of the problem...Maybe the car is on fire or if there's a fuel leaked all around. He's walking around in it to get a better video picture, I don't know if that's going to be a good thing. – P3

Five participants commented on what they felt were very serious privacy issues that might come with capturing video of others in public spaces using a mobile phone (e.g., bystanders, an injured person) when they did not want to be captured or did not know they were being captured. They felt this could easily compromise what video 9-1-1 callers were able to capture or be comfortable in doing so. On one hand, they felt that because situations were emergencies, privacy issues were less of a concern. Yet, because the severity of the situation was subjective, people in the general public may have differing views about whether their privacy rights were superseded by the supposed emergency-nature of the situation. For example, one participant talked about respecting people who had passed away and not capturing videos of dead bodies. He related this to their current practices of immediately placing a tarp over a dead body at the scene of an accident out of respect.

Two participants were concerned that people may continue video recording or streaming past a point at which it was valuable for emergency crews to the point at which it was focused more on

sensationalism rather than help. They felt that those who called 9-1-1 using a video call should stop recording or sharing video information once the crew had arrived on the scene. There were concerns about people getting in the way of their work. One participant felt that continued video capture of the scene could raise liability issues if the 9-1-1 video caller captured footage that they believed showed malpractice on the part of the firefighters.

6 DISCUSSION AND CONCLUSIONS

Overall, our study points to the value that 9-1-1 video call information could provide firefighters when they are enroute to an emergency. Yet it also raises important points about the difficulties in designing within this space, and the possible effects on firefighter's work practices and communication exchanges with 9-1-1 call centres.

6.1 Viewing Visual Information

Similar to the related work, we found that visuals would be valuable for firefighters to see of emergency situations [8,37]. We extend past research to illustrate the desire for such visual information by firefighters while enroute to an emergency and when the visual information is coming from everyday people who are calling 9-1-1. Yet viewing this information raises challenges. At a pragmatic level, we see that video call information would be desirable within the cab of a firetruck such that it could be viewed by the officer (but not the driver). For example, the officer could glance down and see video of the current emergency situation. However, it is clear that this view could easily become distracting for officers who are also trying to help the driver navigate to the scene. This suggests that there would be value in making this view optional such that an officer could turn it on or off, along with ways to quickly glance at it to gain information, rather than requiring long inspections or interactions. Officers may find value in being able to easily move backwards and forwards through the video (akin to scrubbing) in case they want to see key visuals such as the origin of a situation, or key moments in time. These visuals were noted as being valuable pieces of information by our participants. Yet, again, this type of interaction would need to be extremely lightweight in order to perform. A large difference between our findings and the related work on mobile video usage (e.g., [30,31,40,49,50]) is that firefighters are under intense time pressures for viewing video.

6.2 Video as Data

Past work has illustrated the role that video can play as 'data.' For example, video feeds have been found to let surgical staff predict what tools a surgeon may need next [41]; video media spaces in office settings presented availability 'data' to help colleagues time social interactions with others [10]; and, families use video call 'data' to see how children have grown [35]. Our study of firefighters revealed that video from 9-1-1 video calls could be used as data for firefighters to mentally prepare for a situation and plan out a sequence of tasks. While similar to the related research, (in particular to work around video feeds during surgery [41]), the difference is that firefighters only have several minutes of travel

to think about what they have seen and what they might do at an emergency when they arrive there. It is also the case that such video as data may be difficult to see on a firetruck and understand, thereby requiring multiple reviews. Again, as mentioned, this could be quite challenging to do and would require lightweight tools to support video review and scrubbing. However, it could be very important for firefighters in order to mentally prepare for an emergency. In turn, there are also design opportunities to explore how visual information can be presented to firefighters enroute such that it does not cause additional trauma and negative mental health situations, such as Post-Traumatic Stress Disorder (PTSD). This type of challenge is not something seen in the related work where video surfaces as data for understanding contextual information [10,41].

6.3 Information Sharing and Curation

Information exchange between 9-1-1 dispatchers and firefighters is currently a curated process where dispatchers select and filter the information that they share with firefighters in an abbreviated manner [45,53]. This workflow and summarization is important. Firefighters have very little time to act and comprehend situations when they are traveling to them and so they must rely on others (e.g., the 9-1-1 caller, the call taker, and the dispatcher) to help them with this process. The introduction of 9-1-1 video call data raises questions about how this information flow and curation may work in the future. It would seem pertinent that dispatchers be able to curate the video that they receive from 9-1-1 callers, such that they could highlight or send particular sections of video, or select still frame images to send fire fighters. In turn, the officers in our study felt it was important to maintain a level of control over what information their crew members knew. They felt this would help maintain a sense of calm and protect those with less experience from information overload. This reflects the firefighter organizational hierarchy that we found, as well as that found by others [8,37,59]. The crew members in our study who rode in the back of firetrucks wanted to see video information, but similarly cautioned about information overload and 'tunnel vision.' These findings suggest design opportunities for exploring ways that firefighter officers may be able to filter and select pertinent visual information to share with crew members. The challenge is that this would, again, need to involve very lightweight interactions. It would also likely involve additional cognitive loads on officers who would now need to decide what to share. This could be extremely challenging in such a short amount of time and requires cautious design.

6.4 Camera Work by Amateurs

One of the main differences between our work and prior explorations of media sharing by firefighters is who is capturing the media. Past work has explored firefighters capturing videos while on scene [8], while we have focused on amateur video capture by people calling 9-1-1. This is more akin to people who live stream events and happenings [57]. Yet our study raises questions around the abilities of those capturing 9-1-1 video. Live streaming is often done by those who have an affinity for

capturing video and experience in doing so [21,22,57]. When firefighters capture video information, they have a broader understanding of what is valuable to capture. People calling 9-1-1 with a video call will likely be doing so infrequently [45,53], which means that they are likely to have little experience in capturing what could be considered ‘good’ video of an emergency. They may also not be technology-savvy. Like past work, this suggests design opportunities for those in contact with the 9-1-1 callers—the call takers and/or dispatchers—to help 9-1-1 callers capture valuable video data [45,53]. Our study builds on these suggestions to illustrate the types of video footage that firefighters would find valuable. This includes 360-degree panning of a scene to get an overview, as well as close-ups of specific problems (e.g., injuries, vehicles). We also see the concerns that firefighters have about 9-1-1 callers making the situation worse by capturing video in unsafe situations, or the possible privacy concerns of others. Here there are interesting questions around consent and when it is needed during an emergency (e.g., is it okay to video stream bystanders?). 9-1-1 callers may also not necessarily know when video should not be captured out of respect for the family or victims that have passed away. It could be difficult to distinguish death from serious injury, for example.

Camera work by everyday people may also not be enough to adequately help firefighters. There is a possible role to play for other technologies such as drones that are able to easily get an aerial view of a situation. For example, one could imagine a drone quickly flying to the scene of an accident and sharing aerial video with a dispatcher who relays this to the firefighters as one of the video feeds about the call. One could also imagine CCTV cameras playing a similar role if they are available. Yet the challenge with CCTV cameras is that they are stationary and it could be difficult to get the right camera views and angles and it would be unlikely to get the types of close-up video that firefighters wanted. Overall, this suggests there are design opportunities for creating hybrid systems that could, for example, bring together video from a number of different sources, including 9-1-1 callers’ mobile phones, drones, and even CCTV cameras. To date, we see little research that has looked at combining such an array of camera technologies.

6.5 Limitations and Future Work

Overall, our work has helped to open up the design space of Next Generation 9-1-1 calling services, which will be critical as such services move to the use of advanced technologies. We have specifically provided details on the design needs of firefighters when handling and receiving 9-1-1 video call information from dispatchers. This complements other research that has explored the perspectives of callers [53] and call takers [45] in dealing with 9-1-1 video call information. Our study is limited in that we focused on a relatively small sample of firefighters. Yet our interviews were in-depth and time-intensive. We also found that our data was saturated around the completion of ten participants where we then continued interviewing additional participants. Nonetheless, future work should explore additional demographics, including female firefighters, to understand how

their thoughts and experiences may present different views than our participants. Firefighters in our study speculated about a plausible future use of technology where we ground discussions in real work situations. This should be complemented with further design work and field testing of technologies. Our findings are also limited in that we focused somewhat narrowly on video that would be shared by 9-1-1 callers using Skype-like video calling systems. There are a host of other possible technologies that could be incorporated into information sharing practices, such as drones, CCTV cameras in the public, etc. Future work should more deeply explore these technologies and their possibilities.

Our study was conducted specifically in Canada, though at a general level, our findings likely apply to firefighting practices in Western countries where procedures are relatively homogeneous. Differences could lay in the specific information sharing practices, which could vary. For example, firefighting units will all generally have a chain of command and specific information sharing routines, yet the nuances of this may vary. Thus, our findings on how visual information should flow between individuals will generally apply, but the specifics may vary based on the region and country.

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