Supporting Callers' Needs in Crisis: Designing the Next Generation of 9-1-1 for Medical Emergencies

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Abstract

Since its introduction, the 9-1-1 emergency call system has served as a critical lifeline for individuals in urgent crises. However, the traditional audio-only model has limitations in supporting effective communication between callers and call takers. In this paper, we present a mixed-methods study—including a survey, interviews, and participatory design workshops—to examine the challenges and unmet needs of callers during medical emergencies, as well as their visions for the next generation of 9-1-1 communication. Our findings highlight key pain points, including difficulties in conveying precise location and contextual information, language and cultural barriers, a lack of transparency regarding dispatch, and challenges in providing medical history when calling on behalf of others. The study also revealed design opportunities, such as multimodal communication, AI-assisted triage and translation, mobile applications for frequent ambulance riders, and features that prioritize both informational clarity and emotional support. We conclude by discussing the design implications of these findings.

CCS Concepts

• **Human-centered computing → Collaborative and social computing devices**; **Empirical studies in collaborative and social computing**.

Keywords

9-1-1 call, medical emergency, user experience, participatory design

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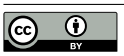

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1 Introduction

Since its introduction in the late 1960s in North America, the 9-1-1 emergency call system has served as the critical first point of contact for individuals in need of urgent medical, police, or fire assistance [67]. Typically, when an individual witnesses or experiences an emergency, they dial 9-1-1 to connect with a call center, where a trained call taker asks a series of protocol-driven questions, evaluates the situation, and decides the appropriate level of emergency response (e.g., dispatching first responders and ambulances) [20, 35]. Traditionally relying on audio-only communication, the system has remained largely unchanged for decades, even as multimedia communication has become standard in everyday life [54]. These limitations of the current 9-1-1 infrastructure often cause communication breakdowns between callers and call takers, hindering the rapid exchange of accurate information [59, 66].

In recent years, policymakers have called for the transition to a "next generation 9-1-1 system" that supports multimedia communication [45, 46]. In particular, video calling has received particular attention in recent HCI research [10, 11, 47, 48, 59]. Prior work has demonstrated that video can help callers better describe or illustrate the emergency situations they face [51, 59] and, on the other hand, allow call takers and first responders to better understand and assess the severity and context of emergencies, and make timely and appropriate decision on the types of support needed [10, 11, 47, 48, 48]. However, despite this growing body of work, most studies to date have primarily focused on the design and user perceptions of video calls alone. There remains a lack of comprehensive research examining the broader challenges of the 9-1-1 call experience and exploring alternative technological approaches beyond video calls.

This paper addresses this gap through a mixed-methods study that integrates surveys, interviews, and participatory design (PD) workshops. Focusing on medical emergencies—among the most time-sensitive and physically and emotionally challenging contexts where clear communication can directly affect patient outcomes—we investigated the following three research questions: RQ 1) What major challenges are faced by callers who have previously called 9-1-1 for medical emergency reasons? RQ 2) What are callers' preferences and visions for new technologies to enhance the 9-1-1

experience? and RQ 3) What concerns and socio-technical considerations must be addressed to ensure wide adoption of these technologies?

In this paper, we report the most essential design insights that emerged from our studies. In particular, our findings highlight key pain points such as difficulties in conveying precise location and contextual information, language and cultural barriers, a lack of transparency regarding dispatch, and challenges in providing medical history when calling on behalf of others. The study also revealed design opportunities, including multimodal communication (video, text, and audio), AI-assisted triage and real-time translation, caregiver-integrated mobile applications for "frequent ambulance riders", and features that prioritize both informational clarity and emotional support (e.g., making the dispatch process more transparent and reassuring for callers while they wait for help to arrive). Our work makes three main contributions to the HCI field: (1) Identifies the major challenges faced by callers during medical emergencies; (2) Explores design opportunities for the next generation of 9-1-1 systems that extend beyond video calls; and (3) Highlights socio-technical considerations that may arise when adopting advanced technologies in emergency 9-1-1 calls.

2 Related Work

2.1 Challenges in Communication and Coordination during 9-1-1 Calls

Supporting communication and coordination in time-critical, high-stakes settings has long been a central focus in HCI research (e.g., [4, 26, 28, 41, 57, 62, 69, 73]). Within this large body of work, emergency call and dispatch centers have received particular attention (e.g., [10, 27, 40, 74, 75]). Studies in this domain have primarily focused on understanding the challenges faced by call takers and the role of technology in supporting—or failing to support—their work. One common issue is the ambiguity or incompleteness of information provided by callers. For example, Forslund et al. [20] found that callers often struggle to articulate key details about the emergency, leading to gaps that make effective triage and dispatch decision-making difficult. Another well-documented challenge is linguistic barriers, which can prevent critical information from being communicated clearly [37, 51]. In these situations, call takers often rely on ad hoc strategies or translation services, both of which can introduce significant delays in emergency response. Beyond informational and linguistic challenges, call takers also face emotional distress and workload pressures. Because they are frequently exposed to traumatic content while working under intense time constraints, call takers are at risk of stress, burnout, and even compassion fatigue [58]. This emotional burden affects not only their well-being but also the quality and consistency of the support they provide to callers. Collectively, these challenges are exacerbated by the limitations of current communication technologies (e.g., voice-only phones), which constrain effective information exchange between callers and call takers.

While much research has focused on call takers, callers themselves also face considerable barriers when engaging with the 9-1-1 system. For many, the first primary challenge lies in describing the emergency clearly and accurately. Under stress, callers may omit important details, misjudge the severity of the incidents, or fail to provide relevant information [37]. Language is another significant barrier. For instance, Ong et al. [51] conducted a qualitative study with limited English proficiency (LEP) adults and found that language difficulties, negative perceptions of emergency service providers, cost concerns, and lack of familiarity with protocols often deterred individuals from calling 9-1-1. Even when LEP callers did make contact, the fear of being misunderstood could create hesitation and slow down the exchange of vital information [19, 65]. In addition, cultural and socioeconomic factors play a role in shaping caller behavior. Prior work has shown that individuals from disadvantaged neighborhoods are often less likely to report emergencies due to mistrust of authorities, fear of legal repercussions, or concerns about financial burden [3, 21, 44, 70]. These barriers mean that the populations most in need of emergency assistance may also face the greatest difficulties in accessing it effectively. Despite this body of research, the perspectives of callers themselves—particularly in medical emergencies—remain underexplored. To address this gap, our study adopts a mixed-methods approach to develop a comprehensive understanding of callers' challenges and to explore design opportunities for addressing them.

2.2 Emerging Technologies for Supporting 9-1-1 Calls

In response to the reported challenges in literature, researchers have investigated how emerging technologies might improve caller–call taker interaction. One major body of work has focused on integrating video capabilities into the 9-1-1 system. Steen-Tveit et al. [61] investigated the use of live video in Norwegian command and control centers and found that it enhanced situational awareness in multi-agency operations, particularly during ambiguous incidents. However, they also noted that the benefits of video must be weighed against the increased manual workload it introduces, which can cause delays in time-sensitive scenarios. Neustaedter et al. [47] conducted ethnographic studies at Canadian call centers and found that while video calling offers valuable situational awareness, it also introduces concerns around privacy, liability, and disruptions to existing workflows. Their findings suggest that future systems must support multiple visual modalities and provide call takers with control over when and how video is used. In later studies [10, 11], they developed a multimedia-enabled 9-1-1 prototype for call takers. Based on situational needs, the system allowed call takers to control interactive features, such as enabling video sharing. Through evaluations, they found that while call taker-controlled video interfaces improved information accuracy and supported situational awareness [11], they also introduced usability challenges for callers, such as confusion from loss of interface control [10]. From the caller's perspective, one study [59] interviewed 17 prior callers and found that video could help convey emergencies more effectively—by allowing them to "show rather than tell" their situations, enabling dispatchers to make more accurate assessments of severity. However, participants expressed concerns about consent, anonymity, and discomfort with being recorded. These studies emphasize that video calling for emergencies is not simply an extension of everyday video communication but requires new design paradigms tailored to high-stress contexts and caller needs.

A few studies have also examined the technical implementation specifics for video-based and multimedia-enabled 9-1-1 systems. Transitioning toward such advanced systems requires extensive infrastructure and system-level changes, such as integrating diverse communication channels into dispatch workflows [36], enabling information sharing across emergency response teams [25, 29, 48], incorporating multimedia displays into the systems already used in call centers [10, 47], while enhancing the accuracy of cell phone location data detection [12, 71], and leveraging IP-based network hubs to enable combined audio–video calls [36].

Taken together, this body of work has largely centered on video-based 9-1-1 communication and the design of camerawork to balance the needs of callers and call takers. However, little research has examined how a broader range of technologies—beyond video communication—could better support callers during urgent and emotionally stressful moments. Moreover, few studies have employed user-centered approaches to explore how diverse emergency communication features should be designed, adapted, and integrated into the 9-1-1 system from the caller's perspective. Our study addresses these gaps by foregrounding the experiences and design visions of callers themselves.

3 Methods

In this work, we used a mixed-methods approach consisting of surveys, semi-structured interviews, and participatory design (PD) workshops to investigate user requirements for the next generation of the 9-1-1 system. These three studies were designed to be sequential and integrative, with earlier phases informing follow-up studies. More specifically, we first conducted a web-based survey and follow-up interviews to gain a holistic understanding of callers' experiences, challenges, and unmet needs when calling 9-1-1 for medical emergencies, as well as the new technologies they would like to see integrated into the system. Building on the insights from these studies, we then conducted a series of PD workshops to generate design concepts for the future 9-1-1 call system and to elicit potential user concerns and socio-technical considerations surrounding the adoption of new technologies. This study was approved by the Institutional Review Board (IRB) of the first author's university.

3.1 Data Collection

3.1.1 Survey. We began our study with a web-based survey created and deployed using Qualtrics. Participants were recruited through Prolific and Amazon Mechanical Turk, two widely used platforms for survey recruitment. To be eligible for taking the survey, the potential respondents must be older than 21 years old, have the cognitive ability to sign the consent form, and have called 9-1-1 previously in the United States for medical emergency reasons. We used screening questions to determine the eligibility of potential respondents. In total, 253 individuals completed our survey, and their characteristics are summarized in Table 1. In brief, most of the participants were male (166/253, 65.6%), White (195/253, 77%), aged between 25 and 34 years (117/253, 46%), had a bachelor's or higher degree (213/253, 84.18%), and self-reported having above medium health literacy (154/253, 60.8%) and technology proficiency (172/253, 68%).

Informed by prior work [59], the survey was developed in an iterative manner by the researchers and pilot-tested with a small group of people (n=20) to ensure the clarity and appropriateness of the questions. In the survey, we emphasized assessing three areas: (1) participants' sociodemographic characteristics, (2) participants' experiences with the 9-1-1 call system during the encounter of a medical emergency, and (3) participants' preferences on the technology that could be used to enhance the 9-1-1 system. Some of the questions can be found in Table 2. Participants' characteristics collected included age, gender, race/ethnicity, language spoken, education, health literacy (assessed using a validated single-item screener) [7, 8], and technology proficiency (measured via participants' self-rated comfort with smartphones, web, and mobile applications). Participants' experiences included the circumstances under which they called 9-1-1, the critical nature of the medical emergency, the effectiveness of their communication with the 9-1-1 call taker, and the challenges they encountered. To assess participants' preferences for enhancing the 9-1-1 call system, we asked them to indicate which new features they would like to see added and whether they had privacy concerns about those features. These feature ideas were informed by prior literature [11, 22, 51, 59] and were iteratively developed by the authors in collaboration with subject matter experts (e.g., emergency response experts).

We directed participants to answer survey questions based on their most recent experience of calling 9-1-1 during the encounter of medical emergencies. Toward the end of the survey, we invited them to participate in a follow-up interview study. Potential participants were instructed to email researchers to arrange a suitable time for the interview. The survey took about 10 minutes to complete, and the respondents received US $2 after they completed the survey.

3.1.2 Semi-structured Interviews. To gain an in-depth understanding of callers' challenges and unmet needs, following the survey, we conducted semi-structured interviews with 12 individuals who had prior experience calling 9-1-1 for medical emergencies. Of these, five had participated in the earlier survey, while seven were newly recruited through social media. The interviews were conducted via Zoom by two trained researchers and lasted between 30 minutes and one hour. To protect participants' privacy and avoid triggering traumatic memories, participants were asked to briefly describe their past experiences calling 9-1-1 without disclosing medical details. We then probed with follow-up questions about the challenges they faced, their perceptions of communication with call takers, their informational needs, and other unmet needs during the call. In particular, participants were invited to share their thoughts on how the 9-1-1 call experience could be improved and whether emerging or existing technologies might help achieve that goal. After the interviews, all participants received a US $30 gift card as compensation.

3.1.3 Participatory Design (PD) Workshops. PD is a user-centered design approach that actively involves end-users in the design process to co-create technology solutions that align with their needs, values, and expectations [43]. We conducted five PD workshops with a total of 12 participants. The inclusion criteria for participation are the same as for the survey and interviews. Although we aimed to recruit three participants per workshop, several experienced last-minute scheduling conflicts, resulting in groups of two or

Table 1: Characteristics of Survey Participants (N=253)

Participant Characteristics	Participants, n(%)	Participant Characteristics	Participants, n(%)
Age (years)		**Health Literacy**	
18-24	7 (2.8%)	Low	0 (0.0%)
25-34	117 (46.2%)	Low to Medium	7 (2.8%)
35-44	81 (32.0%)	Medium	92 (36.4%)
45-54	28 (11.1%)	Medium to High	108 (42.6%)
55-64	15 (5.9%)	High	46 (18.2%)
65 or older	5 (2.0%)	**Technology Proficiency**	
Gender		Low	1 (0.4%)
Male	166 (65.6%)	Low to Medium	10 (4.0%)
Female	87 (34.4%)	Medium	70 (27.6%)
Race/Ethnicity		Medium to High	110 (43.5%)
Asian or Pacific Islander	21 (8.3%)	High	62 (24.5%)
Black/African American	11 (4.3%)	**English Fluency**	
Hispanic/Latino	14 (5.5%)	Very fluent	222 (87.7%)
American Indian/Native American	11 (4.3%)	Somewhat fluent	29 (11.5%)
White/Caucasian	195 (77.2%)	Not too fluent	1 (0.4%)
Other	1 (0.4%)	Not fluent at all	1 (0.4%)
Education Background		**Language Spoken**	
High school degree or equivalent	29 (11.5%)	English	246 (97.2%)
Associate degree	10 (4.0%)	Other	7 (2.8%)
Bachelor's degree	162 (64.0%)		
Master's degree	47 (18.5%)		
Doctorate degree	3 (1.2%)		
Other	2 (0.8%)		

three participants. Among the 12, three had also participated in our earlier survey and interview studies. Their continued involvement allowed them to build on their prior reflections and provide continuity across study phases, offering particularly informed perspectives on whether the challenges and expectations they previously articulated were addressed by the proposed design concepts. Three workshops were conducted online as the participants were located in different places. Each workshop lasted approximately two hours and was roughly structured into four activities: (1) storytelling, (2) storyboard critique, (3) individual design, and (4) group design. All workshop discussions were audio-recorded. Each participant received a US $40 gift card as compensation.

In the storytelling session, participants shared their previous experiences with calling 9-1-1. To maintain a safe and respectful environment, participants were advised not to disclose personal or sensitive information, as they were part of a group setting and may not know other participants. Next, in the storyboard critique activity, we presented four technology concepts—video calling, location sharing, real-time translation, and ambulance tracking—as design probes for discussion. These concepts were informed by insights from our earlier survey and interview studies (e.g., challenges in calling 9-1-1 and desired technology features to enhance the system) and reflect directions highlighted in prior HCI and emergency communication literature as promising yet underexplored in the 9-1-1 context [11, 22, 51, 59]. Participants were asked to reflect on each technology concept, considering the problems it aimed to solve as well as its potential benefits and limitations. These reflections were discussed using the Rose, Thorn, Bud framework, through which participants identified positive aspects (Rose), challenges or concerns (Thorn), and opportunities for improvement (Bud) (Figure 1A). Participants also ranked each feature on a three-point scale: "Very Useful", "Good to Have, but Not Necessary", and "Not Useful at All". Rather than evaluating these as fixed solutions, the probes were intended to elicit reflection on broader design principles—such as transparency, accessibility, and flexibility—that could inform new ideas. For example, while discussing ways to improve location sharing, participants proposed adding a text-based communication channel to make the system more accessible for certain populations and to extend communication beyond a single modality, envisioning a more adaptive 9-1-1 infrastructure. Participants were also encouraged to suggest any other technology features they believed could improve the 9-1-1 experience.

In the individual design phase, each participant was invited to create rough sketches or mockups for both the presented features and any new ideas they had (Figure 1B). After completing their designs, participants shared them with the group and explained their design rationale. Finally, in the group design session, participants collaborated to synthesize their ideas and create one or more collective designs that reflected their shared values and preferences. Each group was encouraged to co-develop at least one design solution, but they were also welcome to propose multiple features if desired (Figures 1C and 1D). Participants of the online workshops were asked to either use a digital tool or draw on paper and then send their drawings to the researchers.

Table 2: Survey Respondents' Experiences and Needs with Calling 9-1-1 for Medical Emergency (Note: participants can select more than one option for those questions with an asterisk (*))

9-1-1 Call Experiences and Encountered Challenges	Participants, n(%)
Who was the medical emergency call for?	
Yourself	185 (73.1%)
Someone else	68 (26.9%)
How critical was the situation?	
Very critical	67 (26.5%)
Somewhat critical	169 (66.8%)
Not critical	17 (6.7%)
How would you rate the communication quality with the call taker?	
Excellent	76 (30.0%)
Good	147 (58.1%)
Fair	25 (9.9%)
Poor	4 (1.6%)
Terrible	1 (0.4%)
How much time did the call taker take to understand your situation?	
Understood and found the solution right away	160 (63.2%)
Took some time to understand and find a solution	90 (35.6%)
Took too long to understand the address the emergency	3 (1.2%)
What challenges did you encounter during the 9-1-1 phone call?*	
Difficulty in verbally explaining the emergency situation	78 (28.8%)
Difficulty in describing the location of the emergency	81 (29.9%)
Language barrier	45 (16.6%)
The call taker did not understand the emergency situation	41 (15.1%)
It took too long for help to arrive	34 (12.5%)
Incorrect ambulance services for the emergency situation arrived	14 (5.2%)
I experienced no challenges	74 (27.3%)
Other	0 (0.0%)
What new features would you like to see added to the 9-1-1 calling experience?*	
Video Calling (video chat with the 9-1-1 call taker)	92 (24.1%)
Text Chat (text chat with the 9-1-1 call taker in case you are not able to speak)	131 (34.4%)
Location Sharing (automatically share your exact location with the 9-1-1 call taker)	178 (46.7%)
Real-time Translation (convert audio or text to preferred language)	69 (18.1%)
View estimated time of arrival (ETA) of ambulance	77 (20.2%)
No changes	6 (1.6%)
Which new feature could trigger privacy concerns?*	
Video Calling	82 (27.4%)
Text Chat	96 (32.1%)
Location Sharing	117 (39.1%)
Real-time Translation	57 (19.1%)
View estimated time arrival (ETA) of ambulance	27 (9.0%)
Are you open to using a mobile application dedicated to calling 9-1-1?	
Yes	235 (92.9%)
No	18 (7.1%)

3.2 Data Analysis

For the survey data, we first used descriptive statistics to summarize participants' responses to each question, such as the number of participants who selected each option. Additionally, to examine how different participant characteristics and experiences influenced their perceptions of 9-1-1 technology features, we conducted a series of bivariate statistical analyses. Relationships between variables were analyzed using Chi-square tests or Fisher's Exact tests, as appropriate, with a significance threshold set at $\alpha = 0.05$. These tests were used to determine whether statistically significant associations existed between demographic or contextual variables (e.g., English fluency, health literacy, prior experiences) and outcomes such as perceived communication quality or preferences for new 9-1-1 features.

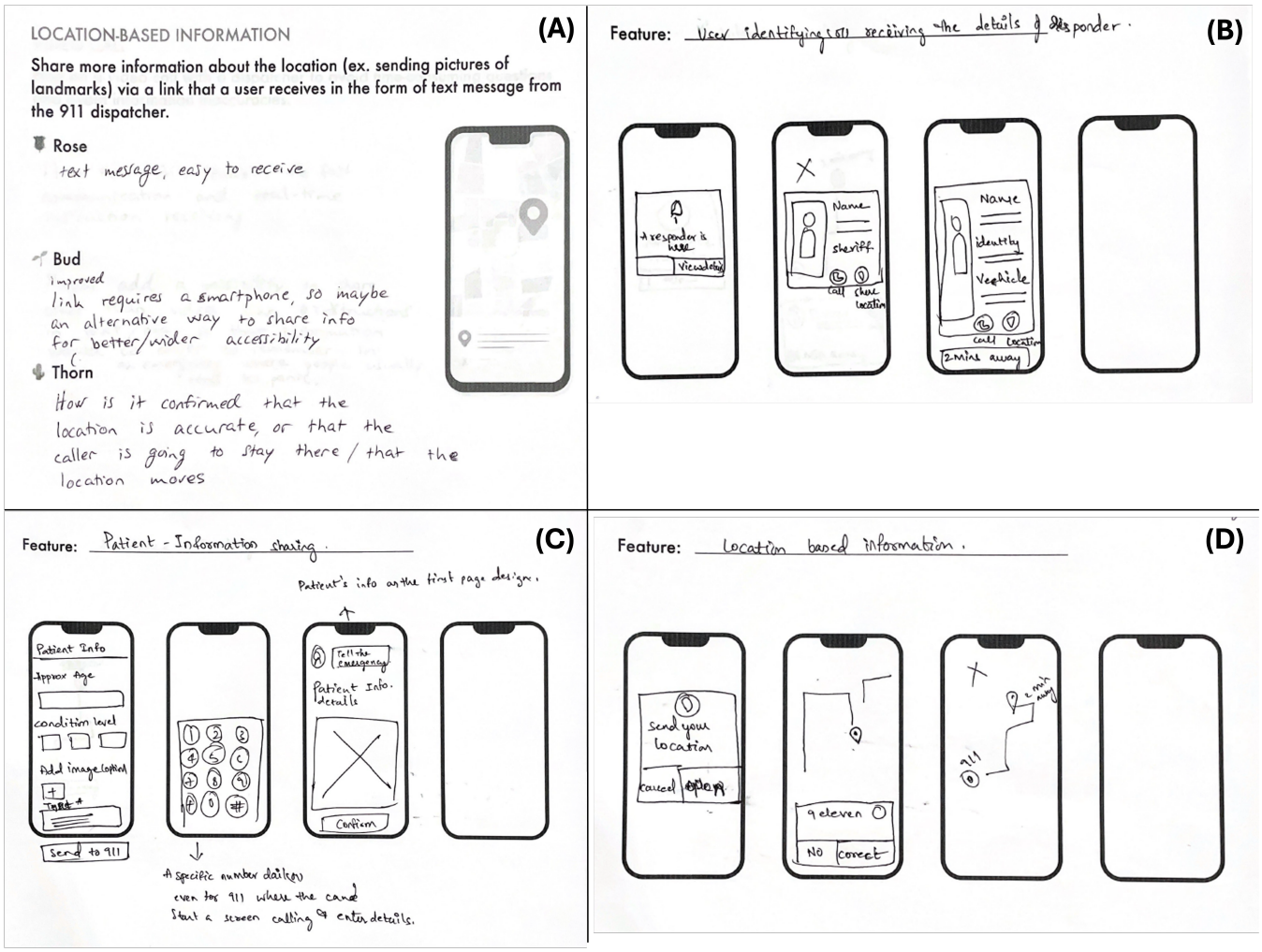

Figure 1: Example of design artifacts created during PD workshops. (A) Participants used the Rose, Thorn, Bud framework to evaluate the proposed location-sharing feature, identifying positive aspects (Rose), concerns (Thorn), and areas for improvement (Bud). (B) In the individual design phase, a participant sketched an interface to help callers identify and receive details about the dispatched units (e.g., an ambulance). (C) In one group design session, participants worked together to sketch a concept for sharing patient information with 9-1-1 using a mobile application. (D) Another example of group design shows a sketched idea for improved location-based information sharing, including a feature that allows callers to confirm and correct their current location.

We conducted a descriptive, codebook-based thematic analysis to identify patterns across the interview and workshop data. Rather than adopting a fully interpretive, reflexive approach, our goal was to capture surface-level themes that reflected participants' articulated challenges, needs, and perceptions. This analytic stance aligns with established guidance on structured thematic analysis [5, 23]. To that end, we first immersed ourselves in the data by reviewing all transcripts to develop an overall understanding of the context. Next, transcripts were imported into NVivo (QSR International), a qualitative data analysis software, to support systematic coding and organization. Following established guidance for structured thematic analysis [5, 23], two researchers independently reviewed a small subset of transcripts (two interview transcripts and one workshop transcript) and generated initial codes. Through iterative discussion, we developed a shared codebook that included code definitions and example excerpts. To assess inter-rater reliability, both researchers then independently coded an additional subset of transcripts using the developed codebook. The level of agreement between coders was evaluated using Cohen's kappa coefficient [9]. Upon achieving substantial agreement, the two researchers proceeded to code the remaining transcripts independently. Any new codes that emerged during this process were added to the codebook. Discrepancies in coding were discussed and resolved during weekly

group meetings with the full research team. Once coding was complete, the final codes were organized into higher-level categories to identify overarching themes.

It is worth noting that during analysis, quantitative and qualitative data were synthesized to develop the final themes. Quantitative patterns (e.g., frequency of caller challenges) provided a descriptive overview of how common particular issues were across the sample. Qualitative interviews and workshop discussions then offered explanatory depth, illustrating why these challenges occurred and how participants envisioned addressing them through design. For example, survey findings about callers' uncertainty during long wait times were contextualized by interview accounts describing emotional distress and by workshop feedback emphasizing the value of real-time status updates. Integrating these datasets enabled triangulation across study phases and strengthened the robustness of the reported themes.

4 Results

In this section, we report the major design insights that emerged through all three studies. For each design insight, we detail the specific challenges it seeks to address, the design ideas discussed by participants, and the associated user concerns and design considerations. We include participants' quotes where appropriate, using I# to denote interview participants and PD# to denote PD workshop participants. A summary of these findings is presented in Table 3.

4.1 Overcoming Difficulty and Uncertainty in Communicating Caller Location

4.1.1 Challenges and Caller Needs. A major recurring theme across the survey, interviews, and PD workshops was the challenge of clearly and accurately conveying the caller's location during a medical emergency. Survey data revealed that nearly 30% of participants encountered difficulty communicating their location, making it the most frequently encountered challenge compared to other issues (see Table 2, under the question *"What challenges did you encounter during the 9-1-1 phone call?"*). While the current 9-1-1 system can approximate a caller's location using GPS, participants noted that this information is too imprecise to be relied upon exclusively, especially in unfamiliar environments (e.g., public spaces); for example, cell phone locations are often triangulated through cell towers and can be inaccurate by up to half a kilometer [49, 63]. As one participant explained: *"When I called, the first thing they asked was, 'Where are you located? What are the cross streets?' But I had just moved to New York City, and I didn't really know the area well. I could see the name of one street from the subway station, but when they asked for the other cross street, I had to really look around to figure it out. In an emergency, that felt overwhelming."* [PD#4]

Additionally, the location details required to dispatch emergency responders (e.g., ambulances) are often more complex than raw GPS coordinates [10, 59]. For instance, if a caller is at a large venue or in an outdoor environment, GPS may provide a rough location but fail to specify the exact section or place (e.g., "near the red bridge on the east trail") where assistance is needed. Due to these issues, many participants expressed concern that responders might not be able to locate them in a timely manner: *"I actually had somebody at my apartment go stand outside and wait. It's just that the subdivision I live in is hard to describe, and it's difficult to explain how to get to where I am living. So I had somebody standing outside to make sure they found it as quickly as possible."* [I#1]

Precise location sharing was consistently identified as the most critical and widely desired feature across our study. Nearly 47% of survey respondents (see Table 2, under the question *"What new features would you like to see added to the 9-1-1 calling experience?"*) and all PD workshop participants (12 out of 12) rated location sharing as a necessary and highly beneficial feature. This finding highlights the central role of location accuracy in emergency response, making it the top-priority feature over all other proposed/discussed ideas.

4.1.2 Design Ideas. To properly design the desired location-sharing feature, participants in the PD workshops were prompted to brainstorm ways to improve the process of communicating a caller's location to 9-1-1 call takers—particularly in situations where basic GPS detection may fall short. One solution that emerged from these discussions focused on sending a text message to the caller's phone, which would contain a link enabling them to share additional location information with call takers after the call (Figure 1D). In addition to confirming or adjusting their GPS location, callers would have the option to upload images of nearby landmarks—such as storefronts, street signs, intersections, or building facades—to help call takers more accurately verify their surroundings, especially when spoken descriptions are difficult or unreliable: *"Sometimes just dropping a pin isn't enough, like if you're in a huge apartment complex or a park. It would be really helpful if I could just snap a photo of a nearby sign or building and send it through a text link. That way, the dispatcher knows exactly what I'm seeing and where I am."* [PD#1]

Participants also highlighted the benefits of using text messaging as a medium for sharing more detailed information about the caller's location. They noted that text messaging is nearly universally supported across mobile devices and that almost everyone is familiar with this mode of communication. Additionally, unlike voice calls, which may drop or become unintelligible due to poor reception, text messages provide a stable, asynchronous channel for communication. This method was seen as technically feasible, user-friendly, and inclusive, especially for individuals who may be hard of hearing or simply unable to speak clearly: *"Sometimes it's just easier to type it out. A text message works on any phone, and if I'm panicking or the call drops, at least they still get my location. Plus, for someone who can't speak well, it's a lifesaver."* [PD#8]

4.1.3 User Concerns, Design Considerations, and Suggestions. While participants generally considered location sharing via text messaging as a viable and valuable feature, user concerns were raised about its practicality across different emergency scenarios. For example, tasks such as taking and sending photos of nearby landmarks were seen as potentially too complex for users who are not digitally savvy, posing a barrier to effective use: *"I think it's a great idea, but not everyone knows how to take a picture and send it, especially older folks. My mom wouldn't even know where to start, she doesn't use smartphones like we do."* [PD#12] In addition, participants emphasized that in high-stress or physically incapacitating situations, even simple phone interactions could become difficult or impossible. For example, holding a phone steady to take a photo may not be feasible for callers who are injured, panicked, or otherwise

Table 3: Summary of Major Design Themes, Challenges to Address, Design Ideas, and User Concerns

Major Design Themes	Current Challenges	Proposed Design Ideas	User Concerns
Overcoming difficulty and uncertainty in communicating caller location	Callers often struggle to describe their exact location, especially outdoors or in unfamiliar areas	Enable sharing of precise location information (e.g., photos of landmarks) via a text-link sent by call takers	Difficult for callers in high-stress or incapacitating situations; Potential privacy concerns
Visual communication for shared understanding of emergencies	Voice-only calls limit callers' ability to convey injuries or scene details	Enable real-time video with call taker–controlled camerawork and visual prompts for guidance	Privacy concerns; Network instability; Difficulty framing the correct camera view
Reassuring callers through transparency and feedback during responder dispatch	Uncertainty about ambulance arrival causes anxiety while waiting for responders	Provide real-time ambulance updates (e.g., ETA); Enable limited two-way messaging between callers and dispatched responders for status updates	Few concerns beyond cybersecurity and data protection
Bridging language barriers in high-stakes communication	Language barriers delay or distort critical information exchange	Use AI to detect spoken language and provide real-time transcription/translation with both languages displayed for verification	Concerns about accuracy, especially for medical terms or dialects
Supporting callers with ongoing or dependent care needs	Frequent 9-1-1 callers or caregivers struggle to convey complete medical histories under stress	Offer a dedicated mobile app to preload health data and emergency contacts; Include a large one-tap "SOS" button and automatic caregiver notification	Usability challenges for older adults and users with limited digital literacy
Expanding communication modalities through text-based chat	Voice communication may be unsafe or impractical in certain situations or for some populations	Add text messaging as an alternative mode, with pre-defined message templates for faster interaction	Typing may be slow and error-prone during emergencies; Risk of misuse or incomplete message
Leveraging AI for call screening and triage	High volumes or duplicate calls during large-scale incidents can overwhelm call takers	Use AI to detect, group, and prioritize calls by urgency or location	Requires call taker oversight to prevent misclassification and ensure accountability

unable to use their device effectively: *"If someone's hurt or panicking, they might not be able to even unlock their phone, let alone take a picture. In that moment, you just want help, you don't have time to figure things out."* [PD#12] Finally, although not raised during interviews or PD workshops, it is noteworthy that nearly 39% of survey respondents reported that location sharing could trigger privacy concerns—making it the top-ranked feature most likely to raise such concerns (see Table 2, under the question *"Which new feature could trigger privacy concerns?"*).

4.2 Making Emergencies Visible: Visual Communication for Shared Understanding of the Context

4.2.1 Challenges and Caller Needs. Another recurring theme across all data sources was the difficulty callers face in accurately describing emergencies (e.g., injury location and severity). Interview participants frequently mentioned that solely relying on verbal explanations was often challenging and inefficient. Survey data supported this finding, with 28.8% of respondents reporting difficulty verbally explaining the emergency—making it the second most frequently encountered challenge—while 15.1% indicated that the call taker did not understand the situation (see Table 2, under the question *"What challenges did you encounter during the 9-1-1 phone call?"*). By examining the association between callers' demographics (e.g., age, health literacy, education) and the challenges they faced, our analysis using Fisher's Exact test revealed that callers with lower

self-rated health literacy levels were more likely to experience difficulty verbally explaining the medical emergency they encountered ($p = 0.028$).

During both interviews and PD workshops, participants expressed strong support for incorporating video calling into the 9-1-1 system, highlighting its potential to facilitate the communication of contextual information with call takers. Specifically, 10 out of 12 workshop participants described this feature as "very useful", while the remaining two rated it as "good to have". They envisioned scenarios in which live video could be used not only to show the condition of the patient or the surrounding environment but also to receive guided instructions from call takers for life-saving interventions: *"I think that definitely could be helpful. So that you could maybe actually show the operator the situation that's happening, and then they can see and better guide you during CPR, or you know, tell you what to do if they can see it. I think that would be very helpful in a lot of situations."* [I#1] Additionally, several participants noted that being able to see a calm call taker through video could make them feel less alone and less stressed: *"A voice is helpful, but a face makes you feel supported. It's like, okay, I'm not doing this by myself."* [I#3] Such reflections reveal the dual value of video: while it primarily enhances informational clarity, it also fosters a sense of presence and empathy between callers and call takers.

4.2.2 Design Ideas. Several compelling ideas for designing the video call feature were discussed during the workshops. For example, to better support callers who face technological challenges or are unable to switch to video calls, participants suggested giving call takers the ability to remotely activate a caller's phone camera. This functionality would relieve callers of the burden of navigating different functionalities during moments of distress. However, participants emphasized that such a feature must respect user autonomy. They highlighted the importance of clear, user-friendly prompts requesting consent and the inclusion of options for callers to decline, pause, or end the video stream at any time: *"If I'm stressed out, it would be a relief if the dispatcher could just take over...only if I say yes, of course. Sometimes even opening the camera feels like too much when everything's going wrong."* [PD#11]

4.2.3 User Concerns, Design Considerations, and Suggestions. Despite strong support for the video calling feature, participants voiced several practical concerns regarding its feasibility and appropriateness. A primary concern was network and data connectivity. Participants noted that in places like subways, basements, or rural areas, cellular reception may be weak or unavailable, and even with basic coverage, video calls can be unstable, bandwidth-intensive, and prone to disconnection. This raised doubts about whether call takers could reliably assess situations if the video stream was disrupted or of low clarity: *"I've been in places where I barely had one bar. There's no way a video call would've worked. If the dispatcher is depending on video to understand what's going on, and the call cuts out or freezes, that could actually make things worse."* [I#10] To address connectivity limitations, participants suggested enabling callers to capture and send short video clips via the same text links used for location sharing, giving them flexibility to share visual details after the call rather than struggling with unstable live streams.

Additionally, participants noted a practical challenge, that is, callers may struggle to provide the right camera angle or visual information, especially under stress or in noisy environments. To address this, they suggested overlaying simple, intuitive icons on the video interface (e.g., arrows for "move left/right" or zoom controls like "pan closer/zoom out"). These visual prompts would allow call takers to guide camerawork through visual cues, reducing reliance on verbal instructions that may be misheard or misinterpreted due to distorted audio or background noise: *"If the dispatcher could just put an arrow on my screen telling me to move the camera left or closer, that would be so much easier than trying to figure it out in all the noise. A picture prompt is faster than words when you're stressed."* [PD#3]

Finally, privacy also emerged as a concern—for example, whether video calls would be recorded or might inadvertently expose family members or private settings (e.g., evidence of drug use). Notably, 27.4% of respondents indicated that they were worried about privacy when using video calling (Table 2).

4.3 Reassuring Callers Through Transparency and Feedback During Ambulance Dispatching

4.3.1 Challenges and Caller Needs. One of the major sources of anxiety reported by participants during medical emergencies was the uncertainty surrounding ambulance arrival, which could add significant stress to an already high-pressure situation: *"I guess the number one concern at that moment is whether they're going to arrive in time. Every second matters."* [I#5] To mitigate this concern, participants envisioned features that would provide continuous updates after the initial call. The most frequently discussed solution was allowing callers to track dispatch status in real time, keeping them informed throughout the waiting period and helping to improve transparency while reducing uncertainty and anxiety: *"If the app or interface could allow people to interact with it in real time, just having something that shows the ambulance is on the way would mean a lot."* [I#5] This user preference was supported by survey data: 20.2% of respondents selected "View estimated time of arrival (ETA) of ambulance" as a top feature they would like to see integrated into the system. Additionally, all 12 workshop participants rated this feature as "very useful".

4.3.2 Design Ideas. As illustrated in Figure 1B, several workshop participants recommended that the tracking interface display not only the ETA information but also live traffic conditions and the remaining distance, to help set realistic expectations for arrival time: *"If I could see where the ambulance is, like how far away they are and if they're stuck in traffic, that would help a lot... because then you're not just sitting there wondering what's happening."* [PD#2] Beyond one-way updates, participants expressed interest in enabling limited two-way communication between callers and emergency responders during transit. For example, if a patient's condition worsened or their location changed, callers could use the interface to send quick updates to the ambulance team. This could help responders better prepare before arriving on the scene: *"Another feature that could be helpful is relaying information to the ambulance itself so that the ambulance comes prepared in real time."* [PD#7] Finally, some participants suggested an integrated system that would combine real-time tracking with other features—such as location

sharing—accessible through the same text message or link initially sent by the call taker: *"So, if I get a text with a link for them to see my location, maybe that same link can also show me the ambulance, like where they are. That way I don't have to open multiple things."* [PD#2]

4.3.3 User Concerns, Design Considerations, and Suggestions. Participants generally expressed little concern about the feature of real-time ambulance tracking, which was also reflected in the survey—only 9% of respondents indicated that this feature could raise privacy concerns (Table 2). However, one participant with a background in homeland security and cybersecurity worried that real-time tracking could expose ambulance vehicles to malicious attacks if not properly secured: *"There have been cities attacked by ransomware. If there were a way to track all the ambulances, it could be hacked. Those ambulances could be taken out or distracted. I'm very conscious of the risks."* [I#7]

4.4 Bridging Language Barriers in High-Stakes Communication

4.4.1 Challenges and Caller Needs. Language barriers pose a critical obstacle during emergency calls, especially for individuals with limited English proficiency (LEP). Even though the current 9-1-1 system offers language support by connecting callers with a translator, it often takes time for call takers to identify the caller's language and connect them with the appropriate interpreter. This limitation of current practice was also echoed by one of our interview participants: *"I wonder about the timing on that, particularly for languages that are maybe less common in the United States, you know, it can take like 15 minutes to get connected to an actual translator. So that would be my concern."* [I#6]

In our survey, 16.6% of respondents identified language barriers as a challenge they faced during their 9-1-1 interaction. Statistical analysis confirmed a significant association between English fluency and communication quality ($p < 0.05$), as well as between lower fluency and the likelihood of encountering language barriers ($p < 0.05$). Callers who were fluent in English were significantly more likely to report excellent or good communication with the call taker and were less likely to experience difficulties related to language. Participants in interviews and PD workshops further emphasized that language barriers can significantly hinder communication with call takers, potentially delaying urgent care. Several shared personal or family experiences, such as relying on children to interpret during emergencies. One participant recalled assisting her grandmother during a medical crisis: *"If my grandma had to call 9-1-1 by herself, she wouldn't be able to. She doesn't speak English. I ended up talking to them instead."* [I#6]

4.4.2 Design Ideas. To address the language barriers, participants across both interviews (5 out of 12 participants) and workshops (7 out of 12 participants) proposed integrating AI-powered real-time translation into the 9-1-1 system. Rather than relying solely on human translators—whose involvement can be delayed by the time it takes call takers to identify the caller's language—an AI system could automatically detect the spoken language and either connect with the appropriate translator or offer instant translation support: *"I've seen cases where the person calling can't explain what's happening because of language problems. It slows things down. If the dispatcher had a way to see and understand directly, maybe with translation, that would save time."* [I#5]

Another design idea involves overlaying both the original spoken words and translated text directly onto the screen during a video-based 9-1-1 call (Figure 2A). Displaying the caller's words alongside the translation allows users to verify accuracy, spot mistranslations, and clarify them before they affect the emergency response. This approach is especially valuable when callers speak regional dialects or less common language variants, where errors are more likely. For instance, a caller speaking a dialect of Chinese could quickly confirm whether the generated Chinese characters accurately represent what they just said. In this way, the system helps ensure that critical details are not lost in translation: *"It makes a lot of sense to use voice-to-text during a 9-1-1 call—especially if it can display what you're saying in your own language and convert it into English for the other side to see. If that translated text just shows up right on the screen, it would really help both people follow the conversation."* [PD#1]

4.4.3 User Concerns, Design Considerations, and Suggestions. Despite strong support for incorporating real-time AI translation into 9-1-1 systems, nearly all participants voiced the same concern—accuracy. In particular, they were concerned about the system's ability to accurately interpret medical terminology, slang, or dialect-specific expressions. Even minor translation errors were seen as potentially dangerous, with risks ranging from misidentifying symptoms to delaying dispatch or sending inappropriate emergency resources. One participant emphasized this risk: *"If the system misunderstands what I'm saying, that could delay the help or send the wrong response."* [I#10]

4.5 Supporting Callers with Ongoing or Dependent Care Needs

4.5.1 Challenges and Caller Needs. A recurring challenge highlighted by participants—particularly those calling 9-1-1 on behalf of someone else (about one-third of survey respondents reported doing so; see Table 2)—was the difficulty of providing accurate and complete medical history (e.g., chronic conditions or current medications) to call takers: *"I remember being nervous about the questions they were going to ask me about my grandma. There were a lot of questions about her medical history. And with the stress I was going through, I was not able to answer any of that."* [PD#12]

4.5.2 Design Ideas. To address these challenges, our participants envisioned a mobile application tailored for "frequent riders"—individuals who may need to call 9-1-1 more frequently than the general population due to age, disability, or chronic conditions. Survey data also reflected this need, with 92.9% of respondents expressing interest in using a dedicated mobile app for individuals who may require ambulance services frequently (see Table 2, under the question *"Are you open to using a mobile application dedicated to calling 9-1-1?"*). The envisioned mobile application would include a patient information repository containing key health records, medication lists, and emergency contacts (Figure 2B). When an emergency call is placed, this information could be automatically shared with call takers and subsequently relayed to dispatched responders, enabling faster and more appropriate delivery of emergency medical services: *"If there*

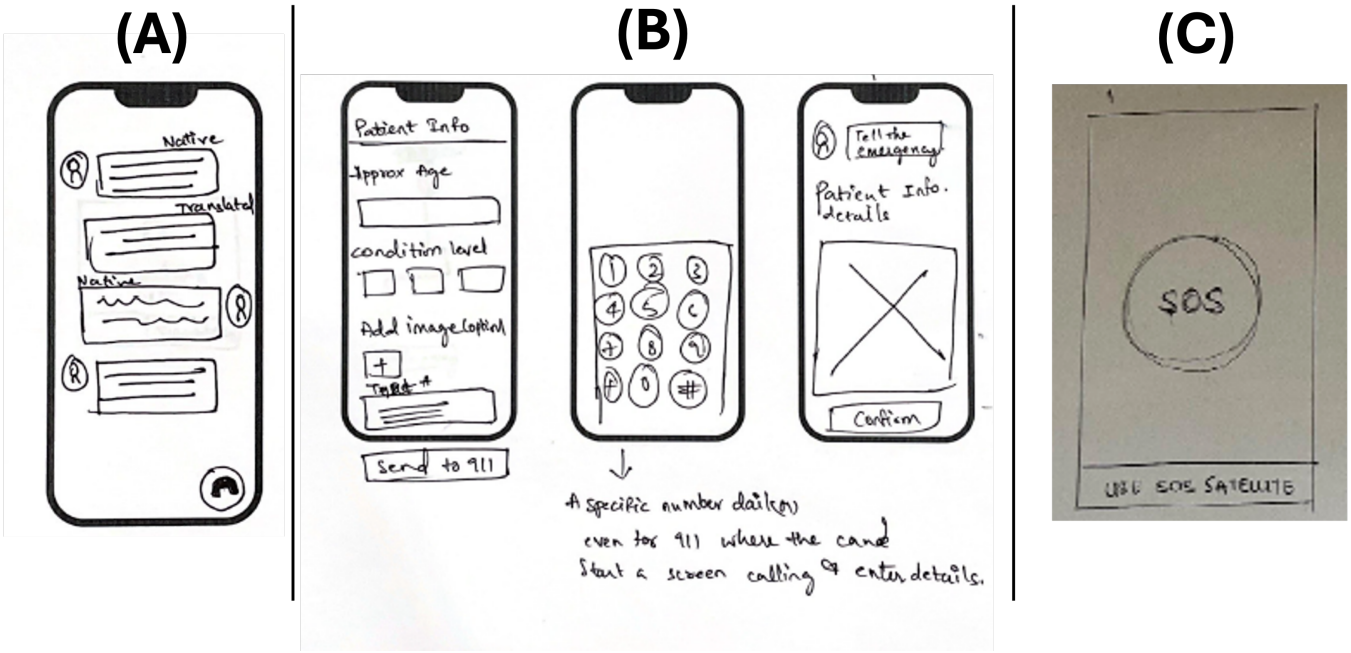

Figure 2: Participant-generated sketches illustrating design ideas. (A) A real-time translation overlay that transcribes and translates spoken language on the video feed during a video-based 9-1-1 call. (B) A form to pre-populate patient information (e.g., age, medical conditions, images) within the mobile application, which can then be shared with call takers once a call is initiated and relayed to responders dispatched to the scene. (C) A large, one-tap SOS button prominently displayed on the mobile application's landing page to enable rapid 9-1-1 call initiation.

were a way to proactively update or upload the person's health status, you wouldn't have to explain to the operator in a strained moment what all their health issues were. It's impossible to distill all that in a short time." [I#5]

Another highly recommended feature was an easily accessible "SOS" button on the application's landing page (Figure 2C). As one participant explained, this feature would allow users to call 9-1-1 with a single tap, without navigating menus or searching for options: *"I think there should just be a big red button right on the main screen, no menus, no scrolling. You open the app and boom, it's right there to call 9-1-1 instantly. In an emergency, you don't have time to think or search around."* [PD#4] Participants emphasized that it was not merely a convenience but a lifesaving necessity, since even minor delays caused by navigating an application during high-stress emergencies could have severe consequences.

Finally, participants suggested that the application support rapid notification of pre-designated emergency contacts whenever the SOS button is pressed. Family members or caregivers could receive immediate alerts via text or automated calls, informing them that the user has contacted 9-1-1. This functionality was seen as especially valuable for older adults living alone or users with limited mobility, where timely family involvement is critical: *"So, I would also like to add one more feature. So there could be a feature wherein all your friends and family who are located within a particular radius are notified when an emergency happens."* [PD#2]

4.5.3 User Concerns, Design Considerations, and Suggestions. While participants were generally enthusiastic about the idea of a dedicated mobile application for frequent 9-1-1 callers, they also voiced concerns about its usability and accessibility—particularly for the populations who would benefit most (e.g., older adults), who may not own smartphones or may lack the digital literacy needed to use such an application. Participants noted that entering and maintaining accurate medical information may require caregiver support, as older adults often rely on family members to manage digital tools. This highlights the need for the application to support caregiver involvement through a dual-user model, allowing both the user and their caregiver to access and manage the same account in different ways. For example, the caller-facing version could remain simple and streamlined, while the caregiver-facing version could provide advanced functions such as updating medical histories or setting up pre-designated emergency contacts: *"My mom wouldn't know how to use an app like that on her own, she still asks me how to turn on the flashlight. If there's a way for the family to help manage it without making it too complicated for her, that would be really helpful."* [PD#11]

4.6 Other Design Considerations: Expanding Communication Modalities and Intelligent Assistance

Participants also discussed other features that could help, including multimodal communication with text-based features and using artificial intelligence (AI) to screen and collect call information.

4.6.1 Multimodal Communication with Text-Based Features. Several participants emphasized the importance of integrating multiple communication modalities—especially text-based options—into the 9-1-1 system. This idea aligns with the survey responses, which indicated that the ability to communicate with 9-1-1 call takers via text was the second most preferred feature—selected by approximately 34.4% of respondents as a functionality they would like to see added to the 9-1-1 call system (Table 2). Participants noted that traditional voice calls do not meet the needs of all users or emergency contexts. In medical situations, for example, callers may be physically unable to speak, such as when experiencing severe respiratory distress. As one participant put it: *"There are situations where you literally can't talk. Imagine trying to speak while you're choking. Text could be a lifesaver."* [I#9] Beyond medical scenarios, participants also pointed to other situations where text-based communication with call takers would be beneficial—such as domestic violence or home intrusions, where speaking aloud could alert a perpetrator and escalate danger, or for individuals with speech or hearing impairments. For these populations, relying solely on verbal communication could either increase their risk or delay timely and effective access to emergency services.

While text-based communication offers essential accessibility, especially for individuals with speech impairments or in situations where speaking is unsafe, participants raised concerns about its efficiency in emergencies. They noted that typing can be significantly slower than speaking, particularly under physical or emotional duress. In such high-stress contexts, users may struggle to formulate coherent messages or make typing errors, leading to miscommunication or delays in receiving help. Additionally, participants worried that text-based 9-1-1 features could be misused or inefficient in practice—some individuals might abuse the system by sending inappropriate or non-urgent messages, while others might send abrupt or incomplete texts and fail to respond promptly, leaving call takers uncertain about the severity of the situation. This uncertainty could lead to unnecessary escalation or delays in dispatching the needed help: *"Texting could be helpful, but only if it's managed carefully. People might just send a quick 'help' and then go silent, and 9-1-1 folks have no idea how serious it is."* [PD#7]

4.6.2 Using AI to Screen and Prioritize Incoming Calls. As emergency call volumes rise—particularly during large-scale events such as natural disasters or mass casualty incidents—participants emphasized the importance of using AI to triage and manage incoming 9-1-1 calls more efficiently. For instance, multiple individuals may simultaneously report the same event, such as a flood, mass shooting, or building fire. In such situations, regional 9-1-1 call centers can quickly become overwhelmed by a large number of calls reporting the same incident or requesting help. AI-powered screening could detect similarities across incoming calls—based on location or event descriptions—and group them as referring to a single incident. AI systems could also categorize cases by urgency, identifying those requiring immediate intervention (e.g., cardiac arrest, active bleeding) and prioritizing them ahead of less critical cases. This capability would allow call takers and call centers to make quicker decisions, maintain situational awareness, allocate resources more efficiently, and avoid redundant dispatches to the same caller: *"When a major accident happens, everyone starts calling 9-1-1 at once. But it's the same incident. If there were a way to group those calls, the dispatcher wouldn't waste time or send too many ambulances to the same place."* [PD#6]

Participants also discussed key limitations and concerns regarding such AI-driven triage systems. They cautioned that misclassification or algorithmic errors could delay urgent responses or overlook atypical emergencies, especially when contextual cues are subtle. As one participant explained: *"I'd be nervous if AI decided what's urgent without a person double-checking it. Machines don't always pick up on context, like someone who sounds calm but is actually having a heart attack."* [PD#9] Several participants questioned how accountability would be ensured if an AI system made an incorrect judgment, emphasizing that such tools should support rather than replace human decision-making: *"If the AI makes a mistake, who's responsible? At the end of the day, a person should still be the one making the final call." [PD#8] Consistent with this view, participants underscored that AI triage systems must operate under the direct oversight of trained call takers, who can monitor flagged cases, validate AI assessments, and intervene when needed to ensure accuracy, fairness, and public trust in emergency response.*

5 Discussion

5.1 "Am I Being Helped?" Supporting Callers' Informational and Emotional Needs

Our study highlights the importance of designing 9-1-1 systems that not only facilitate efficient information exchange but also address callers' informational and emotional needs throughout the emergency response process. A common theme across participant feedback was the anxiety and uncertainty associated with the "black box" nature of current 9-1-1 systems. After making a call and providing initial details, callers are frequently left without any indication of what happens next—whether help (e.g., ambulance) is on the way and how long it might take to arrive. This lack of transparency can affect callers' experience, especially during emergencies where every minute feels critical. To mitigate this, participants advocated for systems that provide real-time status updates regarding ambulance dispatch, including ETA and any changes in the response status. This design insight aligns with findings from prior work [32], which emphasized the importance of procedural transparency in community safety platforms—users who received timely and informative updates about their reports felt more secure, supported, and engaged.

In addition to informational clarity, participants in our study also emphasized the emotional burden that often accompanies emergency situations. Callers experiencing traumatic or emergency events may exhibit what Whalen and Zimmerman [68] describe as "emotional pain". However, delivering emotional support is by no means easy. Participants noted that several design features could

play a crucial role in reducing caller anxiety and stress during emergencies. For instance, real-time updates about dispatched responders were particularly valued for their ability to create reassurance and reduce feelings of panic while waiting for help. Similarly, participants highlighted the importance of human connection during crises: even being able to see a calm and empathetic dispatcher through a brief video-based interaction could offer reassurance and a sense of presence that voice alone might not convey. At the same time, participants recognized that technology alone cannot replace human empathy. Call takers play a vital role in providing emotional stability during crises. Prior research suggests that clear, direct instructions and verbal reassurances can help calm distressed callers [53, 68], while techniques such as repetitive persistence and gentle redirection effectively help de-escalate emotional outbursts [18]. These insights underscore the need for training in empathetic and adaptive communication, ensuring that call takers can effectively integrate supportive technologies with compassionate and strategic interaction to deliver timely and reassuring assistance to emotionally overwhelmed 9-1-1 callers.

5.2 Multimodal Communication and Interaction between Callers and Call Takers

The traditional 9-1-1 system has long relied on audio-only communication between callers and call takers. However, our findings highlight a growing need to expand this modality to better accommodate the needs of diverse users and varied emergency contexts. Multimodal interaction—including video and text—was consistently described as a promising approach to making 9-1-1 systems more inclusive, accessible, and resilient [11]. More specifically, aligning with prior work [10, 47], video-based communication was seen as a valuable enhancement for conveying visual context, which could help call takers assess the situation more accurately and tailor emergency response accordingly. For example, real-time video might allow a call taker to visually confirm if the patient is unconscious, bleeding heavily, or surrounded by potential hazards. Additionally, text-based communication was considered a crucial supplement to voice calls, especially in situations where speaking is unsafe, impossible, or impractical [15, 24]. This form of communication has been implemented in community safety reporting [31, 32], but it remains underdeveloped in 9-1-1 call systems [14].

Despite the promising benefits of this multimodal approach, participants also raised several concerns. For text-based communication, delays in typing under physical or emotional distress, risks of ambiguity or misspellings, and the slower pace compared to spoken dialogue were noted as potential drawbacks. In high-pressure moments, even composing a coherent message can be challenging. To effectively integrate a text-based approach into the 9-1-1 system, thoughtful design considerations are essential. It may be useful to incorporate predefined text templates (e.g., one-touch responses) into the text messaging interface to reduce typing effort. For example, a text-based interface could display large, clearly labeled one-touch buttons such as "Chest Pain", "Difficulty Breathing", "Fire", or "Car Accident". When the caller taps Chest Pain, the system could automatically send a standardized message to the call taker (e.g., "Caller reports chest pain. Requesting immediate medical assistance"), eliminating the need to type out details in a high-stress situation. Intelligent auto-suggestions or emoji-based shortcuts could further streamline the exchange. Another major concern with text-based communication is the potential for misuse. To address this, texting should function primarily as a follow-up channel after an initial call. For example, if a caller is unable to speak or is in danger, a call taker could initiate a text exchange to maintain contact and gather essential details.

For video calls, aligned with prior work [10, 11, 47, 59], our participants emphasized that, to avoid overwhelming callers, call takers need the ability to guide a caller's camera work (e.g., enabling or disabling video functions). Because distressed callers often struggle to frame scenes effectively and noisy or chaotic environments can further hinder communication, call takers should be able to provide structured guidance (e.g., pan, zoom, hold steady) through visual prompts or overlays [10, 11]. Moreover, even though not raised directly by our participants, prior work suggests that call takers should also have the flexibility to toggle video on or off at their discretion to reduce information overload and mitigate exposure to traumatic or inappropriate visuals, while not being required to share their own video [11]. Finally, in situations with limited bandwidth, systems could offer alternative modes—such as sending still frames at intervals, short video clips, or reduced-resolution streams—instead of continuous live video.

5.3 Designing for Both Frequent and Infrequent 9-1-1 Callers

Calling 9-1-1 for emergency medical service is relatively rare for the general population, often occurring only a few times, if ever, in a person's lifetime. For these infrequent callers, every interaction is likely to be high-stakes, stressful, and unfamiliar, meaning that the system must be simple, intuitive, and consistent with well-established norms (e.g., voice-based calls). In contrast, there are groups of individuals for whom calling 9-1-1 is far more common. These include older adults, individuals with chronic health conditions, people living with disabilities, and those who regularly experience medical emergencies—commonly referred to as "frequent riders". For these populations, 9-1-1 calling is not only more routine but also shaped by recurring challenges, such as the need to repeatedly report location, communicate complex medical histories, describe symptoms, or coordinate with caregivers and family members. The disparity between infrequent and frequent callers highlights a key design challenge: a one-size-fits-all approach may fail to meet the needs of either group. Infrequent callers require a system that minimizes confusion during a stressful and unfamiliar moment, while frequent riders benefit from tailored tools that reduce redundancy, lower communication burdens, and provide seamless integration of medical history and support networks [13, 17].

Our study reveals strong support for a dedicated mobile application tailored to the "frequent riders". At its core, such an app should include a secure, pre-populated repository of essential medical information—covering chronic conditions, medications, and treatment preferences—that can be automatically shared with call takers and responders once a 9-1-1 call is initiated. Participants stressed the importance of accessibility, particularly for older adults who make up a large proportion of ambulance users [16]. They

also recommended a simple, intuitive interface with prominently displayed, clearly labeled buttons (e.g., a large "SOS" button) and single-tap access to critical functions. Participants also valued an integrated alert system that would automatically notify caregivers or trusted contacts whenever a 9-1-1 call is placed, with options for caregivers to join the call to provide supplementary information or communication support.

5.4 Accounting for Language and Cultural Needs during Caller-Dispatcher Interaction

As emergency response systems strive to become more equitable and effective, a critical area for improvement lies in supporting multicultural and multilingual populations. Both our study and prior research [22, 51] highlight how language barriers can significantly delay critical care during emergencies. Several participants in our study recounted moments when they or their loved ones struggled to communicate symptoms, conditions, or urgent details to call takers. To address these challenges, participants strongly supported integrating AI-powered, real-time translation into 9-1-1 systems. Such technology could automatically detect a caller's spoken language, provide live transcription and translation, and facilitate smoother communication with call takers. This approach may reduce delays caused by language barriers, which prior studies show can significantly increase dispatch times—sometimes by over 30%—due to interpreter connection delays [38]. At the same time, participants emphasized concerns about accuracy. Even minor misinterpretations can lead to inappropriate triage, resource misallocation, or delayed responses. Accordingly, AI-driven translation should function as an initial support layer. For example, automatically recognizing the caller's spoken language or dialect could allow call takers to quickly connect with the most suitable human interpreter.

Beyond AI-facilitated translation, prior work highlights the importance of institutional and organizational practices in shaping the quality of language support. A Swedish study of multilingual emergency care found that interpreter use was often inconsistent, with ambulance services frequently relying on ad hoc solutions such as family members [34]. These inconsistencies underscore the need for formalized, system-wide protocols to ensure reliable and equitable access to trained interpreters in emergency contexts. Similarly, policy research in the U.S. recommends recruiting and retaining multilingual call takers, along with providing voice and accent sensitivity training to reduce misunderstandings with callers from diverse backgrounds [64]. Finally, linguistic support cannot be separated from cultural sensitivity. The populations with LEP and low socioeconomic status may hesitate to contact 9-1-1 at all [3, 21, 44, 51, 70]. Addressing these barriers requires more than technical solutions—it also involves community outreach and the development of culturally sensitive protocols [52]. These insights highlight that the 9-1-1 system is a complex socio-technical infrastructure requiring multiple complementary approaches—technological, organizational, and cultural—to become both linguistically inclusive and culturally responsive.

5.5 Leveraging AI to Enhance the 9-1-1 Experience: Opportunities and Design Considerations

AI has been explored to expedite medical emergency responses, particularly in clinical settings [39] and during public health emergencies [33]. Our study revealed that this novel technology also holds great potential for enhancing the effectiveness and accessibility of the 9-1-1 emergency response system, especially in situations where human resources are limited or caller communication is constrained. In large-scale emergencies—such as natural disasters or mass casualty events—call volumes can spike beyond the capacity of available call takers, making it difficult for callers to connect in real time. In such instances, people are forced to turn to social media to make requests for help, potentially causing delays in receiving timely assistance [55, 56]. To address these challenges, AI can serve as a triage mechanism by analyzing incoming calls to detect signs of urgency, extracting relevant details, and prioritizing them for immediate human intervention. Additionally, when text-based 9-1-1 reporting is available, AI—especially conversational agents (CAs)—can automate the collection of key event details (e.g., location, time, nature of emergency), minimizing miscommunication, ensuring comprehensive and systematic data collection, and reducing the overall burden on the 9-1-1 system [32, 42, 77].

However, designing AI systems for 9-1-1 contexts presents significant challenges and requires careful consideration of social, emotional, and operational dynamics. As highlighted in prior work on community-based text-reporting systems [32], automating dispatchers' responses in emergency contexts can exacerbate user uncertainty if the system lacks transparency. Users often do not understand what happens after they submit a report or send a text message to 9-1-1, and this "invisible backend" can erode trust. In our study, participants expressed similar concerns. If AI is used to screen, interpret, or prioritize emergency calls, users must be given timely and understandable feedback—such as automated acknowledgment of receipt, confirmation that a human dispatcher is reviewing their case, or updates on estimated response time—so they do not feel abandoned or de-prioritized. To enhance callers' trust and acceptance of AI involvement, systems must also be explicit and honest about when an AI chatbot is collecting information, while clearly offering immediate escalation to a human call taker upon request. Participants emphasized that knowing "a real person is still there" was essential for upholding the relational expectations of emergency communication.

While AI-driven systems can streamline communication and enhance response efficiency, they must not overlook the critical role of emotional support in emergency interactions. Automation cannot replace human empathy. Our findings underscore the importance of dispatcher oversight in all AI-assisted processes. Prior research has shown that AI systems (e.g., CAs) lacking emotional awareness often struggle to establish rapport, leading to awkward or ineffective exchanges [42, 76]. In contrast, emotion-aware CAs can gain users' trust more quickly, helping to elicit accurate information and offering reassurance in high-stress situations [30, 31]. During medical emergencies or emotionally charged incidents, such systems should be capable of detecting signs of distress, responding with calming language, and offering supportive resources, while also

ensuring that a baseline level of assistance is consistently provided [31, 32].

Finally, in emergency situations, even minor delays in communication can have severe consequences, making it essential that AI-mediated interactions remain rapid and seamless. Although automated systems can standardize information gathering and triage, participants expressed concerns that such systems may introduce delays or misclassifications, especially in atypical or ambiguous medical emergencies where subtle contextual cues are difficult for algorithms to interpret. These risks highlight the need for a *human-AI collaboration* model, where automated systems are used to gather essential initial information (e.g., location, immediate medical conditions) using straightforward, predetermined questions, and then seamlessly transfer the call to call takers for more nuanced interaction. Advances in pre-trained language models with domain-specific tuning can further strengthen AI's ability to detect varied emergencies and interpret critical contextual cues [72]. However, such collaboration also requires careful attention to dispatcher workload. While AI may reduce repetitive screening, it can simultaneously introduce new responsibilities, such as validating algorithmic outputs or correcting errors under time pressure, creating a "monitoring burden" that contributes to cognitive fatigue. Ensuring that AI tools integrate smoothly into existing 9-1-1 call-taking workflows is therefore essential to prevent call taker burnout and support reliable, equitable emergency response.

5.6 Balancing the Tension between Privacy Concerns and Safety Needs

While new multimedia features promise to improve emergency response, they also raise significant privacy concerns. For example, location data—though critical for rapid dispatch—can reveal highly sensitive information such as home addresses or frequented places. Participants in our study identified this as the primary feature that triggered privacy concerns. Such worries align with prior work showing that the public often weighs the safety and convenience of location-based technologies against potential intrusions on privacy [2, 60]. Similar concerns arose regarding video calling, which aligns with prior work reporting that, while callers recognized the benefits of sharing live or recorded video with call takers, they were often uncomfortable with the possibility of inadvertently exposing family, friends, or bystanders without consent [10].

To mitigate unintended exposure, features such as automatic background blurring, selective redaction, or camera cropping that focuses solely on the injured individual could help protect the privacy of both callers and bystanders [1, 6, 50]. Our findings highlight the relevance of these approaches and underscore the need for a balanced design strategy—one that provides call takers with sufficient situational visibility while respecting callers' dignity and privacy. Designing for this tension requires privacy-adaptive mechanisms that can adjust to the urgency of the situation. For example, systems could support graduated sharing modes, enabling callers to start with minimal-exposure options (e.g., blurred or partially obscured video) and transition to clearer visibility during life-critical moments. After immediate danger has passed, callers could scale back what information remains visible or shared. Such adaptive controls acknowledge that privacy needs are dynamic during emergencies and must be flexible rather than fixed. Future research should explore how these boundaries shift across cultural contexts and emergency types to inform best practices for privacy-conscious design in next-generation 9-1-1 systems.

5.7 Study Limitations and Future Work

This study is not without limitations. For example, our participant pool included limited engagement from vulnerable populations who are among the most frequent users of 9-1-1, including older adults, individuals with LEP or disabilities, and residents of socioeconomically disadvantaged communities. These groups often face unique challenges—such as lower digital literacy, accessibility barriers, or mistrust of authorities—that may shape how they interact with new technologies in emergency contexts. As a result, some of our design implications may not fully capture the needs and constraints of these populations. Ensuring their perspectives are more systematically included will be essential for designing equitable and inclusive next-generation 9-1-1 systems. In addition, this study focused exclusively on the perspectives of callers. While this provides important insight into user needs, many of the proposed design solutions—such as AI-assisted triage, video calling, text messaging, or mobile applications—will need to be validated with call takers and tested for feasibility within existing 9-1-1 workflows and infrastructure. Future research should therefore engage both callers and call takers, as well as emergency service agencies, to ensure that innovations can be effectively and sustainably integrated into practice.

6 Conclusion

Through surveys, interviews, and participatory design workshops, this study illuminated the challenges callers face during medical emergencies and their expectations for next-generation 9-1-1 communication. We identified persistent pain points—including difficulties conveying location and context, language and cultural barriers, lack of post-dispatch transparency, and challenges in communicating medical history when calling on behalf of others. At the same time, participants envisioned new possibilities, such as multimodal communication, AI-assisted triage and translation, caregiver-integrated applications for frequent ambulance riders, and features that combine informational clarity with compassionate support. Taken together, these insights underscore the importance of designing 9-1-1 as a socio-technical system—one that integrates technological innovation with cultural sensitivity, organizational practices, and human support to meet the complex realities of emergency care.

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