The Benefits and Challenges of
Video Calling for Emergency Situations

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ABSTRACT
In the coming years, emergency calling services in North America will begin to incorporate new modalities for reporting emergencies, including video-based calling. The challenge is that we know little of how video calling systems should be designed and what benefits or challenges video calling might bring. We conducted observations and contextual interviews within three emergency response call centres to investigate these points. We focused on the work practices of call takers and dispatchers. Results show that video calls could provide valuable contextual information about a situation and help to overcome call taker challenges with information ambiguity, location, deceit, and communication issues. Yet video calls have the potential to introduce issues around control, information overload, and privacy if systems are not designed well. These results point to the need to think about emergency video calling along a continuum of visual modalities ranging from audio calls accompanied with images or video clips to one-way video streams to two-way video streams where camera control and camera work need to be carefully designed.

Author Keywords
Mobile video calling; emergency calling; call takers; dispatchers; situation awareness; collaboration

ACM Classification Keywords
H.5.3 [*Computer-supported cooperative work*]: Group and Organization Interfaces

INTRODUCTION
Since the late 1960s, 9-1-1 services in North America have offered people a means to place telephone calls asking for emergency assistance in cases requiring an ambulance, the police, or fire fighters [58]. Audio-based calls can be made from landline phones, IP-based phones, or (most) mobile phones and they are received by a call taker who assesses the situation and dispatches the appropriate responders [15,16]. While technology has long evolved past the telephone, it remains the main communication technology for information exchange between those in emergency situations and 9-1-1 services. Within Canada, we are seeing efforts to move towards 'Next Generation 9-1-1' where citizens could use text messaging, video streaming, or the sharing of photos or videos during a 9-1-1 call [15,41]. Policy efforts suggest that infrastructure for such services should be in place by the year 2020 [15,16,41].

We focus on this topic by exploring the idea of video calling for 9-1-1 calls—technology akin to a Skype or FaceTime call between a 9-1-1 call taker and a person experiencing an emergency. While the ability to show a call taker an emergency situation via a video call seems to hold promise and 'keep pace' with current communication technology advancements, many open questions remain. In what ways might video calls enhance 9-1-1 services and when might they inhibit them? How should video calling technologies be designed such that they meet the needs of the caller, call taker, and dispatcher to ensure emergency calls are efficient and effective? What effects might there be on the work practices of 9-1-1 call takers if video calls are introduced?

We explored these research questions by studying the 9-1-1 call taking practices within three 9-1-1 call centres in Canada. Our overarching goal was to understand what factors would be important for the design of such video calling systems if 9-1-1 services were expanded to include them. We observed police, fire, and ambulance call takers and dispatchers during their normal work practices and conducted contextual interviews with them about their work. We probed about a possible future with video calling technologies incorporated into 9-1-1 services.

Our results show that 9-1-1 video calling—and the sharing of images or video more broadly during calls—creates the potential for many benefits, including the acquisition of additional contextual information of scenes, the ability to overcome information inaccuracies, and a means to acquire information from those who cannot easily speak (e.g., children, elderly, those injured). Yet video calling also raises many challenges and concerns, including the

possibility of additional workplace stress, information overload, and privacy challenges related to the autonomy of the caller and call taker. Compared to commercial video chat software (e.g., Skype, FaceTime), video calling for 9-1-1 should be thought of as a continuum where audio is the primary communication medium and the sharing of video-based media varies from being turned off and not utilized, to the use of images or video clips as part of an audio call, to live video of a scene. This needs to be coupled with features that focus on supporting intricate camera work and decision making around when and how to show the emergency situation and how to easily transition between different visual modalities within the call.

RELATED WORK

Emergency Calling and Dispatch

In emergency call centres, call takers receive calls and get details about the incident in order to classify and prioritize it [20,35,45,57]. Textual information is then recorded in a Computer-Aided Dispatch (CAD) system [56]. Dispatchers review call information and send an appropriate response team, either police, fire, or ambulance [20,35]. It can be hard to figure out where a caller is because incoming location data may not be accurate from mobile phones, or people's descriptions of a location may be ambiguous [20,45]. Call centres can easily become chaotic if call volume is high [35]. Many callers are frantic, desperate, or hysterical so it can be hard to get accurate or enough information [4,58]. Call takers are trained to take control of the call so they can ask specific questions; however, hostile callers may not want to give up control [52].

Situation awareness is critical in emergency call centres [10]. Situation awareness on the part of a caller taker is a moment-to-moment understanding of what is happening during an incident and how this information should be acted upon [2,17]. It can be gained by listening to others, by purposefully looking around, or by noticing information in one's visual periphery [8,10,24,26,55]. Call takers use situation awareness to maintain an understanding of incoming calls to ensure that multiple calls about the same incident are known [4,35,45]. They can also maintain awareness by scanning call lists in the CAD system [35,45].

Call takers can face a great deal of distress from dealing with traumatic situations and have had to rely on coping mechanisms such as counseling [36] and peer support [1,49]. Stress results from the complex nature of incoming calls, ambiguous information from the caller, multifaceted medical needs, and communication difficulties (e.g., poor English) [1,22]. Stress can be exacerbated because callers often imagine what the caller is telling them and call takers can have lasting memories of calls [1]. Life and death calls [7] and calls involving children [22] are particularly stressful. Sometimes call takers form personal connections with callers [1]. Feelings of helplessness can contribute to stress [29] as can shift work and a lack of sleep [49].

Many people who are deaf or hard of hearing find emergency situations challenging and rely on friends or family to call 9-1-1 operators [51]. Teletypewriters have been used in the past, but they are not usually with a caller when mobile [51]. Text-to-911 services are available in most areas within North America, though some regions require special permission or signup to use the service [16,54]. Researchers have even designed special-purpose apps for deaf users [51].

In emergency situations involving ambulance response, studies have shown the value in timely communication between emergency responders and trauma teams [59]. Hospitals would value more visual information from incident scenes to understand the severity of the situation in order to better prepare for the arriving ambulance [59]. Studies and technology designs have shown the value in providing hospital staff with video of patients who are on their way to the hospital [5,6,44]. Video can be used to show patient trauma, body details, and display screens of medical equipment [5]. In natural disaster response, decentralized uses of media have been shown to be critical [9,34], if information can be deemed credible [48].

Our research expands on the related work by exploring the prospective benefits and challenges of using video calling within 9-1-1 call centres, which has not been done before. We explore scene assessment, situation awareness, software and hardware usage, and workplace stress, from the perspective of how they may be affected by video calling.

Video Communications

Video calling amongst family and friends has become prevalent in the last decade within homes [3,13,31,33] and while mobile and in the outdoors [30,42]. Using video calls (e.g., Skype, FaceTime), people converse and show views of activities that are occurring [31,33,42]. This allows people to share what an environment or object looks like as well as activities that people are able to perform [13,14,31]. These findings suggest the potential for video calls where a person might similarly be able to share views of an emergency scene or person(s) with 9-1-1 call takers.

Yet video calling in domestic settings is not without its challenges. Calls amongst family/friends are sometimes hard to maintain because of connectivity issues or user difficulty in operating the interface [3,33]. We also know that not everyone is comfortable being on camera because of how they might look [11,19,39], which sometimes brings into question whether both parties need to share their video view [11]. The 'camera work' needed to orient a mobile phone to show the scene or another person can be difficult [27,30,37,47]. This can make it hard for the remote person to see what they want to see, thereby often wanting more control over the remote camera [30,32]. Privacy concerns exist for bystanders in a public setting who are caught in a video stream unexpectedly or undesirably [40,46,50]. This relates to autonomy—one's ability to participate in a video call at their discretion and according to their own terms

[11]. Similarly, people are often concerned about strangers seeing their video screen during a video call [42], thereby breeching their confidentiality [11]. Our work explores how such issues around privacy and camera work might appear for 9-1-1 video calls if they were in existence.

We have also seen the novel design of video calling technologies. Researchers have investigated ways of linking together video views from multiple cameras [18,40] or using 360-degree video cameras to provide greater control over one's viewpoint for the remote user [53]. Multiple viewpoints, such as a first person and third person views of the environment, can be valuable for the remote person to see simultaneously or to choose from selectively [40]. Our research builds on this work to present ideas around the ways in which 9-1-1 video calls should be designed, which leverages some of these concepts to aid camera work.

STUDY METHODOLOGY
We conducted a study of 9-1-1 call centres to understand call taker and dispatch work practices, the potential benefits of video calling for 9-1-1, and the challenges that 9-1-1 video calls might create. The study was approved by our research ethics board.

Participants Demographics
We contacted 9-1-1 organizations within Western Canada and established ties with three that represented diversity in terms of the types of regions and services covered, ranging from small rural areas to larger urban centres and varying degrees of services where some supported all of police, fire, and ambulance calls, and others did not.

Call Centre 1: The first call centre covered a large rural area of a province with a collection of small cities and towns. The region had a population of approximately 130,000 people and handled calls for fires and acted as a dispatch centre for communication and location tracking with/of peace officers (akin to a rural police officer). Typically two call takers/dispatchers were on at all times. Calls for ambulance were transferred to a nearby metropolitan city. Calls for police were transferred to call centres in the particular jurisdiction of the caller. Our participants comprised of three people from Call Centre 1: two call takers/dispatchers and one operations superintendent who also handled calls/dispatches.

Call Centre 2: The second centre covered a medium-sized city with a population of approximately 100,000 people plus adjacent communities and rural areas. Typically, six call takers/dispatchers were on at all times. Calls for police were transferred to a police call centre, while calls for ambulance and fire were taken and dispatched within the centre. Our participants were seven people from Call Centre 2: six call takers/dispatchers and one assistant deputy chief who acted in a supervisory role, but who had also previously worked as a call taker/dispatcher.

Call Centre 3: The third centre covered a metropolitan city with approximately 1.4 million people. The centre handled calls for police, fire, and ambulance and approximately 60-80 staff were working at any one time given the size of the population the centre handled. Participants were eight call takers/dispatchers from Call Centre 3.

Across all three centres, we had seven participants who handled fire calls/dispatches, five who handled police calls/dispatches, four who handled fire and ambulance, and two who handled ambulance. In addition to these 18 participants, we conducted phone interviews with two people outside of these centres who were interested in participating in the study but who we could not visit in person due to time and cost. One was a supervisor at a another major metropolitan city's call centre, and the other was a retired public safety communications officer for a major metropolitan city. Thus, we studied the practices and thoughts of twenty participants in total, 17 female, 3 male. The large number of female participants reflected the high proportion of female workers at the call centres. Participant ages ranged from the early 20s to late 50s. Their experience working at the call centre varied from only a few months to over three decades. All participants were familiar with video calling technologies (e.g., Skype) and had used them before in their personal lives.

Participants in our study had between 8 and 12 weeks of training specific to call taking/dispatching. The time varied depending on the time period in which a person was hired and how training had evolved. Training focused on course work, job shadowing, practice call taking, and psychological tests to understand people's personality, ability to handle stress, etc. Course work included the card set of questions to ask during a 9-1-1 call, typing, and conversational skills to show empathy and control the call. Beyond this training, some call takers had previously been paramedics so they had additional knowledge and training.

Method
We spent between 7 and 10 hours at each of the call centres where we observed work practices, listened in on calls and conducted *in situ* interviews. Call takers answered the calls while dispatchers monitored the incoming call needs through a CAD system and used a radio system to dispatch the appropriate responder. Sometimes a call taker performed both call taking and dispatch operations. Other times a person was dedicated to one or the other job. The majority of our interviews occurred sporadically throughout our observations; at times there were lulls between calls of 15-20 minutes, which facilitated our *in situ* interviews. Nine interviews were conducted in private rooms away from the call taker's desk in order to ask more in-depth questions without the distraction of incoming calls. During our observations, we watched and listened to how call takers and dispatchers worked, what software and hardware systems they used, how they organized their work and work area, how they maintained situation awareness and what they asked callers during calls. Our interview questions focused on two main areas.

1. We were interested in understanding work practices in terms of what was done during calls and why. We probed participants with questions about the same areas that our observations focused on. We also asked about the challenges that were faced with different types of calls, and if and how the job caused stress or anxiety.

2. We probed specifically about future technology usage where we asked questions about the possibility of using video calling for 9-1-1 calls. We asked participants about the benefits they thought that video calls might bring, the disadvantages of video calls, what kinds of camera views they felt would be best/worst, where they would want to see a video call in their existing software, 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, "In the call you just took, how might video have been used if it were available? Would it have benefitted the call? Why or why not? Would it have created any problems with the call?" We also asked them to tell us about a time when a 9-1-1 call went especially well, and one where it did not go well, and, in both cases, what effect video might have had if it was a video call.

Data Collection and Analysis
We audio-recorded or kept detailed notes of all interview portions of our study and, with permission, captured photos of the first two call centres for analysis of work setups. We sketched drawings of the third call centre for analysis purposes. All interview data was transcribed and then open, axial, and selective coding were used to analyze the data and draw out main themes. Open codes described the specific benefits and challenges of video calling along with the various work practices being performed. For example, codes included "see location" and "see assailant" as ways video was felt to be valuable. Axial codes grouped open codes into categories, such as "see contextual information," "privacy concerns", "situation awareness," etc. During our selective coding stage, we saw main themes emerge around video calling providing contextual information of a situation, video calling supporting demonstrations, stress challenges with video calls, and privacy concerns with camera views, autonomy, and sharing. Following our analysis stage, we shared our research findings with our main contact at each call centre to receive feedback.

We now describe our main themes. Participant quotes are listed with a P# showing who gave the quote. In order to preserve additional anonymity, we do not list which call centre each participant was from when quoting participants.

CONTEXTUAL INFORMATION OF A SITUATION
Call taking begins with asking what service the caller requires—fire, police, or ambulance—and then asking for the caller's name, phone number, and location for re-contact in case the call is dropped. Next, call takers are required to ask a sequence of questions about the caller and their situation. This is a standardized process based on a set of "emergency response cards" designed and refined by medical experts since 1978 [28]. Presently, the questions from the card set appear within a CAD system on a display in front of the call takers. Information is entered and stored textually in the CAD system and can been seen by call dispatchers and emergency responders or police services. Despite the systematic process used to acquire these details, information is not always clear, complete, or easily acquired from callers. Video calling was seen by most participants as a means to acquire more contextual information about the call situation. Contextual information fell into several categories, described next.

Caller Uncertainty or Inability to Describe a Situation
First, callers are often in a state of panic when they call in. Many participants talked about such calls and we observed them as well. In cases where a person was having a difficult time describing a situation because of stress, emotional distress, or injury, participants felt that being able to see the situation for themselves on a video call would be highly beneficial. Participants wanted to be able to see both a first person view of the scene as well as a third person view of the caller in order to provide them with as much information about the call as possible. Our participants also thought that, because of their training, they might notice things in a video feed that the caller would not notice or think to comment on. For example, if a caller used a first person view to show an injured person, small changes to a person's facial expression could indicate signs of a stroke, yet callers may focus on other symptoms when describing the person. If a caller was injured herself because of domestic abuse, for example, a third person view of the caller could fully show the extent of any injuries to the face.

Because usually callers are very frantic, it's hard to understand what's going on. If they're not able to relay that information, it might be helpful to have a video. – P9

Participants also found that callers were not always the best at describing situations. For example, they might not be good at describing the size of fires or the size of trauma to a person's body. Some callers had difficulties in describing particular colors or shapes of objects, for example, in the case of potentially harmful substances or the size of weapons. Participants also described challenges with getting accurate descriptions of assailants from callers. In all of these cases, participants felt that being able to see a video of the person, object, or scene would help them dispatch the appropriate personnel to handle the situation.

If I come to one caller and I said to what size or area is burning and she said well I don't know, I'm not really good at estimating…if we were Skyping with somebody, they could've turned and said there's the fire. – P3

In situations involving assailants, video recordings and still images (rather than live video) were thought to be more valuable in case the assailant had already left the scene.

Situations Where People Cannot Speak

In some cases, callers were unable to effectively communicate orally in English, the language used by call takers in our study. For example, callers might be young children, deaf, slipping in and out of consciousness, or unable to speak clearly for other reasons such as accents. Participants thought that video calling in these kinds of situations could allow the caller to show the call taker the scene so they could assess it on their own.

As bad as it would be, I would prefer to see it, see what the child's seeing, and be better able to help them, 'cause a lot of times it's just, "Mommy won't wake up." I could see there being benefits especially with a child call taker. – P15

Sometimes a lot of language issues….Accents…I had one earlier today where he said it was a homeless person and they found a cash machine inside a cart, so I'm assuming it's a shopping cart…He's like, "No, it's not a shopping cart. It's a cart." And I didn't know what he meant… As it turned out, it was a baby cart. It was a baby stroller. – P16

Some participants talked about situations where callers could not speak because of security risks. For example, one participant talked about a person calling from within a 7-Eleven convenience store while a suspicious individual was present. The caller had to try to describe the situation using simple 'yes' or 'no' answers to the call taker. However, she felt that showing a video of the scene may have provided more information in a shorter period of time, such as a view of the potential assailant. In this situation, it may have been safe to show a video of the scene within the 7-Eleven, however, more generally, callers may need to be careful in terms of how they use a camera during a video call, such that they do not aggravate the situation by having a person of interest know that they are being captured in a video call. There is also the risk of assailants hearing audio from the call, especially if the caller has to hold a phone outward to capture video of the scene.

Scene Size-Up and Detecting Hazards

Participants felt that seeing a video call could help 'size-up' the scene to know the severity of the situation and determine if there were any hazards that first responders should know about. For example, if a person is injured from a gunshot and requires ambulance services, it is important for first responders to know if the assailant is still present and could potentially harm the responder when they arrive. A video call might capture them in the background. In other situations, a call may be about a single person being injured, but there may be others injured close-by. This happened frequently in calls about multi-car accidents. Call takers felt they could look at a video feed and see additional information about the scene beyond just the single caller's needs. It could also help to triage calls.

We could see any hazards that may be involved. It may be up against a telephone pole or a power pole. Could be close to a house. Some kind of, so there are advantages to it. – P3

In all of these cases, the value that video calling would bring could easily be hampered by the caller's ability to perform the necessary camera work to show the pertinent information. For example, to notice information in the background of a video feed, the caller would need to be showing a wide field of view of the scene, rather than close-up video of a person or object.

Location Information

Landline telephones provided call takers with the precise location of the caller. However, mobile phones were problematic as their location was based on cell tower triangulation. This meant that the accuracy of location detection varied between several meters and up to a half kilometer. This was especially problematic if buildings surrounded the location and responders could not see the caller when they arrived at the suggested location. Some of our participants answered calls within the city that they lived and so they felt that their personal knowledge of what places looked like could help them determine a caller's specific location by looking at the background of a video call, if the person was outdoors. In cases where they did not know the area, they felt that visual landmarks (e.g., a McDonald's restaurant) in the background could help them more precisely determine location, as long as the location was not too generic (e.g., in a field).

If you did see something you could be like, oh, it's in front of Joel's Burgers. And then [the paramedics] will know where Joel's Burgers is. Or you can do a quick Google search, "Joel's Burgers [city]". – P8

Location information was even valuable within buildings. The background of a video could help first responders know the caller's specific location. For example, one participant talked about frequently receiving calls from elderly adults who had fallen in their bathroom.

Information Inaccuracies

Our participants told us that not all callers told the truth when they called. They found this out throughout the call as more information became apparent. At times the call taker would place the caller on 'mute hold' while they performed short snippets of work, such as talking to a dispatcher. The caller was told this, but did not always realize that the call taker could still hear the call when they were on hold. Call takers used this opportunity to perform their work but also to listen in to see if they heard anything else while the caller thought they were not being listened to. For example, participants talked about hearing other people in the background that might suggest a slightly different sequence of events than the caller was explaining. In some cases, callers tried to hide what happened to them if the situation involved breaking the law (e.g., dealing drugs).

Call inaccuracies were said to be quite common in cases of domestic abuse as the caller often did not want to describe how they actually became injured (e.g., by a partner hitting them). Participants felt that video calls could be one way to get truthful information about a situation, as they might be

able to see 'what actually happened.' In the case of domestic abuse, this might mean seeing bruises in areas not described by the caller, or seeing a partner present.

When it comes to domestics, sometimes they're not very truthful with us...I get the feeling that a lot of them are injured but they don't want their spouse, or boyfriend, or whoever to get in as much trouble as they're already in. It would be nice to see them. To see if there is any physical injuries at all. That would help. - P18

Naturally, these situations presuppose that callers would have video turned on during a video call and not trying to hide certain aspects of the scene on camera. One could imagine that people might try to 'turn off' the video in a 9-1-1 call akin to how one can mute video in a Skype call. People could also use camera views to show what they want while hiding pertinent information.

Sometimes information inaccuracies were not intentional, but stemmed from a lack of clear understanding of the situation by the caller, e.g., not knowing for sure if someone was breathing. Naturally, video calls could similarly create incorrect information, for example, if a person appears to be breathing in the video when they are actually not.

Evidence
Lastly, participants talked about the importance of video calls as recorded evidence. Under federal law, this would be mandatory if video calls were to be implemented for 9-1-1 services in Canada. Call takers described such video recordings as being important for court cases after an incident occurred. Two participants were concerned that with the need to record all videos would also come the need for large video archives, which could operationally become challenging to store and search through. There is also the potential that knowledge of recording of 9-1-1 video calls may present a barrier for people wanting to use them given the possible legal ramifications.

DEMONSTRATIONS AND INSTRUCTIONS
Once a call taker has asked the required questions to understand a situation, the CAD system tells them instructions to read verbatim to the caller so they can help the situation. In cases involving an injury, this might include, for example, applying pressure to an area to slow down bleeding. Many participants felt that video calls could help in these situations. First, video might allow call takers to *show* how to do something. Showing a visual demonstration could also help in cases where the caller was hearing impaired and did not understand verbal instructions.

For me, if they could see me, if I was demonstrating proper CPR [Cardiopulmonary Resuscitation] instructions, or how to help somebody who's choking, like do the Heimlich properly? If I could demonstrate that on video, that's helping somebody right. – P13

Several participants felt that it would be hard to demonstrate an act over a video call because it might be hard to repeat the method the same way for each call, or to show one's whole body when demonstrating. An arguably more efficient method described by some participants was to show a short pre-recorded video clip on the phone.

Maybe I have a 10 second video clip of somebody doing CPR, or a cartoon stick figure doing CPR. Like, here's where you place your hands, here's where you do this...If I could then basically say, "I'm gonna tell you how to do the CPR. Look on your phone. I'm gonna send you a 20 second video. Listen to my instructions."– P14

Pre-recorded video of demonstrations was seen as a means to provide a consistent set of instructions, to circumvent potential liability issues if improper instructions were given.

Second, video calls were seen as a possible means to monitor if and how the person was following the instructions, and whether they were doing it correctly. The downside was that many of the demonstrations required a caller to use both of their hands to perform an action. This would make it extremely challenging to perform the necessary camera work during a video call to still hold their phone while show the call taker what was happening.

If you're on a video call and then you have to talk someone through CPR, that's fantastic, but when they're doing CPR, typically they put in on speaker, they put the phone down, because you need both hands. – P11

Some participants felt that certain actions could be difficult to see if a caller was doing it correctly given the complexity of acts such as CPR.

CHALLENGES WITH EMERGENCY VIDEO CALLING
Despite the likely benefits of 9-1-1 video calling, our participants talked about challenges that they felt they would face with emergency calls if they were video-based.

Controlling the Call
First, we learned that call taking involves a carefully controlled sequence of questioning to lead call takers to an understanding of the situation that is detailed enough to dispatch first responders. Some participants felt that this sequencing could be disrupted if calls contained a video component. There was concern that video calls may require a careful sequencing of what to show over the video link, in addition to audio sequencing. Video sequencing could require specific camera work by the caller in order to show what is being asked. If a caller was already in distress, the act of trying to show the right camera angle or viewpoint could be additionally challenging. This could be in addition to calming a caller down enough to get a verbal description.

I mean dispatchers, call evaluators are taught as part of their training, the first thing you do is take control of the call. You don't let the caller ramble. You have specific questions. You manage the call. – P2

Call takers are trained in techniques to calm callers down. This typically involves repeating instructions to the caller multiple times until they listen. Participants also told us that sometimes giving callers a specific task to do helps them to

focus and calm themselves. Such techniques might similarly be applied to the specifics of camera work..

Liability and Training
Second, many participants were concerned about liability issues that might be associated with seeing video calls, as well as their knowledge and training. The problem was that they felt their job role would move from being purely information takers—following a prescribed set of questions in order to understand a situation—to workers who had to assess a scene themselves and make inferences based on what was being shown. There were questions around what would happen if they did not understand an injury correctly, misunderstood a location based on what they saw, etc. and this negatively affected the response the caller received. Participants were also concerned about potentially needing to evaluate a caller's performance over a video link at possibly life-saving methods such as CPR.

I take it our role is to take information from the public, to go through it so we can get a police officer there. Our role is also to make sure we get the police officer there safely and home safely, and three, to enhance an investigation, not to impact an investigation. We're not investigators, but we certainly ask questions that later come up in court. - P1

Participants raised the concern that they would need to deal with two types of information—what the caller was telling them and what they saw—and they could be pointing to different problems or assessments of the situation.

Someone tells you something and then you see something else going on, and then you change what they're saying. You go based on what you're looking at, and then we're now liable. – P11

Several participants talked about the need to have a new protocol put in place that would determine if and how call takers would respond to what they saw in a video call, or how video could be used throughout the call. This would be similar in nature to the sequence of questions that call takers are required to ask when a call comes in.

Distraction and Information Overload
Call takers had five computer displays placed in front of them in a single row and all were generally full with information and software, with little screen real estate to spare. Visible software included the CAD system, one or two full-screen maps, radio dispatch software, email, and a web browser. Participants did not want to have to switch what was visible on the screen—all information had to remain static so it was easy to find and process, as well as enter new call information. There were questions and concerns of where a video call might appear, since all displays were currently used. Despite the limitations of their current display setup in terms of a lack of screen real estate, all participants said that a video call would need to appear 'front and centre' or close to it.

Yet many participants saw the addition of more information in front of them as a challenge. They already dealt with a

large volume of information simultaneously and in very short order and there were concerns about distraction, information overload, and the cognitive processing of information if video calls were prevalent and visible.

Because we're just bound by information gathering and our job is to get the call going and then we have a huge amount of checks we have to do. We're multitasking, we're listening to the caller, we're watching the call, we're searching different screens to find as much information out about the offender or the person calling that we need to. It almost adds one more thing that we have to do. - P17

Participants were concerned that seeing visuals of the event via a video link would cause them to become distracted from the gathering of pertinent information because not everything they saw on the video call might be relevant. This contrasted the targeted questions they asked orally, which typically helped gather information quickly if the caller was answering the questions in a controlled manner.

...how much technology are we going to put in front of our dispatchers, expect them to process in a reasonable amount of time in order to initiate a response? – P2

I guess it would be something that we certainly have to get used to but that was just my first thought, was distractibility and getting the key information that we need right away and not being distracted by a video. – P17

Seeing Challenging Scenes
Many participants had concerns that a video call would force them to see a potentially challenging or difficult situation that they would normally not see with audio calls. There was a feeling that such exposure could create cases of workplace stress or post-traumatic stress disorder.

My operators take a lot of really ugly stuff. We have quite a bit of PTSD type symptoms in the group. Time off work for mental health issues and medical issues. – P1

For me, I might find it hard to see the caller's face, and to see their expression of anxiety. It's different on the phone when you're not associated with that caller. For me, if it was something that was serious they were calling about, or even for themselves, it would stick to my brain more. – P5

Some participants compared their job role to that of a paramedic who would be at the scene and handling the situation in person. They felt that paramedics were trained to see 'bad' situations, but they were not. On the other hand, many felt that if a call taker had emergency response training, such as was the case with paramedics, it could be easier to handle seeing a difficult scene during a video call. They also felt that paramedics had a warning as to what they were about to experience (e.g., scene information from the CAD system). Call takers have no idea what to expect when a call first comes in.

Because the medics know what they're going into. They can be like, there's a hanging. I know what I'm walking into,

this is… if it pops up on the screen and there is a body right there, that's what fucks with you really. – P8

Sexual Harassment
Some participants talked about the possible risk of video calls being exploited by callers for sexual purposes, such as callers showing their private parts. Another participant talked about pedophiles who already call in as a means of achieving sexual gratification.

We have some that unfortunately get off on calling to tell you that they've breached their conditions of parole... and they say that they're a pedophile….And they're actually taking enjoyment of your reaction to that. So that would be a call that I would not want to see. - P16

Generally speaking, participants felt that as a result of potentially challenging scenes being shown on a video call or the possibility of sexual harassment, that video should be considered secondary in nature. Audio could act as the primary communication mode for handling calls and video could augment it periodically, possibly being turned on and off at the discretion of the call taker.

I think that shouldn't be video all the time. I think that there should be certain times when video is allowed. I don't think it should be for the entire call. I don't think it should be for every call…it should be in certain circumstances. – P13

Selectively available video raised questions with participants over when and how its playability could be accessed. Some felt that it should be turned on and off by the call taker at their will. Others wanted to simply be able to minimize it. In either case, this raises questions about what the caller would know about if and when the call taker was actually seeing the video feed.

Sharing Video Call Information
Much like prior research [4,35,45] situation awareness was a critical component of work practices in the call centres we visited. It was gathered by overhearing other call takers while on the phone where they would sometimes repeat information aloud. Other times, co-workers would talk between calls or while the caller was on mute hold. In addition, situation awareness was gathered visually. Two centres displayed information about the most recent incoming calls on large television displays hanging on the wall such that all call takers and dispatchers could easily see them. Employees could also see textual information about a call within the CAD system. Gathering situation awareness from video calls raised two main issues.

First, if a call taker gathered information visually from a video call, it would not likely be said aloud for others to hear. The call taker would still need to verbalize what they saw in the video in order for others to overhear what was going on. Second, some participants felt that it could be valuable to see video calls from other call takers on the large wall displays. Yet the public display of video calls raised privacy concerns. Many participants were, again, concerned about seeing scenes that bothered them. Because

the display would be public, people could not adjust what was seen based on individual preferences. Instead, all call takers would be forced to see the same thing.

Lastly, some participants talked about the technical challenges with sharing video call information between their CAD system and other centres if calls needed to be transferred. All centres would need to have video calling enabled or the ability to share and store video call data. There were also questions around if and how video call information might be shared with those responding to a scene, e.g., police, fire fighters, paramedics. Those traveling to a scene are sometimes going at fast speeds and do not have a lot of time to process information. For example, textual data appears on a screen within an ambulance and must be read by a co-pilot who is also watching the street for driving hazards. Suggestions included the sharing of images or video clips, rather than long videos or live calls.

I wouldn't say [to share it] live just because when you put your crews going there, on top of driving, they're reading and they're trying to get ready for whether they've got to get drugs ready. They already have so much going on that maybe I would only say that if the crew requested a little clip or picture or something. – P15

VIDEO VIEWS OF CALL TAKERS
We talked with our participants about whether they would want to have themselves visible in the video call so callers could see them. However, this was strongly seen as being undesirable. First, call takers must manage many things at the same time when a call comes in. Their viewpoint changes between the CAD system where they enter notes to the map where they look-up location to sometimes a dispatch screen that shows where various units are located. Sometimes call takers are talking to each other while the caller is on mute hold. If video of the call taker was shown, callers would see a call taker who was not focused on 'just them', despite the perception that this was the case.

For a caller to see that we're distracted and we're doing a million things at once would not instill a lot of confidence in them, I don't think. Unless we could do like, you've seen that we mute. Unless we could like, pause our video. – P9

Second, many call takers had strong feelings about their identity staying anonymous. They did not want people to know they were a 9-1-1 call taker because they felt there was a chance of harm if a person saw them in public, e.g., if situations had gone poorly during a call, or an assailant somehow knew they had had handled a call about them.

It's like, you just took a call from a bad guy and he got arrested because you sent the police and you don't want him to come after you. – P13

Third, call takers typically worked 12-hour shifts, sometimes through the night if they were on the night shift. Several participants felt they did not 'look their best' as a result so they did not want to show themselves to the caller.

Our job isn't to be smiling and look friendly. We're not a face of emergency services. They're the face. It's true. We have a face for radio, not for TV. Sometimes at 3:00 in the morning, yeah. That's true. – P8

Many call takers described their job as involving two components: information connection and empathy. They said they needed to collect information from the caller in order to quickly get emergency responders to them, and, in they also needed to reassure the caller that help was on the way and everything would end up okay. We probed if sharing the view of their own face on the video call might help them calm the caller down and show a degree of empathy; however, again, this was not seen as a positive. The benefit this might provide the caller was not seen as superseding the issues, as described above, with showing the caller their face. Instead, they felt that their voice was already well trained to provide empathy and a sense of support and connection to the caller.

Our voices have a calming effect as well. I think that we're trained to have control of the call but also be a calming voice when someone's upset. - P17

Other participants clearly drew a line in their job as being one of just collecting information. For these participants, there would be no need to show their face to the caller.

DISCUSSION AND CONCLUSIONS

We now outline the implications of our results for the design and use of future 9-1-1 video calling systems. Our results point to a number of possible benefits that call takers and dispatchers could receive from video calls, ground in the current challenges they face when handling audio 9-1-1 calls. However, the complexities of what happens in 9-1-1 call centres means that the current design paradigm for video communication technologies, found in commercial video chat software (e.g., Skype, FaceTime), will not suffice for addressing the real needs of emergency calls and call taker/dispatcher work practices. The design of 9-1-1 video calling systems is a complicated endeavor with many competing needs and challenging socio-technical circumstances.

Controlling the Call

9-1-1 video calling is largely about *control* and a level of control that has not been seen before in any of the literature around video chat or mobile video calling (e.g., [3,13,14,31,33]). Of vital importance is that call takers be able to take control of the emergency call, even if it is a video call, and acquire information in a specific order and manner that reflects the need to acquire pertinent information while balancing situations in the stressful and challenging environment that is an emergency call centre. This relates to existing protocols and 'card' question sets [28] and suggests that new protocols and sequencing be created to prescribe what information should be shown and in what order over a video call, as well as how call takers should act on that information in order to ensure the best care while limiting liability issues.

Yet control is also about much more than just that. It is about when and how video is used, including who has access to whom, and how, where, and when visual information is presented to call takers. Being confronted visually by a caller can create a sense of moral accountability, which can be challenging in situations when a person wants to maintain some social distance. Our participants had many concerns when it came to their own autonomy—being able to choose what they saw on video, when they saw it, and whether or not their own video would appear. In particular, calls may be challenging or undesirable to see despite the potential value for assessing scenes and gaining additional contextual information. What this means is that call takers should be given the ability to choose when to view calls, based on their discretion. Video calls should be considered secondary in nature, where they augment an audio call and not replace it. It may not always be the case that a person knows when they should be viewing a call ahead of time, though. Live video may also be difficult to fully utilize and, in some cases, our results pointed to the value in still images or video clips as opposed to streaming video live. In many cases, still images could be faster to capture and share and easier for call takers to understand.

Together, these findings point to a different way of thinking about video calling than conventional video chat where rather than simply seeing a live stream of video, the notion of what *is* a video call may vary between live one-way video, live two-way video, video accompanied by still images, or an audio call that involves images or video clips. Being able to fluidly move between different visual modalities as part of the video call becomes critical as the visual needs of the call taker may change. Callers and call takers would require interfaces that made it easy to transition between these different visual modalities. Video blurring techniques could be used to help call takers transition into and out of live video, especially if they are not sure if they want to see what is being shown. Similar solutions have been proposed for office settings for balancing privacy and awareness [12,25,38]. Across all of these ideas, it would be pertinent to be able to go 'back in time' and replay the video call in whatever visual form is needed in case a call taker did not realize that they needed to see the call using a different modality than they had chosen at the time.

There are also questions around when and how a caller should know if the call taker is looking at their video or using different visual modalities. The caller may be showing critical information and thinking the call taker sees it when actually they may not. This raises open design questions and suggests studies of callers to learn about their needs and reactions to such varied forms of video calls.

Camera Work

Control of a 9-1-1 video call is also about the specific *camera work* that is needed to capture and achieve control

of the information being presented. The use of video during a 9-1-1 call relies on the ability of the caller to provide the necessary camera views so that call takers are able to understand and acquire needed information. Such 'camera work' is a known challenge with mobile video calling [30,37,42], yet in typical domestic situations where a video call might be connecting family or friends, the specifics of what is needed to be shown are far less critical than video footage during a 9-1-1 call. This suggests critical design implications for aiding callers in performing camera work.

One way to do this might be to display on-screen instructions on a video call, including the possible use of augmented reality. Such on-screen additions could allow callers to know what they should capture and how it should be captured. Yet even with such instructions, there is a chance that video could be captured quickly and it could be difficult for the call taker to see and process it. Past research on remote troubleshooting has shown that additional visual information can sometimes make troubleshooting more challenging [23,43]. It can also change the nature of conversations and make them less efficient [23,43]. These points and our findings, again, suggest the need for a range of visual options as a part of 9-1-1 video calls. For example, small video clips or images could be automatically captured at various points in the video call, and possibly mapped to the information being shown (e.g., person, place, problem). There might also be challenges in getting the call taker to remain calm enough to capture the requested video footage, though the delegation of subtasks around camera work could help to calm them. This maps to participants' responses that said call takers were generally calmer when given a set of tasks to do.

Callers may need easy mechanisms to be able to surreptitiously stream video of an assailant if a crime was in progress, such that they do not create additional risk for themselves. For example, they would need a means to know what they were showing on video to the call taker without necessarily having to look at a viewfinder, which could easily 'give away' the fact that they are streaming the person via a video call. A simple solution might involve the call taker being able to relay verbal instructions over the audio channel such as, 'move the camera left'. Video calling software could also detect people or objects in the scene using computer vision and automatically generate oral instructions for camera movement.

An alternative means to acquire information could be to simply give control of the camera to the call taker where the caller is instructed to hold their phone in front of them at arm's length. The call taker could then be given access to all cameras available on the device (e.g., both front and rear facing cameras) and be able to pan, tilt, or zoom within these images. This would shift the camera work to a call taker who could be more familiar with video calls and cast an 'expert gaze' on the situation. In the future, mobile phones will likely contain 360º cameras, which would make

remote camera work more easily possible as a call taker would then have a 360º view of the remote area [53].

While it could be beneficial for the call taker to have control of the camera, this could infringe on the caller's autonomy to choose what they share with the caller. This raises questions around what rights the caller might have to report information or not, in particular if it is self-incriminating. These questions would have to be addressed by policy. In addition, further study of the needs of callers would be of benefit.

Conclusion
We believe that this work sets the scene for a rich research agenda. Of course, this study has its limitations. Currently many 9-1-1 centres in Canada use the same card set for answering calls and assessing information. Thus, despite the fact that we studied call centres in only one province of Canada, it is likely that our findings around 9-1-1 work practices would be similar to other call centres in Canada. Given that we have not studied emergency call centres in other countries, it is unknown if our results generalize to them. However, our results on call taking procedures were similar to studies reported in other Western countries, including the United States and the UK [4,35,45,56]. This suggests that work practices may be similar, though reactions to video calling and individual preferences may differ across the world.

Our work was specifically scoped to focus on the experiences of call takers and dispatchers, given the depth needed to understand this perspective. Yet this does mean that we do not have data from actual callers that might show what their specific needs would be for video calls and what privacy concerns they might have. This suggests future studies aimed at a broad spectrum of callers, with varying backgrounds and experiences. Future research should also explore the interactional exchanges between callers and call takers in more detail. A deeper comparison to remote troubleshooting work would also hold value.

What we see as the key benefit of our work is the opening up of the design space around future emergency calls and call handling. While organizations continue to move to new solutions for emergency calls in Canada and others countries, it is not the case that there is a narrow set of possibilities for such technologies. In fact, the design space is rich with possibilities *and* potential problems that will need to be addressed. We have looked at one specific angle and there are many more, including the specific needs of callers and first responders who receive the information dispatched by call centres. There is also much work to be done on exploring the design of video calling solutions and testing out the ideas that may stem from our research.

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