

Canadian Paramedic Perceptions and Requirements for Adoption of Speech Recognition
Technology: A Mixed Methods Study

By

Desmond Hedderson
BSc, University of Prince Edward Island, 2022

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Abstract

Paramedicine workflows and working conditions make accurate and timely documentation of patient care challenging. These documentation challenges can lead to disruptions in the continuity of patient care and potential adverse patient events. Speech recognition-aided documentation has the potential to alleviate some of these challenges and improve the continuity of patient care. To accelerate the adoption of speech recognition documentation within Canadian paramedicine, we sought to understand user requirements and perceptions of the technology. This study undertook a scoping review of the current literature and a pan-Canadian mixed-methods study of user requirements and perceptions. The results included ranking the 45 listed features based on their value to end users and detailed analyses of the current perceptions of the accuracy, efficiency, disruptiveness, and completeness of speech recognition documentation. The study also identified six additional features not included in the questionnaire and what users would include as a minimum set of features to adopt the technology. This study's results can benefit software developers, administrators and researchers. It provides the foundation for further research, policy and product development.

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Dedication

You will never see this, but to you, JL, for failed challenges, dreams never realized, unnecessary commas, and singular moments that don't need to exist beyond the positive places they hold within us.

To my family and friends, who tried their best to support me even when I didn't know what I really needed. I love you all for trying.

To everyone and anyone who played a role in supporting me through this challenging work. You have my eternal gratitude and loyalty.

Chapter 1 Introduction

Paramedics provide emergency medical care to patients with traumatic injuries and medical emergencies, generally in the prehospital environment. Similar to in-hospital providers' documentation requirements, paramedics must accurately document patient assessments, scene assessments, interventions, and any care provided (Al Haliq & Al Jumaan, 2022). The information that paramedics document is of high value to numerous stakeholders. Paramedic data can influence care continuity and the treatment course of patients (Cram et al., 2017; Knutsen & Fredriksen, 2013; O'Connor & Golding, 2021), improve treatments and assessments (Cone et al., 1995; Coventry et al., 2014; Pennardt & Zehner, 1994), and provide opportunities for research at the community and health system levels (Al Haliq & Al Jumaan, 2022; Short & Goldstein, 2017). Paramedics document this important patient information, including demographic, geographical, clinical and social data, in paper or, more commonly, electronic patient care report (ePCR) (Short & Goldstein, 2017). This report can be called different names depending on the jurisdiction, including ambulance call report, chart of call, contact report, patient care record, and patient report form. The ePCR is intended as a reference for emergency department (ED) staff once care is transferred from the paramedic to the receiving ED staff (Cram et al., 2017). The ePCR is meant to relay all valuable patient information, including information that ED staff may not have received from a verbal handover, either through paramedic omission or failure to record or retain the information by ED staff (Cram et al., 2017; Knutsen & Fredriksen, 2013; O'Connor & Golding, 2021).

The patient information in the ePCR is valuable for ED staff and can help make appropriate decisions regarding treatment and initial diagnoses (Zhang et al., 2020). However, the ePCR is not always available during ED decision-making (Bledsoe et al., 2013). Documentation and workload

burdens on paramedics cause these delays in delivering the ePCR. During emergency response calls, paramedics must balance the need to provide immediate life-saving interventions and accurately documenting those interventions and examination findings in an ePCR. Despite recommendations that the ePCR be available to ED staff in a relevant timeframe to impact patient care, many paramedic services do not require the ePCR to be completed prior to responding to another patient care call (Cram et al., 2017). Further, when patient care must be prioritized, and documentation is completed after arrival at the hospital or after another response, the report's accuracy may be compromised because more time has elapsed and paramedics must recall details when the patient is no longer in their care (Meier et al., 2020). An information gap occurs when important information that could assist ED staff in providing the most appropriate and efficient care is missing or delayed (Cram et al., 2017). A study by Stiell et al. found missing or omitted information for as many as 32% of patients delivered to the ED by paramedics (Stiell et al., 2003). ED physicians have also reported being frustrated by delays in obtaining the ePCR, and 98% would prefer it to be attached to the patient's electronic medical record (EMR) upon arrival at the hospital (O'Connor & Golding, 2021).

Information gaps whereby crucial information is unavailable can contribute to adverse patient events (Cram et al., 2017; Sujan et al., 2014). A European project from 2015 found that these gaps account for 25-40% of adverse events (Eggins & Slade, 2015). Of those patients who arrived with information gaps, 48% stayed an additional 1.2 hours in the ED (Stiell et al., 2003). Given the inherent risk to patient safety from information gaps, verbal handovers techniques were developed. However, several barriers exist to effective paramedic-to-ED staff handovers, including interprofessional knowledge translation, cognitive demands during transfer, workflow interruptions, lack of integration between paramedic service ePCR and the ED electronic medical records (EMR), and ED staff recall (Benner et al., 2008; Carter et al., 2009; Cram et al., 2017; Evans et al., 2010;

Maddry et al., 2021; Reay et al., 2017). Moreover, it has been found that between 25-27% of important patient details are omitted in verbal handovers (Evans et al., 2010). Efforts to improve information capture during verbal handovers have focused primarily on developing standardized mnemonic devices (Iedema et al., 2012). However, these mnemonic devices have been shown to either be overly simplistic, meaning important patient information is excluded or the mnemonic devices have too much complex information to be easily recalled by paramedics or ED staff (Iedema et al., 2012; Maddry et al., 2021). In fact, studies have shown that at the time of transfer, almost all transfers (99.4%) between paramedics and ED staff are deficient in structure (the order of information), and scope (the extent of information itself) (Ehlers et al., 2021; Iedema et al., 2012; Maddry et al., 2021). The strategy of using verbal handovers between paramedics and ED staff has been minimally effective, showing at most modest improvements in information capture (Ehlers et al., 2021; Maddry et al., 2021; Starmer et al., 2014). More reliable and effective methods of relaying important patient information must be pursued.

Speech Recognition (SR) hands-free charting systems for paramedics could address the missing or omitted patient information caused by retrospective ePCR charting, delays in marrying ePCR and EMR, and suboptimal verbal handovers. SR aided medical documentation has been used by physicians and has been well studied for decades (Johnson et al., 2014). SR technology used by physicians in medical charting has been shown to reduce charting time, produce more complete notes, and is less error-prone than typed charting (Shagoury, 2010). A controlled observational study by Blackley et al. found that SR documentation takes less time, produces more complete documentation, and is less error-prone than typing (Blackley et al., 2020). Zuchowski and Goller performed a similar observational study of physicians and found that there were significant time and cost savings when using SR documentation (Zuchowski & Goller, 2022). In a direct comparison

of SR documentation and typed documentation by emergency department physicians Cruz et al. identified fewer workflow interruptions when using SR documentation (Cruz et al., 2014).

While the benefits of SR documentation have been well studied with clinicians in hospital, the pre-hospital world of paramedicine is more challenging. Sirens, road noise, outside conditions, dynamic patient care conditions, and bystander noise make SR documentation with accuracy difficult. Recent technological advancements in artificial intelligence (AI), natural language processing (NLP), text pre-processing and algorithmic noise reduction make it possible to implement SR-aided documentation in the paramedicine workflow (Kemppainen, 2022; Shagoury, 2010; Tanberk et al., 2021). Leveraging these advancing technologies, like NLP, AI and SR documentation has been identified by Tavares et al. as one of the enabling factors of the future of paramedicine in Canada (Tavares et al., 2022).

Despite the demonstrated benefits of SR documentation, negative perceptions about the technology and its use persist. For example, Zuchowski & Goller, found that 55% of physicians surveyed stated that they would still prefer to use typed documentation even after SR-aided documentation demonstrated significant time savings (Zuchowski & Göller, 2022). This negative perception can be attributed to early and suboptimal SR documentation integration, which occurs when the SR technology is a less efficient version or the SR to EMR optimization is poorly executed. (Hodgson et al., 2017). These negative perceptions can lead to failures to implement or adopt systems that use an SR documentation component. With failure rates of health information technology projects between 40-70% (Kaplan & Harris-Salamone, 2009), and paramedicine is already a laggard in adopting digital documentation strategies more generally (Al Haliq & Al Jumaan, 2022), it is important to take all necessary steps to increase adoption. Applying user centered design principles can potentially increase adoption rates of new technologies (Dutta & Dhar, 2021). User centered design involves several phases of research and design to understand user

requirements, perceptions and expectations of technologies and uses an iterative approach to ensure alignment between the needs and work of users and their tools (Dutta & Dhar, 2021).

Understanding paramedic requirements, perceptions, and expectations of SR hands-free documentation would help guide the design and development of this technology.

The purpose of this study was to identify Canadian paramedics' perceptions of and requirements for SR hands-free documentation technologies. The research objectives included:

1. Identifying potential user requirements for SR charting technology and informing strategies to increase the likelihood of paramedic end-user adoption. To this end, the study investigated which features or functions would be most important to end-users.
2. Identifying paramedics' attitudes towards hands-free documentation and technology use levels. Understanding the current landscape of paramedics' attitudes and use of SR will be important in future implementation planning.

To address these objectives, this study began with a review of the existing literature on user requirements and perceptions of SR documentation technologies within paramedicine. This was followed by a mixed-method study using a nationwide survey of Canadian paramedics and targeted semi-structured interviews.

Chapter 2 Literature Review

As a part of objective 1, I (Desmond Hedderson (DH)) led a research team (Karen Courtney (KC), Helen Monkman (HM) and Ian Blanchard (IB)) to conduct a scoping review to assess the current relevant literature regarding paramedics' use of and attitudes toward SR documentation technologies (Hedderson et al., 2025). The team identified studies highlighting user requirements and recommendations for SR documentation technologies in paramedicine. Acting as the primary researcher, DH developed the initial concept, review design, search strategy, inclusion/exclusion analysis, manuscript preparation and knowledge translation. KC contributed to the initial concept, review design, inclusion/exclusion analysis and manuscript preparation. HM contributed to the review design, manuscript preparation and knowledge preparation. IB contributed to the review design, manuscript preparation and paramedicine specialization. The manuscript produced from the scoping review is currently in press for publication in the International Journal of Medical Informatics.

2.1 Methods

In this study, we conducted a scoping review based on the PRISMA-SCR framework (Tricco et al., 2018). A scoping review was selected because it is well suited to exploratory research, effectively examines the extent of existing evidence, and identifies gaps in current knowledge. The scoping review followed the Joanna Briggs Institute (JBI) methodology outlined in the JBI Manual for Evidence Synthesis (*11.3.7 Methods - JBI Manual for Evidence Synthesis - JBI Global Wiki*, n.d.). This method includes outlining the search strategy, sources of evidence screening and selections, data extraction and analysis, and presentation of results.

2.1.1 Inclusion and Exclusion

The review remained open to all evidence sources, including primary research studies, opinion writing, unpublished academic papers, guidelines, websites, trade magazine articles and reviews. Any studies that focused on paramedics' use and perceptions of SR technology were eligible, which may include the use of SR documentation technology or identified user requirements for its adoption. The scoping review included studies conducted in the prehospital environment, ED, and other emergency settings (i.e., fire, police, military) to focus on the entire paramedicine workflow.

2.1.2 Search Strategy

The primary researcher (DH) performed the initial search (Appendix 1, Table 8.1). DH analyzed known seminal article titles, abstracts, and indexed keywords to develop a complete search strategy for MEDLINE, Google Scholar, IEEE Explore, ProQuest, and CINAHL (Appendix 1, Table 8.2). ProQuest Dissertation and available search engines, like Google, were also used to identify unpublished and grey literature. DH adapted the search strategy for each database based on interface requirements. Studies published in English since January 1, 2014, were considered in this review. The year 2014 was chosen because it was the year Amazon launched the modern intelligent voice assistant, Alexa, changing the SR landscape and making SR more common in everyday life (Hoy, 2018). The reference lists of the included articles were hand-searched for any additional relevant studies.

2.1.3 Source of Evidence Selection

All identified citations were uploaded via research information document (RIS) and exported to the Covidence (Veritas Health Innovation, Melbourne, Australia) web-based collaboration

software platform (*Covidence - Better Systematic Review Management*, n.d.), where duplicates were removed. Titles and abstracts were screened by reviewers DH and KC against the inclusion criteria using the Covidence platform. DH and KC assessed the full text of the identified citations against the inclusion criteria. Reasons were recorded for any articles excluded from the full-text review, and disagreements at each stage of the review process were resolved through discussion.

2.1.4 Data Extraction

DH extracted data using two modified versions of the standardized JBI data extraction tool (Tricco et al., 2018) developed for this review, one for research reports and one for grey literature. The extracted data focused on specific population details, concepts, and context. DH extracted data for any user requirements or recommendations for future work made by studies. Examples of both data extraction tools are available in Appendix 1, Tables 8.3 and 8.4.

2.1.5 Data Analysis and Presentation

The data from the studies are presented in a narrative, tabular form, highlighting the types of analyses performed and the population targeted. Any recommendations and user requirements are presented in figures with a narrative summary of the studies.

2.2 Results

There were 11 studies that underwent full-text screening (Figure 2.1), with two studies excluded for context (not using SR documentation technology), and one for population incompatibility (no emergency providers). The remaining eight studies underwent data extraction. The search yielded no results in either grey literature, opinion pieces, or trade magazines.

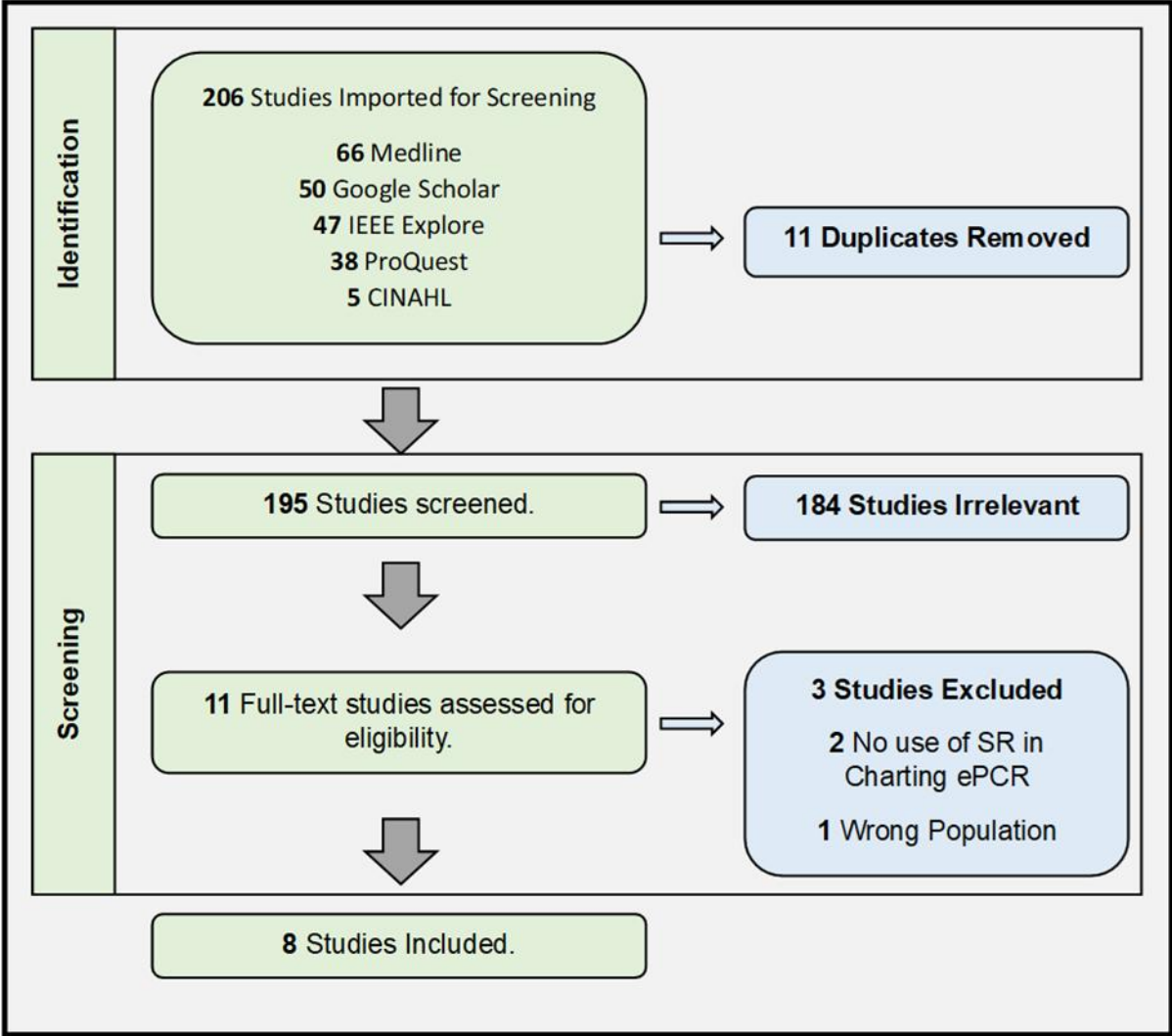


Figure 2.1. PRISMA-SCR flowchart for article selection.

All the included studies were small and were based on focus groups; no large population trials or generalizable samples were found. Of the eight studies examined, five were conducted in the United States, two in Switzerland, and one in Japan (Appendix 2, Table 8.5). Six studies tested SR technology in a laboratory or simulated setting (Denecke et al., 2020; Kar et al., 2021; Meier et al., 2020; Shimazui et al., 2021; Woo et al., 2021; Zhang, Luo, et al., 2022) and two were prototype development focus groups (Zhang, Joy, et al., 2022; Zhang, Ramiya Ramesh Babu, et al., 2022).

None of the identified studies tested SR in a live service environment. Two development studies exclusively gauged focus groups' attitudes about SR technology without testing any technology.

Two articles directly studied SR documentation technology (Meier et al., 2020; Shimazui et al., 2021). Specifically, Meier et al. used a smartphone-enabled Bluetooth microphone to interface with an SR documentation application (Meier et al., 2020). Shimazui et al. directly compared times for SR documentation and SR documentation with typed correction but did not define which technology they used (Shimazui et al., 2021). The remainder of the studies evaluated audio-video hardware (as opposed to strictly audio), with the SR technology a part of the video hardware (Denecke et al., 2020; Kar et al., 2021; Woo et al., 2021; Zhang, Luo, et al., 2022). For example, two studies used GoPro cameras with embedded microphones for SR testing (Kar et al., 2021; Woo et al., 2021). SR was also evaluated as a broader documentation and workflow system using smart glasses hardware (Zhang, Luo, et al., 2022).

All eight studies included recommendations for further research and development of SR technology in paramedicine (Figure 2.2). Five of the studies recommended further live environment testing (Kar et al., 2021; Meier et al., 2020; Zhang, Joy, et al., 2022; Zhang, Luo, et al., 2022; Zhang, Ramiya Ramesh Babu, et al., 2022). Three studies recommended using user-centred design principles to develop SR technology further in paramedicine (Denecke et al., 2020; Woo et al., 2021; Zhang, Ramiya Ramesh Babu, et al., 2022). Two studies recommended using a closed-domain natural language processing model (Woo et al., 2021; Zhang, Luo, et al., 2022) and SR-specific training for paramedics (Woo et al., 2021; Zhang, Joy, et al., 2022). Engaging in usability testing (Zhang, Ramiya Ramesh Babu, et al., 2022), using a close-talking microphone (Shimazui et al., 2021), and developing a paramedicine-specific lexicon (Zhang, Luo, et al., 2022) were recommendations for improving the usability of SR technology.

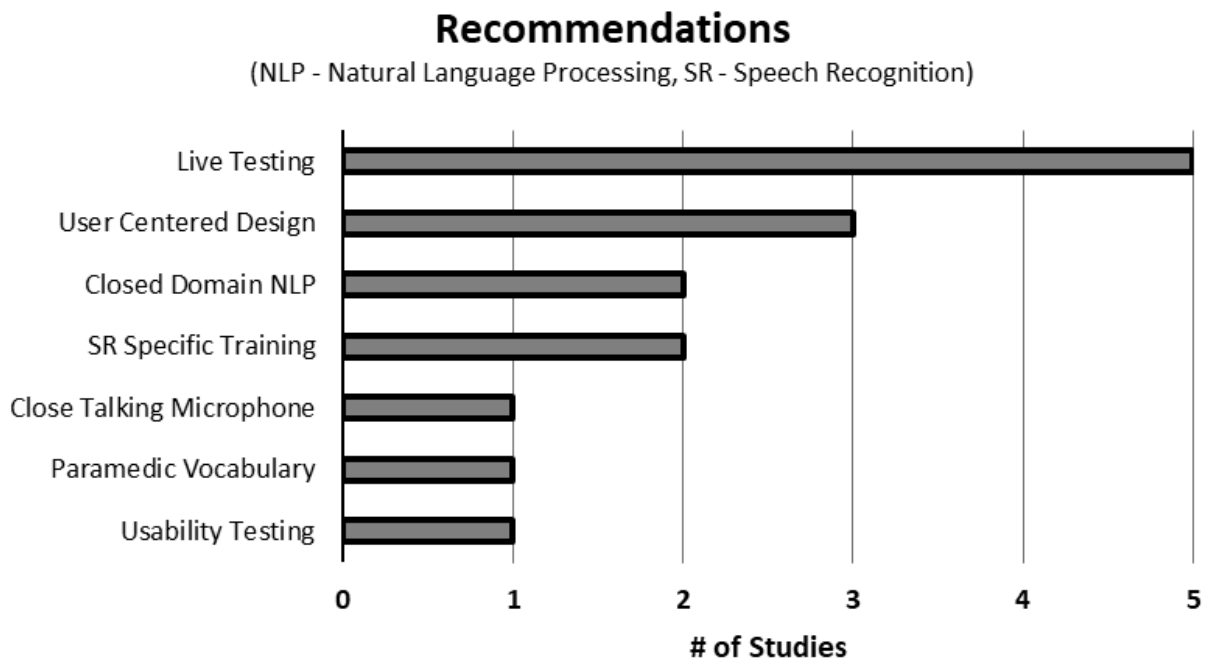


Figure 2.2. Recommendations extracted from eight included studies.

Only four of the eight studies identified user requirements for adopting SR technology (Figure 2.3). The most common user requirement was the ability to use the SR technology hands-free to create documentation. In three of those studies, this was about using the SR functions of smart-glass technology (Zhang, Joy, et al., 2022; Zhang, Luo, et al., 2022; Zhang, Ramiya Ramesh Babu, et al., 2022), and one referenced a preference for voice recordings over video because of the ability to use SR for hands-free documentation (Denecke et al., 2020). Noise reduction capabilities, battery life, high word accuracy rates, and the ability to use SR for dictation were all identified in two studies as user requirements (Zhang, Luo, et al., 2022; Zhang, Ramiya Ramesh Babu, et al., 2022). The remaining user requirements, including workflow integration, comfort, interoperability, minimal interface, and decision support, were identified by the series of works on smart-glasses-based documentation (Zhang, Joy, et al., 2022; Zhang, Luo, et al., 2022; Zhang, Ramiya Ramesh Babu, et al., 2022).

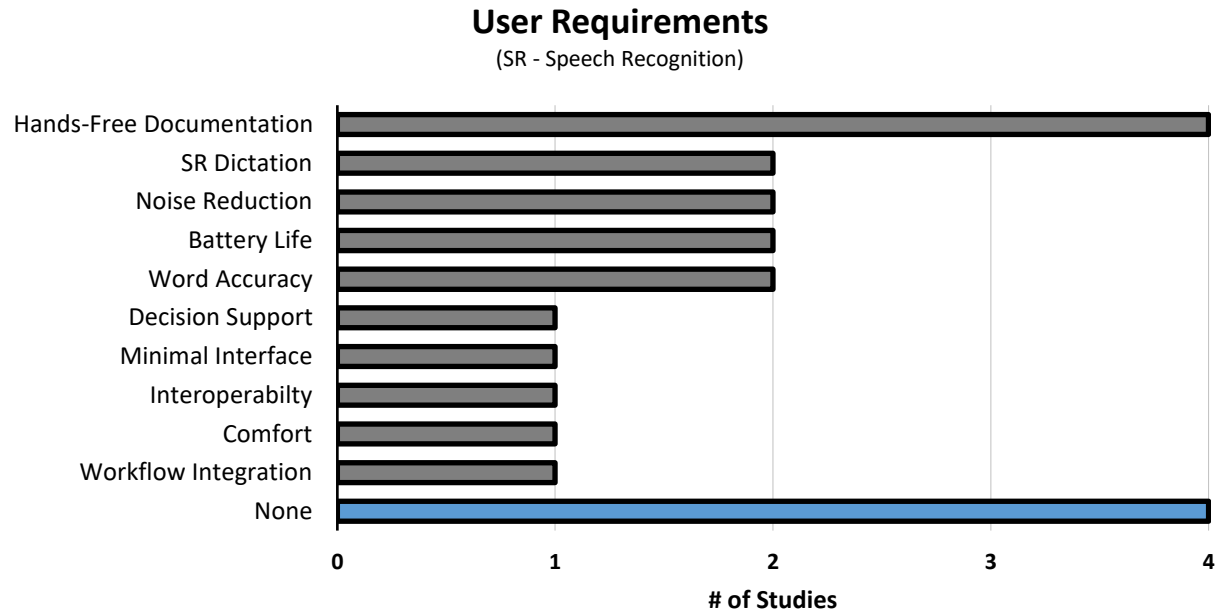


Figure 2.3. User requirements extracted from eight included studies.

2.3 Discussion

This scoping review identified eight studies, all of which were published since 2020. The most significant gap in knowledge is the assessment of SR documentation technology in a live environment, which was also the most frequent recommendation. Live testing will pose an important barrier to any implementation of SR documentation technology. While the simulated testing has shown that SR documentation technology can be effective in noisy environments (Kar et al., 2021; Meier et al., 2020; Woo et al., 2021), the live environment can introduce unknown variables that may affect both effectiveness and efficiency. Live testing may highlight new user requirements that are not evident in the simulated settings.

Applying user-centred design principles was another common recommendation in the identified literature (Denecke et al., 2020; Woo et al., 2021; Zhang, Ramiya Ramesh Babu, et al., 2022). Applying user-centred design principles leads to higher adoption rates and overall

satisfaction with health IT products (Dutta & Dhar, 2021). Few studies focused on user requirements for SR documentation technology (Denecke et al., 2020; Zhang, Joy, et al., 2022; Zhang, Luo, et al., 2022; Zhang, Ramiya Ramesh Babu, et al., 2022). The most common user requirement was the ability to use the SR documentation in a hands-free manner. While others, like recorded word accuracy, noise reduction, device battery life and the ability to use SR to dictate narrative sections, were all mentioned (Zhang, Luo, et al., 2022; Zhang, Ramiya Ramesh Babu, et al., 2022).

Prehospital care environment workflows could benefit from SR documentation technologies. Tavares et al. identified that leveraging advancing technologies would be an enabling factor for paramedicine's future in Canada (Tavares et al., 2022). The use of advanced SR technology could allow for live hands-free documentation (Meier et al., 2020; Zhang, Luo, et al., 2022). Hands-free documentation would eliminate the need for paramedics to recall important patient details after the patient is no longer in their care. SR documentation could also increase the efficiency of paramedic documentation. Shimazui et al. identified that SR documentation is significantly faster than hand-typing documentation (Shimazui et al., 2021). The increased efficiency would lead to more complete ePCRs and reduce delays in providing ED staff with complete patient information. Having a complete and accurate ePCR available on arrival to the ED would also reduce the reliance on verbal handovers. With high word accuracy rates (Meier et al., 2020), reduced documentation times (Shimazui et al., 2021), and the ability to do live hands-free documentation (Zhang, Luo, et al., 2022), the completed ePCR could be transmitted or transferred to the ED staff on arrival.

The studies captured in this scoping review are recent, with the published date range between 2020 and 2022. The proliferation of recent studies may suggest that advancements and availability in wearable, hands-free communications technologies and natural language processing

techniques are driving interest in using SR documentation technology to improve the prehospital workflow. However, the identified literature included only small focus group studies ($4 \leq n \leq 26$), which may not include the necessary breadth and depth of user opinions. Larger studies with more generalizable data would augment user-centered design and identify more potential user requirements (Dutta & Dhar, 2021). Several studies also only included SR documentation as a feature of a smart glasses-based documentation solution and was not the main focus of the investigation (Zhang, Joy, et al., 2022; Zhang, Luo, et al., 2022; Zhang, Ramiya Ramesh Babu, et al., 2022). A large study focused solely on the perceptions and user requirements for SR documentation technology would provide foundational information for the design and implementation of SR documentation in the paramedic workflow.

While the scoping review investigated all published and unpublished literature, the search was limited to English. There are ongoing advancements in prehospital technologies in countries like Singapore and Sri Lanka (*New Digital Platform for Paramedics and Hospitals to Share Patient Data in Real Time*, n.d.; *Sri Lanka's National Emergency Service Launches AI, Mixed Reality-Powered Connected Ambulance*, 2023), and the English-only restriction may have excluded some studies on this work. The scoping review was also limited to studies after January 1st, 2014. The intent was to capture only more recent applications of SR technology to avoid early implementations that may be biased toward negative experiences with nascent technology. This may have excluded some available literature that was published before that date.

2.4 Conclusion

This scoping review found that the use of SR documentation technology in paramedicine is limited. Only small sample lab-based experiments and prototype design studies were identified. The major recommendations identified in the review were live environment testing and further

application of user-centred design. While some user requirements were identified they were in relation to using SR as a feature of a smart glasses-based technology. This highlights a gap in the study of the perceptions and user requirements of SR documentation technology in paramedics. To date, no large-scale user requirements and perception studies focused on paramedicine were identified.

This scoping review has highlighted that while there is a growing interest in SR technology in the paramedicine workflow, more work is needed. To fully explore this thesis's two objectives, original research will be required. A large-scale study will produce generalizable data on the features and functions required for adoption and shed light on current paramedic perceptions of speech recognition documentation. The user requirements and perceptions of SR documentation technology in paramedicine need to be better understood for successful implementation with high adoption rates and for improvements in the effectiveness and efficiency of the system to be realized.

To that end, this work was an initial attempt to create generalizable data. Using a mixed methods approach, the study aimed to identify the user requirements that would increase the adoption of SR documentation, identify strategies for implementation, and assess paramedics' current attitudes towards hands-free SR documentation and their personal technology use and familiarity with SR technology.

Chapter 3 Methods

3.1 Methodology

This research was a 2-phase explanatory mixed methods (i.e., collecting qualitative and quantitative data) study (Creswell & Plano Clark, 2007). A mixed methods study design is commonly used when determining user preferences and beliefs (Hartstein et al., 2022; Haynes-Brown, 2023; Pluye & Hong, 2014). Combining the qualitative and quantitative data provided a more robust picture of which aspects of the SR technology would be most important in determining end-user requirements for paramedics. For this study, a web-based questionnaire including quantitative and qualitative questions, and a semi-structured interview process were applied.

3.2 Ethics

Approval for this study was obtained on December 21, 2023, from the University of Victoria Human Ethics Research Board (Ethics Protocol Number 23-0450). Primary Researcher (DH) TCPS2 certificate and ethics approval certificate is attached in Appendix 3, Figures 8.1 and 8.2. Data were collected between January and June 2024.

3.2.1 Consent

Informed consent was obtained for the web-based questionnaire by including a detailed pre-amble and an initial question which confirmed that the respondent was granting free and informed consent by continuing (Appendix 4, Table 8.6). For those respondents who agreed to participate in the interview phase, a letter of information for implied consent (Appendix 4, Table 8.7) was attached to the invitation email. The participants' consent for the recording of the interview was confirmed verbally in the interview itself.

3.2.2 Confidentiality

All data collected by this study were stored and protected in line with the University of Victoria's data management guidelines. Data collected from the web-based survey were anonymous aside from the respondents who agreed to participate in the interview phase. These respondents provided contact information, including their name and email address. The contact information was separated from the survey data and stored separately in an encrypted file. Participants selected for an interview were assigned a participant ID (PP##), which was used to report results from the qualitative analysis. Participants' raw interview data, which consists of video, audio and text transcription of the Zoom interview, was stored in an encrypted file on a password-protected, restricted-access computer. Any data used for analysis and reporting had all identifying information removed, and only the principal researcher (DH) had access to the raw data.

3.2.3 Use of Data

The data collected were used to complete the analysis and answer the intended research questions to complete this thesis. Portions of these data may also be used to publish sections of this thesis in any relevant journals or presented at relevant conferences. The data will be stored for a period of no less than two years after the final publication of the results.

3.3 Population and Sample

Participants for this study included clinically active Canadian paramedics in paid or voluntary positions and Canadian paramedic students. The approximate paramedic population in Canada was 30,000 at the time of this study (Rowland & Brydges, 2021). Participants were recruited for the web survey via professional registration bodies, professional associations, school alumni associations, and social associations (such as Facebook groups) using an anonymous survey link

to increase distribution (n = 323, with CI = 95%, produced a margin of error at 5.4%). The web-based survey included an opt-in function to allow survey respondents to participate in the interview phase. Interview participants were selected from survey respondents for the most remarkable diversity of experience and opinions; data saturation determined the final number of interviews (n = 14).

3.4 Data Collection

3.4.1 Phase 1 – Web-based Questionnaire

The initial phase of the study consisted of a web-based questionnaire. Using Survey Monkey the web-based questionnaire collected information about the SR functions, such as ‘closed loop’ notifications and command word usage, that paramedics value, which will likely increase adoption. The included functions built on earlier findings from smaller focus groups (Meier et al., 2020; Zhang, Ramiya Ramesh Babu, et al., 2022). The features were organized around the eight dimensions outlined by Sittig and Singh’s socio-technical model (Sittig & Singh, 2015). The model’s eight dimensions include 1) Hardware and Software Computing Infrastructure, 2) Clinical Content, 3) Human-Computer Interface, 4) People, 5) Workflow and Communication, 6) Internal Organizational Policies, 7) External Rules, Regulations and Pressures and 8) System Measurement and Monitoring (Sittig & Singh, 2015). The survey required respondents to rank prospective functions on a 1 to 5, “least to most” valuable (or important) Likert scale. Participants also identified features from a fixed dropdown menu they wanted to include as a minimum set and were asked to rank which of the dimensions would be most important using a scale from 1 to 8, with 1 being the most and 8 being the least. Demographic data, including the participant’s current role in paramedicine, province of practice, years of experience, age, and gender, were collected to identify any possible differences

by grouping. Open-ended questions allowed for descriptions of additional functionality, exposition on prospective function rankings, and any implementation challenges they foresee.

3.4.2 Phase 2 – Interviews

The study's second phase included iterative, semi-structured interviews (30-60 minutes each) conducted using Zoom® videoconferencing software. The Zoom® platform transcribed interview data, and the primary researcher performed manual correction post-interview using the recordings. The manual correction used a denaturalized approach by removing stutters, gap words (such as like or um), pauses, interruptions, or non-related conversation; however, non-verbal communications, such as nods and shrugs, were included for context (Oliver et al., 2005). The interviews intended to better understand the current challenges with documentation, paramedic perceptions, and perceived benefits of SR technology and the day-to-day barriers or enablers to SR technology adoption. Sampling for the interviews was determined by the quantitative findings, identifying the demographic groups that presented differences in opinions or had various perceptions of technology (Guetterman & Fetters, 2022). The selection matrix is available in Appendix 5 (Table 8.8). The interview guide was structured around the four-stage process described by Stanfield, consisting of objective, reflective, interpretive and decisional questions (Stanfield, 2000). The interview guide template that was developed is included in Appendix 6 (Table 8.9). The iterative guide approach allowed for follow-up clarifications and the inclusion of unforeseen additional questions that arose during the interview process. The guide changed as a result of the analysis of the quantitative data and informed some interview questions (Guetterman & Fetters, 2022).

3.5 Data Analyses

3.5.1 Quantitative Analysis

The quantitative data from the questionnaire was analyzed using descriptive and associative statistics to identify the most valued features and functions. The Likert ratings from each of the new socio-technical models' eight dimensions (Sittig & Singh, 2015) were isolated, as well as the Likert ratings for familiarity with SR technology, use of SR technology, and perceptions of SR technology. Correlation analysis was performed with each of the groups listed above with the respondent demographics, including overall perception, province, gender, area of practice, years of experience and age group. All analysis of quantitative data was performed in R Studio and the code used is included in Appendix 7, Table 8.10.

3.5.2 Qualitative Analysis

The qualitative data were analyzed using thematic content analysis (Smith, 1992). The NVivo 14 software suite was used for qualitative analysis of both the open-ended questions from Phase 1 and the transcripts from Phase 2. First-cycle coding included descriptive coding, followed by second-cycle pattern and relationship coding (Saldaña, 2020). The primary researcher used joint displays to integrate the quantitative and qualitative data from phase 1 where possible (Haynes-Brown & Fetters, 2021). The quantitative data were amalgamated for the joint display analysis, and the quotes were selected based on which best exemplified the theme or idea.

Chapter 4 Results

4.1 Survey Results

The results of the phase 1 survey are presented here. Because the questions in the survey required an exposition that was too long to include in the charts, a table of the original question, its short form and associated abbreviations are available in Appendix 8 Table 8.11. The total number of respondents to the survey was n = 534. Given the voluntary nature of the survey, there were fewer responses to each consecutive question. The number of responses to each question is presented in Table 4.1. Some questions were also optional (Questions 11-14, 18, 19), and respondents had the ability to skip them.

Table 4.1. Total responses per question and section based on percent of total responses

Question/Section Number	Responses (% of total)
Question 1 (Do you wish to participate)	534 (100%)
Question 2 (Hardware)	446 (84%)
Question 3-4 (Clinical Context)	409 (77%)
Question 5 (Human-Computer Interface)	384 (72%)
Question 6 (People)	376 (70%)
Question 7 (Workflow and Communication)	370 (69%)
Question 8 (Organizational Policies)	362 (68%)
Question 9 (External Rules, Regulations and Pressure)	357 (67%)
Question 10 (System Measurement and Monitoring)	354 (66%)
Question 11 (Open Ended Comments)	158 (30%)
Question 12 (Additional Features)	61 (11%)
Question 13 (Minimum Feature Set)	164 (31%)
Question 14 (Trade-Offs)	275 (51%)
Question 15 (Familiarity)	327 (61%)
Question 16 (Use)	327 (61%)
Question 17 (Specific perceptions)	323 (60%)
Question 18 (Open-ended, less likely to adopt)	182 (34%)
Question 19 (Open-ended, more likely to adopt)	168 (31%)
Question 20 (Overall perceptions)	323 (60%)
Questions 21 – 26 (Demographic Questions)	323 (60%)

The survey had a completion rate of 60%, which leaves $n = 323$ responses available for analysis. The remaining partial responses ($n = 211$) resulted from failure to complete the survey, with respondents dropping out at various points. Therefore, partial responses were not used in the correlation analyses. However, all collected responses were used in the descriptive statistics for each question. All descriptive statistics were performed in R Studio, and the associated R code is included in Appendix 7, Table 8.10.

4.1.1 Respondent Demographics

The survey was distributed to all Canadian provinces and territories. We received responses from all regions except Yukon, Northwest Territories, and Nunavut. While attempts were made to distribute the survey to paramedics in these territories, the lack of regulatory bodies and lack of cooperation of employers in the regions made the deployment difficult and resulted in no responses from these areas.

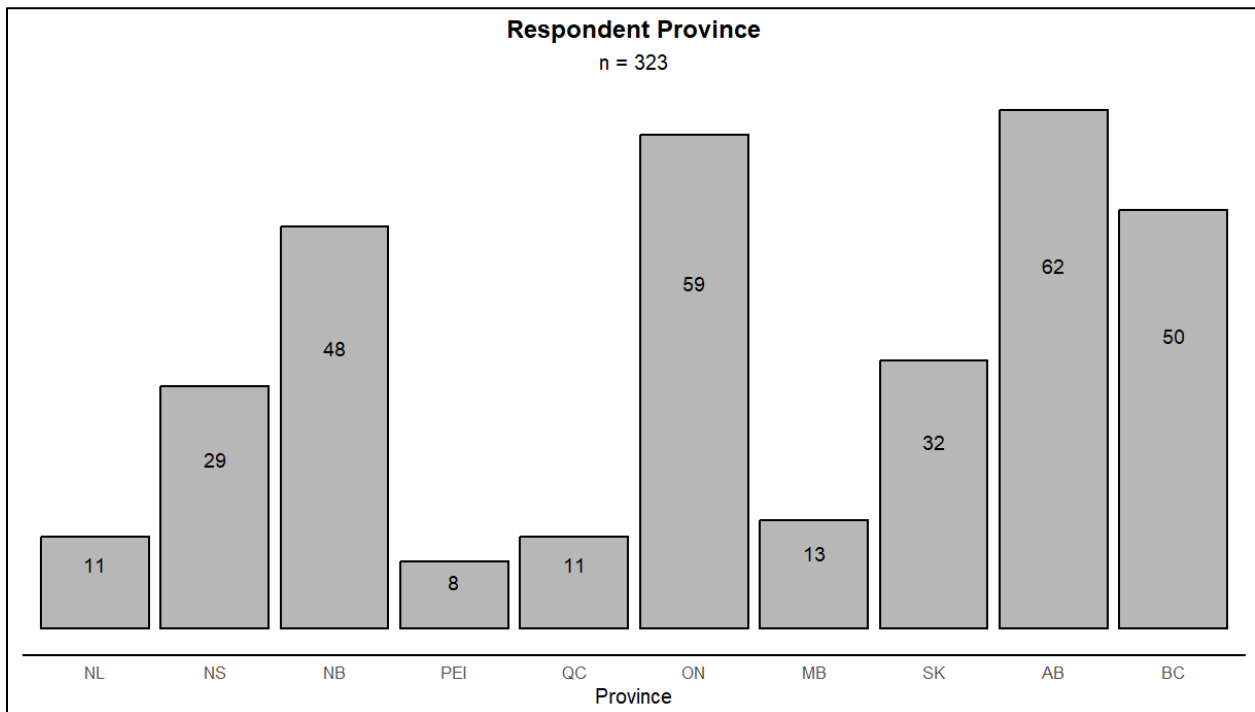


Figure 4.1. Number of respondents from eastern to western provinces.

The respondents' area of practice is presented in Figure 4.2. The area of practice included options for urban, rural and remote practice settings. Any submission that included a suburban option was included in the urban selection.

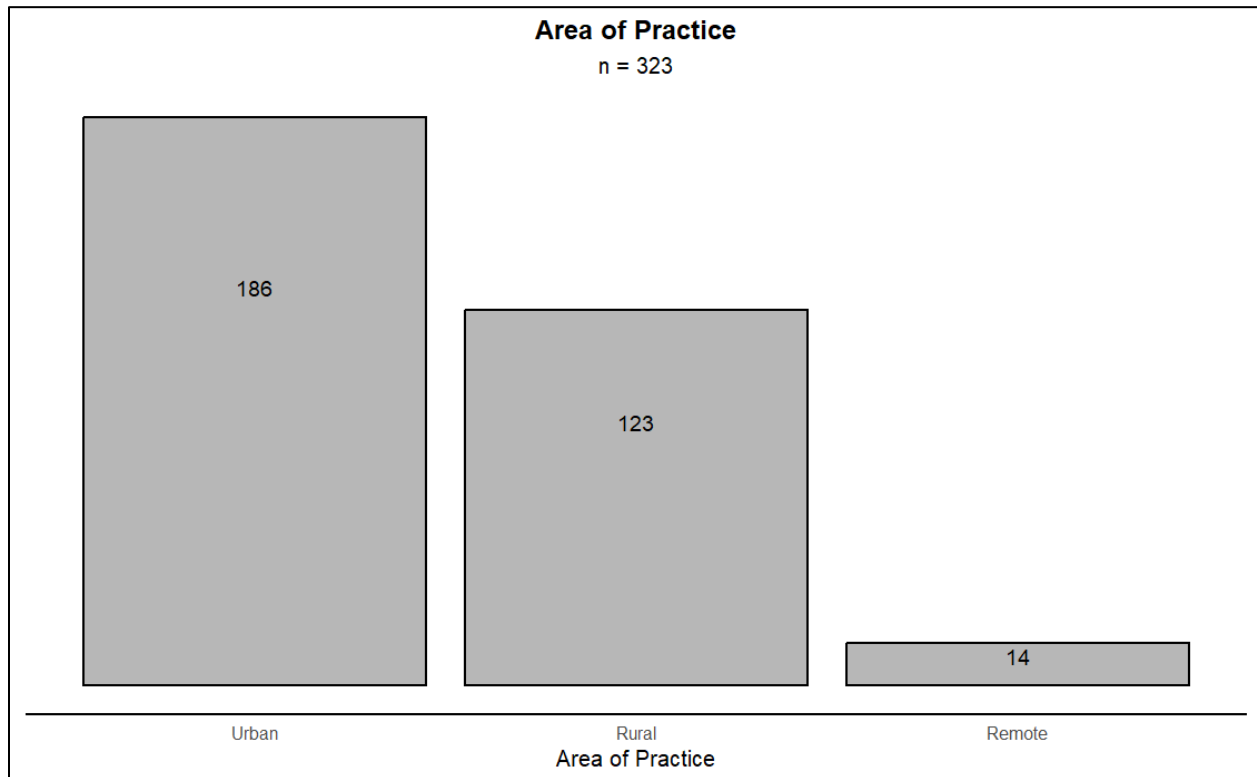


Figure 4.2. Area of practice for survey respondents.

The respondent's ages were grouped in ten-year brackets (Figure 4.3), and years of experience in paramedicine were grouped into five-year brackets (Figure 4.4).

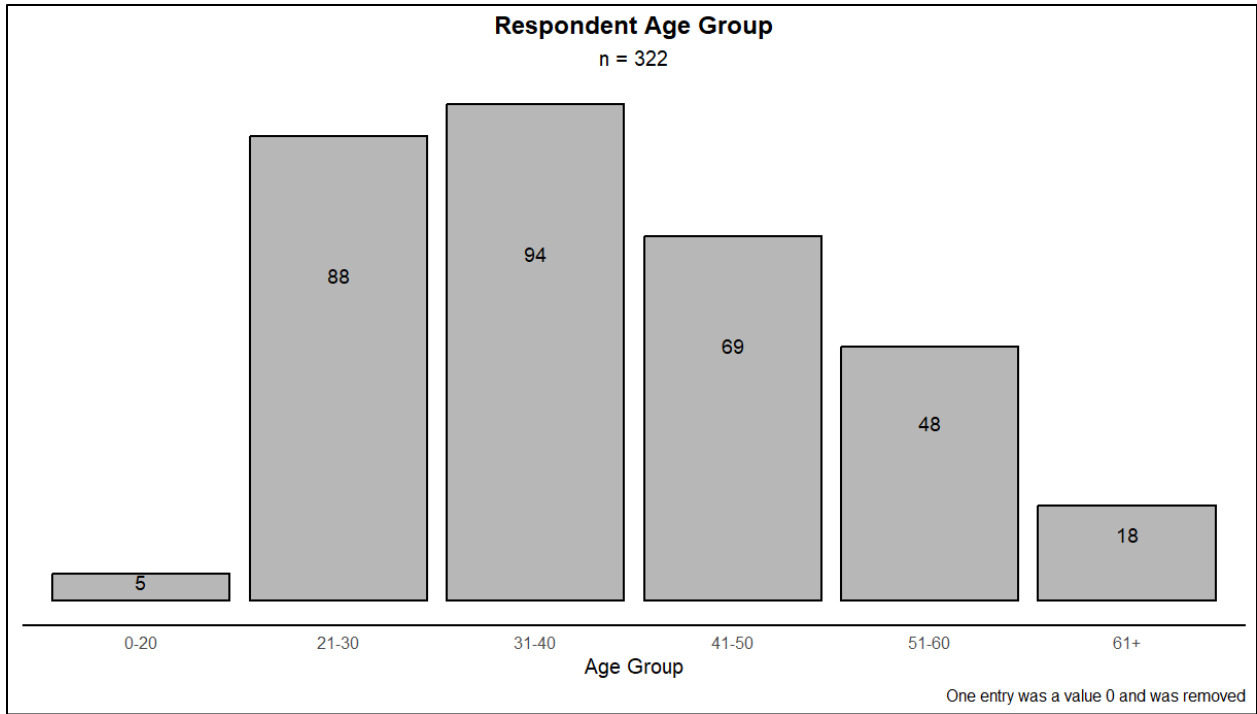


Figure 4.3. Survey respondent age brackets, with one entry removed.

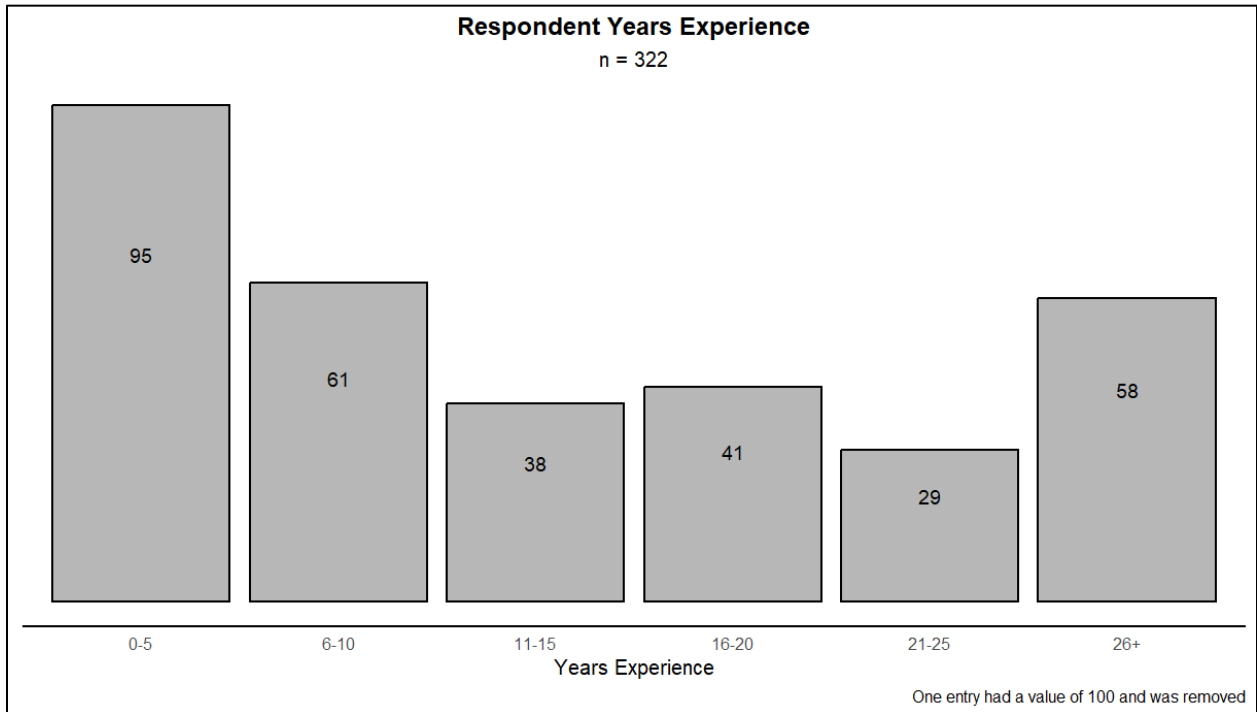


Figure 4.4. Survey respondent years of paramedicine experience, with one entry removed.

The survey respondents' gender is presented in Figure 4.5. The respondents were asked to self-select their gender: 59% identified as men, 37% as women, 2% preferred not to say, 2% as non-binary, and > 1% self-identified their preferred gender term.

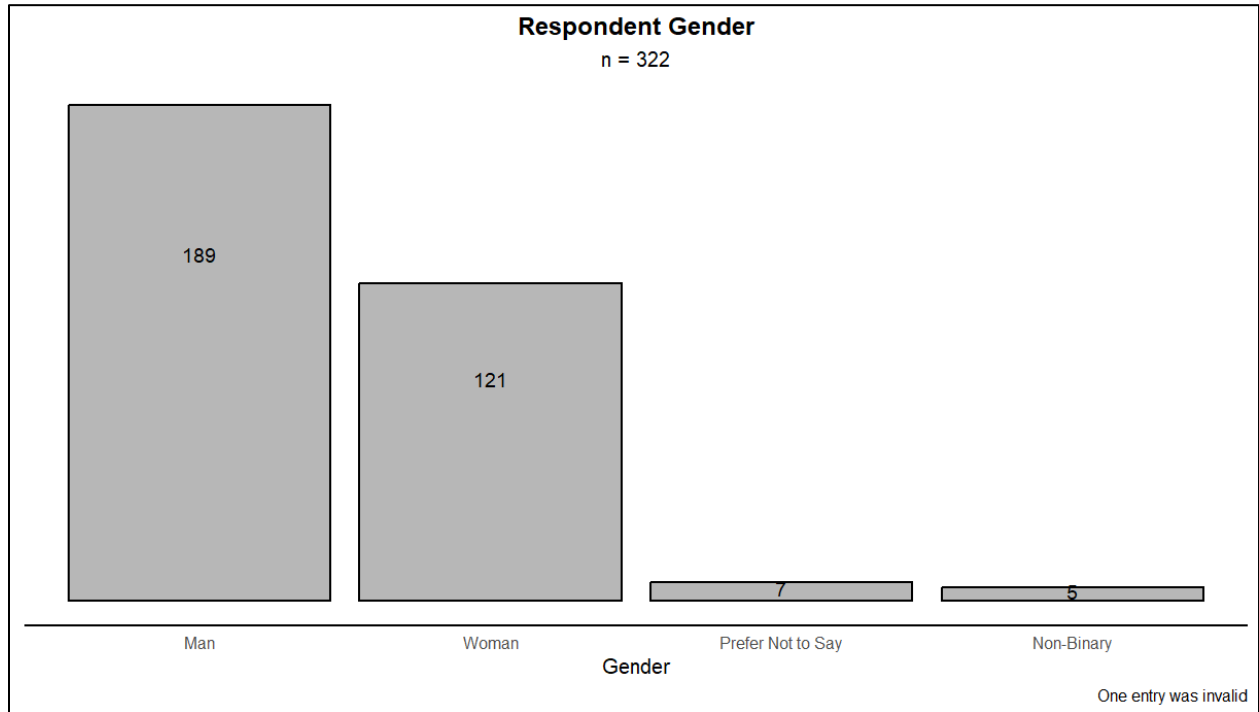


Figure 4.5. Respondent self-selected gender.

The respondents also characterized their role within paramedicine (Figure 4.6). This survey question allowed for multiple responses. For example, a respondent could have classified their role as an Educator and Frontline Staff, or as a Supervisor and Researcher and Frontline Staff, or any such combination of roles. This means that while there were n = 323 responses, the number of roles counted is 416.

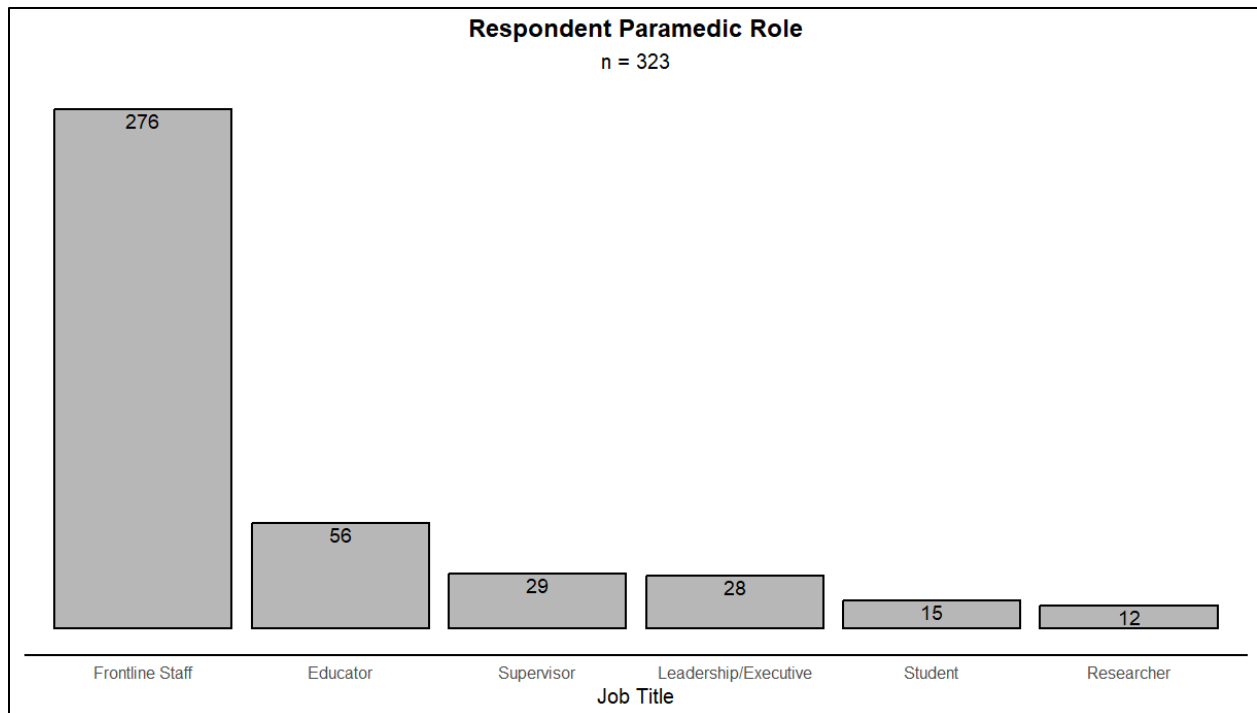


Figure 4.6. Self-identified role within paramedicine, respondents could select multiple roles

The demographics of the respondents are in line with the general population of paramedics who are currently working in Canada. Other than missing respondents from Yukon, Northwest Territories, and Nunavut, the current sample covers all regions in Canada. Figure 4.7 shows the paramedic population by province in Canada (Rowland & Brydges, 2021), and the number of responses by province. Only Quebec seems to be underrepresented, while Nova Scotia, New Brunswick, and Saskatchewan are overrepresented. The reported gender split in paramedicine in Canada is reported to be 64% men, 35% women, and 1% non-binary and self-identified. The survey respondents followed a similar pattern, with 59% identifying as men, 37% as women, and 5% as non-binary, preferred not to say, and self-identified. The median age of paramedics in Canada is recorded as 39 (Canada, n.d.), and the median age for survey respondents was 38.

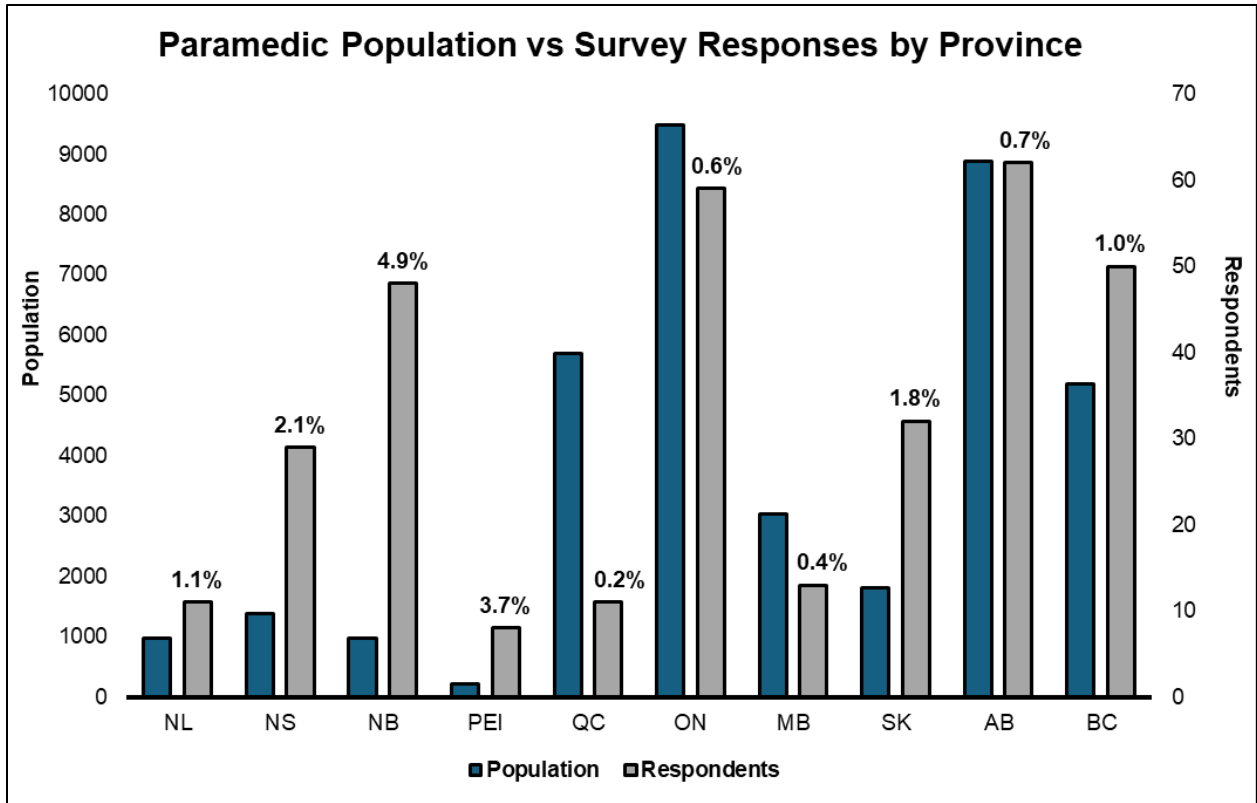


Figure 4.7. Paramedic population and survey responses (percentage of the population included above respondents) by province, most provinces are represented by the proportion of the population.

4.1.2 Socio-technical Model Dimensions

4.1.2.1 Hardware and Software Computing Infrastructure

Hardware and software computing infrastructure refers to specifically the hardware and software that runs the system (Sittig & Singh, 2015). This includes networks and connections required, as well as any physical properties of the device, such as battery life. Figure 4.8 shows the respondents' ratings of the provided features in the hardware and software computing infrastructure dimension.

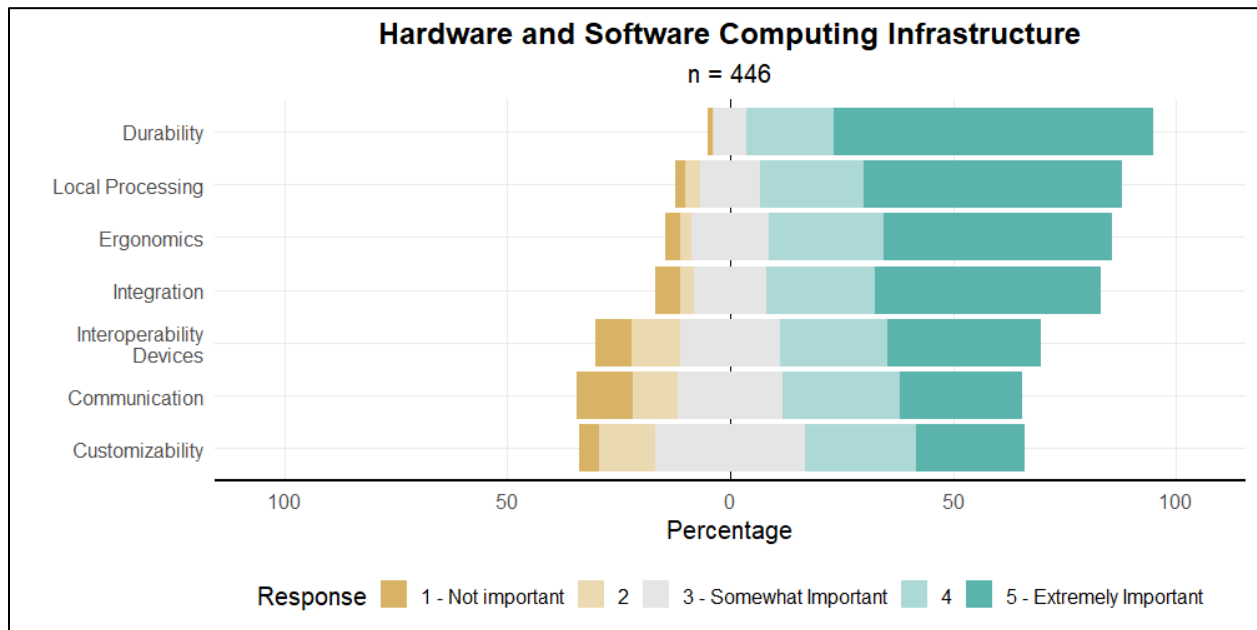


Figure 4.8. Likert results from question 2 organized from least to most important.

Durability, which includes the sturdiness of the device, the ability to easily sanitize the device, its overall battery life and the ability of the device to operate in adverse weather conditions, was rated as the most important at 91% high importance (either rated 4 or 5), 7% medium importance (rated 3), and 2% low importance (rated either 1 or 2), of the provided options. The durability of the device was also mentioned in the open-ended responses within the survey as a reason for adoption or, if done poorly, a lack of adoption. Some respondents stated that if it were

“difficult to clean” or if the device was unable to be “used with approved PPE,” they would be less likely to adopt and more likely to adopt if the device was “lightweight, durable, with a long battery life” or “durable, and rechargeable”. One respondent stated:

“I am concerned that the technology will have a hard time functioning consistently in our work environment.” – Respondent #17 Q11

Local processing, referring to the ability to use the device without a cellular or Wi-Fi connection, was ranked as the second most important by the respondents, with 81% high, 13% medium and 6% low importance. However, the only mentions of the feature in the open-ended questions were of concern that the lack of local processing would make paramedics less likely to adopt the technology. Paramedics listed “Connection issues,” “Slow processing,” and poor connectivity causing malfunctions within rural environments as reasons they would not adopt SR technology.

“My concern is that if this system requires cellular connection when working in a rural area that could be compromised.” – Respondent #219 Q11

The ergonomics of the device was rated as the third most important by respondents, with a 77% high, 17% medium, and 6% low importance rating. Ergonomic issues such as “having a bulky headpiece”, “cumbersome,” or “aesthetically unpleasant” were mentioned frequently in the open-ended responses as reasons respondents would be less likely to adopt SR technology. The device being “comfortable to wear for 12+ hrs” or “something that does not look out of place on my head/face” were mentioned as features that would make respondents more likely to adopt the technology.

4.1.2.2 Clinical Context

The clinical context dimension includes everything that is considered a part of the knowledge to practice to information continuum (Sittig & Singh, 2015). This can include a wide range of data used to configure software elements, specific vocabulary items, elements of the patient's specific condition, or lists of data for recording or ordering medications. Figure 4.9 shows the Likert responses from the survey.

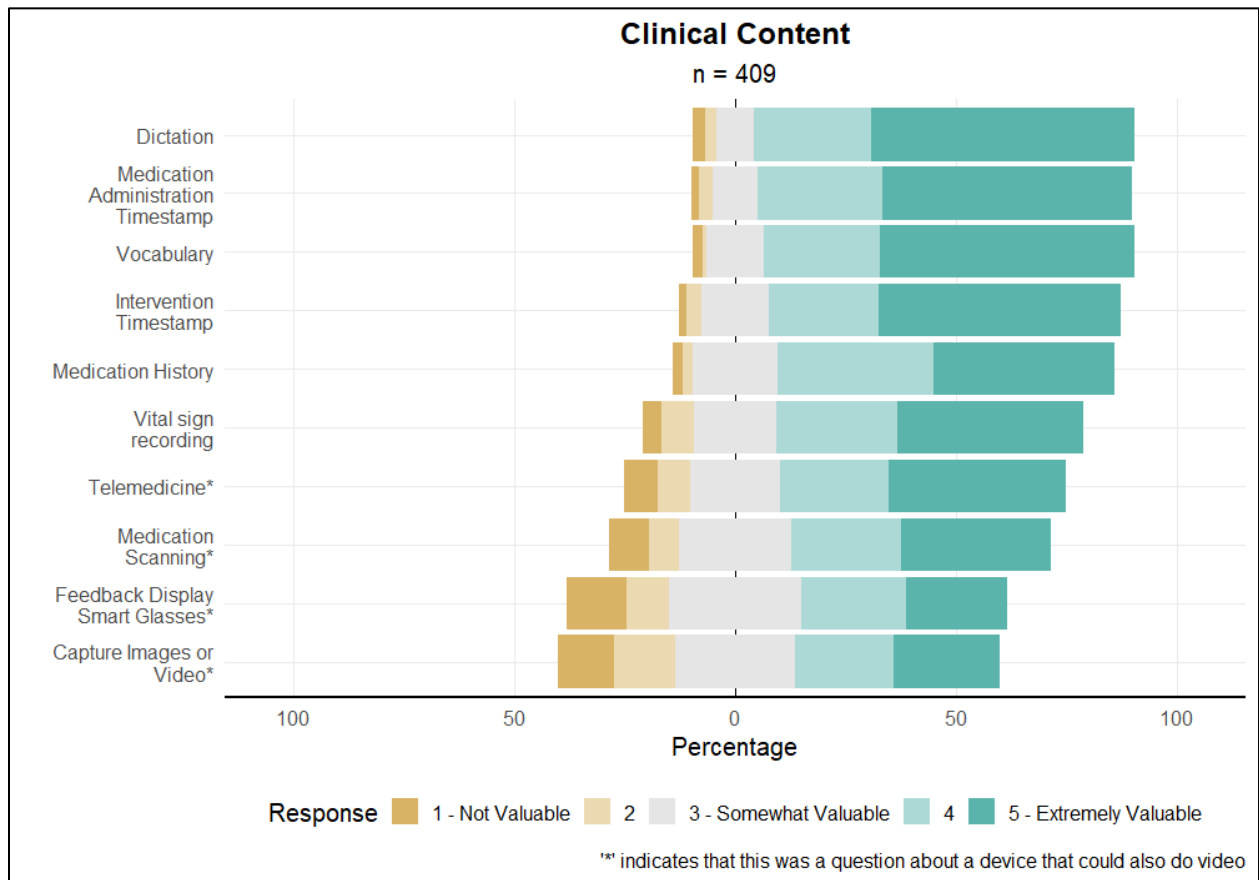


Figure 4.9. Likert results from questions 3-4 organized from most to least valuable; those with an '*' refer to a hypothetical implementation with a video component.

The most valuable feature, according to respondents, was dictation, which referenced the ability to use the device to dictate the narrative documentation into the ePCR. This would include long-form free-text sections that are normally used for a history of the incident or on-scene

assessments. Dictation had an 86% high value (rated 4 or 5), 9% medium value (rated 3), and 5% low value (rated 1 or 2) and featured prominently in free-text responses about which features would make respondents more likely to adopt SR documentation.

The second most valuable feature, with 85% high, 10% medium, and 5% low-value ratings, was the ability to timestamp medication administration using hands-free SR technology. The intervention timestamp was also rated highly, with 80% high, 15% medium, and 5% low value ratings. These two features were often interchanged or included together in the free-text responses. However, they were only reflected positively, and there were no negative sentiments regarding timestamping.

“Time stamping would be one of the best benefits, especially on more chaotic calls where a lot of interventions are happening.” – Respondent # 442 Q11

Four of the included features were included based on a hypothetical implementation that included a device capable of video, like smart glasses or body cameras. These four features were rated the lowest, with the highest rated being telemedicine, which is the ability to stream video directly to consulting physicians, at 65% high, 20% medium, and 15% low value. Capturing images and video of patient injuries was the lowest-rated feature at 46% high, 27% medium, and 26% low value.

4.1.2.3 Human-Computer Interface

The human-computer interface dimension includes all facets that involve user interaction with the device or software (Sittig & Singh, 2015). This includes the initial recording accuracy, editing ability, how the feedback is displayed and underlying software that processes the user interaction. Figure 4.10 shows the respondent's Likert ratings of selected features.

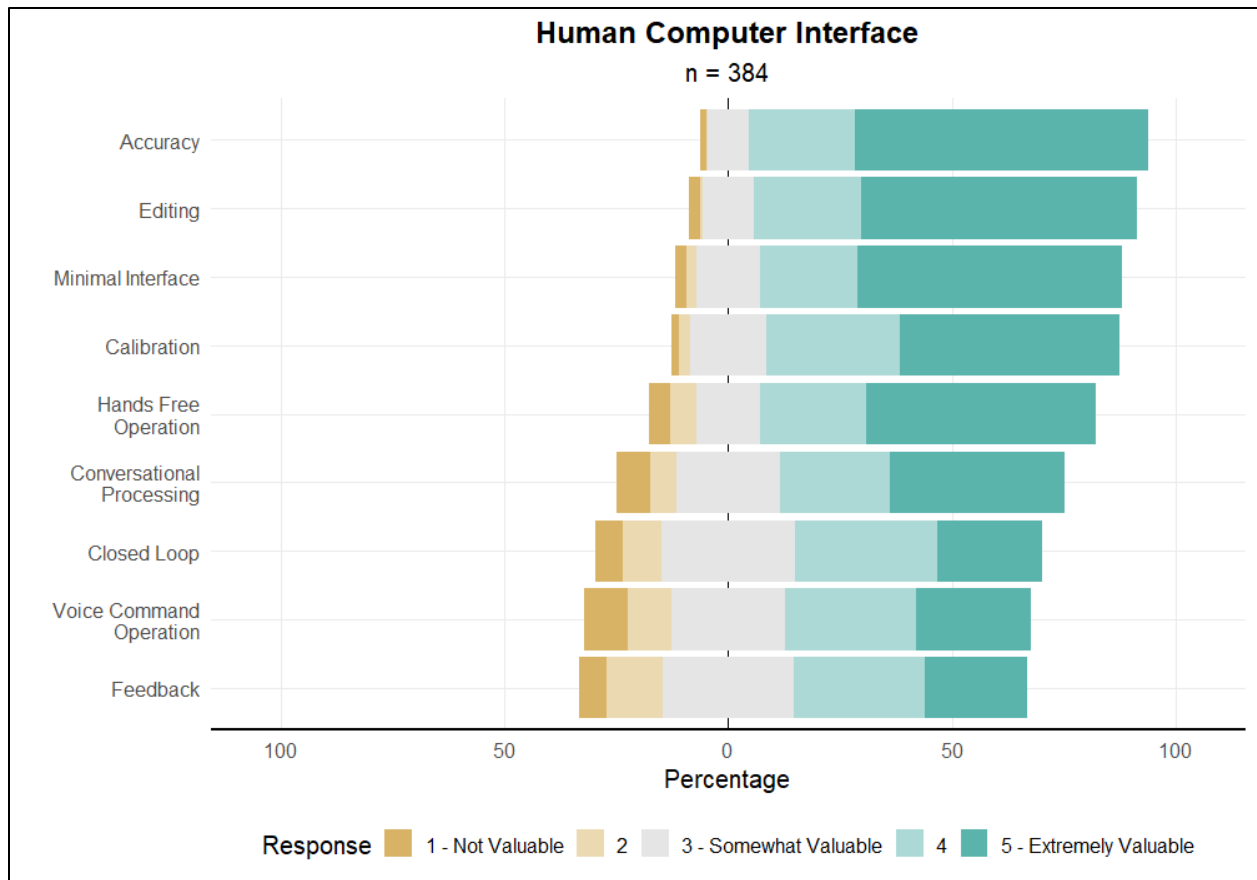


Figure 4.10. Likert rankings from questions 5 ordered from most to least valuable.

The accuracy of the speech recognition interface, including high word recognition rates and the ability to select best-fit words from a paramedicine-specific vocabulary, was the highest-rated feature, with 89% high, 9% neutral, and 2% low-value rating. High accuracy was the most frequently mentioned feature in what was likely to increase respondents' adoption of the technology. Conversely, poor accuracy was mentioned frequently as a reason that would reduce adoption rates.

“The system will save the most time when it makes the least mistakes possible; otherwise, I’ll just have to do a ton of editing afterwards.” – Respondent # 161 Q11

Editing, the ability to manually edit or correct SR entries using a keyboard or digital interface, was the second highest-rated feature, with 86% high, 11% medium, and 3% low-value

ratings. The inability to edit was mentioned frequently as a reason that respondents would be less likely to adopt SR technology. The free text comments indicated that the ability to edit any entries made by the SR technology will be important to users.

“I need the ability to edit after the call for accuracy, I want it to be smart & not have to change the way I do a call to have it recognize things” – Respondent # 288 Q11

Having a minimal interface, referring to either the screen or the headset, which would not interfere with the patient interaction, was the third most valuable feature, rated at 81% high, 14% medium, and 5% low value. However, most of the free text sections only refer to the interface disrupting patient care. The concerns were about the interface being “distracting” or “a barrier to patient interaction”.

4.1.2.4 People

This dimension involves the clinicians who use the system, the patients affected by it, the staff that supports the implementation, and those who receive or transmit the information (Sittig & Singh, 2015). The features that were presented in this section revolved around different aspects of user support or how important affected stakeholders would be to the respondents. The respondent's ratings are presented in Figure 4.11.

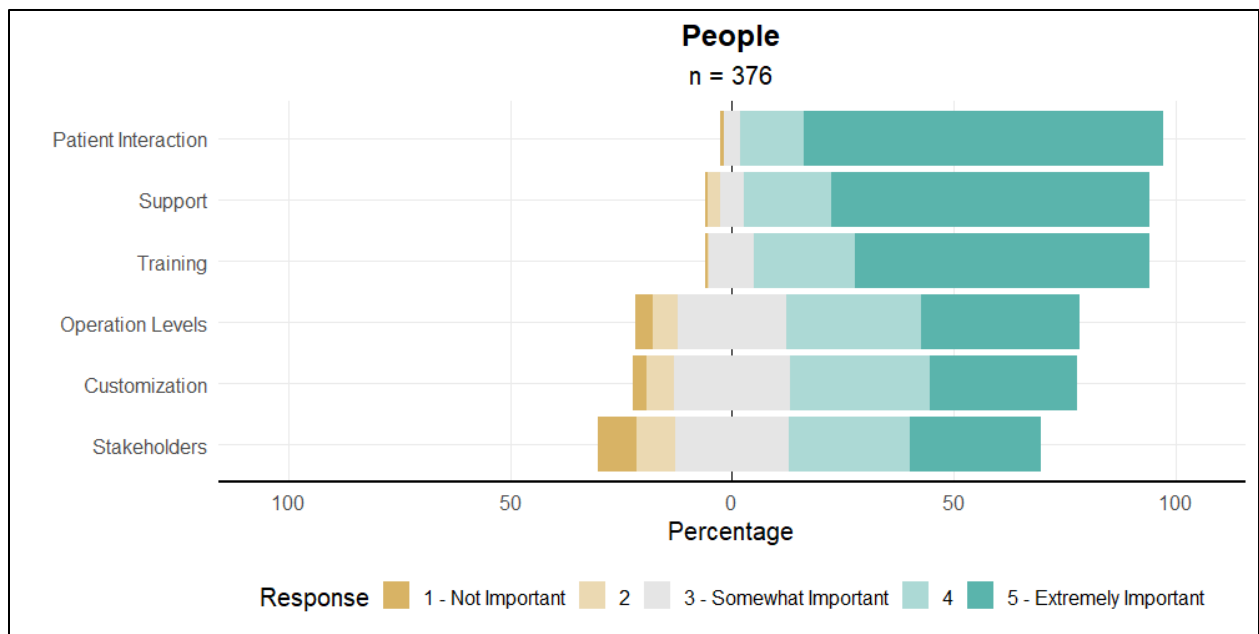


Figure 4.11. Likert responses to question 6, ordered from most to least important.

Patient interaction refers to the device and its effect on patient interaction. Specifically, the device should not interfere with the interaction between the patient and the paramedic. This feature was rated the highest with 95% high, 3% medium, and 1% low importance ratings. Interference or disruption to patient care was cited 39 times in the free text question 18 regarding what would make paramedics less likely to adopt speech recognition technology.

“If speech-recognition technology distracts from or otherwise compromises patient care, I would be less likely to use it.” - Respondent # 398 Q18

Easily accessible technical support was the second highest-rated feature, with 91% high, 5% medium, and 3% low importance ratings. However, the idea of technical support was not mentioned in any of the free text sections of the survey.

Adequate training time for practitioners to practice with and learn the interface was the third highest-rated feature, with 89% high, 10% medium, and 1% low importance ratings. The lack of adequate training was again referenced as a reason not to adopt the technology, and having “lots

of opportunity to practice prior to using (the device) on calls” was mentioned as a condition that would make respondents more likely to adopt SR technology.

“(If) We don't receive proper training, no one will be good at it, nor will I feel comfortable using it should we lack training.” – Respondent # 15 Q18

4.1.2.5 Workflow and Communication

The workflow and communication dimension acknowledges that working in healthcare requires working cohesively with others (Sittig & Singh, 2015). This is especially true in paramedicine, where patients are transferred from the paramedic's care to another facility relatively quickly, and often two paramedics attend each patient interaction. With this in mind, the following features were suggested as part of the SR documentation system, with results presented in Figure 4.12.

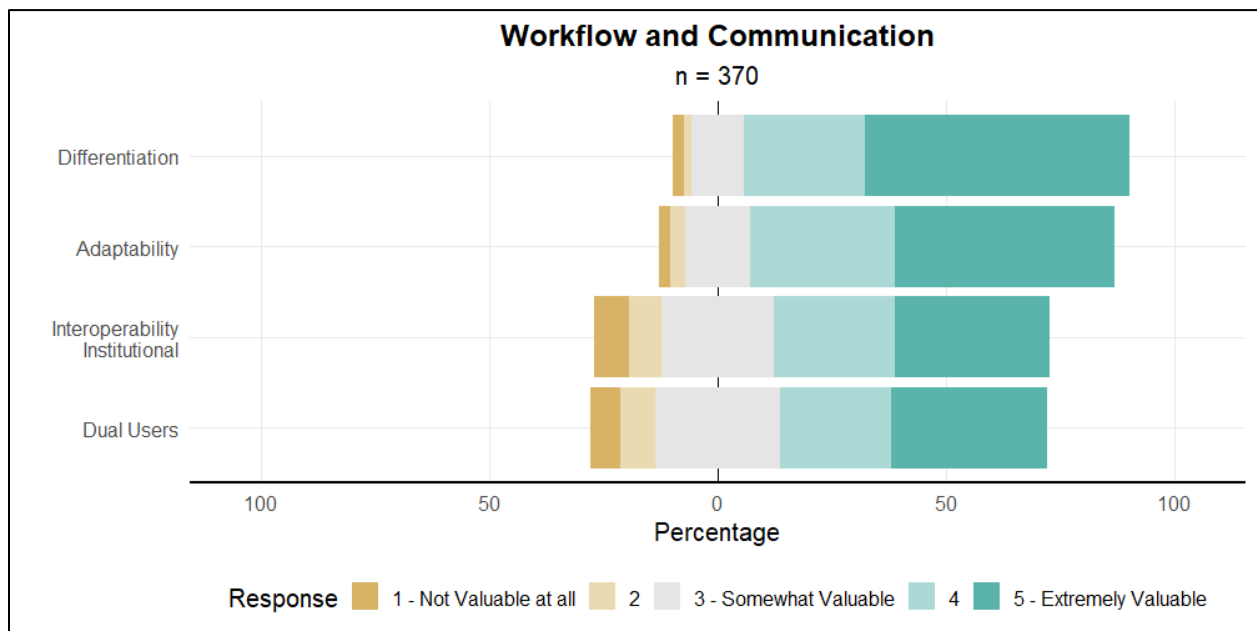


Figure 4.12. Likert responses to question 7, ordered from most to least valuable.

Differentiation, which is the ability of the device to recognize and differentiate conversations between paramedics or conversations in the room and active patient care, was the

most valuable at 85% high, 11% medium, and 4% low-value ratings. The lack of differentiation, or the ability of the system to parse “in-the-room conversation”, was mentioned in question 18 as a reason that they would be less likely to adopt the technology. It was also mentioned as a lack of paramedic privacy.

“Perception of capturing less than professional interactions” – Respondent # 204 Q18

The adaptability of the SR documentation system, which would be its ability to integrate into existing workflows, and technologies, such as cardiac monitors, communication systems and existing ePCRs, was rated the second most valuable at 80% high, 14% medium, and 6% low value ratings. This feature of the SR documentation was not cited as a reason that paramedics are more likely to adopt the system, but the lack of integration was cited as a reason users would be less likely to adopt the technology.

“Technology and integration hiccups - having been through many poor integrations or challenges between MDT/dispatch/ePCR/life pack - integration is great when it works, totally more work when the pieces don't sync or talk to each other, or the tech fails.” – Respondent # 464 Q18

The ability to use the SR technology to transmit the ePCR or any piece of the ePCR, such as vitals, electrocardiograms (ECGs), or a list of interventions, which was termed institutional interoperability, was the third highest rated at 61% high, 25% medium, and 15% low-value ratings. The feature was recognized as an important way to improve patient care. However, the lack of integration was listed as a reason not to adopt the SR technology.

“I think the ability of the hospitals, especially some areas, to access our records and telemetry would be invaluable for patient care.” – Respondent # 204 Q11

4.1.2.6 Organizational Policies, Procedures, Environment and Culture

An organization's internal policies and structures can affect most aspects of technology adoption (Sittig & Singh, 2015). The control of capital budgets determines the quality of the device, and well-thought-out internal documentation support policies and engagement of external stakeholders are part of the organizational operation. The organization will set the tone for the implementation of the SR device, which can have a large effect on its adoption. The Likert results are presented in Figure 4.13.

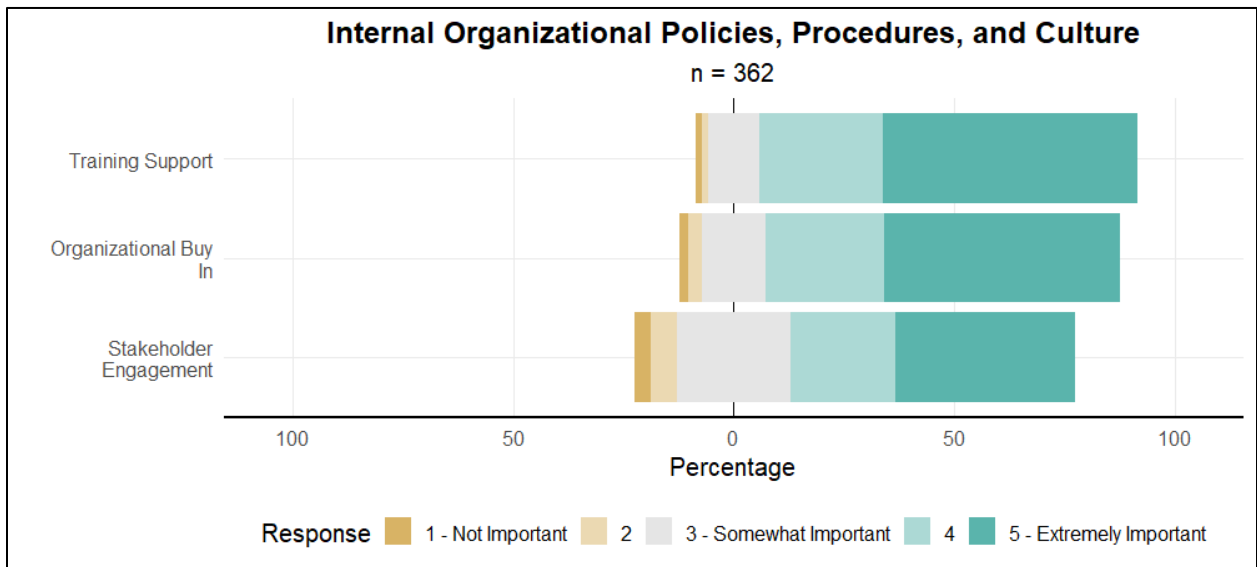


Figure 4.13. Likert responses to question 8, ordered from most to least important.

Training support is similar to the feature adequate training; however, this referred specifically to the organization putting policies around the training regiment in place. Training support was rated as the highest, with 86% high, 12% medium, and 3% low importance ratings. One comment suggested that if the quality and amount of training provided were poor, it would be a reason not to adopt SR technology.

“If time was not given (*by the organization*) to properly learn and integrate the technology” –

Respondent # 491 Q18

Organizational buy-in was the second highest rated, with 80% high, 14% medium, and 5% low importance ratings. This referenced the buy-in of the senior leadership within the organization and their commitment to the benefits and potential time savings of SR documentation. There were no mentions of this feature in the survey's free text questions.

Stakeholder engagement, in this instance, refers to the organization's willingness to work with other response organizations, hospitals, and health authorities to create policies that allow the integration of SR technology. This feature received 65% high, 26% medium, and 10% low importance ratings and was not mentioned in the free-text questions.

4.1.2.7 External Rules, Regulations and Pressures

External rules, regulations and pressures explore the external forces that dictate or constrain how the system can be designed, used and evaluated (Sittig & Singh, 2015). This would include privacy legislation and barriers to patient data use, storage or transmission. These questions did not attempt to gauge the ability of SR technology to meet the regulations, but how respondents perceived the importance of each possible way to address the regulations or barriers. The results of the Likert responses are presented in Figure 4.14.

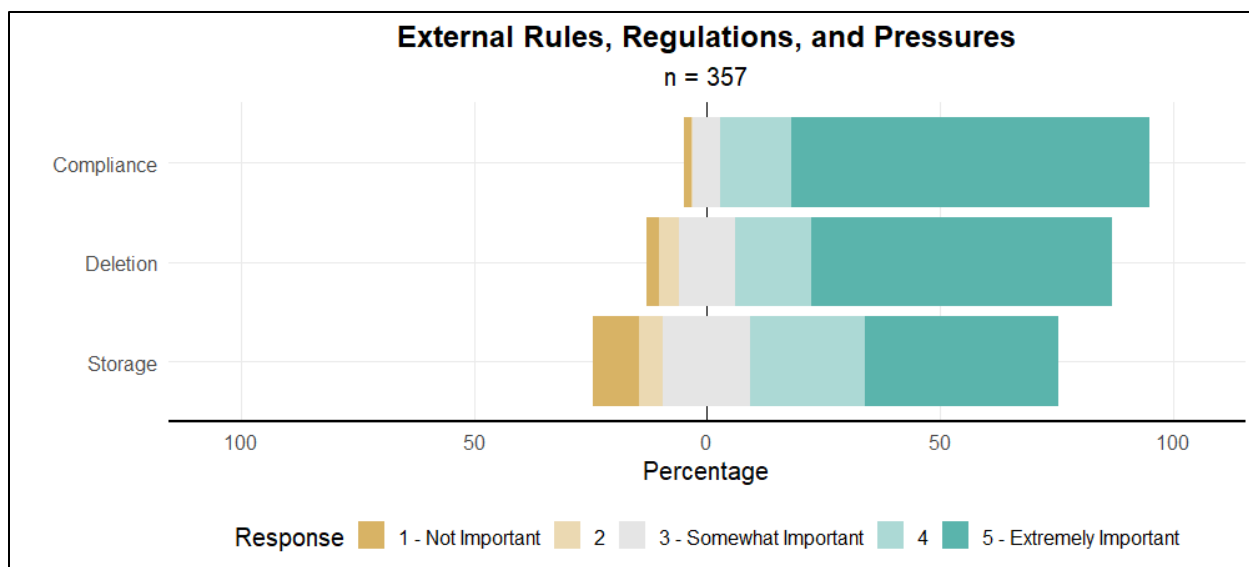


Figure 4.14. Likert responses to question 9, ordered from most to least important.

The highest-rated feature was compliance, which was described as the technology's ability to meet all medicolegal requirements for recording audio and video of patients. It was rated at 92% high, 6% medium, and 2% low importance. The lack of compliance with privacy legislation was mentioned as a reason not to adopt SR technology.

“Privacy legislation is possibly the largest barrier and would need to be addressed specifically. When documenting (for example), other people could overhear what is being said into the device when they were not involved in the circle of care.” – Respondent # 363
Q11

Deletion was rated the second most important feature to comply with regulation, at 81% high, 12% medium, and 7% low importance. This refers to the software deleting any recordings stored on the local device as the user logs out. It was included as a feature that would make respondents more likely to adopt the technology.

The storage of all recorded conversations in a cloud service for the required period for recall, when mandated legally, was rated as the least important at 66% high, 19% medium, and

15% low importance ratings. Concerns regarding the ability to protect the patient data if it were stored in a cloud-based service.

“My main concern with this and other data collection technologies is the security of the data both in transmission and storage. While meeting legal standards is routinely done, those standards repeatedly fail to protect patient information. This is especially problematic with centralized online cloud storage solutions. A single large target merits the effort of obtaining and decrypting the stored data on potentially every patient in the system. While much more cumbersome and expensive, offline data storage increases the effort and expense of data theft. Often to a prohibitive degree.” – Respondent # 426 Q11

4.1.2.8 System Measurement and Monitoring

The system measurement and monitoring dimension addresses the availability of the features, clinician use, system effectiveness, and documenting unintended consequences (Sittig & Singh, 2015). In the survey context, the questions asked intended to gauge the importance of the measurements and corrections that can be produced before or during the implementation of an SR technology (Figure 4.15).

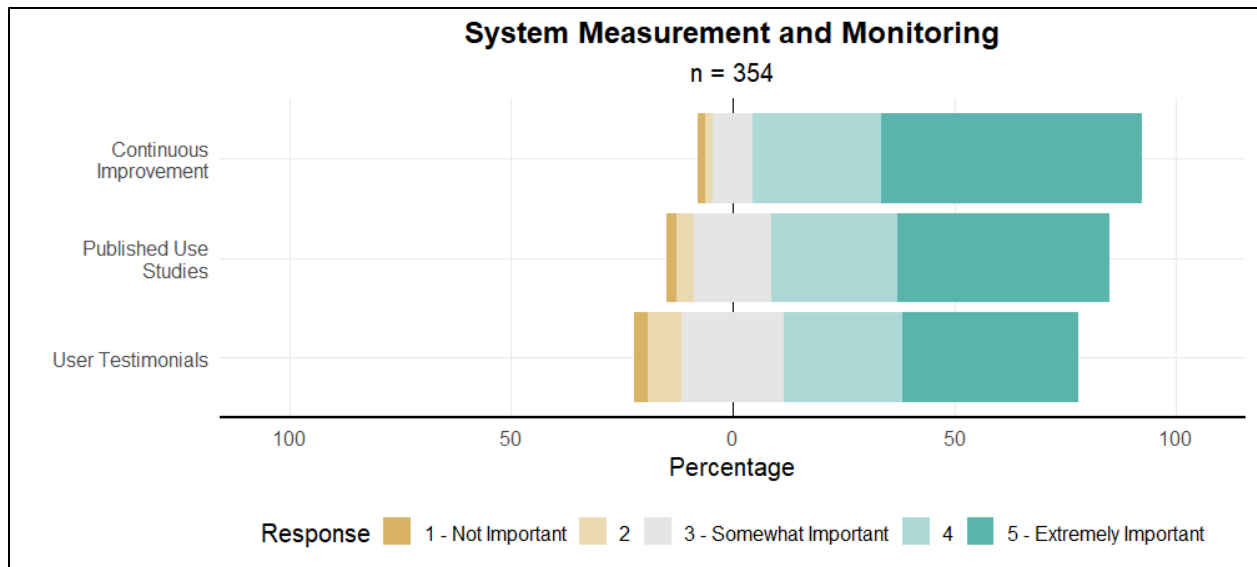


Figure 4.15. Likert responses to question 10, ordered from most to least important.

Continuous improvement refers to the implementation of regular feedback sessions to identify areas of improvement or areas for further expansion or use, which was rated as the most important at 88% high, 9% medium, and 3% low importance ratings. In the free-text questions, respondents commented that they would be more likely to adopt the technology if their feedback was likely to lead to change.

“That our input of what doesn't work ACTUALLY equates to change” – Respondent # 15 Q19

Published use studies were rated the second most important at 76% high, 18% medium, and 6% low importance ratings. This question referred to the availability of published group studies that identify the efficiency and effectiveness of the SR technology in a live environment. The only mention of use studies was a single comment regarding change management.

“Paramedics do not always receive change well. However, with the proper proof of concept and training, I think it would be an extremely useful addition to our practice!” – Respondent # 497 Q11

User testimonials were rated as the least important, with 66% high, 23% medium, and 11% low importance ratings. The ability to hear from services or paramedics who have used the SR technology was not mentioned in the free text questions within the survey.

4.1.2.9 Ranking Dimensions

Question 14 in the questionnaire asked respondents to rank which sections of features they believed were most important to keep and which were less critical. Respondents were asked to rank the sections of the new socio-technical models in order from 1 to 8, with 1 being the most important and 8 being the least important. The results from question 14 are presented in Figure 4.16.

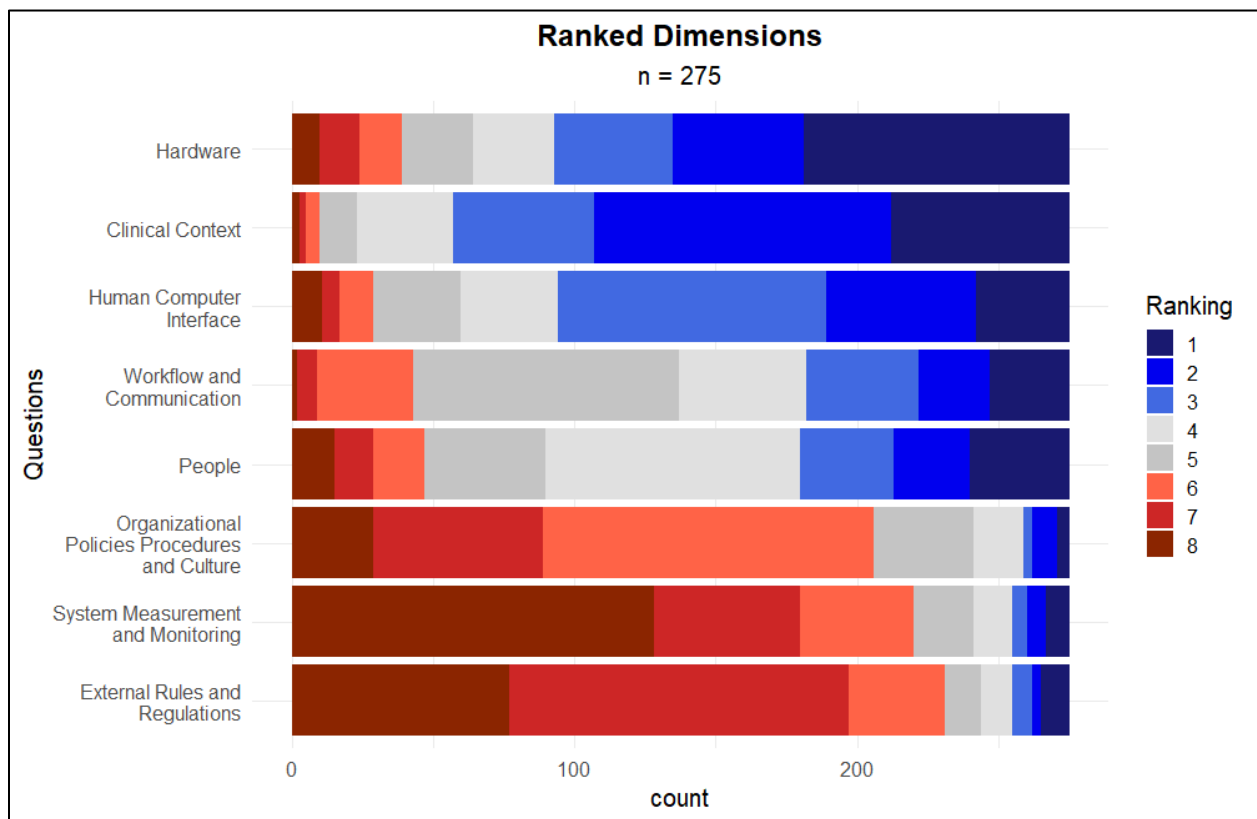


Figure 4.16. Ranked dimension, with 1 being important to keep and 8 being more willing to trade-off.

The hardware section had the largest number of top rankings. However, the clinical context section had more high rankings (rankings 1-3) and fewer low rankings (rankings 6-8). Human-computer interface was ranked third most important, with fewer top rankings but a large number of high rankings and fewer low rankings. The workflow and communication, and people sections both had large numbers of neutral rankings (rankings 4, 5). Workflow and communication had fewer lower rankings, and people had more higher rankings. Organizational policies, procedures and culture, system measurement and monitoring, and external rules and regulations sections were consistently lowest ranked. While system measurement and monitoring received the largest number of the lowest rankings, external rules and regulations received the highest number of overall low rankings.

4.1.3 Overall Feature Rankings and Classification

All features that were presented to respondents are combined and ranked using their overall high importance or value ranking (rated 4 or 5). This included a total of 45 features, which are presented in Figure 4.17.

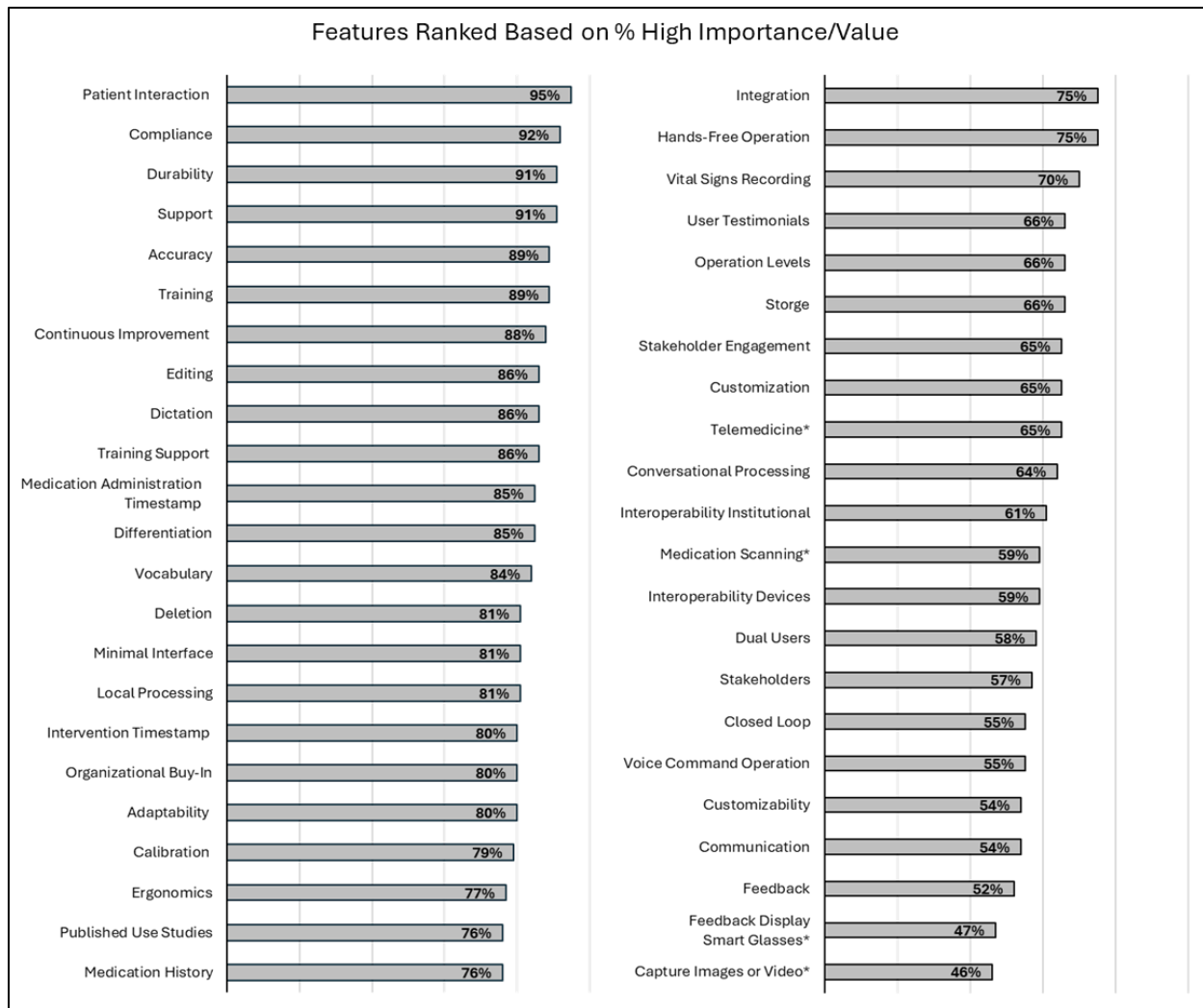


Figure 4.17. All provided features, those with an ‘*’ were listed as a part of a smart-glasses implementation. The graphic is split along the median value, with everything below on the right side.

To classify the features, the difference between the highest-value feature (95%) and the lowest-value feature (46%) was divided into five equal groups. Must have features (86-95%), very important features (76-85%), important features (66-75%), less important features (56-65%), and unnecessary features (46-55%). Each feature is classified and presented in Table 4.2, along with the mean Likert score.

Table 4.2. Questionnaire features are categorized by the % importance into equal-sized groups; features with an ‘*’ represent a smart glasses-based implementation.

Classification (# in class)	Feature	% High Importance/Value	Mean Likert Score
Must-Have Features (10)	Patient Interaction	95%	4.74
	Compliance	92%	4.66
	Durability	91%	4.60
	Support	91%	4.59
	Accuracy	89%	4.53
	Training	89%	4.52
	Continuous Improvement	88%	4.42
	Editing	86%	4.42
	Dictation	86%	4.37
	Training Support	86%	4.36
Extremely Important Features (13)	Medication Administration Timestamp	85%	4.36
	Differentiation	85%	4.36
	Vocabulary	84%	4.36
	Deletion	81%	4.36
	Minimal Interface	81%	4.33
	Local Processing	81%	4.31
	Intervention Timestamp	80%	4.28
	Organizational Buy-In	80%	4.26
	Adaptability	80%	4.19
	Calibration	79%	4.22
	Ergonomics	77%	4.19
	Published Use Studies	76%	4.16
	Medication History	76%	4.11
Very Important Features (6)	Integration	75%	4.11
	Hands-Free Operation	75%	4.11
	Vital Signs Recording	70%	3.96
	User Testimonials	66%	3.92
	Operation Levels	66%	3.88
	Storage	66%	3.83
Less Important Features (9)	Stakeholder Engagement	65%	3.92
	Customization	65%	3.85
	Telemedicine*	65%	3.82
	Conversational Processing	64%	3.82
	Interoperability Institutional	61%	3.72
	Medication Scanning*	59%	3.67
	Interoperability Devices	59%	3.66
	Dual Users	58%	3.72
	Stakeholders	57%	3.60

Unnecessary Features (7)	Closed Loop	55%	3.58
	Voice Command Operation	55%	3.51
	Customizability	54%	3.52
	Communication	54%	3.46
	Feedback	52%	3.51
	Feedback Display*	47%	3.33
	Capture Images or Video*	46%	3.31

There are a total of ten features included in the 'Must Have Features' class. They include three features from the People dimension, two from the Human-Computer Interface dimension, and one from each of the Hardware and Software, Clinical Content, Internal Policies, Procedures, and Culture, External Rules, Regulations, and Pressures, and System Measurement and Monitoring. The only dimension not represented was Workflow and Communication.

4.1.3 The Minimum Set and Additional Features

In question 13, respondents were asked to list the five features selected from a drop-down list, including all features and functions listed in the survey (44 total features), that they would want to see as a minimum for them to consider adopting the technology. 40 total features were selected at least once by respondents. Figure 4.18 shows the top five results from question 13.

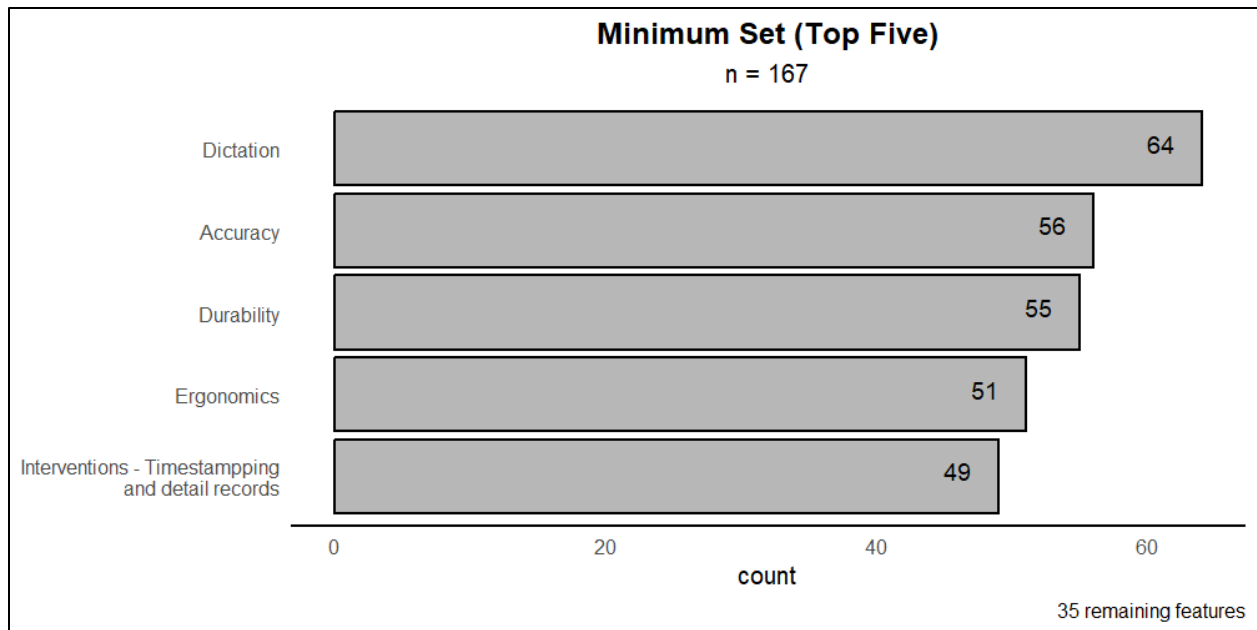


Figure 4.18. The top five most requested features for a minimum set, there were 40 total features selected.

There were 40 total features selected by participants. Given that there was a significant drop in count (from 49-40) the remaining 35 were separated and only the top five are shown here. The counts ranged from 64 to a single count for several features. The remaining 35 features are presented in Appendix 9 Figure 8.3. Dictation was the most frequently requested as a part of the minimum set and was rated as the most valuable in the clinical context section of the survey. Accuracy was rated the most valuable in the human-computer interface section. Durability was likewise rated the most important feature in the hardware section, and ergonomics was the third most important feature. Intervention timestamping was rated the fourth most valuable feature in the clinical context section.

Respondents were asked to write in additional features that were not included in the survey that they believed could be possible with SR technology, in question 12. There were 67 responses to this question; however, some were re-wordings of features that were included in the survey. Figure 4.19 lists the additional features that were suggested by respondents.

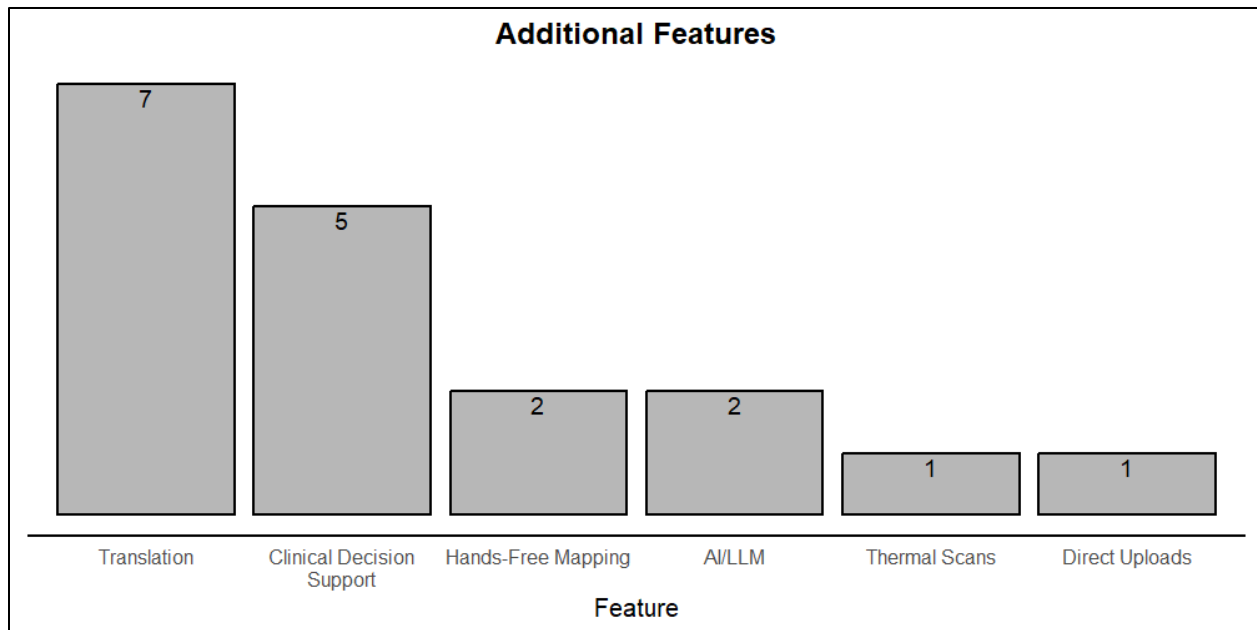


Figure 4.19. Additional features that were listed in response to question 12. (AI = Artificial Intelligence, LLM = Large Language Models)

The ability to have live language translation services embedded in the SR documentation software was mentioned 7 times by respondents. The use of the SR interface to deliver clinical decision support was mentioned 5 times. Hands-free mapping, referred to as using the SR technology to interface with the mapping software used in ambulances, was mentioned 2 times. Using the SR technology to interface with an “AI doctor” or a large language model was mentioned 2 times. The ability of the smart glass implementation to perform thermal scans was mentioned 1 time, and the ability to directly upload information to the patient's hospital EMR was mentioned 1 time. The live translation service feature was mentioned more frequently than 11 of the features listed for the minimum set question.

4.1.3 Familiarity and Use of SR Technology

The questionnaire attempted to gauge respondents' familiarity with and use of SR-based technologies. The questions were framed to understand respondents' personal use of existing and well-known SR technologies. The familiarity and use of smart glasses were also included, as they have been examined as an SR technology interface. The respondents were asked to use a Likert scale to list their familiarity from 1 – Not Familiar at all to 5 – Extremely Familiar (Figure 4.20), and their use from 1 – Never Use to 5 – Daily Use (Figure 4.21).

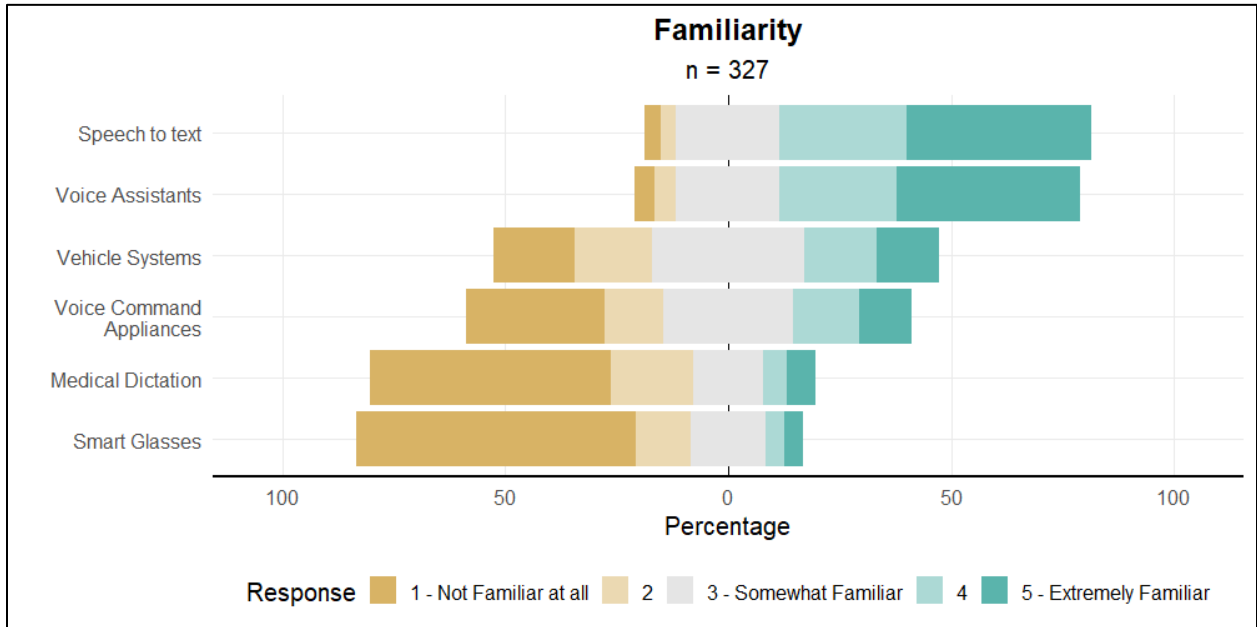


Figure 4.20. Likert responses to question 15, ordered from most to least familiar.

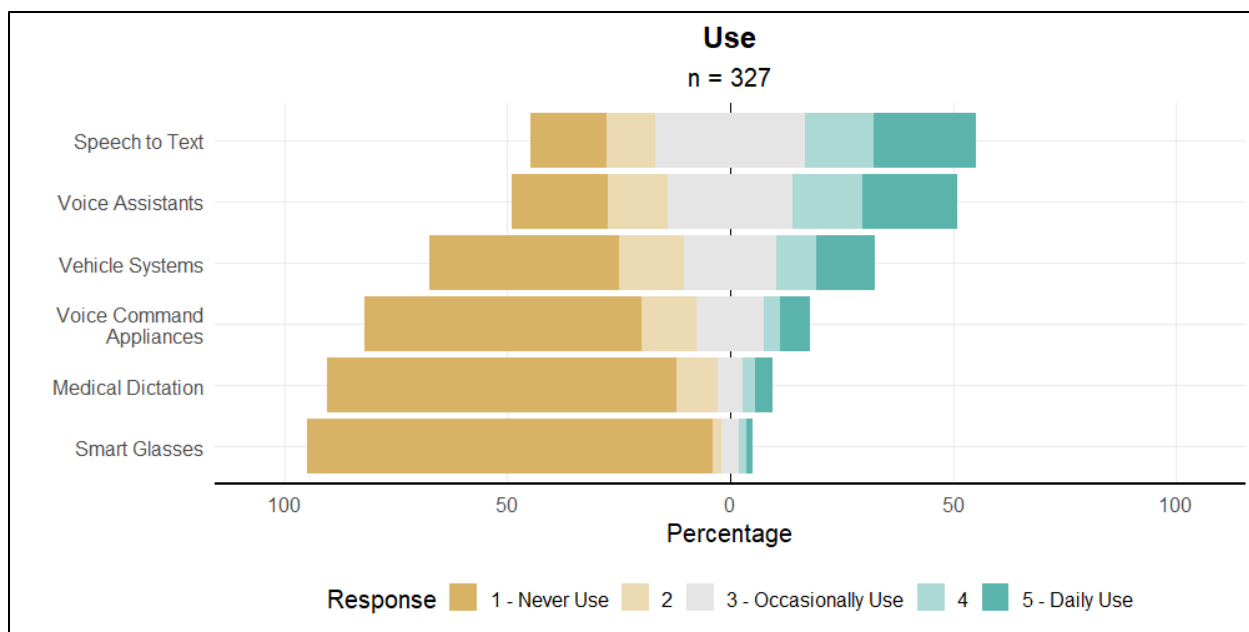


Figure 4.21. Likert responses to question 16, ordered from most to least frequently used.

As shown in the figures above, the respondents' familiarity ratings mirrored the respondents' use ratings. Overall, the use ratings were shifted left, indicating that even though respondents are familiar with the technology, it did not mean they used that technology. The speech-to-text function of smartphones and voice assistants (Siri, Alexa, and Google Home) was the SR technology that respondents were familiar with and used on a regular basis. Although 41% of respondents were extremely familiar, only 23% stated that they use the speech-to-text functionality daily. Similarly, 41% of respondents were extremely familiar with voice assistants, however only 22% reported daily use. The smart glasses received the lowest familiarity and use scores, which also saw a proportional decrease between familiarity and use.

4.1.4 Perceptions of Speech Recognition Technology

This section of the survey attempted to understand the current perceptions among paramedics of SR technology. Respondents were asked to rate the statements about SR technology from 1 – Strongly Disagree to 5 – Strongly Agree. The statements were related to the accuracy, and

efficiency vs typed documentation, the disruption of patient interaction, and the ability to have more complete and accurate notes at patient handover (Figure 4.22). The full questions are available in Appendix 8 Table 8.11.

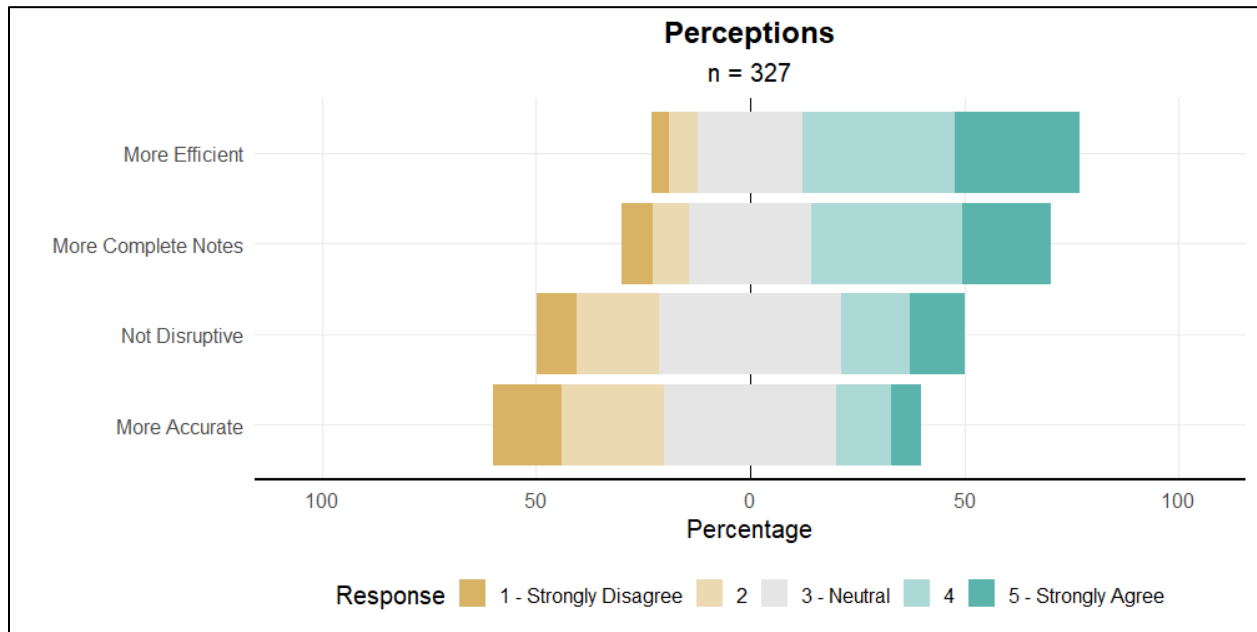


Figure 4.22. Respondents' general perceptions of SR technology.

While respondents perceive that SR technology could be more efficient and create more complete and accurate notes at handover, they do not agree that SR technology would not be disruptive to patient care and would be more accurate than typed documentation. The majority of respondents agreed that SR technology would be more efficient than typed documentation (65%), with 24% being neutral and 11% disagreeing. Similarly, 56% agreed that SR technology would help produce more complete notes, while 29% were neutral, and 15% disagreed. However, only 29% of respondents agree that SR technology would not disrupt patient care, with 43% neutral and 28% disagreeing. Only 20% of respondents agreed that SR technology would be more accurate than typing, with 40% being neutral and 40% disagreeing.

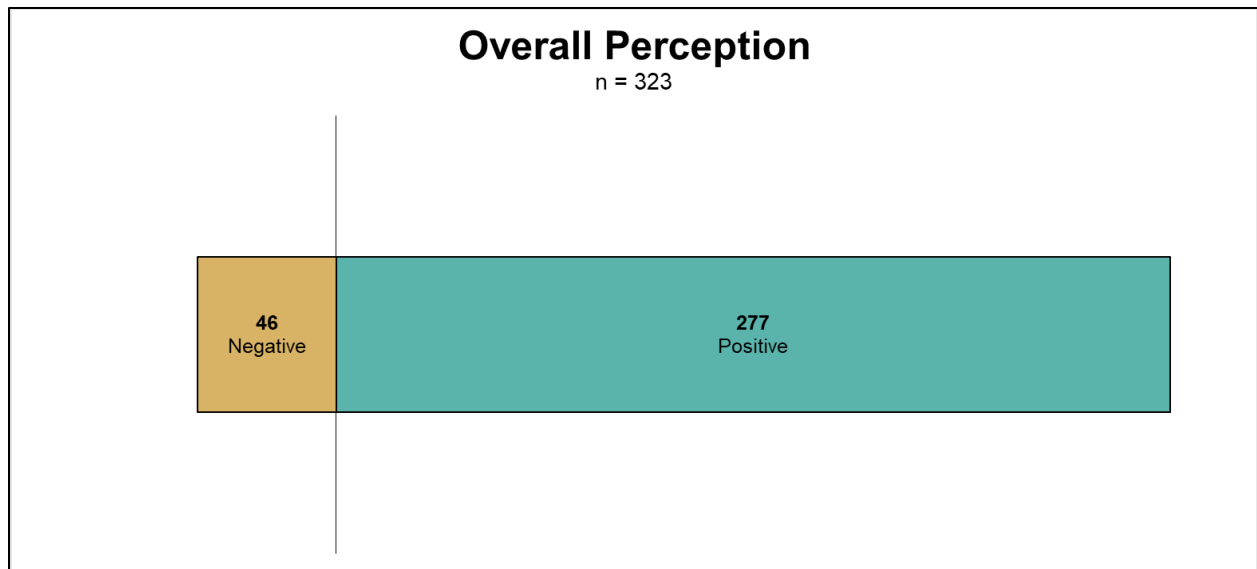


Figure 4.23. Overall perceptions of SR technology by respondents.

Overall, the majority of respondents have a positive perception of SR technologies and their potential impact on paramedicine. Many positive statements were included in the free-text questions.

“I believe it would be incredibly valuable to the profession, I believe it would not only alleviate some of the medics' heavy workload but also provide an abundance of resources and opportunity for better and more effective patient care” – Respondent # 178 Q11

There were also very strong negative sentiments regarding SR documentation technology. Some free-text responses included extreme examples of respondents who would likely never adopt the technology.

“I would NEVER use this. If this becomes a thing, I will leave the profession. There are FOIP issues all over this. As well as care is a dynamic and multi-interactive dynamic in the ambulance. I DO NOT want a constant recording or video. ALSO the minute you add technology that does the work for you, is the minute, your brain gets lazy, and you lose all sense of what happened on the call. MEMORY is crucial, and exercising memory is what

saves us and our pts (*patients*) in a court trial. Quit trying to make our jobs like robots we are HUMANS, and this is a HUMAN job. If you take that away from us, then what is the point of being a first responder” - Respondent # 51 Q11

4.1.6 Quantitative Analyses

Exploratory analyses were performed on the qualitative data. The ordinal Likert scale questions (Questions 2-10, 15-17) were compared with the collected demographics (Questions 20-26). A correlation analysis was performed on each section, and an ordinal regression analysis was performed for each group. All analyses were performed using R and R Studio, and the code for the analysis is included in Appendix 7, Table 8.10.

4.1.6.1 Correlation Analyses

Spearman’s correlations were performed on each of the eight sections of Sittig and Singh’s socio-technical model (Sittig & Singh, 2015) and the familiarity and use questions, with the demographic data collected and specific user perceptions of SR technology. The full results for the correlation matrices are available in the supplemental files. The analysis produced only very weak ($0 \leq |\rho| \leq 0.19$) to weak ($0.20 \leq |\rho| \leq 0.39$) correlation coefficients between demographics and the new socio-technical model dimensions. The exceptions were two specific perception questions that produced moderate ($0.40 \leq |\rho| \leq 0.49$) correlation coefficients with the overall perception demographic. The largest number of significant correlations were produced by the demographic predictor variable Overall Perceptions. It had 38 significant correlations with the socio-technical model dimension questions and perceptions, all of them being positive. For example, the strongest correlation present was between Dictation and Overall Perception ($S = 3957694$, $\rho = 0.295323$, p -value = 6.396×10^{-8}). The age group and years of experience demographics had 13 and 10 significant correlations, respectively. Most of these correlations occurred together, with a mix of positive and

negative correlations. There were only very weak positive and negative correlations between other demographics, such as area of practice (urban vs rural), province of practice, or gender. There were moderate, strong ($0.60 \leq |\rho| \leq 0.79$), and very strong ($0.80 \leq |\rho| \leq 1.00$) inter-question correlations. For example, in the clinical context dimension, the correlation coefficient between the intervention timestamp and medication administration timestamp is 0.86.

4.1.6.2 Ordinal Regression Analyses

Ordinal regression analysis was performed on the Likert responses in each of the eight dimensions of the new sociotechnical model using the demographic responses as predictor variables. The predictor variables included age, years of experience, overall perception and paramedicine role. This produced 12 models using different combinations of the predictor variables for each feature within the eight dimensions. Using an analysis of variance (ANOVA) test, the Akaike information criteria (AIC) for each of the 12 models were compared to the AIC for the Null model, which included no predictor variables. The full results of the analysis are available in supplemental files. Overall perception was the predictor variable that produced the best-fit (lowest AIC) model in the majority of the dimensions, either on its own (20 models) or in combination with other predictors (10 models). For example, when the dependent variable is interoperability devices, the overall perception model (AIC = 976.08) was a significantly better fit than the null model (AIC = 984.06; $X^2 = 9.799$, $df = 1$, $p = 0.002$). However, when the dependent variable is voice commands, the age+years experience+overall perception model (AIC = 951.46) was the model of best fit compared to the null model (AIC = 984.86; $X^2 = 39.403$, $df = 3$, $p < 0.0001$).

4.2 Interview Results

In this section, we present the results of the thematic analysis of the interviews conducted. In total, 14 interviews were completed, and data saturation was achieved. The themes are organized around current documentation challenges, perceived benefits of SR, SR acceptance enablers, and SR acceptance barriers, with five, five, four and four subthemes, respectively. Additional themes centred on SR technology in paramedicine also arose throughout the interview process. These included inevitable change, paramedicine innovation, technology in paramedicine education, and improving paramedic practice.

4.2.1 Current Documentation Challenges

The participants described some of the challenges that they face with their current charting systems. The subthemes that emerged and how they relate to documentation input or outputs are presented below in Figure 4.24.

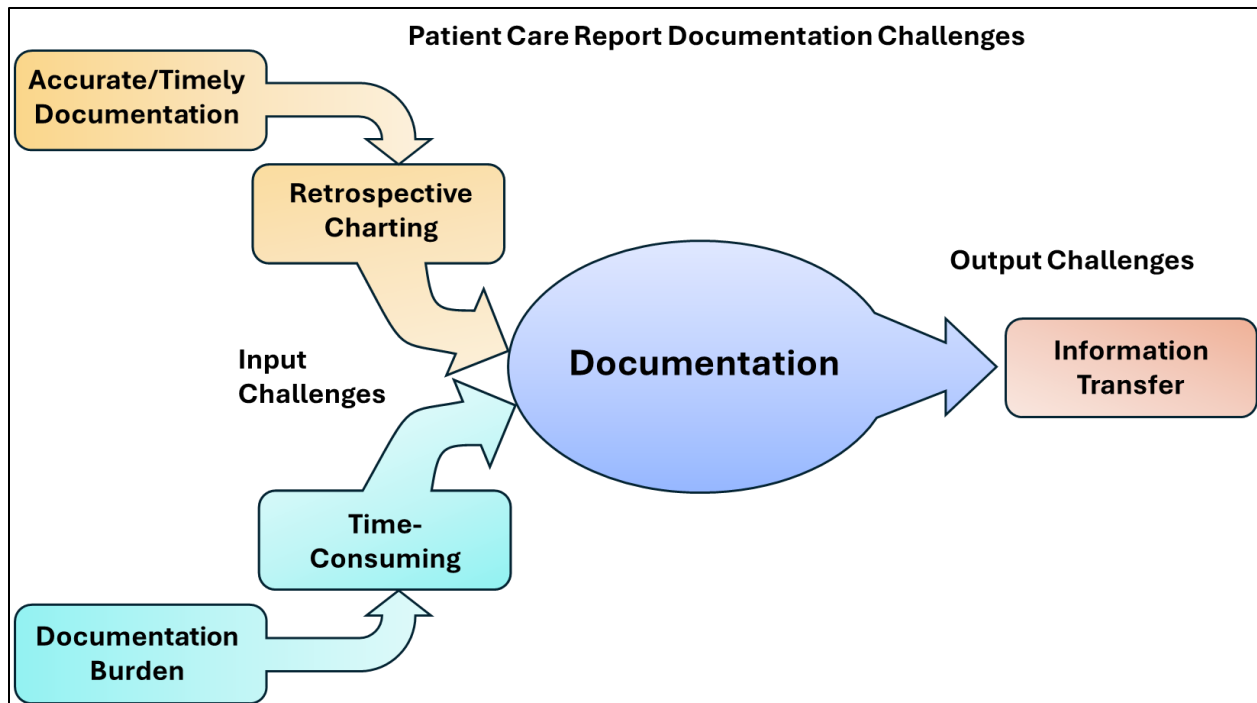


Figure 4.24. Current Documentation Challenges

Participants highlighted that they find that their current systems are time-consuming, regularly taking longer than the allotted time to complete.

“In general, it takes longer than we’re allotted, I suppose. I’m not sure how it is, you know, globally or nationally. We have sort of an allotted time to complete our charting, and I find that it’s difficult to write a comprehensive chart in the time allowed.” – PP09

The time-consuming aspect is exacerbated by the fact that paramedics face an increased documentation burden, with high service demands meaning shorter turnaround times and larger, more detailed ePCRs requiring more time to complete.

“As paramedics, we are expected to complete the paperwork in about 20 minutes post-patient care. 20 minutes, depending on the patient, is not enough time. And there are a lot of distractions going on when you’re trying to complete your documentation. Oftentimes, you’re doing it while you’re in a hospital environment. There are lots of other people around.

It's busy. It's loud. There's no dedicated time or space to it. So, it is not given its importance.”

– PP10

While the subtheme of retrospective charting does impact the accuracy of documentation, it was included separately. Retrospective charting occurs due to the time-consuming nature of current documentation systems and the increased documentation burden due to system demands.

“So, when (busy days) happen, yes, there will be three to four calls. Not just like between you and your partner, but each of us has like three or four calls on pending, and just like, I've got to finish that.” – PP14

Participants described the challenges of accurately completing documentation. Participants gave several reasons for the lack of accuracy in documentation, including the hands-busy nature of paramedic work and the lack of tools to record various findings accurately. Participant 04 best summarizes the challenge.

“You know, in trauma handover there's a nurse who does that task of recording everything that's happening and the story you give and all that stuff. So, we have that recognition within medicine more broadly of the importance of that accurate, on time, at the moment, documentation of things, and we don't do that in our world, partly because there's only two of us most of the time. Or maybe two and a half if you want to count a student as a half but it's not something that we're doing. We're not recording the stuff as we go in the same way as we could be.” – PP04

Transferring patient information to receiving facilities was another common challenge subtheme identified by interview participants. This ranged from physicians having to access

paramedicine documentation through a separate system to the challenge of marrying paper PCRs with in-hospital EMRs.

“Well, right now our province is rolling over from a paper documentation system to an ePCR. So, between health authorities or even between services, it is very disjointed, and it's very hard to transfer information. My service still uses paper PCRs. But also, if I'm working in town or if I'm communicating with medics in town, they have the ePCR, so they are unable to transfer care in the same way to us while we're still on paper. So that is definitely a big problem, and then also I know I've heard from nurses at the hospital that they are currently unable to access the ePCRs that some medics are using. So there's not a very smooth transfer of information from our electronic PCRs to other providers.” – PP06

4.2.2 Perceived SR Documentation Benefits

Participants outlined what they perceived as the largest benefits of implementing SR documentation technology. This theme and subthemes emerged from what interview participants could imagine based on their daily workflows and the day-to-day tasks involved with their specific services. The subthemes are presented in Figure 4.25, grouped by which aspect of the system it would affect, either documentation input, output or system benefits.

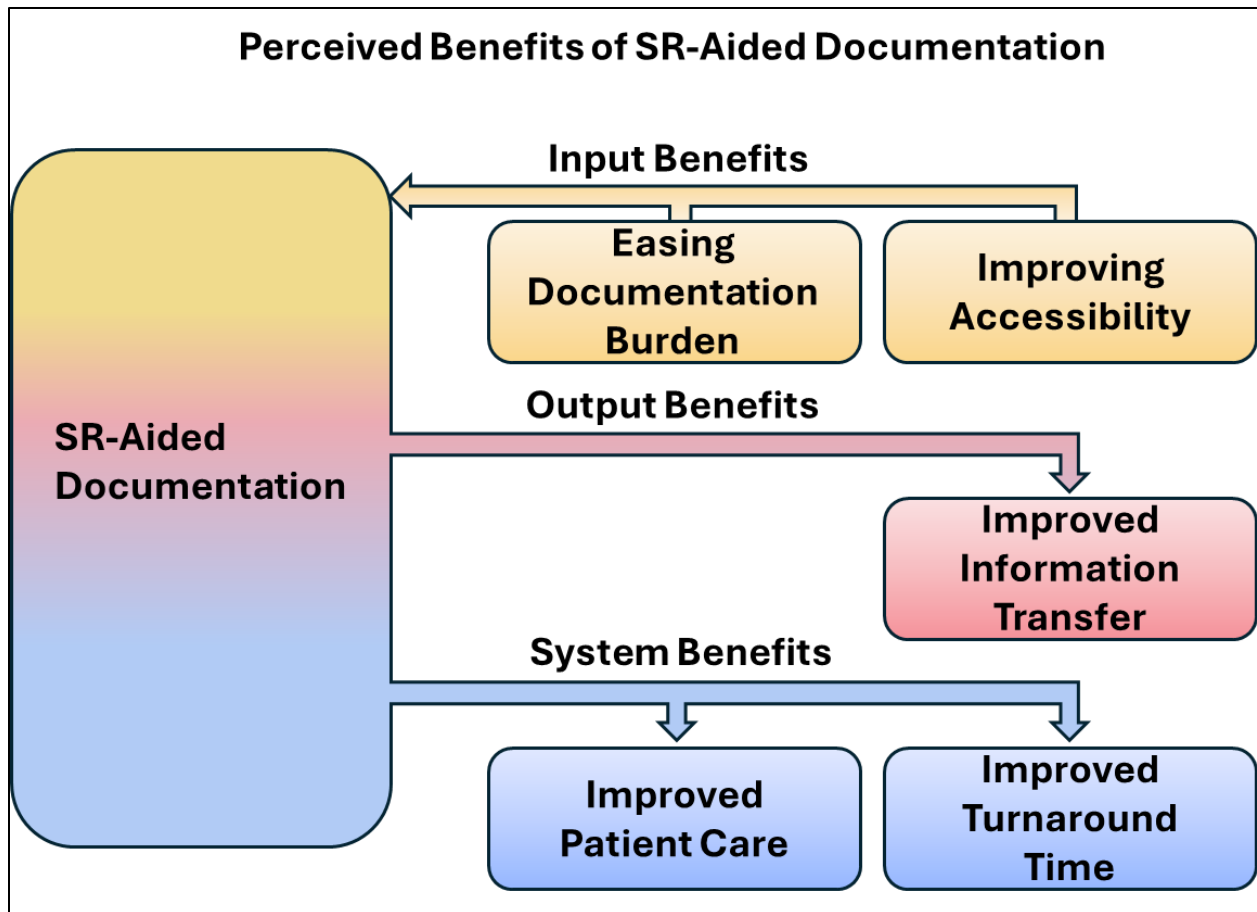


Figure 4.25. Perceived Benefits of SR-Aided Documentation.

Easing the documentation burden paramedics face was something that participants identified. Participants described how SR documentation could decrease the cognitive load and decrease the amount of time spent doing documentation.

“Yeah, that would be a huge time saver. It would also just be like cognitive offload. Okay, I'm speaking to the monitor; the patient's PHN (personal health number) is yadda yadda, and the patient's first last name is yadda yadda; please transmit ECG number 3 to (the hospital). That's as quick as that. Huge cognitive offload. Rather than having to use the little dial to pick each letter or number it can be quite cumbersome. When the patient's sweating, I'm

sweating, my partner's sweating like that's just, yeah, because it's just cumbersome.” –

PP02

The participants discussed how the SR documentation could provide more complete information upon handover to the ED staff. This included more accurate information, improved communication, and a summary of the “key points” of a busy call.

“So many errors that are made are based on communication and a breakdown in communication and not because someone did not know something or because they blatantly disregarded something; we can trace almost every error back to you didn't confirm, or you didn't check, or you didn't communicate that clearly. So anything that improves communication. Between two people or eight people or however many people in a scene or afterwards or sitting in a charting room is going to have a positive impact on patient care.” – PP03

Participants identified that SR documentation could improve patient care by allowing more time to be dedicated to patient interaction. The participants noted that spending less time interacting with the documentation screen or buttons allows more attention to be dedicated to the patient.

“I think it would provide better care for our patients. Because we would be able to focus on our patients rather than focusing on clicking a button on a screen. Right, because you could look and be like, hey, can you mark this like this? But still have that personal connection to the patient rather than to a computer.” – PP12

Participants also identified the potential for SR documentation to improve turnaround times. This could be achieved through expediting the documentation process and allowing paramedics to get “back in service” faster.

“Quicker, patient care for sure. Maybe not better per se. I don't know how much it would change my clinical skills and the things that I'm doing from a patient. But it would definitely help me get in service quicker to go help the next patient.” – PP19

The use of SR documentation to increase the accessibility of documentation for paramedics with learning disabilities or who generally struggle with computer use was also identified as a benefit.

“And also people who may have learning disabilities or spelling concerns. Like that's a real struggle for them when there are other ways that you could use it, and they are incredible clinicians, but what gets them stuck is this trying to document what they're doing, and then that's what's reflected that's the legal document. In their head, they've got it, and they've done all the right things, but it's not coming through in the paper because that's a struggle for them.” – PP03

4.2.3 Barriers and Enablers

Participants touched on different factors affecting their willingness to adopt SR documentation technology. These factors could be categorized as either an acceptance barrier or an enabler. These barriers and enablers are broken down into three divisions: external factors, which are beyond the control of the paramedicine service or users (such as design choices by vendors, regulations, and government policies); internal factors which are in direct control of the paramedic service (such as internal policies, culture and procedures), and practice factors which consider how well the systems fit into paramedicine daily practice (for example, how well the system understands paramedic workflow, and how it will affect patient interactions). These themes and factors are presented in Figure 4.26.

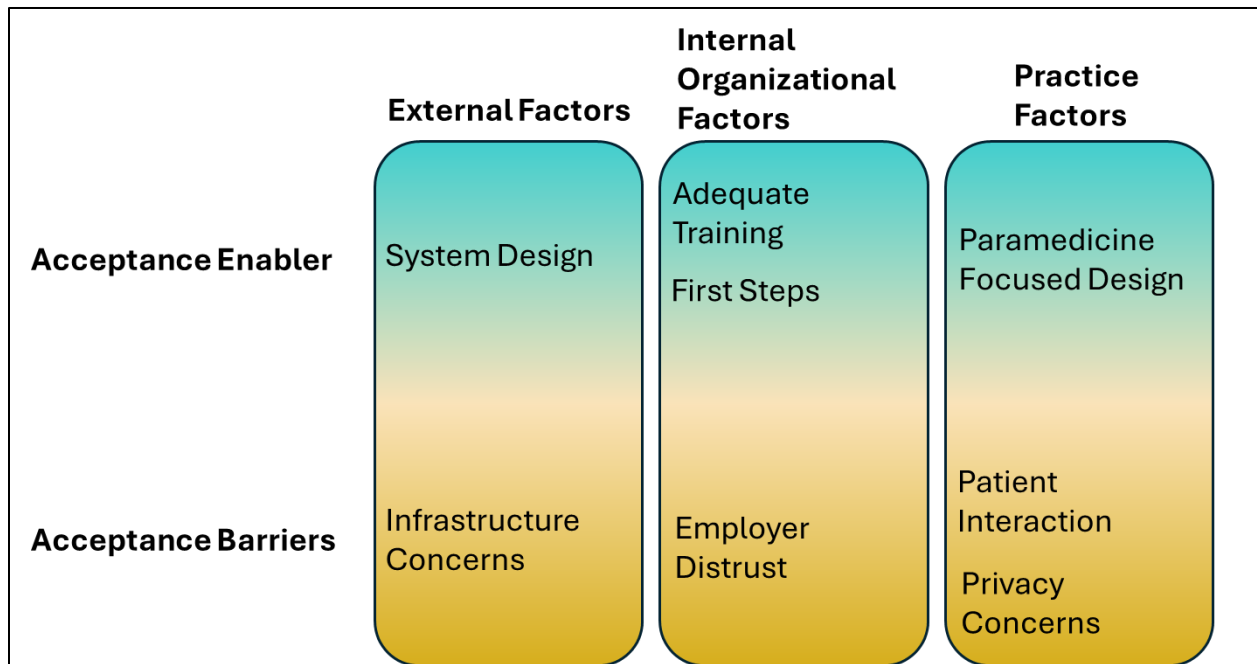


Figure 4.26. Barriers and Enablers separated by determining factors.

4.2.3.1 SR Acceptance Barriers

Participants also touched on barriers limiting their willingness to adopt SR documentation technology. Participants expressed distrust of their employers and how the technology could be used to punish, reprimand, or micromanage paramedics.

“Our medics, I know, are very nervous about our management. We don't trust our management. So, they would look at it as going, well, they just want this because they want to use it against us. Right. So that would be the biggest challenge.” – PP05

The privacy and confidentiality of patient information were also a major concern for participants. Some participants indicated that to accept SR technology, the recording of patient information in uncontrolled areas would have to be addressed.

“I'm concerned about confidentiality. A lot of paperwork is done at the hospital by paramedics and it's, done in busy crowded hallways. I wonder about (if) you're speaking a lot about your patient, are you maintaining confidentiality? You know, you have crowded hallways with other patients. You have other paramedics, nurses, and doctors. I don't go to a hospital, and I go to a lot of them (in my region), which has much private space where I do documentation.” – PP07

The participants were also very concerned about the patient-paramedic interaction. Participants outlined that the device must not alter or interfere with patient interaction in order for it to gain widespread acceptance in the profession.

“Well, for me, it's not interfering with patient interaction. Both the use of it (and the device itself.)” – PP07

There were concerns about the technologies ability to function in areas with poor cellular and Wi-Fi coverage. The concern was amplified in paramedic services that provided rural coverage.

“I don't think that's capable up here. Because we don't have a lot of Wi-Fi or Bluetooth connections suck. Because we're usually too far away. So, it makes it (*difficult*), even with the radio communication here, we have issues. So, I guess if you go get over all those glitches, then yes.” – PP12

4.2.3.1 SR Acceptance Enablers

Participants highlighted some specific elements that would likely improve their willingness to accept an SR documentation system into their workflows. Participants discussed some of the different functionalities, the ease of use, and the device's physical dimensions, all of which could improve the acceptance of SR documentation. These specific system design aspects could be a positive enabler.

“I think just ease of use. It needs; I don't know your background, but I know that paramedics are often very opposed to change, to put it lightly. So user friendly, and that's not really a suggestion in terms of, like, how to make it so, but making sure that the technology is easy to use, it's streamlined from start to finish of the call so there's not this kind of like Oh, I have to do this specifically at the beginning of the call versus at the end of the call, kind of thing. It's all very neat and tidy if you will; yeah, I think that would be my biggest suggestion, just ease of use.” – PP02

The participants also outlined some of the “first steps” that an organization can take to increase the adoption rate of new SR documentation systems. These ranged from trial periods, making the software optional and organizational buy-in.

“Yeah, the first. Without a question, it would just be organizational buy-in. Yeah, I mean, we have other things now for example, you know, just culture. We, some of our teams, really buy into just culture, and others do not, and that causes problems. And that's just a theory on how you manage decisions kind of thing. So if it would be a hard sell if part of the organization didn't buy-in, and so, you'd need the whole place to say like, yeah, we're all in on this because there's an expense to it. Every division is impacted, so it would have to start on both sides. The top-down is gonna have to be interested in the ground up because if you do all this work and then the ground is like, nope, then you're in a bad place.” – PP03

Adequate training was a common enabler discussed by participants. This included the employer's introduction of the system, the training they provide, and the inclusion of SR documentation in paramedicine education.

“Not to speak negatively of our organization. But I do know from experience that our organization is notoriously bad at training us on new technologies and services or whatever

it is. Skills. So, there would really need to be robust training. And it's probably not something offered by the company itself. Maybe something more so by the manufacturers of the technology. The people that know it best. Kind of hear the information from the horse's mouth, so to speak. Yeah, I think that would be the number one, training.” – PP19

Participants indicated that if a system was designed from the ground up to work in paramedicine, that would increase the likelihood of adoption. A system that would easily fit into a paramedic workflow and that isn't being adopted from another profession.

“With enough testing, and if there's a device specifically targeted towards our line of work. You know, with AI that's advancing so quickly. There are a lot of new capabilities with great potential that exist. But it would be key to find the device and system that works and recognizes terminology the paramedics use it in their day-to-day life without having to change too much of what the paramedics are doing already.” – PP19

4.2.4 Additional Themes

The following themes emerged throughout the interview process. While they did not revolve around documentation challenges or the acceptance of SR technology, they described how paramedicine, in many ways, can embrace new technologies and highlighted the current trajectory of technology within paramedicine.

4.2.4.1 Inevitable Change

Participants understand that technologies in healthcare are moving forward at a rapid pace. With rapidly improving software and rapidly shrinking hardware, we will inevitably see more advancements in paramedicine. While some see this as a positive direction, others are more

hesitant. The following quote from PP04 highlights that some participants believe that it will become a part of routine paramedic practice once the technology reaches its potential.

“I mean, docs have, as we mentioned, already adopted language processing software for, I imagine, some time. Dictations have been a part of their routine for quite a long time. And that dragon software, right? That's been around for a long time. My great-grandfather used to use it when he lost his eyesight. So I think it's kind of inevitable. It just is a matter of it reaching the point where it's functionally useful both in its capabilities, its robustness offline, and the durability of the actual hardware because no one wants to bring a giant gaming computer in the ambulance in addition to all of the stuff that we have in there.” – PP04

The following quote from PP06 shows that while some may see the advance of technology, specifically SR-aided documentation, as inevitable, they are hesitant about whether it will have a positive impact.

“I think that the future of medicine as a whole is kind of moving more towards technology that's for better or for worse. And I think that paramedicine as a whole kind of just follows what the rest of medicine does.... Naturally just the way that our world is evolving, paramedicine is also going to follow suit and rely more on technology.” – PP06

4.2.4.2 Paramedicine Innovation

Some interview participants identified that paramedicine is a profession that thrives on innovation and is more willing to adopt changes than other healthcare professions. Paramedicine is a relatively young profession that has been seeing rapid changes and growth. There exists in paramedicine a complicated relationship with change. Highlighted by a quote by PP08, the profession is driven by and thrives on innovation; however, can be resistant to change.

“Yeah, like, of course, you know, you must know this quite well, we're in a profession that depends on change but also hates changes at the same time. Even within my short career, I've barely been working for almost five years.” – PP08

Participants believed that innovation within paramedicine could be fostered and leveraged to improve outcomes and practices. This attitude is shown in the quote from PP19.

“I'm really someone who thinks a lot, that innovation has a strong place in our industry. Especially where paramedics are a relatively new profession within the greater healthcare role. I think we have a unique opportunity to adapt to the times a lot quicker than other professions do that have been around for a lot longer than we have and have the practices really set in stone. We are newer, we have this unique opportunity that we can kind of, not invent the wheels, so to speak, but kind of keep up with the times a lot quicker through innovation....like I said, for innovation in our job really has great potential. There's a lot of things that we're doing because we're doing them because we've always done them. But if you start to think a little bit differently, especially in the challenging times that we're going through with staff shortages and retention issues, and all of it, like. It's time for innovation, I think. I think this is definitely something that would offer some benefits to paramedics.

While serving locations and their communities.” – PP19

4.2.4.3 Technology in Paramedicine Education

Several participants discussed the need to integrate new technologies into the education of paramedics. Participants highlighted the need to introduce new documentation technology in formal education to prepare paramedics for the modern working environment. Participant PP06 highlights the importance of introducing technologies early for future success.

“I think it will be really important to look into training how to use it efficiently for education programs. I work on service, but I'm also in school right now as a PCP school, and we are still practicing on paper PCRs because the ePCRs haven't been introduced at our college. They haven't gotten the funding to use ePCRs. That's just not setting us up for the workforce for when we enter as PCP. So I think if there's going to be speech recognition, I think that that needs to be also implemented in education or even in education first.” – PP06

Participants also highlighted that technology could enhance paramedic education by leveraging virtual environments. Participant PP03 highlights how these technologies could be combined to provide more robust education opportunities.

“I actually hadn't truly thought of some of the smart glasses and stuff, and this was focused on sort of fieldwork, but I'm also sort of dabbling in how can we use, you know, Apple's got these new glasses coming out, that we could use in education. Sort of that's where I'm going with some of these things and I know that wasn't really the purpose of this. But that's another thing to look into in doing speech recognition in evaluating simulation and just speech behaviours and speaking with patients and clarity and all that kind of stuff. Then also, you could teach in a virtual reality sort of world. It could be having a team dynamic with this and through speech recognition, and you are seeing the same thing, but you're not in the same room.” – PP03

4.2.4.4 Improving Paramedicine

Participants also identified that embracing SR documentation, or technology advances in general, could improve paramedicine. This included the possibility of further professionalization of the practice by providing accurate, timely documentation, the need for disruption for progress, and the realization of gains from technology introduced in paramedicine. The following quote from PP10

highlights how having documentation completed in an accurate and timely manner could improve professional perceptions of paramedicine.

“I think we need it yesterday. I think, again, it's beneficial for everyone involved. You know, our highest level of government, to the municipalities that are running the service to the individuals who are responsible for overseeing the service, to the paramedics who are doing the great work, to the patients, to the outside stakeholders. There's nobody that this technology wouldn't touch and affect in a positive way in a very short time period. And help us again as a profession to grow. Cause here in (*my province*), we're not, we're not a regulated health profession and we're moving towards that very slowly. But I think, I think this adoption of technology would help propel us into the future and, again, help us be recognized as more professional. Because when you when you demonstrate that you're a professional and you carry yourself in a certain way and you have you know, professional documentation to support what you're doing then people are more likely to buy into that.” –

PP10

Participant PP03 discussed the hesitation with new technologies and the need for disruption within paramedicine. This quote below highlights how paramedicine services must embrace disruptive technologies for the profession to progress.

“I think a lot of people, there is fear of a lot of AI stuff. There's a lot of lack of knowledge of AI, and there's still a lot of bugs in AI. So that can really cause some hesitation for people, and they may not buy into things, maybe staying further back in technology than they need to because of that fear of the unknown. It's a valid fear, it's not there yet for some things. But you have to be disruptive; you can't progress without being disruptive, and you need to find the technology to help with that disruptive behaviour and not just close it out.” – PP03

Technology has become commonplace in some aspects of paramedic practice. Technologies like advanced cardiac monitors, automated computer-aided dispatch, and automated CPR machines have been integrated into paramedicine. The quote that follows from PP12 highlights how once a technology becomes commonplace and the benefits are realized, it will be well integrated into practice.

“Yeah, some of the gadgets, I think you can get to the point where it's like, okay, do we really need this? But a lot of them and I would say most of them, they're definitely really beneficial. At first, when I was like, okay, we have this auto pulse and is that, do we really, okay, what should we not do CPR, right? But now I've used it several times and I'm like, no, this is amazing. This is really cool. I like using this thing. I think you just have to get on board with it. And then I'd be like, oh my gosh, I have to type out my whole ePCR No way. You get used to things. And then you can't go without it. You're like, oh my gosh, I can't believe I used to do paper maps.” – PP12

4.3 Integrated Questionnaire and Interview Results

We applied joint display analysis to understand the survey and interview results fully. Specifically, it was applied to both research questions. First, the features and functions that respondents found most and least valuable in each of the eight sociotechnical model domains. Second, the respondent's current perceptions and attitudes regarding SR documentation technology. Interview quotes are identified by the participant's ID (PP##), and questionnaire-free text responses are denoted by using a respondent number (Respondent ##).

4.3.1 Identification of Potential User Requirements

The following takes the highest-rated features from each of the eight dimensions of the new sociotechnical model. These features, mean Likert scores, free-text questionnaire responses and interview quotes from participant interviews are presented in Table 4.3.

Respondents identified that the device would need to be durable, as PP10 identified the device will likely have multiple users, and multiple use environments, and easily damaged equipment would be cost prohibitive. Paramedic users would also need the device to have high accuracy rates; as PP06 points out, if paramedics get frustrated and feel they can more easily and quickly type the information, they will be less likely to adopt the SR documentation. The ability to dictate the narrative section of an ePCR was identified as the most valuable feature, and PP03 highlighted why this may be the most impactful by allowing paramedics to complete narratives quickly and assisting those who struggle with organizing thoughts while typing. Users would also want the ability to differentiate between different speakers while using the device, with it identifying the paramedic versus patients and bystanders. These features would have to be contained in a device or devices that would not interfere with the patient interaction or treatment, summarized by PP07 as both the use system and, if the device is worn, the device itself.

Table 4.3. List of the top features by sociotechnical dimension

Sociotechnical Dimension – Feature (Definition)	Mean Likert	Survey Support	Interview Support	Meta-inferences
Hardware – Durability (<i>Sturdiness of the device, ability to easily sanitize, battery life, weatherproofing, etc</i>)	4.60	<p>“I am concerned that the technology will have a hard time functioning consistently in our work environment.” – Respondent #17</p> <p>“Must be easy to use. Long battery life.” – Respondent #107</p>	<p>“Durability, paramedics are tough on equipment. Oh, my stars. We've had stuff run over like thousands of dollars, so I could just see this. Like we have to hand off a piece of equipment, so if I'm using these safety devices, this radio, this backup safety device, this cell phone, I have to make sure that I'm leaving it for the next crew that's coming in and even doing that like I think even just the durability (for constant multiple users), we would definitely (need it to be durable).” – PP10</p>	<p>Paramedicine workflows necessitate a robust hardware design. The need to design the system for multiple users, long battery life (12+ hour shifts), to function in harsh conditions and to be easily sanitized for the next users is a high priority.</p>
Clinical Content – Dictation (<i>Ability to dictate narrative documentation to the device and have that transcribed into an ePCR.</i>)	4.37	<p>“Being able to dictate my PCRs” – Respondent # 17</p> <p>“I would use medical dictation to supplement normal ePCR charting.” – Respondent # 231</p>	<p>“That is a tough one cause if I look most globally, it would be speech-to-text within a chart. I can see all kinds of, you know, on-scene, stating things that will then upload into your chart, but I think most people struggle with getting that narrative in a period of time. So, if they could speak it, I think that would have the largest impact for everyone, the whole system” – PP03</p>	<p>The ability for users to dictate narrative sections of their ePCR was identified as a feature that would have the most impact.</p>

<p>Human-Computer Interface - Accuracy (High word recognition rates and ability to select a best-fit word from a paramedicine-specific vocabulary.)</p>	4.52	<p>“I worry about acronyms and having to correct inaccurate recordings ...if these aren't caught, there is an inaccurate log of something or delays caused by correcting the inaccuracies.” – Respondent # 356</p> <p>“Paramedic profession specific design.” – Respondent # 268</p>	<p>“So I think for me, the biggest thing would be, yeah, comprehension and clarity, but then also if I think that if it was transcribing my speech and it was incorrect would be very frustrating and very discouraging. I wouldn't want to use the technology. I would find it just easier just to write it out myself.” – PP06</p>	<p>Paramedic vocabulary is unique. There are many acronyms, short forms and abbreviations in use, similar to, yet unique from the rest of healthcare. Ensuring that the SR documentation software has high word accuracy and accounts for paramedicine specific vocabulary is important to users.</p>
<p>People - Patient (<i>The device used to interact with speech recognition must not interfere with patient interaction.</i>)</p>	4.74	<p>“If it were disruptive to patient care. I.e. constant alerts or pop ups” – Respondent # 511</p> <p>“Ease of use that does not impair patient interaction” – Respondent #70</p>	<p>“Well, for me, it's not interfering with patient interaction. Both the use of it (and the device itself.)” – PP07</p>	<p>Paramedics value the importance of the patient interaction and care. Any technology introduced must be careful to not be intrusive to the patient relationship.</p>
<p>Workflow and Communication - Differentiation (<i>The ability of the speech recognition technology to differentiate between active patient care and conversation between paramedic partners.</i>)</p>	4.36	<p>“Also, it is extremely important that it be able to differentiate between conversation in the room and dictation.” – Respondent # 14</p>	<p>“Usually, when I use stuff in the past, it just says speaker one, speaker two. So, if we could somehow program like, this is the paramedic and then anyone else is the patient speaking that would be great.” – PP10</p>	<p>Paramedics understand that there are many simultaneous conversations happening at once in their care environment. The ability of the software to differentiate speakers will be important to users.</p>

<p>Organizational Policies, Procedures and Culture - Training Support (<i>Policies to support adequate time and training on the use of speech recognition devices.</i>)</p>	4.39	<p>“Lots of opportunity to practice prior to using on calls.” – Respondent # 290</p> <p>“We don't receive proper training, no one will be good at it nor will I feel comfortable using it should we lack training.” – Respondent # 15</p>	<p>“I'm never going to say no to training. Always give me all the training. That you, during work hours, get to go to headquarters or training academy or wherever and practice with it for an hour. Yeah, before you're using it with a real patient. Yeah, I don't want just a 20-minute PowerPoint that I have to do.” – PP17</p>	<p>The importance of proper training was present throughout the analysis. Paramedics want to have the appropriate time to train on any new technology to ensure they can competently use the device.</p>
<p>External Rules, Regulations and Pressures - Compliance (<i>The speech recognition device meets all required medicolegal requirements for recording audio and video of patients.</i>)</p>	4.66	<p>“Privacy legislation is possibly the largest barrier and would need to be addressed specifically. When documenting (for example), other people could overhear what is being said into the device when they were not involved in the circle of care.” – Respondent #363</p>	<p>“I think the thing that would present the biggest barrier is getting city privacy legal and service, privacy and legal onboard with the like protective measures within the software and the device to prevent privacy breaches. Because I think that that would be the first concern they would raise, and until it's addressed to their satisfaction, there's no chance of moving forward with it as a deployed device.” – PP04</p>	<p>Ensuring that patient privacy is protected is very important to paramedics. Ensuring that any device or software introduced meets all necessary legal requirements will be critical.</p>
<p>System Measurement and Monitoring - Continuous Improvement (<i>Regular feedback sessions to determine areas of improvement or identify areas for further expansion.</i>)</p>	4.42	<p>“that our input of what doesn't work ACTUALLY equates to change” – Respondent # 15</p>	<p>“I think definitely having a trial period and kind of figuring out if this says something that does work for us or not. We tend to do that a lot with our equipment. Just because we can figure out, okay, this is working or okay, this works, but 95% of the time, this is what's hindering our ability to use it. That kind of thing.” – PP12</p>	<p>Paramedics value having their input heard. The ability to provide feedback and have regular improvements to the SR documentation software was rated high for most respondents.</p>

The survey respondents also highlighted what would be important from an organizational level that can improve user adoption of the technology. Adequate training, which includes training time and training on the device itself, was the highest rated, and PP19 highlighted that paramedicine services have a history of not providing enough, or not adequate, training on new technologies, opting for in-house training rather than expert training. Paramedic users also want the organization to ensure that any device that is implemented is compliant with all privacy and confidentiality legislation. As PP04 points out, ensuring that the privacy experts within the organization properly review the device and make sure safeguards are in place will be important to end users. Finally, paramedics want to know that the organization will adopt policies of continuous improvement; as PP12 described, it will be important to implement a trial period where any functions that are not working as intended or points of friction with the device will be addressed and corrected

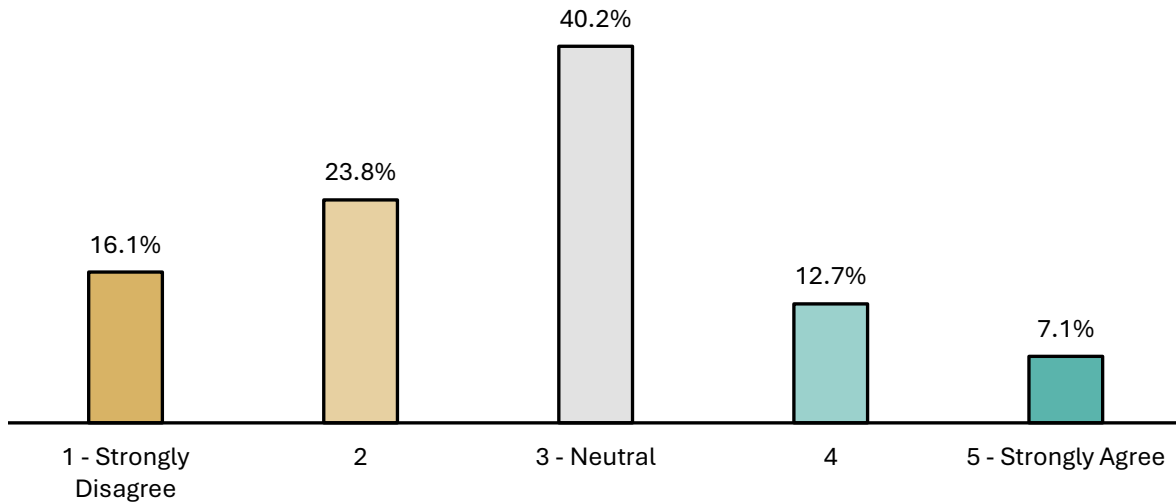
4.3.2 Examination of Current Attitudes Toward SR Documentation

4.3.2.1 Perceptions of Speech Recognition Capabilities

Paramedics' current perceptions of four aspects of SR documentation were recorded in the survey. These included the perceptions of SR documentation accuracy, its efficiency, whether it would be disruptive to patient care, and whether it could help produce more complete notes on arrival to the hospital. These perceptions were also followed up with the interview participants and are presented here in Figure 4.27.

Paramedic Perceptions

Accuracy Perceptions - *Speech recognition documentation is more accurate than typed documentation.*



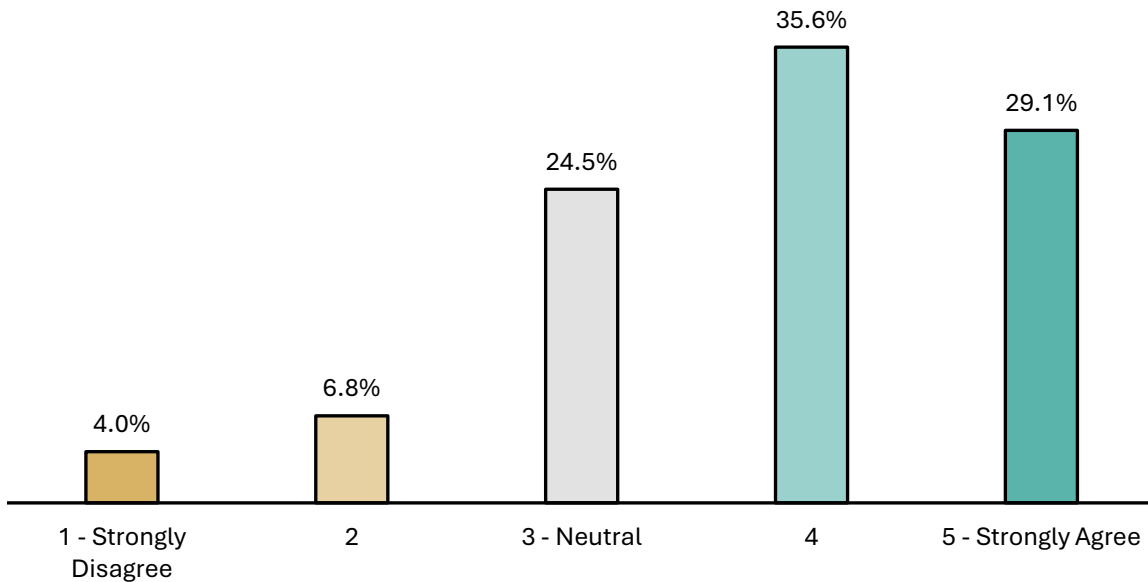
Negative Perception:
 “It's not always accurate, and I guess I would worry if I were doing something more important than sending a text or setting a reminder that something important could get mixed up. I guess that would be my biggest concern.”
 – PP09

Neutral Perception:
 “Well, it's hard to say because I don't really use it, so I don't know what its accuracy is. Okay, see, my mother-in-law asked like, hey, Siri, what's this? Like, it's usually quite accurate. My brother will tell Siri to put an alarm on or something whatever and that seems to work well. Where when my mom does the voice-to-text, (motions indicating So-So) is it just my mom, or is it like the voice-to-text? Yeah. I don't know, but it's not great.”
 – PP17

Positive Perception:
 “I know that, you know, with Siri, it's there and I know that Siri is not even the best out there. So, I do believe it's pretty accurate.” – PP08

Meta Inferences: Paramedics are skeptical that any speech recognition technology would be accurate enough to function in a paramedicine workflow. Their perceptions are heavily influenced by existing consumer technologies and how others interact with those technologies.

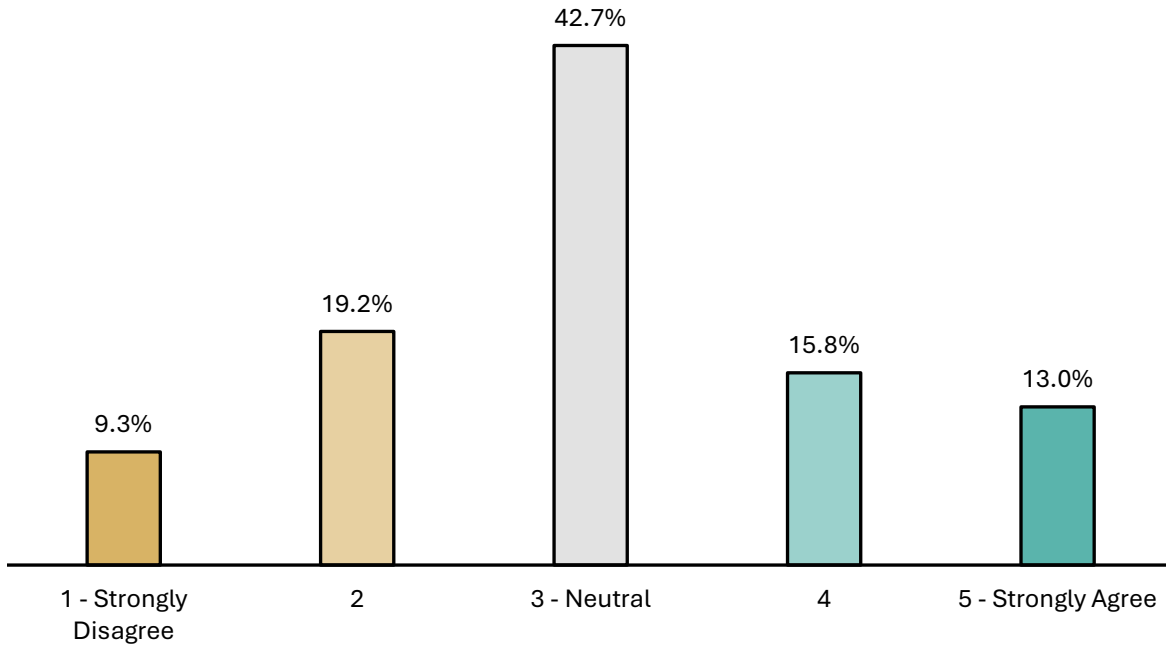
Efficiency Perceptions - Speech recognition documentation takes less time to complete than typed entry.



<p>Negative Perceptions: “I think it's based on the user partly. I worked in a doctor's office a while ago, and I watched one doctor use it quite effectively and another wasn't as fast. So I think it's potentially user-based. Yeah, this one doctor can do everything quickly, and he seemed to get reports done really fast, and they seemed to be effective.” – PP07</p>	<p>Neutral Perceptions: “It probably is faster, though I've never used it in that capacity. I know that my thesis supervisor will often dictate his commentary to his computer, and I think that allows him to get through more documents in a day than he (normally) would. There are errors, and it is sometimes difficult to read fluidly, but I'm sure those things could be corrected though. I suppose it would be a balance because how much time do you spend correcting what's written, you know?” – PP09</p>	<p>Positive Perceptions: “Yes. Oh yes, like, 100%. I would still use it even if there was the odd (correction). It just means I would go through it maybe quicker or more thorough at the end of the call to make sure what it wrote down was correct and I'm not missing something or it translated something different. But I would 100% use it and I think yeah, it would make everything go a lot quicker and we wouldn't have issues not getting your document done.” – PP05</p>
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Meta Inferences: The majority of respondents to the questionnaire agreed or strongly agreed (64.7%) that speech recognition documentation would take less time. However, the interview participants identified that it could be user-based and that the efficiency would highly depend on the number of corrections and editing that were required to complete the record, thereby tying efficiency to the accuracy of the system.

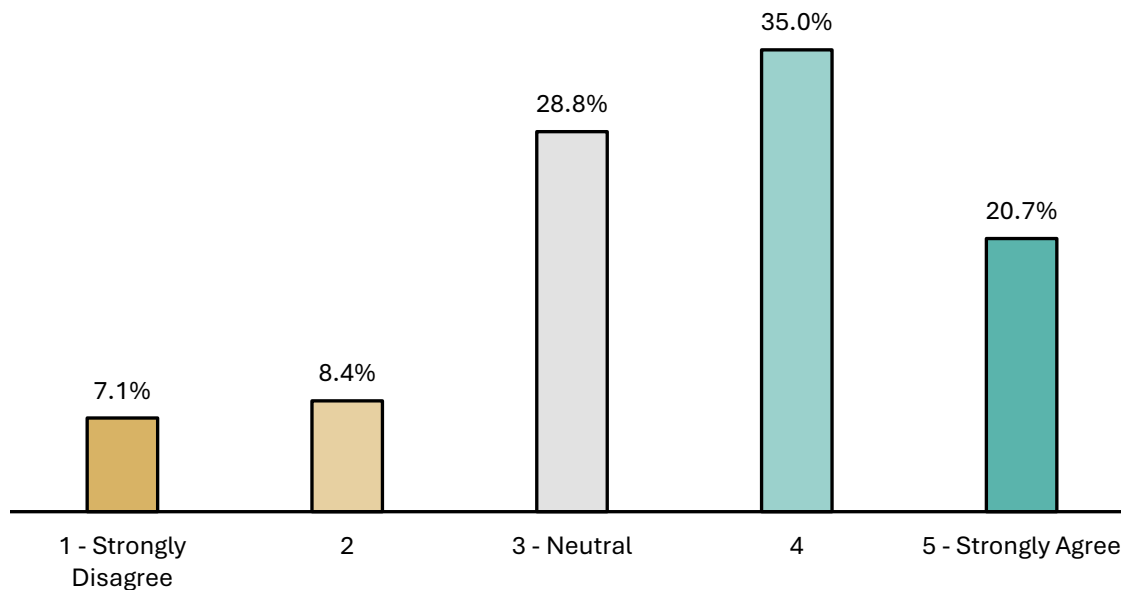
Patient Interaction Perceptions - *Speech recognition documentation would not be disruptive to my patient interactions*



<p>Negative Perceptions: “You don't want something to be hindering patient care, and if you're constantly trying to talk to this robot that's driving you crazy, that's not going to help you.” – PP17</p>	<p>Neutral Perceptions: “Still without creating barriers to our patient interaction. I think that is a lot of it, you're constantly building trust, so if you're wearing, I don't know, a giant headset or you have big goggles on or something, you just want to make sure, especially some of our population is a bit, older, and so they may not feel as comfortable with seeing all that technology.” – PP10</p>	<p>Positive Perceptions: “I think it would provide better care for our patients. Because we would be able to focus on our patients rather than focusing on clicking a button on a screen. Right, because you could look and be like, hey, can you mark this like this? But still have that personal connection to the patient rather than to a computer.” – PP12</p>
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Meta Inferences: The majority of respondents (42.7%) are unsure if the use of speech recognition would be disruptive to patient interactions. Most concerns come from the possibility of discomfort in an older population that doesn't understand the technology if it is obvious or intrusive. However, those paramedics who see it as positive believe that it would improve their patient interactions by allowing focus on the patients themselves.

More Complete Notes - *Speech recognition documentation would help me produce more complete and accurate notes at handover that will increase patient safety.*



<p>Negative Perceptions: “I can't see dictating in front of the patient. Like I can, on some calls, not all of them. Some of them I can type and talk to the patient, but I don't think I could dictate about them in front of them. Yeah, so that's my biggest hang-up from what I know of the technology.” – PP07</p>	<p>Neutral Perceptions: “I tend to engage with my patient, or I'm busy with medications, that type of thing. I typically don't tend to spend a lot of time charting when I'm actually physically with my patient in the back of the ambulance. I don't know if that would change.” – PP09</p>	<p>Positive Perceptions: “I think that'd be much easier just to be able to dictate that to my ePCR and the written notes. And again, pulling out keywords and key phrases and putting them and automatically uploading them into my PCR would be nice. Again, it makes things easier so by the time I'm at the hospital. Most of my paperwork is already done, and then the little I have to do can just be quickly spoken out in like five minutes.” – PP13</p>
<p>Meta Inferences: Respondents mostly agree that having the ability to use speech recognition could help them complete their documentation in a timelier manner. Some respondents believe that they would not use the technology in front of patients, believing that it would distract from the patient or make them uncomfortable, tying into patient interaction concerns.</p>		

Figure 4.27. Joint Display analysis of paramedic perceptions of various aspects of SR documentation.

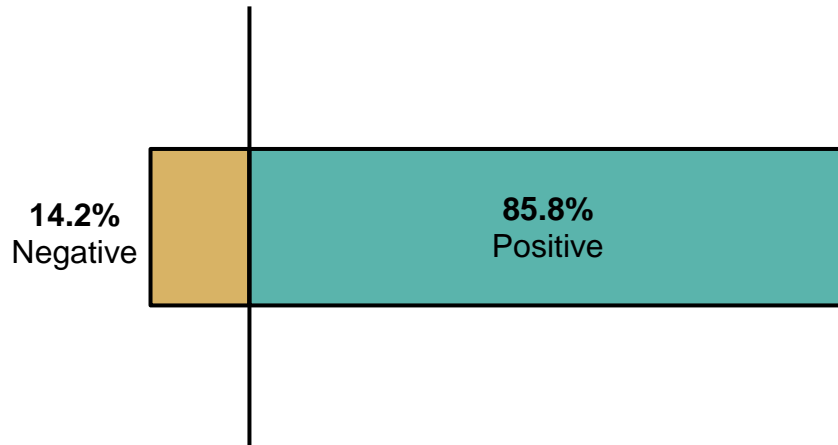
Paramedics do agree that SR documentation would be more efficient and produce longer, more complete notes upon arrival at the hospital. Respondents are primarily neutral on whether SR documentation will not be disruptive to their patient care and are either neutral or disagree that SR documentation will be more accurate than typed documentation.

4.3.2.2 Overall Usefulness Perceptions

Survey respondents were asked to identify whether they had an overall positive or negative perception of the usefulness of SR documentation technologies. The interview participants were also asked to explain why they held a positive or negative perception of the technology. The combined results are presented in Figure 4.28.

Overall Usefulness Perceptions

Current Attitudes – identifying paramedic attitudes towards speech recognition documentation.



Overall Negative:

“I think that speech recognition is pretty limited in its use if its only use is to like transcribe things; I don't think that that is worth implementing, especially here in (*province*). It feels like we're so behind the times with stuff already. As I said, most of the province still uses paper PCRs. We've only switched over to a provincewide 9 1 1 system this year. In some places. It feels like putting the cart before the horse.’ – PP06

“No, no, I think pretty much zero (*usefulness*)” – PP07

Overall Positive:

“I think it would definitely be a positive thing in the workplace and then in my personal life, yeah, it's definitely a huge help being able to know what the text message that came in is and answer it in the car is fantastic and then being able to add things to my shopping list while I'm cooking and covered in raw chicken again it's so much easier, right? And I don't have to try and retain this little task or piece of information to put on the shopping list or whatever later. So there are definitely benefits to it and overall positive. It's just that it's still growing, I think, in some ways.” – PP04

“I use speech to text, and I use speech to email; I use all these different things. So I'm kind of on the go and we are an on-the-go world and speech to making notes for yourself and everything else. So I do see it as a positive” – PP03

Meta Inferences: Paramedics view speech recognition as a helpful tool in most everyday tasks. Those who have a positive view of the technology likely use it in their daily personal lives. Those who view it negatively either have not used the technology, do not see the usefulness of the tool, or see larger problems with paramedic documentation that must be solved first.

Figure 4.28. Overall Perceptions of SR technology and their usefulness.

Respondents view SR documentation as an overall positive, with 86% choosing the positive option. The positive responses during the interview fell into three broad categories. The first is the technology-savvy, best exemplified by PP04, who described how using technology in their personal lives could be extended into hands-free documentation in their professional lives. The second category is current users; PP03 describes their use of speech-to-text technology in daily life and how it has positively impacted them. The final category would be paramedics who see the potential benefits of SR documentation and more, as PP19 describes how it would be useful for paramedics and could be used to implement clinical decision support tools.

There was a smaller number of survey respondents, 14%, that had a negative overall perception of SR documentation. Through the interviews, the reasons for the negative perceptions once again fit into three broad categories. The first category would be paramedics who see larger problems that must be solved before implementing SR documentation and see it as a distractor. PP06 provides a quote that outlines how they believe investigating SR documentation before the entire province has moved to an electronic ePCR format is "putting the cart before the horse," and its usefulness is limited. The second category would be paramedics who do not use any SR technologies, don't see benefits, or have no opinion; as PP17 highlights, with no experience using the technology, they have no strong opinion. The third category is paramedics who are resistant to any technological changes. The simple quote from PP07 exemplifies this attitude that there would be no usefulness in the technology at all, and they have no desire to try the technology.

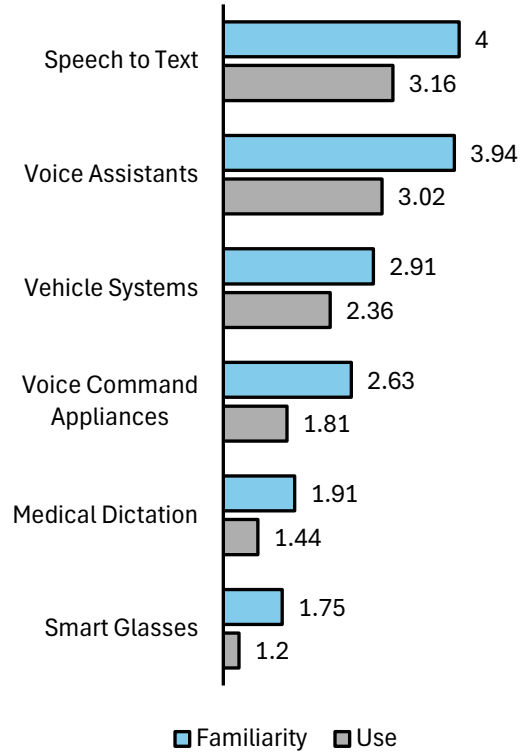
4.3.2.3 Technology Use

To understand paramedics current technology use levels the survey asked respondents to rank their familiarity and use of various speech recognition technologies. The mean Likert scale

responses for each of the presented technologies, along with some of the most representative quotes, are presented in Figure 4.29.

The use of speech-to-text functions on smartphones and voice assistants, like Alexa, Google Home or Siri, are the technologies that respondents are most familiar with and use most frequently. This was reflected in the interviews when participants were asked about their personal technology use. The responses from participants ranged greatly regarding their personal use from frequent daily use of these two technologies to not at all. We included quotes specifically about either speech-to-text or voice assistants since they were most common and to illustrate the reasons for frequent use or infrequent use. The first quote from PP01 represents the group that uses some form of SR technology daily and has high levels of comfort with the technology. The quote from PP10 illustrates how some paramedics are willing to use the technology but are frequently frustrated by some inaccuracies. The final quote from PP09 is a good example of how negative experiences with SR technologies can be a hindrance to any adoption of that technology, either personal or professional. The remaining two quotes illustrate paramedics who fall between these categories.

Speech Recognition Technologies Familiarity and Use



Presented as Likert Scale means
 1 representing Not Familiar or Never Use
 5 representing Extremely Familiar or Daily Use.

Supporting Quotes:

“I use voice regularly on the TV if you're searching for music, searching for a show, and things like that. Just because the keyboards are slow to use, and then I regularly use a smartwatch for Google Assistant. To fire off a text, answer a phone call. Whatever it may be or if someone has phoned, to just be like a quick, for my wife, text my wife I'll call you back in 15 on a call.” – PP01

“Yeah. I do, I find it pretty good. I think. There's definitely the classic “that's not what I said” that occurs from time to time, but that's usually when I'm far away from the device or I'm saying something more complex. I find it's pretty accurate if I'm right there and it can hear me very clearly... But overall, I think the voice-to-text on my phone seems to work really well. We have Google Home, and that seems to work really well as well. We use it for very basic things like, oh, hey, play this song by this person, turn on the lights and stuff, but it seems to work well for us.” – PP02

“So often times I actually have to pull over so that I can text someone back. Because paramedics like to text now, they don't like phone calls. So, I should be able to use it more, I just find it doesn't act the way I want it to and so I get frustrated. So I would say, I would say I'm kind of 50 50. Some things are great, and if they work well, they work well. And as soon as something doesn't work the way I want it to, I'm done with that, I write it off. And I assume most people are like that.” – PP10

“Not very much. We're (referring to partner) pretty analog. If anything, I guess I use Siri when I want to shazam something or if I'm driving. I'll do speech-to-text while I'm driving. But other than that, I don't use anything else.” – PP06

“No, I don't, and I guess I don't because, say, for example, my brother has Alexa, and he's just constantly shouting at her. So, I don't want that at my home.” – PP09

Meta Inferences: Experiences and familiarity with common consumer technologies have an impact on use patterns. Sub-par implementations or performance, either in their personal use or amongst peers can impact their use and opinion of technology. Given current use and familiarity patterns, a smart glasses-based SR documentation approach may be difficult to implement.

Figure 4.29. The Familiarity and Use of speech recognition technology by paramedics.

Chapter 5 Discussion

This study was the first large-scale, nationwide examination of Canadian paramedics' potential user requirements and current attitudes regarding SR documentation technology. The study aimed to address the gaps in the literature identified in Chapter 2 for large studies that can produce generalizable information. While this study is original research, it built upon previous work done both using the Sittig and Singh sociotechnical model (Sittig & Singh, 2015) to structure the data for features (Zhang, Ramiya Ramesh Babu, et al., 2022), and in choosing the features themselves (Woo et al., 2021; Zhang, Luo, et al., 2022; Zhang, Ramiya Ramesh Babu, et al., 2022).

In this chapter, the research results will be discussed in relation to the study's research objectives, investigating which features and functions will be important to end users and understanding the landscape of paramedic attitudes towards and current use of SR technologies. This chapter will expand into technology's role within paramedicine in the future and where the results support the case for technological integration. The discussion will close with an analysis of the study's limitations and recommendations for further future research.

5.1 Research Objectives Findings Discussion

The survey was distributed to paramedics across Canada using professional registration bodies, associations, employers and alumni associations. This wide distribution allowed for the capture of paramedics who work in various practice environments, roles and regions, addressing the need for a large study with generalizable results. For the purposes of this discussion, a modified version of the Sozen and Guven (2019) Likert scoring range (Sözen & Güven, 2019) is applied to

categorize features as extremely important (4.21-5.00), very important (3.41-4.20), somewhat important (2.61-3.40), less important (1.81-2.60) or not important (1.00-1.80).

5.1.1 User Requirements

While the user requirements identified by previous literature were few, they did align with the findings from the survey. Previously identified features such as accuracy, durability, minimal interface, and dictation (Zhang, Joy, et al., 2022; Zhang, Luo, et al., 2022; Zhang, Ramiya Ramesh Babu, et al., 2022), were all listed as extremely important features by survey respondents. Other previously identified user requirements, like ergonomics (comfort), interoperability, hands-free operation and workflow integration (Denecke et al., 2020; Zhang, Joy, et al., 2022; Zhang, Luo, et al., 2022; Zhang, Ramiya Ramesh Babu, et al., 2022) were rated as very important by survey respondents. This further validates the findings of the smaller focused group studies and confirms that while these smaller studies may not be wholly generalizable, some requirements remain consistent.

The highest-rated (extremely – very important) user requirements reflect the nature of paramedicine work in Canada. Working in unpredictable, hectic conditions spanning urban environments to rural and remote communities underscores the need for durable, comfortable devices with robust local processing capabilities. The requirements also reflect paramedics' professional commitment to patient care, safety and comfort. This influences the desire for an accurate device to ease documentation burden while not interfering with the paramedic-patient relationship and complying with all medicolegal requirements. Respondents also highlighted the need for a paramedic service to commit resources to implement new technology, like SR documentation. This includes investing in adequate training for paramedics, technical support, listening to user feedback and making changes to the system based on feedback.

Using integrated joint display analysis on the user requirements allows the reader to understand why each feature is important to end users (Dutta & Dhar, 2021; Fetters & Tajima, 2022). This allowed for interview participants to expand on why a requirement is important or how it could be addressed. For example, in *section 4.3.1*, it is highlighted that while adequate training is important, it may be in the organization's best interest to invest in training that comes from the device developers themselves to provide a deeper understanding of the device and to answer questions that users may have. In certain cases, it allowed participants to explain how the absence or failure of certain functions, like accuracy, would cause them to become frustrated or discouraged from using the device at all.

5.1.2 Paramedic Perceptions

Understanding paramedic perceptions of SR documentation technology will be important in increasing adoption (Zuchowski & Göller, 2022). The exploratory correlation analysis highlighted that overall perceptions of the technology had the strongest correlations to higher importance ratings than any other demographic metric. These perceptions can be influenced by personal use of SR technologies, like voice assistants, speech-to-text on smartphones, or observing others using the technology. Participants who had indicated on the survey that they had a negative overall perception of SR technology also indicated during the interview that they do not use, or infrequently use SR technologies in their personal life. To improve the overall perceptions, trial periods or technology demonstrations could be used to allow users to gain comfort with the technology.

Respondents' overall perception of SR documentation was overwhelmingly positive. However, their perceptions of certain aspects of SR documentation varied. The perceptions of SR technology's accuracy were rated as mostly neutral, skewing into the negative perceptions. Its efficiency and ability to create more complete notes were rated more positively. This aligns with a

similar disconnect found in an earlier study where clinicians would still prefer to use typed notes because they believed them to be more accurate, even though the SR documentation was shown to be faster and produce longer, more detailed notes, with a higher accuracy (Zuchowski & Göller, 2022). The joint display analysis indicated that participants were concerned that it may not be accurate enough when completing an important legal document like an ePCR and that they may be held accountable for transcription errors.

These perceptions are helpful to understand when designing or implementing technologies. It will allow the organization to target training to promote or demonstrate the device's accuracy, develop policies and procedures to accommodate paramedic concerns and develop adequate trial periods to improve perceptions.

5.2 Technology in Paramedicine

Embracing and leveraging advancing technologies was identified by Tavares et al. (2022) as one of the key cross-cutting enabling factors that will help achieve principles guiding paramedicine. This is described as “the use and integration of advanced existing and emerging technologies (e.g., artificial intelligence) in all aspects of the profession to ensure principles are realized.” pg.7 (Tavares et al., 2022). The idea that paramedicine must embrace and leverage new and existing technologies appeared in the participant interviews. Several participants identified that paramedicine is moving toward an inevitable increase in the amount and types of technology. The inclusion of AI and NLP in medical documentation is accelerating rapidly (Bongurala et al., 2024), and participants identified several scenarios where paramedics have turned to outside applications to use AI as a workaround for documentation. Paramedics are regular technology users (Rinkinen et al., 2024) and currently use consumer applications to set timers, reminders, and, in some cases, SR-enabled NLP applications to complete documentation. Paramedicine services should consider

involving paramedics in user-centred design development projects to integrate these technologies (Rinkinen et al., 2024).

The use of technology in education, specifically SR documentation technology, was also discussed as an important piece of paramedicines future. Participants recognized that if paramedicine is to embrace and fully utilize these technologies, new paramedics should be given the skills and knowledge to use them effectively. In paramedicine education, paramedics are taught the basics of documentation using paper PCRs. While this is necessary, it does not give them the skills to chart effectively electronically nor prepare them for the reality that documentation technology is changing rapidly. Several participants also highlighted other ways smart glass and SR technology could improve education through virtually simulated scenario training and improve recollection of detailed feedback.

Paramedicine is a young profession and is undergoing rapid change, expansion, and growth in many areas (Rinkinen et al., 2024; Rowland & Brydges, 2021; Tavares et al., 2022). Participants identified that this makes paramedicine an excellent place for disruptive innovation. The profession itself is still elastic and adept at change, although begrudgingly. Participants believe that paramedics should be involved in this innovation and that the systems and technologies should be developed specifically for paramedicine as the profession has unique needs compared to other in-hospital professions (Rinkinen et al., 2024). Unfortunately, participants identified that paramedicine services often fail to invest properly in technology, and a lack of roles that are dedicated to technology development hinders innovation.

Participants saw embracing SR documentation technologies as a way to improve numerous aspects of paramedic practice. This included patient care continuity, team communication, turnaround delays, research, and direct patient care. By providing more accurate time-based data,

allowing more complete reports on arrival and allowing paramedics to be available to respond to more patients, they see how technology can advance practice (Tavares et al., 2022). Participants believe that the expanding healthcare technologies will offer them tools that will allow them to focus on the human side of the job: providing care for and connecting with patients.

5.3 Future Implications

This broad exploratory study addresses the need to understand better paramedics' unique user requirements and perceptions of SR documentation technology. Although the need for understanding user requirements and perceptions is well understood in user-centred design principles (Dutta & Dhar, 2021), paramedicine is often not consulted in developing these technologies (Rinkinen et al., 2024). Paramedicine has many unique needs which cannot be addressed by technology adapted from other professions. The acknowledgement that technology will play a large role in paramedicines' future (Tavares et al., 2022) and the lack of roles for paramedicine informatics (Rinkinen et al., 2024) need to be reconciled and addressed.

This baseline information provides a foundation for the potential development of these technologies. It can also inform implementation strategies for employers or development companies. This exploratory study will serve as a platform to create more detailed and advanced research in the field of paramedicine informatics.

5.4 Future Research

This exploratory study invites other interesting avenues of research. One example would be an employer-focused study that examines the barriers to introducing SR documentation technologies. To complement the work already completed by this study, examining employer barriers and expectations of SR documentation could help accelerate the development of the

technology. This could also identify incongruencies or potential friction points between the user's and employers' needs. Identifying these issues in advance would help with a successful implementation.

As was evident from the results of this study, there is a need for research demonstrating that SR documentation can meet the accuracy standards required by paramedics. One of the persistent perceptions is that SR documentation is not accurate enough to use for medical documentation. Designing a study that could definitively demonstrate that the accuracy of SR documentation could meet or exceed the needs of paramedics would be beneficial in adjusting those perceptions.

Developing a paramedic-specific lexicon to use in SR documentation would be a beneficial area of research. Participants identified that an SR documentation system would need to recognize the terms and short-hand used exclusively in paramedicine. Developers could potentially use this lexicon to develop software that recognizes the many different terms that are used in paramedicine and adapt the documentation system to meet the commonly used terms.

5.5 Study Strengths

This study was an ambitious project that sought to provide reliable, generalizable data about the user requirements and perceptions of SR documentation in Canadian paramedicine. As suggested by Fetters (2020), steps were taken to ensure the quality and rigor of the mixed methodology at the quantitative, and qualitative stages (Fetters, 2020). For the quantitative piece of the study, the focus was on internal and external validity. The use of Likert rankings ensured that the data produced were an accurate representation of the user requirements and perceptions of paramedics. The large sample size and nationwide distribution ensured that paramedics from every demographic had an opportunity to participate and ensured that the data would be more

generalizable than a single service or province study. Finally, to ensure replicability in the results, the entirety of the analysis coding is included in Appendix 8.7 (Fetters, 2020). All deidentified questionnaire responses, and analyses results will be available in the supplemental files.

To ensure rigor in the qualitative section, steps were taken to reduce the influence of the interviewer's bias (Fetters, 2020). Given my professional history as a practicing paramedic, I was aware of the overall documentation challenges facing paramedics in their daily workflows. While I believe that SR documentation technology may improve practice, we used selective sampling to capture different perspectives. The interview sampling used data from the quantitative section to ensure a maximum range of opinions was captured in the interview process, the selection matrix is available in Appendix 8.5. The interviews also followed the template as closely as possible, minimizing the amount of personal bias injected; the interview template is available in Appendix 8.6. During the interviews, if there was any ambiguity in the answers, I sought clarifying statements from the interviewee. During the interview phase, I met regularly with my advising committee to debrief regarding my ongoing analysis of the interviews. Finally, to improve the quality and depth of the results, joint display analysis was used to triangulate the multiple streams of data (Fetters & Tajima, 2022).

5.6 Study Limitations

There were several limitations to this study, both in design and execution. Since the study took place in two phases, the limitations of both will be discussed separately in this section. The integrated analysis limitations will also be discussed at the end of this section.

5.6.1 Questionnaire Limitations

The survey had many limitations. The first of which was the design of the survey itself. The survey was ambitious and attempted to capture a lot of information. This led to the survey being long and taking a long time to complete (estimated 20 minutes), and this may have led to a large drop in the response rate. The survey was also designed so that the demographic questions were at the end of the survey. This design choice led to many of the incomplete survey responses being unusable for further analysis involving demographics.

Second was the distribution and response to the survey. Professional associations, employers, registrars and other paramedic-specific groups were used as pass-throughs to distribute the survey. This meant that the survey distribution relied heavily on the membership's engagement with their organization and the organization's willingness to promote the survey. The survey was also completely voluntary, with no compensation provided for respondents. This may have led to a nonresponse bias (Groves & Peytcheva, 2008), with most respondents having a keen interest in the subject and missing the portion of the population that views it negatively or has no strong opinions.

Finally, the survey was not designed with further quantitative analysis in mind. The questions within the survey were not structured in a way that made the resulting data easily comparable. Since this was an exploratory study and the data results were unknown until they were collected, it was difficult to anticipate the severity of this limitation.

5.6.2 Interview Limitations

The limitations of the interview portion of the study were largely based on my novice interviewing skills. The art of interviewing effectively is a skill that needs to be practiced and

developed. The interview guide was followed to attempt to keep the conversation focused on the interviewees' perspectives. If this portion of the study had been completed by a more skilled interviewer, perhaps different or more relevant insights may have been gained.

The same holds true for the qualitative analysis. The qualitative analysis process is, again, an acquired and trained skill. Although I attempted to follow best practices and avoid personal biases in the analysis of interview transcripts, a more skilled reviewer may find different results.

5.6.3 Integrated Analysis

While designing and planning this study, the intention of using joint display analysis was considered, as suggested by Fetters & Tajima (2022)(Fetters & Tajima, 2022). However, the nature of the collected data and the interviews created challenges in finding the best way to display and integrate the data. The limitations of both the questionnaire and interview portions likely played a role in this challenge.

Chapter 6 Conclusions

The intended purpose of this study was to evaluate the user requirements for SR documentation technology and to identify strategies that would improve the likelihood of user adoption, as well as determine Canadian paramedics' current perceptions, attitudes, and use of SR technology. The results of this study provide a robust list of user requirements and an in-depth look at the attitudes and use levels that underlie those needs. As intended, this study's results can provide a foundational platform for further development and research in SR documentation technology in paramedicine. Some key takeaways from this work are presented here in Table 6.1.

Table 6.1. Key Takeaways for stakeholders of SR documentation in paramedicine

Key Takeaways		
Developers	Administrators	Researchers
<ul style="list-style-type: none"> • The interaction between paramedics and patients is critical, and any interface should not interfere with that interaction. • The device used for the interface must be able to accommodate multiple users, adverse weather and be able to sustain use for extended periods. • Ease of use and alignment with emergency response call flows will be critical for adoption and use. 	<ul style="list-style-type: none"> • A robust training program that allows time for users to fully understand the technology would be recommended. • Responsive continuous improvement programs, where feedback is able to quickly lead to change, will be beneficial in improving adoption among end users. • Establishing transparent policies for the use of any data will be key to building trust with users. Identifying what the transcripts will be used for, how long they will be stored, etc. 	<ul style="list-style-type: none"> • More work is required to understand friction points for system implementation from the organizational lens. • Using this foundational work, more robust, focused studies to understand specific domains could be undertaken to further define user and system needs.

Paramedicine is a young profession with unique challenges, needs and working conditions. The need for specific solutions for paramedicine is clear. However, little research has been conducted into understanding the technology needs of paramedics. This study is a small step in a burgeoning field of paramedicine informatics that hopefully will influence more paramedicine-focused and led research.

Chapter 7 References

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Chapter 8 Appendices

8.1 Appendix 1

Table 8.1. Initial search terms used in the preliminary search.

Category	Search Terms Used
Population	paramedic* or "emergency medical technologist*" or "emergency medical service*" Subject Headings - Allied Health Personnel/ or Emergency Medical Technicians/ or Paramedics/ or exp Emergency Medicine
Concept	"speech-recognition" or SR or "speech-to-text" or StT or "hands-free" or "natural language processing" or "ePCR charting" Subject Headings – Speech Recognition Software
Context	"pre-hospital*" or prehospital* or "emergency department*" or "emergency setting*" or ED or emergenc*

Table 8.2. Example of an adapted search strategy for MEDLINE database.

Search #	Query	Limits	Results
1	(paramedic* or "emergency medical technologist*" or "emergency medical service*").mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word]	No Full-Text Search	61344
2	("speech-recognition" or SR or "speech-to-text" or StT or "hands-free" or "natural language processing" or "ePCR charting").mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word]	No Full-Text Search	72061

3	("pre-hospital*" or prehospital* or "emergency department*" or "emergency setting*" or ED or emergenc*).mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word]	No Full-Text Search	620727
4	Allied Health Personnel/ or Emergency Medical Technicians/ or Paramedics/	No Full-Text Search	18220
5	Speech Recognition Software/	No Full-Text Search	813
6	exp Emergency Medicine/	No Full-Text Search	15579
7	1 and 2 and 3	No Full-Text Search	66
8	(1 or 6) and 2 and 3	No Full-Text Search	81
9	2 and 3 and 6	No Full-Text Search	16
10	(1 or 4 or 6) and 2 and 3	No Full-Text Search	81
11	(1 or 4 or 6) and (2 or 5) and 3	No Full-Text Search	81

Table 8.3. Example data extraction table for published literature.

Evidence Source Details and Characteristics – Research Report	
Author(s) - Year	
Research Question/Objective	
Type of Evidence: (Qualitative, Quantitative, Mixed Methods, Literature Reviews)	
Population: (Canadian paramedics, International Paramedics, and others)	
Concept: (SR technology, end-user requirements, technology preferences of paramedics)	

Context: (Pre-hospital context, ED context, another emergency context)	
Reviewer Comments:	

Table 8.4. Example data extraction table for grey literature.

Evidence Source Details and Characteristics – Grey Literature	
Author(s) - Year	
Documents Purpose/Nature:	
Type of document: (Expert opinion, government report, trade magazine article)	
Population: (Canadian paramedics, International Paramedics, and others)	
Concept: (SR technology, end-user requirements, technology preferences of paramedics)	
Context: (Pre-hospital context, ED context, another emergency context)	
Reviewer Comments:	

8.2 Appendix 2

Table 8.5. Overview of included studies.

Author (Year)	Country	Findings	Technology Examined	Study Environment	Study Size
Meier et al. (2020)	Switzerland	Preliminary findings show that SR documentation can be accurate and reduce documentation workload for paramedics.	Smartphone-based SR app with Bluetooth headset.	Lab Setting/ Simulation	n = 20
Kar et al. (2021)	US	Improvements in word error rates of existing SR systems can be realized using advanced algorithmic approaches.	Hands-free SR documentation using a GoPro camera and microphone.	Lab Setting/ Simulation	n = 6
Zhang et al. (2022)	US	User perceptions of the prototype are positive. Hands-free operation is a high concern for providers. The NLP-based system extracted the most important medical information from free text narratives.	Real-time documentation prototype using smart glasses SR function and NLP free text extraction.	Lab Setting/ Focus Group	n = 13
Denecke et al. (2020)	Switzerland	Findings supported more studies for real-time documentation in the pre-hospital environment. Audio recordings were most frequently requested to aid in documentation.	Audio and Visual recording using a GoPro camera and microphone.	Lab Setting/ Simulation	n = 4

Table 1. Continued

Shimazui et al. (2021)	Japan	SR documentation was significantly faster than typed and faster than SR aided with manual error correction in pre-hospital documentation.	Comparison of time for SR and typed documentation.	Lab Setting/ Simulation	n = 10
Woo et al. (2021)	US	Using noise resilience SR technology showed statistically significant improvements in word error rate.	GoPro camera and microphone interface for advanced SR with noise resiliency function.	Lab Setting/ Simulation/ Focus Group	n = 26
Zhang et al. (2022)	US	Hands-free documentation was a significant benefit of using smart glasses in a PS Workflow.	Perceptions of smart glasses use in paramedicine workflows.	Interviews/ Focus Group	n = 13
Zhang et al. (2022)	US	Based on the sociotechnical framework, some design elements that would help increase paramedic adoption of technology were identified.	Smart glasses-based documentation system – design study.	Focus Group	n = 15

8.3 Appendix 3



Figure 8.1. TCPS 2 Certificate



Certificate of Approval - Annual Renewal

PRINCIPAL INVESTIGATOR: Karen Courtney (Supervisor)	ETHICS PROTOCOL NUMBER: 23-0450 Expedited review - delegated
PRINCIPAL APPLICANT: Desmond Hedderson Master's student	ORIGINAL APPROVAL DATE: 21-Dec-2023
UVIC DEPARTMENT: Health Information Science HEIS	APPROVED ON: 18-Nov-2024
	APPROVAL EXPIRY DATE: 20-Dec-2025

PROJECT TITLE: Canadian paramedic perceptions and requirements for speech recognition technology

RESEARCH TEAM MEMBERS:
 Helen Monkman - committee member, UVic
 Ian Blanchard - committee member, Alberta Health Services

DECLARED PROJECT FUNDING:
 University of Victoria (UVIC), University of Victoria

DOCUMENTS INCLUDED IN THIS APPROVAL:
 Interview template.docx - 03-Nov-2023
 tcps2_core_certificate.pdf - 04-Nov-2023
 E-Mail Template Org V3.docx - 17-Dec-2023
 E-Mail Template V3.docx - 17-Dec-2023
 SurveyMonkey_Final.pdf - 18-Dec-2023
 Interview Email Template.docx - 20-Dec-2023
 Information Letter.docx - 20-Dec-2023

Conditions of approval

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Amendments
 To make changes to the approved research procedure in your study, please submit "Amendments" or "Annual renewal with amendments" form. You must receive research ethics approval before proceeding with your amended protocol.

Renewals
 Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

Project Closures
 When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a "Notice of Project Completion" form.

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropriate standards of ethics as outlined by the University of Victoria's policies for research involving human participants.

Dr. Sandra Gibbons
 Chair, Human Research Ethics Board

Dr. Cindy Holder
 Vice-chair, Human Research Ethics Board

Figure 8.2. University of Victoria Research Ethics Board Approval Certificate.

8.4 Appendix 4

Table 8.6. Survey preamble free and informed consent

Survey Preamble for Free and Informed Consent
<p>Paramedics and Speech Recognition Technology</p> <p>Welcome! You are invited to participate in the "Paramedics and Speech Recognition Technology" study by Desmond Hedderson.</p> <p>Desmond is a graduate student in the School of Health Information Science at the University of Victoria, and you may contact him if you have any further questions at dhedderson@uvic.ca.</p> <p>As a graduate student, I must conduct research as part of the requirements for a degree in Health Informatics. It is being conducted under the supervision of Karen Courtney. You may contact my supervisor at court009@uvic.ca.</p> <p>Desmond has received funding from the Canadian Institute of Health Research - Canada Graduate Scholarship Masters Award.</p> <p>Speech Recognition Technology: also known as automatic speech recognition (ASR), computer speech recognition, or speech-to-text, is a capability which enables a program to process human speech into a written format. While it's commonly confused with voice recognition, speech recognition focuses on the translation of speech from a verbal format to a text one, whereas voice recognition just seeks to identify an individual user's voice. This technology can be executed by various devices like smart glasses, Bluetooth headsets, wired headsets, body cameras, etc.</p> <p>This technology could be used for real-time, hands-free documentation in the paramedicine workflows.</p> <p>Purpose and Objectives: The purpose of this study is to gain an understanding of Canadian paramedics' current perceptions and familiarity with speech recognition technologies.</p> <p>Importance: This research will help guide the development and design of future speech recognition documentation and control technologies and improve adoption.</p> <p>Participants Selection: You are being asked to participate in this research because you are either an actively registered paramedic in a Canadian jurisdiction or a current paramedic student.</p> <p>What is Involved: This web-based survey is phase 1 of the project, which includes an option to Opt-in for phase 2, consisting of semi-structured one-on-one interviews. In phase 1 (survey), no contact information or identifiers are collected, and you can participate in phase 1 only if you wish. Contact information is only collected for those who wish to participate in phase 2 (interview).</p> <p>Please be advised that this study uses an online program located in the U.S. or a program that can</p>

be accessed from the US (SurveyMonkey). As such, there is a possibility that information about you may be accessed without your knowledge or consent by the US government in compliance with the US Freedom Act.

Risks: There are no known risks to you by participating in this research.

Benefits: This research can help increase the usability and adoption rates of future implemented technologies.

Voluntary Participation: Your participation in this research is completely voluntary. If you decide to participate, you may withdraw at any time without any consequences or any explanation. In phase 1 (survey), no information is collected until you hit submit at the end of the survey. If you chose to participate in phase 2 (Interviews) and provide contact information and your data has not yet been manipulated and analyzed, then you may request the removal of your data. Once the data is anonymized, separated from the contact information, and further analyzed, it will not be possible to identify and retrieve it. Should you decide during the survey you wish to stop participating, simply do not hit submit and close the survey link.

Anonymity: In terms of protecting your anonymity, no identifying information will be used in the final results. Any demographic information from Phase 1 will be grouped and bracketed. No personal data will be used in reporting phase 2 results and evaluation.

Confidentiality: Your confidentiality and the data will be protected by following the University of Victoria data storage guidelines. All raw data files with identifying information will be stored in an encrypted file on a secure, password-protected computer. Only Desmond Hedderson will have access to the raw data.

Dissemination of Results: It is anticipated that the results of this study will be shared with others in the following ways: a published article chapter or book, a thesis defence, presentations at meetings, internet (stored on 'UVicSpace'), or directly presenting to organizational bodies at their request. Individuals may request a copy of the final results of this study by emailing the researcher at: dhedderson@uvic.ca

Disposal of Data: Data from this study will be disposed of after a period of 2 years after final publication. All data will be stored electronically and deleted.

Contacts: Individuals that may be contacted regarding this study include:

Desmond Hedderson dhedderson@uvic.ca
Karen Courtney court009@uvic.ca

In addition, you may verify the ethical approval of this study or raise any concerns by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

By completing and submitting the survey, **YOUR FREE AND INFORMED CONSENT IS IMPLIED.** It indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

Table 8.7. Letter of informed consent provided to interview participants

Letter of informed consent
<p style="text-align: center;">Canadian Paramedic Perceptions and Requirements for Adoption of Speech Recognition Technology</p> <p>You are invited to participate in a study entitled <i>“Canadian Paramedic Perceptions and Requirements for Adoption of Speech Recognition Technology”</i> that is being conducted by Desmond Hedderson.</p> <p>Desmond is a graduate student in the School of Health Information Science at the University of Victoria, and you may contact him if you have further questions at dhedderson@uvic.ca.</p> <p>As a graduate student, I am required to conduct research as part of the requirements for a master’s degree in health informatics. It is being conducted under the supervision of Karen Courtney. You may contact my supervisor at court009@uvic.ca.</p> <p>Desmond has received funding from the Canadian Institute of Health Research – Canadian Graduate Scholarship Masters Award.</p> <p>Purpose and Objectives</p> <p>The purpose of this research project is to gain an understanding of Canadian Paramedics’ current perceptions and familiarity with speech recognition technologies.</p> <p>Importance of this Research</p> <p>This research will help guide the development and design of future speech recognition documentation and control technologies and help improve adoption rates.</p> <p>Participants Selection</p> <p>You are being asked to participate in this research because you are either an actively registered paramedic in a Canadian jurisdiction or a current paramedic student.</p> <p>What is involved</p> <p>If you consent to voluntarily participate in this research, this phase includes an interview (approximately 30-60 minutes) to be scheduled at a time convenient for you. Interviews will be conducted using Zoom. You will receive a \$50 e-gift card from Tim Hortons or substitute, as compensation for your time.</p> <p>Please be advised that Zoom is an online platform located in the US. As such, there is a possibility that information about you may be accessed without your knowledge or consent by the US government in compliance with the US Freedom Act.</p> <p>Risks</p> <p>There are no known or anticipated risks to you by participating in this research.</p> <p>Benefits</p> <p>This research can help increase future implemented technologies’ usability and adoption rates.</p>

Voluntary Participation

Your participation in this research must be completely voluntary. If you decide to participate, you may withdraw at any time without any consequences or explanation. If you do withdraw from the interview phase of the study, you will be asked if the researcher can retain your data, and if you choose not to allow them to retain the data, it will be immediately deleted. If you wish to withdraw after completing the interview, please contact the principal researcher if your data has not yet been included in the data analysis, it can be removed if you wish. Once it has been included in the analysis, it is not possible for us to separate and remove your data. If you withdraw either during or after the data collection period, you will still receive the gift card. If you withdraw before the process begins, you will not. That gift card will be used as another participant will be selected to fill that slot.

Anonymity

In terms of protecting your anonymity, no identifying information will be used in the final results. Any demographic information from Phase 1 will be grouped and bracketed. No personal data will be used in the reporting of Phase 2 results and evaluation.

Confidentiality

University of Victoria data management guidelines will protect your confidentiality and the data. All raw data files with identifying information will be stored in an encrypted file on a secure, password-protected computer. Only Desmond Hedderson will have access to the raw data.

Dissemination of Results

It is anticipated that the results of this study will be shared with others in the following ways: a published article chapter or book, a thesis defence, presentations at meetings, internet (stored on 'UVicSpace'), or directly presenting to organizational bodies at their request.

Disposal of Data

Data from this study will be disposed of after a period of two (2) years after final publication. All data will be stored electronically and deleted.

Contacts

Individuals that may be contacted regarding this study include:

Desmond Hedderson – dhedderson@uvic.ca

Karen Courtney – court009@uvic.ca

In addition, you may verify the ethical approval of this study or raise any concerns you might have by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

By agreeing to the interview, **YOUR FREE AND INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

Please retain a copy of this letter for your reference.

8.5 Appendix 5

Table 8.8. Participant selection matrix based on demographic responses and perception responses.

Participant ID	Gender			Paramedicine Role						Location			Practice area			Work Experience			O. Percep.		Specific Perceptions			
	M	W	Non-B	FS	E	L/E	R	St	Sup	E	C	W	U	SU	R	0-5	6-10	11+	P	N	Td	Lt	Nd	Ma
PP01	X			X								X	X					X	X		5	4	3	4
PP02	X			X								X	X				X		X		5	5	4	5
PP03		X			X	X	X			X				X	X			X	X		3	4	2	4
PP04		X		X							X		X			X			X		1	2	1	2
PP05		X		X							X		X				X		X		2	4	3	4
PP06			X	X				X		X				X	X	X				X	2	2	1	2
PP07	X			X								X	X					X		X	2	3	1	2
PP08	X			X							X		X	X		X				X	2	4	2	3
PP09		X			X	X	X			X			X				X			X	1	3	3	3
PP10		X			X		X		X		X		X					X	X		4	5	4	5
PP12		X		X				X				X			X			X	X		3	5	1	1
PP13	X			X	X				X			X	X					X	X		4	5	4	5
PP17		X		X							X		X			X				X	3	3	2	2
PP19	X			X						X					X	X			X		4	4	4	5

Abbreviations: Gender - M (Man), W (Woman), Non-B (Non-Binary); Paramedicine Role – FS (Frontline Staff), E (Educator), L/E (Leadership/Executive), R (Researcher), St (Student), Sup (Field Supervisor); Location – E (Eastern Canada – Newfoundland, Nova Scotia, PEI, New Brunswick), C (Central Canada – Quebec, Ontario, Manitoba), W (Western Canada – Saskatchewan, Alberta, British Columbia); Practice Area – U (Urban), SU (Suburban), R (Rural); O. Precep – Overall Perception; Specific Perceptions – Td (More accurate than typed), Lt (Less time than typed), Nd (Not disruptive to patient interaction), Ma (More complete notes available).

8.6 Appendix 6

Table 8.9. Interview template for semi-structured interviews.

Participant ID#:
<p>Preamble:</p> <p>Thank you for participating in the interview process.</p> <p>The goal of this interview is to help gain more insight into the responses that we received in the survey. It will also help you understand your practice's contexts and how speech recognition would fit into your workflows.</p> <p>This process helps to increase the likelihood that any future development of this type of technology will have a base of user requirements and perceptions to consider.</p>
Objective Questions
Question 1. What are some current challenges you face with documentation at work?
Response:
Follow up:
Question 2. For most response calls are you able to complete an ePCR prior to arrival to the emergency department?
Response:
Follow-up:
Question 3. Which features of speech recognition technology would you find most valuable and why?
Response:

Follow-up:
Question 4. Which features of speech recognition technology would you find least valuable and why?
Response:
Follow-up:
Question 5. Were there any features that were not listed that you would like to see implemented?
Response:
Follow-up:
Question 6. Do you use any speech recognition technologies in your personal life? (Ex. Alexa, Siri, speech-to-text messaging, etc.) Why or why not?
Response:
Follow-up:
Reflective Questions
Question 7. What is your perception of speech recognition technology efficiency?
Response:
Follow-up:
Question 8. What is your perception of speech recognition technology efficacy?
Response:

Follow-up:
Question 9. Why do you associate speech recognition technology with a (positive or negative) experience?
Response:
Follow-up:
Question 10. Which features of speech recognition technology surprised you in the survey?
Response:
Follow-up:
Interpretive Questions
Question 11. Do you believe that speech recognition technology can improve paramedic practice?
Response:
Follow-up:
Question 12. Is technology, like speech recognition technology, going to play an essential role in the future of paramedicine?
Response:
Follow-up:
Question 13. What daily tasks in your workflow could be made easier with SR technology? Why?
Response:

Follow-up:
Question 14. What daily tasks in your workflow could be more difficult with SR technology? Why?
Response:
Follow-up:
Question 15. Would speech recognition technology make your work more efficient and effective?
Response:
Follow-up:
Question 16. Would you need less time to complete an ePCR, or could you provide a more complete ePCR at handover using speech recognition-enabled automated documentation?
Response:
Follow-up:
Decisional Questions
Question 17. Would you accept a speech recognition-based ePCR in your current workflow, why or why not?
Response:
Follow-up:
Question 18. Would you prefer a speech recognition device that can do audio and video? (E.g., Body worn GoPro or smart glasses)

Response:

Question 19. What would be an important first step in implementing a speech recognition documentation system in your workflow?

Response:

Follow-up:

Question 20. Would you implement speech recognition technology into your paramedic service based on your current knowledge of the technology?

Response:

Follow-up:

Additional Questions

8.7 Appendix 7

Table 8.10. R code used throughout the thesis project

```
R code for descriptive statistics and chart generation

#setwd(dirname(getActiveDocumentContext())$path)
#getwd()

setwd("~/UVIC/Thesis Work/Data Files/Survey/Workspace")
survey <- read.csv("surveydeidentifiedmain.csv")
surveymin <- read.csv("surveymin.csv")

library(ggplot2)
library(likert)
library(dplyr)
library(tidyr)
library(forcats)
library(stringr)

#####Respondent Demographics#####

#Age Group
age <- survey[,c(1,81)]
age <- age[!is.na(age$Age..Please.use.slider.or.text.box.on.the.right.), ]
age <- age %>%
  rename(Age = Age..Please.use.slider.or.text.box.on.the.right.)
age <- age[!(age$Age == "0"),]
age <- age %>%
  mutate(
    "Age Group" = dplyr::case_when(
      Age <= 20 ~ "0-20",
      Age > 20 & Age <= 30 ~ "21-30",
      Age > 30 & Age <= 40 ~ "31-40",
      Age > 40 & Age <= 50 ~ "41-50",
      Age > 50 & Age <= 60 ~ "51-60",
      Age > 60 ~ "61+"),
    `Age Group` = factor(`Age Group`, levels = c("0-20","21-30","31-40","41-50","51-60","61+")))

ggplot(age, aes(`Age Group`))+
  geom_bar(stat = 'count', alpha = 0.5,color = "black", fill = "grey44", size = 1)+
  stat_count(geom = "text", color = "black", size = 5, aes(label = ..count..), position =
  position_stack(vjust = 0.7))+
  theme_minimal(base_size = 15)+
  theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.line.x =
  element_line(color = "black", size = 1))+
  theme(axis.text.y = element_blank(), axis.ticks.y = element_blank(), axis.title.y =
  element_blank())+
```

```

labs(title = "Respondent Age Group", subtitle = "n = 322", caption = "One entry was a value 0 and
was removed")+theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust =
0.5))+
  theme(plot.title = element_text(face = "bold"))

#Years Experience
exper <- survey[,c(1,80)]
exper <-
exper[!is.na(exper$Years.of.paramedicine.experience..Please.use.slider.or.text.box.on.the.right..
numeric.), ]
#may need to change
exper <- exper %>%
  rename(Years =
Years.of.paramedicine.experience..Please.use.slider.or.text.box.on.the.right..numeric.)
exper <- exper[!(exper$Years == "100"),]
exper <- exper %>%
  mutate(
    "Years Experience" = dplyr::case_when(
      Years <= 5 ~ "0-5",
      Years > 5 & Years <= 10 ~ "6-10",
      Years > 10 & Years <= 15 ~ "11-15",
      Years > 15 & Years <= 20 ~ "16-20",
      Years > 20 & Years <= 25 ~ "21-25",
      Years > 25 ~ "26+",
    `Years Experience` = factor(`Years Experience`, levels = c("0-5","6-10","11-15","16-20","21-
25","26+")))

ggplot(exper, aes(`Years Experience`))+
  geom_bar(stat = 'count', alpha = 0.5,color = "black", fill = "grey44", size = 1)+
  stat_count(geom = "text", color = "black", size = 5, aes(label = ..count..), position =
position_stack(vjust = 0.7))+
  theme_minimal(base_size = 15)+
  theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.line.x =
element_line(color = "black", size = 1))+
  theme(axis.text.y = element_blank(), axis.ticks.y = element_blank(), axis.title.y =
element_blank()+
  labs(title = "Respondent Years Experience", subtitle = "n = 322", caption = "One entry had a value
of 100 and was removed")+theme(plot.title = element_text(hjust = 0.5), plot.subtitle =
element_text(hjust = 0.5))+
  theme(plot.title = element_text(face = "bold"))

#Paramedic Role
jobdf <- survey[,c(72:77)]
jobdf <- jobdf[!apply(jobdf == "",1,all),]
job <- data.frame(apply(jobdf[,c(1:6)],2,table))

job <- job[-1,]
job <- gather(job, "Job Title", Number)

```

```

job$` Job Title` [job$` Job Title` == "Frontline.Staff"]<-"Frontline Staff"
job$` Job Title` [job$` Job Title` == "Leadership.Executive"]<-"Leadership/Executive"

job_order <- c("Frontline
Staff","Educator";"Supervisor";"Leadership/Executive";"Student";"Researcher")

ggplot(job, aes(` Job Title` ,Number))+
  geom_col(alpha = 0.5,color = "black", fill = "grey44", size = 1)+
  geom_text(aes(label = Number), size = 5, vjust = 1.2)+
  theme_minimal(base_size = 15)+
  theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.line.x =
element_line(color = "black", size = 1))+
  theme(axis.text.y = element_blank(), axis.ticks.y = element_blank(), axis.title.y =
element_blank()+
  ggtitle("Respondent Paramedic Role", subtitle = "n = 323")+theme(plot.title = element_text(hjust
= 0.5), plot.subtitle = element_text(hjust = 0.5) )+
  theme(plot.title = element_text(face = "bold"))+
  scale_x_discrete(limits = job_order)

#Gender
gen <- survey[,c(82:83)]
gen <- gen[!(gen$Gender == "Prefer to Self Describe"),]
gen <- gen[!(gen$Gender == ""),]

gen_order <- c("Man";"Woman";"Prefer Not to Say";"Non-Binary")

ggplot(gen, aes(Gender))+
  geom_bar(stat = 'count', alpha = 0.5,color = "black", fill = "grey44", size = 1)+
  stat_count(geom = "text", color = "black", size = 5, aes(label = ..count..), position =
position_stack(vjust = 0.7))+
  theme_minimal(base_size = 15)+
  theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.line.x =
element_line(color = "black", size = 1))+
  theme(axis.text.y = element_blank(), axis.ticks.y = element_blank(), axis.title.y =
element_blank()+
  labs(title = "Respondent Gender", subtitle = "n = 322", caption = "One entry was
invalid")+theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5))+
  theme(plot.title = element_text(face = "bold"))+
  scale_x_discrete(limits = gen_order)

#Province
pro <- data.frame(survey[,c(79)])
pro <- data.frame(pro[!(pro$survey...c.79.. == ""), ])
pro <- rename(pro, pro...pro.survey...c.79.....,Province)
prov_order <- c('NL';'NS';'NB';'PEI';'QC';'ON';'MB';'SK';'AB';'BC')

ggplot(pro, aes(Province))+
  geom_bar(stat = 'count', alpha = 0.5,color = "black", fill = "grey44", size = 1)+

```

```

stat_count(geom = "text", color = "black", size = 5, aes(label = ..count..), position =
position_stack(vjust = 0.7))+
  theme_minimal(base_size = 15)+
  theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.line.x =
element_line(color = "black", size = 1))+
  theme(axis.text.y = element_blank(), axis.ticks.y = element_blank(), axis.title.y =
element_blank()+
  labs(title = "Respondent Province", subtitle = "n = 323")+theme(plot.title = element_text(hjust =
0.5), plot.subtitle = element_text(hjust = 0.5))+
  theme(plot.title = element_text(face = "bold"))+
  scale_x_discrete(limits = prov_order)

```

#Area of Practice

```

area <- survey[,c(1,84)]
area <- area[!(area$Area.of.Practice == ""),]
names(area) <- gsub("\\.", "",names(area))
area$` Area of Practice ` [area$` Area of Practice ` == "Urabn"]<-"Urban"
area_order <- c("Urban","Rural","Remote")

```

```

ggplot(area, aes(` Area of Practice ` ))+
  geom_bar(stat = 'count', alpha = 0.5,color = "black", fill = "grey44", size = 1)+
  stat_count(geom = "text", color = "black", size = 5, aes(label = ..count..), position =
position_stack(vjust = 0.7))+
  theme_minimal(base_size = 15)+
  theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.line.x =
element_line(color = "black", size = 1))+
  theme(axis.text.y = element_blank(), axis.ticks.y = element_blank(), axis.title.y =
element_blank()+
  labs(title = "Respondent Area of Practice", subtitle = "n = 323")+theme(plot.title =
element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5))+
  theme(plot.title = element_text(face = "bold"))+
  scale_x_discrete(limits = area_order)

```

####Likert Scale for New Sociotechnical Model components####

Set up Hardware plots

Isolate Hardware Question

```
hardware <- survey[,c(2:8)]
```

Remove Empty Rows

```
hardware <- hardware[!apply(hardware == "",1,all),]
```

Clear White Space

```
hardware <- data.frame(lapply(hardware, trimws))
```

Setting Factor Levels

```
lev <- c("1 - Not important","2","3 - Somewhat Important","4","5 - Extremely Important")
```

```
hardware <- data.frame(lapply(hardware, function(x) factor(x, levels = lev)))
```

```

# Cleaning Data
names(hardware) <- gsub("\\.", "", names(hardware))

# Setting Likert Function
h_results <- likert(hardware)

# Likert Plot
hardware.plot <- plot(h_results, text.size = 5, wrap = 20, plot.percent.low = FALSE,
plot.percent.high = FALSE,
plot.percent.neutral = FALSE)+
theme_minimal(base_size = 15)+
theme(legend.position = "bottom")+
ggtitle("Hardware and Software Computing Infrastructure", subtitle = "n = 446")+theme(plot.title
= element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5) )+
theme(plot.title = element_text(face = "bold"))+
theme(panel.grid.minor = element_blank(), axis.line.x = element_line(color = "black", size = 1))
hardware.plot

# Set up Clinical Content plots
# Isolate Clinical Content Question
#clinical <- survey[,c(9:14)]
# Remove Empty Rows
#clinical <- clinical[!apply(clinical == "", 1, all),]

# Clear White Space
#clinical <- data.frame(lapply(clinical, trimws))

# Setting Factor Levels
lev_c <- c("1 - Not Valuable at all","2","3 - Somewhat Valuable","4","5 - Extremely Valuable")
#clinical <- data.frame(lapply(clinical, function(x) factor(x, levels = lev_c)))

# Cleaning Data
#names(clinical) <- gsub("\\.", "", names(clinical))

# Setting Likert Function
#c_results <- likert(clinical)

# Likert Plot
#clinical.plot <- plot(c_results, text.size = 5)+
# theme_minimal(base_size = 15)+
# theme(legend.position = "bottom")+
# labs(title = "Clinical Content", subtitle = "n = 409")+
# theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5) )+
# theme(plot.title = element_text(face = "bold"))+
# theme(panel.grid.minor = element_blank(), axis.line.x = element_line(color = "black", size = 1))
#clinical.plot

```

```

### TEST
# Set up Clinical Content plots
# Isolate Clinical Content Question
clinicaltest <- survey[,c(9:18)]
# Remove Empty Rows
clinicaltest <- clinicaltest[!apply(clinicaltest == "",1,all),]

# Clear White Space
clinicaltest <- data.frame(lapply(clinicaltest, trimws))

# Cleaning Data
clinicaltest <- data.frame(lapply(clinicaltest, function(x) gsub("Not Valuable at all","Not Valuable",
x)))
# Setting Factor Levels
lev_cs <- c("1 - Not Valuable","2","3 - Somewhat Valuable","4","5 - Extremely Valuable")
clinicaltest <- data.frame(lapply(clinicaltest, function(x) factor(x, levels = lev_cs)))

med <- c("Medication Administration Timestamp")
medo <- c("Medication.Administration.Timpstamp")
clinicaltest <- clinicaltest %>% rename_with(~ med, all_of(medo))

names(clinicaltest) <- gsub("\\.", " ",names(clinicaltest))
clinicaltest <- clinicaltest %>% rename("Telemedicine*"="Telemedicine","Feedback Display Smart
Glasses*"=" ` Feedback Display Smart Glasses `","Medication Scanning*"=" ` Medication
scanning `","Capture Images or Video*"=" ` Capture Images or Videos `")
# Setting Likert Function
ct_results <- likert(clinicaltest)

# Likert Plot
clinicalt.plot <- plot(ct_results, text.size = 5, wrap = 20, plot.percent.low = FALSE,
plot.percent.high = FALSE,
plot.percent.neutral = FALSE)+
theme_minimal(base_size = 15)+
theme(legend.position = "bottom")+
labs(title = "Clinical Content",subtitle = "n = 409",caption = "'*' indicates that this was a question
about a device that could also do video")+
theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5) )+
theme(plot.title = element_text(face = "bold"))+
theme(panel.grid.minor = element_blank(), axis.line.x = element_line(color = "black", size = 1))
clinicalt.plot

# Set up Human Computer Interface plots
# Isolate Human Computer Interface Question
interface <- survey[,c(19:27)]
# Remove Empty Rows
interface <- interface[!apply(interface == "",1,all),]

```

```

# Cleaning Data
# Clear White Space
interface <- data.frame(lapply(interface, trimws))

# Setting Factor Levels
interface <- data.frame(lapply(interface, function(x) factor(x, levels = lev_cs)))
names(interface) <- gsub("\\.", "", names(interface))

# Setting Likert Function
i_results <- likert(interface)

# Likert Plot
interface.plot <- plot(i_results, text.size = 5, wrap = 20, plot.percent.low = FALSE,
plot.percent.high = FALSE,
plot.percent.neutral = FALSE)+
theme_minimal(base_size = 15)+
theme(legend.position = "bottom")+
labs(title = "Human Computer Interface", subtitle = "n = 384")+
theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5) )+
theme(plot.title = element_text(face = "bold"))+
theme(panel.grid.minor = element_blank(), axis.line.x = element_line(color = "black", size = 1))
interface.plot

# Set up People plots
# Isolate People Question
people <- survey[,c(28:33)]
# Remove Empty Rows
people <- people[!apply(people == "", 1, all),]

# Cleaning Data
# Clear White Space
people <- data.frame(lapply(people, trimws))

# Setting Factor Levels
lev_i <- c("1 - Not Important","2","3 - Somewhat Important","4","5 - Extremely Important")
people <- data.frame(lapply(people, function(x) factor(x, levels = lev_i)))
names(people) <- gsub("\\.", "", names(people))

# Setting Likert Function
p_results <- likert(people)

# Likert Plot
people.plot <- plot(p_results, text.size = 5, wrap = 20, plot.percent.low = FALSE, plot.percent.high
= FALSE,
plot.percent.neutral = FALSE)+
theme_minimal(base_size = 15)+
theme(legend.position = "bottom")+

```

```

labs(title = "People", subtitle = "n = 376")+
theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5) )+
theme(plot.title = element_text(face = "bold"))+
theme(panel.grid.minor = element_blank(), axis.line.x = element_line(color = "black", size = 1))
people.plot

# Set up Workflow plots
# Isolate Workflow Question
workflow <- survey[ ,c(34:37)]
# Remove Empty Rows
workflow <- workflow[!apply(workflow == "",1,all),]

# Cleaning Data
# Clear White Space
workflow <- data.frame(lapply(workflow, trimws))

# Setting Factor Levels
lev_c <- c("1 - Not Valuable at all","2","3 - Somewhat Valuable","4","5 - Extremely Valuable")
workflow <- data.frame(lapply(workflow, function(x) factor(x, levels = lev_c)))
names(workflow) <- gsub("\\.", "",names(workflow))

# Setting Likert Function
w_results <- likert(workflow)

# Likert Plot
workflow.plot <- plot(w_results, text.size = 5, wrap = 20, plot.percent.low = FALSE,
plot.percent.high = FALSE,
plot.percent.neutral = FALSE)+
theme_minimal(base_size = 15)+
theme(legend.position = "bottom")+
labs(title = "Workflow and Communication", subtitle = "n = 370")+
theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5) )+
theme(plot.title = element_text(face = "bold"))+
theme(panel.grid.minor = element_blank(), axis.line.x = element_line(color = "black", size = 1))
workflow.plot

# Set up Internal Organizational Policies, Procedures, and Culture plots
# Isolate Internal Organizational Policies, Procedures, and Culture Question
ioppc <- survey[ ,c(38:40)]
# Remove Empty Rows
ioppc <- ioppc[!apply(ioppc == "",1,all),]

# Cleaning Data
# Clear White Space
ioppc <- data.frame(lapply(ioppc, trimws))

# Setting Factor Levels
lev_c <- c("1 - Not Valuable at all","2","3 - Somewhat Valuable","4","5 - Extremely Valuable")

```

```

ioppc <- data.frame(lapply(ioppc, function(x) factor(x, levels = lev_i)))
names(ioppc) <- gsub("\\.", "", names(ioppc))

# Setting Likert Function
ip_results <- likert(ioppc)

# Likert Plot
ioppc.plot <- plot(ip_results, text.size = 5, wrap = 20, plot.percent.low = FALSE, plot.percent.high
= FALSE,
                plot.percent.neutral = FALSE)+
  theme_minimal(base_size = 15)+
  theme(legend.position = "bottom")+
  labs(title = "Internal Organizational Policies, Procedures, and Culture", subtitle = "n = 362")+
  theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5) )+
  theme(plot.title = element_text(face = "bold"))+
  theme(panel.grid.minor = element_blank(), axis.line.x = element_line(color = "black", size = 1))
ioppc.plot

# Set up External Rules, Regulations, and Pressures plots
# Isolate External Rules, Regulations, and Pressures Question
errp <- survey[,c(41:43)]
# Remove Empty Rows
errp <- errp[!apply(errp == "", 1, all),]

# Cleaning Data
# Clear White Space
errp <- data.frame(lapply(errp, trimws))

# Setting Factor Levels
lev_c <- c("1 - Not Valuable at all","2","3 - Somewhat Valuable","4","5 - Extremely Valuable")
errp <- data.frame(lapply(errp, function(x) factor(x, levels = lev_i)))
names(errp) <- gsub("\\.", "", names(errp))

# Setting Likert Function
erp_results <- likert(errp)

# Likert Plot
errp.plot <- plot(erp_results, text.size = 5, wrap = 20, plot.percent.low = FALSE, plot.percent.high
= FALSE,
                plot.percent.neutral = FALSE)+
  theme_minimal(base_size = 15)+
  theme(legend.position = "bottom")+
  labs(title = "External Rules, Regulations, and Pressures", subtitle = "n = 357")+
  theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5) )+
  theme(plot.title = element_text(face = "bold"))+
  theme(panel.grid.minor = element_blank(), axis.line.x = element_line(color = "black", size = 1))
errp.plot

```

```

# Set up System Measurement and Monitoring plots
# Isolate System Measurement and Monitoring Question
smm <- survey[,c(44:46)]
# Remove Empty Rows
smm <- smm[!apply(smm == "", 1, all),]

# Cleaning Data
# Clear White Space
smm <- data.frame(lapply(smm, trimws))

# Setting Factor Levels
lev_c <- c("1 - Not Valuable at all","2","3 - Somewhat Valuable","4","5 - Extremely Valuable")
smm <- data.frame(lapply(smm, function(x) factor(x, levels = lev_c)))
names(smm) <- gsub("\\.", "", names(smm))

# Setting Likert Function
smm_results <- likert(smm)

# Likert Plot
smm.plot <- plot(smm_results, text.size = 5, wrap = 20, plot.percent.low = FALSE,
plot.percent.high = FALSE,
plot.percent.neutral = FALSE)+
theme_minimal(base_size = 15)+
theme(legend.position = "bottom")+
labs(title = "System Measurement and Monitoring", subtitle = "n = 354")+
theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5) )+
theme(plot.title = element_text(face = "bold"))+
theme(panel.grid.minor = element_blank(), axis.line.x = element_line(color = "black", size = 1))
smm.plot

####Familiarity and Use####

# Set up Familiarity plots
# Isolate Familiarity Question
fam <- survey[,c(55:60)]
# Remove Empty Rows
fam <- fam[!apply(fam == "", 1, all),]

# Cleaning Data
# Clear White Space
fam <- data.frame(lapply(fam, trimws))

# Setting Factor Levels
lev_f <- c("1 - Not Familiar at all","2","3 - Somewhat Familiar","4","5 - Extremely Familiar")
fam <- data.frame(lapply(fam, function(x) factor(x, levels = lev_f)))

new_nf <- c("Speech to Text")
old_nf <- c("Speech.to.text")

```

```

fam <- fam %>% rename_with(~ new_nf, all_of(old_nf))

names(fam) <- gsub("\\.", "", names(fam))

# Setting Likert Function
fam_results <- likert(fam)

# Likert Plot
fam.plot <- plot(fam_results, text.size = 5, wrap = 20, plot.percent.low = FALSE, plot.percent.high
= FALSE,
                plot.percent.neutral = FALSE)+
  theme_minimal(base_size = 15)+
  theme(legend.position = "bottom")+
  labs(title = "Familiarity", subtitle = "n = 327")+
  theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5) )+
  theme(plot.title = element_text(face = "bold"))+
  theme(panel.grid.minor = element_blank(), axis.line.x = element_line(color = "black", size = 1))
fam.plot

plot(fam_results, type = "heat")
# Set up Use plots
# Isolate Use Question
use <- survey[,c(61:66)]
# Remove Empty Rows
use <- use[!apply(use == "", 1, all),]

# Cleaning Data
# Clear White Space
use <- data.frame(lapply(use, trimws))

# Setting Factor Levels
lev_u <- c("1 - Never Use","2","3 - Occasionally Use","4","5 - Daily Use")
use <- data.frame(lapply(use, function(x) factor(x, levels = lev_u)))

new_nu <- c("Voice Command Appliances","Medical Dictation","Smart Glasses","Vehicle
Systems","Voice Assistants")
old_nu <- c("Voice Command Appliances 1","Medical Dictation 1","Smart Glasses 1","Vehicle
System","Voice Assistant")
use <- use %>% rename_with(~ new_nu, all_of(old_nu))

names(use) <- gsub("\\.", "", names(use))

# Setting Likert Function
use_results <- likert(use)

# Likert Plot
use.plot <- plot(use_results, text.size = 5, wrap = 20, plot.percent.low = FALSE, plot.percent.high
= FALSE,

```

```

        plot.percent.neutral = FALSE)+
theme_minimal(base_size = 15)+
theme(legend.position = "bottom")+
labs(title = "Use", subtitle = "n = 327")+
theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5) )+
theme(plot.title = element_text(face = "bold"))+
theme(panel.grid.minor = element_blank(), axis.line.x = element_line(color = "black", size = 1))
use.plot

plot(use_results, type="heat")

#####Perceptions#####

# Set up Perception plots
# Isolate Perception Question
perception <- survey[,c(67:70)]
# Remove Empty Rows
perception <- perception[!apply(perception == "",1,all),]

# Cleaning Data
# Clear White Space
perception <- data.frame(lapply(perception, trimws))

# Setting Factor Levels
lev_p <- c("1 - Strongly Disagree","2","3 - Neutral","4","5 - Strongly Agree")
perception <- data.frame(lapply(perception, function(x) factor(x, levels = lev_p)))

names(perception) <- gsub("\\.", " ",names(perception))

# Setting Likert Function
perception_results <- likert(perception)

# Likert Plot
perception.plot <- plot(perception_results, text.size = 5, wrap = 20, plot.percent.low = FALSE,
plot.percent.high = FALSE,
        plot.percent.neutral = FALSE)+
theme_minimal(base_size = 15)+
theme(legend.position = "bottom")+
labs(title = "Perceptions", subtitle = "n = 327")+
theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5) )+
theme(plot.title = element_text(face = "bold"))+
theme(panel.grid.minor = element_blank(), axis.line.x = element_line(color = "black", size = 1))
perception.plot

#Set up overall perceptions
#Isolate overall perception
over <- survey[, c(1,71)]

```

```

#Remove Empty Rows
over <- over[!(over$Overall.Perception == ""),]

#Clearing white space
over <- data.frame(lapply(over, trimws))
names(over) <- gsub("\\.", "", names(over))

fi <- c("#D8B365", "#5AB4AC")
#Plot
ggplot(over, aes(` Overall Perception `))+
  geom_bar(stat = 'count', alpha = 0.5, color = "black", fill = fi, size = 1)+
  coord_flip()+
  stat_count(geom = "text", color = "black", size = 5, aes(label = ..count..), position =
position_stack(vjust = 0.7))+
  theme_minimal(base_size = 15)+
  theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.line.x =
element_line(color = "black", size = 1))+
  theme(axis.ticks.y = element_blank(), axis.title.y = element_blank()+
labs(title = "Overall Perception", subtitle = "n = 323")+theme(plot.title = element_text(hjust =
0.5), plot.subtitle = element_text(hjust = 0.5))+
  theme(plot.title = element_text(face = "bold"))

#####Ranking and Minimum Set#####

# Set up Ranked Data
# Isolate the Ranking Question
ranked <- survey[,c(47:54)]

# Removed Blank or NA rows
ranked <- ranked[complete.cases(ranked),]

names(ranked) <- gsub("\\.", "", names(ranked))

# Set Factor levels for categorical variables
ranked <- ranked %>% mutate_if(is.integer, factor, levels = 1:8)
# Reorganize column

ranked1 <- ranked %>% gather(key=Questions, value=Ranking, "Hardware":"System
Measurement and Monitoring")
ranked1 <- ranked1 %>% mutate(Questions = fct_reorder(Questions, desc(Ranking)))

# Assign colors
colors <-
c("midnightblue", "blue2", "royalblue", "grey88", "grey77", "tomato1", "firebrick3", "orangered4")

# Plot

ggplot(ranked1, aes(x=Questions, fill=Ranking))+

```

```

geom_bar()+
coord_flip()+
theme_minimal(base_size = 15)+
scale_fill_manual(values = colors)+
labs(title = "Trade Offs", subtitle = "n = 275")+
theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5) )+
theme(plot.title = element_text(face = "bold"))+
scale_x_discrete(labels = function(x)lapply(strwrap(x, width = 20, simplify = FALSE), paste,
collapse="\n"))

#Set up minimum set data
minset <- surveymin[,c(1:5)]

#Remove Empty Rows
minset <- minset[!apply(minset == "",1,all),]

#Reorganize
minset1 <- minset %>% gather(key = Order, value = set, First:Fifth)
minset1 <- minset1 %>% mutate(id = row_number())
minset2 <- minset1 %>% group_by(set) %>% summarise(count = n_distinct(id))
minset2 <- minset2[!(minset2$set == ""),]
minset2 <- minset2 %>% filter(count>40) %>% arrange(desc(count))
minset2$set <- factor(minset2$set, levels = minset2$set[order(minset2$count, decreasing =
FALSE)])
minset3 <- minset1 %>% group_by(set) %>% summarise(count = n_distinct(id))
minset3 <- minset3[!(minset3$set == ""),]
minset3 <- minset3 %>% filter(count>13 & count<41) %>% arrange(desc(count))
minset3$set <- factor(minset3$set, levels = minset3$set[order(minset3$count, decreasing =
FALSE)])
minset4 <- minset1 %>% group_by(set) %>% summarise(count = n_distinct(id))
minset4 <- minset4[!(minset4$set == ""),]
minset4 <- minset4 %>% filter(count<13) %>% arrange(desc(count))
minset4$set <- factor(minset4$set, levels = minset4$set[order(minset4$count, decreasing =
FALSE)])

minset5 <- minset1 %>% group_by(set) %>% summarise(count = n_distinct(id))
minset5 <- minset5[!(minset5$set == ""),]
minset5 <- minset5 %>% filter(count>32) %>% arrange(desc(count))
minset5$set <- factor(minset5$set, levels = minset5$set[order(minset5$count, decreasing =
FALSE)])

##Needs Fixing

ggplot(minset2, aes(set,count))+
geom_col(alpha = 0.5,color = "black", fill = "grey44", size = 1)+
geom_text(aes(label = count), size = 5, hjust = 2, vjust = 0.2, position = "stack")+
coord_flip()+
theme_minimal(base_size = 15)+

```

```

theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.line.x =
element_line(color = "black", size = 1))+
theme(axis.ticks.y = element_blank(), axis.title.y = element_blank()+
labs(title = "Minimum Set (Top Five)", subtitle = "n = 167", caption = "35 remaining
features")+theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5))+
theme(plot.title = element_text(face = "bold"))+
scale_x_discrete(labels = function(x)lapply(strwrap(x, width = 30, simplify = FALSE), paste,
collapse="\n"))

ggplot(minset3, aes(set,count))+
geom_col(alpha = 0.5,color = "black", fill = "grey44", size = 1)+
geom_text(aes(label = count), size = 5, hjust = 2, vjust = 0.2, position = "stack")+
coord_flip()+
theme_minimal(base_size = 15)+
theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.line.x =
element_line(color = "black", size = 1))+
theme(axis.ticks.y = element_blank(), axis.title.y = element_blank()+
labs(title = "Remaining 35 - Part One", subtitle = "n = 167")+theme(plot.title = element_text(hjust
= 0.5), plot.subtitle = element_text(hjust = 0.5))+
theme(plot.title = element_text(face = "bold"))+
scale_x_discrete(labels = function(x)lapply(strwrap(x, width = 30, simplify = FALSE), paste,
collapse="\n"))

ggplot(minset4, aes(set,count))+
geom_col(alpha = 0.5,color = "black", fill = "grey44", size = 1)+
geom_text(aes(label = count), size = 5, hjust = 2, vjust = 0.2, position = "stack")+
coord_flip()+
theme_minimal(base_size = 15)+
theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.line.x =
element_line(color = "black", size = 1))+
theme(axis.ticks.y = element_blank(), axis.title.y = element_blank()+
labs(title = "Remaining 35 - Part Two", subtitle = "n = 167")+theme(plot.title = element_text(hjust
= 0.5), plot.subtitle = element_text(hjust = 0.5))+
theme(plot.title = element_text(face = "bold"))+
scale_x_discrete(labels = function(x)lapply(strwrap(x, width = 30, simplify = FALSE), paste,
collapse="\n"))

ggplot(minset5, aes(set,count))+
geom_col(alpha = 0.5,color = "black", fill = "grey44", size = 1)+
geom_text(aes(label = count), size = 5, hjust = 2, vjust = 0.2, position = "stack")+
coord_flip()+
theme_minimal(base_size = 15)+
theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.line.x =
element_line(color = "black", size = 1))+
theme(axis.ticks.y = element_blank(), axis.title.y = element_blank()+
labs(title = "Minimum Set (Top Ten)", subtitle = "n = 167", caption = "25 remaining
features")+theme(plot.title = element_text(hjust = 0.5), plot.subtitle = element_text(hjust = 0.5))+
theme(plot.title = element_text(face = "bold"))+

```

```

scale_x_discrete(labels = function(x)lapply(strwrap(x, width = 30, simplify = FALSE), paste,
collapse="\n"))

##Open Ended Additional Features##

openended <- data.frame(Feature = c("Translation","Clinical Decision Support","Hands-Free
Mapping","AI/LLM","Thermal Scans","Direct Uploads"), Count = c("7","5","2","2","1","1"))
openended$Count <- as.numeric(as.character(openended$Count))
oe_order <- c("Translation","Clinical Decision Support","Hands-Free Mapping","AI/LLM","Thermal
Scans","Direct Uploads")
ggplot(openended, aes(Feature,Count))+
  geom_col(alpha = 0.5,color = "black", fill = "grey44", size = 1)+
  geom_text(aes(label = Count), size = 5, vjust = 1.2)+
  theme_minimal(base_size = 15)+
  theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.line.x =
element_line(color = "black", size = 1))+
  theme(axis.text.y = element_blank(), axis.ticks.y = element_blank(), axis.title.y =
element_blank()+
  ggtitle("Additional Features")+theme(plot.title = element_text(hjust = 0.5), plot.subtitle =
element_text(hjust = 0.5) )+
  theme(plot.title = element_text(face = "bold"))+
  scale_x_discrete(limits = oe_order, labels = function(x)lapply(strwrap(x, width = 20, simplify =
FALSE), paste, collapse="\n"))

```

R code for correlation and regression analysis

```

#####ANALYSIS#####

#Spearmens correlations

library(dplyr)
library(tidyr)
library(likert)
library(ggplot2)

options(scipen = 999)

corra <- survey[,c(2:46,55:71,79:84)]
corra <- corra[!(corra$Overall.Perception == ""), ]

corra <- corra %>%
  rename(Years =
Years.of.paramedicine.experience..Please.use.slider.or.text.box.on.the.right..numeric.)
corra <- corra %>%
  mutate(
  "Years Experience" = dplyr::case_when(
    Years <= 5 ~ "0-5",
    Years > 5 & Years <= 10 ~ "6-10",
    Years > 10 & Years <= 15 ~ "11-15",

```

```

Years > 15 & Years <= 20 ~ "16-20",
Years > 20 & Years <= 25 ~ "21-25",
Years > 25 ~ "26"),
`Years Experience` = factor(`Years Experience`, levels = c("0-5","6-10","11-15","16-20","21-
25","26")))

corra <- corra %>%
  rename(Age = Age..Please.use.slider.or.text.box.on.the.right.)
corra <- corra %>%
  mutate(
    "Age Group" = dplyr::case_when(
      Age <= 20 ~ "0-20",
      Age > 20 & Age <= 30 ~ "21-30",
      Age > 30 & Age <= 40 ~ "31-40",
      Age > 40 & Age <= 50 ~ "41-50",
      Age > 50 & Age <= 60 ~ "51-60",
      Age > 60 ~ "61"),
    `Age Group` = factor(`Age Group`, levels = c("0-20","21-30","31-40","41-50","51-60","61")))

corra <- corra[,c(-67,-64,-65)]

corra <- corra %>%
  rename(Province = `Province Territory of Practice If registered in multiple provinces please
select the area of residence If Student then the province of study Select only one `)

corra <- data.frame(lapply(corra,function(x) gsub("1 - Not important","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("3 - Somewhat Important","3",x)))
corra <- data.frame(lapply(corra,function(x) gsub("5 - Extremely Important","5",x)))
corra <- data.frame(lapply(corra,function(x) gsub("Positive","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("Negative","0",x)))
corra <- data.frame(lapply(corra,function(x) gsub("1 - Not Valuable at all","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("1 - Not Valuable","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("3 - Somewhat Valuable","3",x)))
corra <- data.frame(lapply(corra,function(x) gsub("5 - Extremely Valuable","5",x)))

corra <- data.frame(lapply(corra,function(x) gsub("1 - Not Important","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("1 - Not Familiar at all","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("3 - Somewhat Familiar","3",x)))
corra <- data.frame(lapply(corra,function(x) gsub("5 - Extremely Familiar","5",x)))
corra <- data.frame(lapply(corra,function(x) gsub("1 - Never Use","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("3 - Occasionally Use","3",x)))
corra <- data.frame(lapply(corra,function(x) gsub("5 - Daily Use","5",x)))
corra <- data.frame(lapply(corra,function(x) gsub("1 - Strongly Disagree","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("3 - Neutral","3",x)))
corra <- data.frame(lapply(corra,function(x) gsub("5 - Strongly Agree","5",x)))
corra <- data.frame(lapply(corra,function(x) gsub("Woman","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("Non-Binary","0",x)))
corra <- data.frame(lapply(corra,function(x) gsub("Man","2",x)))

```

```

corra <- data.frame(lapply(corra,function(x) gsub("Prefer Not to Say","3",x)))
corra <- data.frame(lapply(corra,function(x) gsub("Prefer to Self Describe","4",x)))
corra <- data.frame(lapply(corra,function(x) gsub("1 - Not Important at all","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("0-5","0",x)))
corra <- data.frame(lapply(corra,function(x) gsub("6-10","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("11-15","2",x)))
corra <- data.frame(lapply(corra,function(x) gsub("16-20","3",x)))
corra <- data.frame(lapply(corra,function(x) gsub("21-25","4",x)))
corra <- data.frame(lapply(corra,function(x) gsub("26","5",x)))
corra <- data.frame(lapply(corra,function(x) gsub("0-20","0",x)))
corra <- data.frame(lapply(corra,function(x) gsub("21-30","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("31-40","2",x)))
corra <- data.frame(lapply(corra,function(x) gsub("41-50","3",x)))
corra <- data.frame(lapply(corra,function(x) gsub("51-60","4",x)))
corra <- data.frame(lapply(corra,function(x) gsub("61","5",x)))

corra <- data.frame(lapply(corra,function(x) gsub("NL","0",x)))
corra <- data.frame(lapply(corra,function(x) gsub("NS","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("PEI","2",x)))
corra <- data.frame(lapply(corra,function(x) gsub("NB","3",x)))
corra <- data.frame(lapply(corra,function(x) gsub("QC","4",x)))
corra <- data.frame(lapply(corra,function(x) gsub("ON","5",x)))
corra <- data.frame(lapply(corra,function(x) gsub("MB","6",x)))
corra <- data.frame(lapply(corra,function(x) gsub("SK","7",x)))
corra <- data.frame(lapply(corra,function(x) gsub("AB","8",x)))
corra <- data.frame(lapply(corra,function(x) gsub("BC","9",x)))

corra <- data.frame(lapply(corra,function(x) gsub("Urban","0",x)))
corra <- data.frame(lapply(corra,function(x) gsub("Rural","1",x)))
corra <- data.frame(lapply(corra,function(x) gsub("Remote","2",x)))
corra <- data.frame(lapply(corra,function(x) gsub("Urabn","0",x)))
corra <- data.frame(sapply(corra, as.numeric))
names(corra) <- gsub("\\\\.", " ",names(corra))
new_col <- abbreviate(names(corra), minlength = 5)
ab_col <-
c("Ergo","Dura","Cust","LocPro","InterOpD","Comms","Integrat","MedHis","Vocab","Dict","VitSigRec","
InterTimes",

"MedAdTime","MedScn","CapImgVid","Telemed","FeedDSG","Editing","Calib","Accuracy","MinInter","
VocComOp","Feedback",

"ConvPro","Clsdloop","HFops","Supp","Patient","Train","OpLvls","StakeHo","Custom","DualUse","Diff
er","Adapt","InteropIns",

"TrainSup","StakHEng","OrgBuyIn","Compl","Storag","Delet","PublishUS","ContinImp","UserTest","StT
Fam","VcAssFam",

```

```
"MedDicFam","VhclSysFam","VoComAppFam","SmrtGFam","StTUse","VcAssUse","MedDicUse","VhclSysUse","VoComAppUse","SmrtGUse",
```

```
"MoAcc","MoEff","NotDis","MoCompN","OverallP","Provs","Gender","AreaofP","YrsExp","AgeGrp")
```

```
#Load libraries for analysis
```

```
library(corrplot)
```

```
library(metan)
```

```
library(PerformanceAnalytics)
```

```
library(ordinal)
```

```
library(MASS)
```

```
library(brant)
```

```
library(pwr)
```

```
#Running correlation matrices
```

```
D=corra[1:67]
```

```
D <- setNames(D,new_col)
```

```
D <- setNames(D,ab_col)
```

```
#Hardware vs Demographics
```

```
M <- cor(D[,c(1:7,62:67)],method = "spearman")
```

```
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag = FALSE, title = "Hardware and Demographics", mar=c(0,0,1,0))
```

```
pwr.r.test(r = 0.04, n = 323, sig.level = 0.25)
```

```
#Clinical Context vs Demographics
```

```
M <- cor(D[,c(8:17,62:67)],method = "spearman")
```

```
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag = FALSE, title = "Clinical Context and Demographics", mar=c(0,0,1,0))
```

```
#Human-Computer interface vs Demographics
```

```
M <- cor(D[,c(18:26,62:67)],method = "spearman")
```

```
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag = FALSE, title = "Human-Computer Interface and Demographics", mar=c(0,0,1,0))
```

```
#People vs Demographics
```

```
M <- cor(D[,c(27:32,62:67)],method = "spearman")
```

```
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag = FALSE, title = "People and Demographics", mar=c(0,0,1,0))
```

```
#Workflow and Communication vs Demographics
```

```
M <- cor(D[,c(33:36,62:67)],method = "spearman")
```

```
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag = FALSE, title = "Workflow and Demographics", mar=c(0,0,1,0))
```

```
#Internal Policies vs Demographics
```

```

M <- cor(D[,c(37:39,62:67)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "Internal Organizational Policies and Demographics", mar=c(0,0,1,0))

#External Rules and Regulations vs Demographics
M <- cor(D[,c(40:42,62:67)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "External Rules and Demographics", mar=c(0,0,1,0))

#System Measurement vs Demographics
M <- cor(D[,c(43:45,62:67)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "System Measurement and Demographics", mar=c(0,0,1,0))

#Familiarity vs Demographics
M <- cor(D[,c(46:51,62:67)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "Familiarity and Demographics", mar=c(0,0,1,0))

#Use vs Demographics
M <- cor(D[,c(52:57, 62:67)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "Use and Demographics", mar=c(0,0,1,0))

#Perception vs Demographics
M <- cor(D[,c(58:61,62:67)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "Perception and Demographics", mar=c(0,0,1,0))

#Familiarity vs Use
M <- cor(D[,c(46:57)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "Familiarity and Use", mar=c(0,0,1,0))

#Hardware vs perceptions
M <- cor(D[,c(1:7,58:61)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "Hardware and Perceptions", mar=c(0,0,1,0))

#Clinical context vs Perception
M <- cor(D[,c(8:17,58:61)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "Clinical Context and Perceptions", mar=c(0,0,1,0))

#human-computer interface vs Perceptions
M <- cor(D[,c(18:26,58:61)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "Human-Computer Interface and Perceptions", mar=c(0,0,1,0))

```

```

#People vs Perceptions
M <- cor(D[,c(27:32,58:61)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "People and Perceptions", mar=c(0,0,1,0))

#Workflow and Communication vs Perceptions
M <- cor(D[,c(33:36,58:61)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "Workflow and Perceptions", mar=c(0,0,1,0))

#Internal Policies vs Perceptions
M <- cor(D[,c(37:39,58:61)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "Internal Organizational Policies and Perceptions", mar=c(0,0,1,0))

#External Rules vs Perceptions
M <- cor(D[,c(40:42,58:61)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "External Rules and Perceptions", mar=c(0,0,1,0))

#System Measurement vs Perceptions
M <- cor(D[,c(43:45,58:61)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "System Measurement and Perceptions", mar=c(0,0,1,0))

#Familiarity vs Perceptions
M <- cor(D[,c(46:51,58:61)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "Familiarity and Perceptions", mar=c(0,0,1,0))

#Use vs Perceptions
M <- cor(D[,c(52:57,58:61)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "Use and Perceptions", mar=c(0,0,1,0))

M <- cor(D[,c(1:7,52:57)],method = "spearman")
corrplot(M, method = 'color', type = 'upper', tl.col = "black", addCoef.col = 'black' ,tl.srt = 45, diag
= FALSE, title = "Hardware and Demographics", mar=c(0,0,1,0))

#Ordinal Regression Analysis
ordianldf <- survey[,c(2:46,55:71,72,79:82,84)]
ordianldf <- ordianldf[!(ordianldf$Overall.Perception == ""), ]

ordianldf <- ordianldf %>%
  rename(Years =
Years.of.paramedicine.experience..Please.use.slider.or.text.box.on.the.right..numeric.)

```

```

ordianldf$Frontline.Staff[ordianldf$Frontline.Staff==""] <- 'other'

ordianldf <- ordianldf %>%
  rename(Age = Age..Please.use.slider.or.text.box.on.the.right.)

ordianldf <- ordianldf %>%
  rename(Province =
Province.Territory.of.Practice..If.registered.in.multiple.provinces..please.select.the.area.of.reside
nce.....If.Student..then.the.province.of.study..Select.only.one.)
names(ordianldf) <- gsub("\\.", "", names(ordianldf))

ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("1 - Not important","1",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("3 - Somewhat Important","3",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("5 - Extremely Important","5",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("Positive","1",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("Negative","0",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("1 - Not Valuable at all","1",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("1 - Not Valuable","1",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("3 - Somewhat Valuable","3",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("5 - Extremely Valuable","5",x)))

ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("1 - Not Important","1",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("1 - Not Familiar at all","1",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("3 - Somewhat Familiar","3",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("5 - Extremely Familiar","5",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("1 - Never Use","1",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("3 - Occasionally Use","3",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("5 - Daily Use","5",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("1 - Strongly Disagree","1",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("3 - Neutral","3",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("5 - Strongly Agree","5",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("Woman","2",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("Non-Binary","1",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("Man","3",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("Prefer Not to Say","4",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("Prefer to Self Describe","5",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("1 - Not Important at all","1",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("other","0",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("Frontline Staff","1",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("NL","0",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("NS","1",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("PEI","2",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("NB","3",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("QC","4",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("ON","5",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("MB","6",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("SK","7",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("AB","8",x)))

```

```

ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("BC","9",x)))

ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("Urban","0",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("Rural","1",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("Remote","2",x)))
ordianldf <- data.frame(lapply(ordianldf,function(x) gsub("Urabn","0",x)))
ordianldf <- data.frame(sapply(ordianldf, as.numeric))

###Test1
options(scipen = 999)

Hware_or <- ordianldf[,c(1:7,62:68)]
names(Hware_or) <- gsub("\\.", "",names(Hware_or))
Hware_or$Ergonomics <- factor(Hware_or$Ergonomics, levels = c(1,2,3,4,5), labels = c("1 - Not
Important", "2", "3 - Somewhat Important","4","5 - Extermely Important"))
Hware_or$Durability <- factor(Hware_or$Durability, levels = c(1,2,3,4,5), labels = c("1 - Not
Important", "2", "3 - Somewhat Important","4","5 - Extermely Important"))
Hware_or$Customizability <- factor(Hware_or$Customizability, levels = c(1,2,3,4,5), labels = c("1
- Not Important", "2", "3 - Somewhat Important","4","5 - Extermely Important"))
Hware_or$` Local Processing` <- factor(Hware_or$` Local Processing`, levels = c(1,2,3,4,5),
labels = c("1 - Not Important", "2", "3 - Somewhat Important","4","5 - Extermely Important"))
Hware_or$` Interoperability Devices ` <- factor(Hware_or$` Interoperability Devices `, levels =
c(1,2,3,4,5), labels = c("1 - Not Important", "2", "3 - Somewhat Important","4","5 - Extermely
Important"))
Hware_or$Communication <- factor(Hware_or$Communication, levels = c(1,2,3,4,5), labels =
c("1 - Not Important", "2", "3 - Somewhat Important","4","5 - Extermely Important"))
Hware_or$Integration <- factor(Hware_or$Integration, levels = c(1,2,3,4,5), labels = c("1 - Not
Important", "2", "3 - Somewhat Important","4","5 - Extermely Important"))

Hware_or$` Overall Perception ` <- factor(Hware_or$` Overall Perception`, levels = c(0,1), labels
= c("Negative","Positive"))
Hware_or$Province <- factor(Hware_or$Province, levels = c(0,1,2,3,4,5,6,7,8,9), labels =
c("NL","NS", "PEI","NB","QC","ON","MB","SK","AB","BC"))
Hware_or$Gender <- factor(Hware_or$Gender, levels = c(1,2,3,4,5), labels = c("Non
Binary","Woman","Man","Perfer Not to Say","Perfer to Self Describe"))
Hware_or$` Area of Practice ` <- factor(Hware_or$` Area of Practice`, levels = c(0,1,2), labels =
c("Remote","Urban","Rural"))
Hware_or$` Frontline Staff ` <- factor(Hware_or$` Frontline Staff`, levels = c(0,1), labels =
c("Other","Frontline Staff"))

Clin_or <- ordianldf[,c(8:17,62:68)]
names(Clin_or) <- gsub("\\.", "",names(Clin_or))
Clin_or$` Medication History ` <- factor(Clin_or$` Medication History`, levels = c(1,2,3,4,5),
labels = c("1 - Not Valuable", "2", "3 - Somewhat Valuable","4","5 - Extermely Valuable"))
Clin_or$Vocabulary<- factor(Clin_or$Vocabulary, levels = c(1,2,3,4,5), labels = c("1 - Not
Valuable", "2", "3 - Somewhat Valuable","4","5 - Extermely Valuable"))
Clin_or$Dictation<- factor(Clin_or$Dictation, levels = c(1,2,3,4,5), labels = c("1 - Not Valuable",
"2", "3 - Somewhat Valuable","4","5 - Extermely Valuable"))

```

```

Clin_or$`Vital sign recording` <- factor(Clin_or$`Vital sign recording`, levels = c(1,2,3,4,5),
labels = c("1 - Not Valuable", "2", "3 - Somewhat Valuable","4","5 - Extermely Valuable"))
Clin_or$`Intervention Timestamp` <- factor(Clin_or$`Intervention Timestamp`, levels =
c(1,2,3,4,5), labels = c("1 - Not Valuable", "2", "3 - Somewhat Valuable","4","5 - Extermely
Valuable"))
Clin_or$`Medication Administration Timpstamp` <- factor(Clin_or$`Medication Administration
Timpstamp`, levels = c(1,2,3,4,5), labels = c("1 - Not Valuable", "2", "3 - Somewhat
Valuable","4","5 - Extermely Valuable"))
Clin_or$`Medication scanning` <- factor(Clin_or$`Medication scanning`, levels = c(1,2,3,4,5),
labels = c("1 - Not Valuable", "2", "3 - Somewhat Valuable","4","5 - Extermely Valuable"))
Clin_or$`Capture Images or Videos` <- factor(Clin_or$`Capture Images or Videos`, levels =
c(1,2,3,4,5), labels = c("1 - Not Valuable", "2", "3 - Somewhat Valuable","4","5 - Extermely
Valuable"))
Clin_or$Telemedicine <- factor(Clin_or$Telemedicine, levels = c(1,2,3,4,5), labels = c("1 - Not
Valuable", "2", "3 - Somewhat Valuable","4","5 - Extermely Valuable"))
Clin_or$`Feedback Display Smart Glasses` <- factor(Clin_or$`Feedback Display Smart
Glasses`, levels = c(1,2,3,4,5), labels = c("1 - Not Valuable", "2", "3 - Somewhat Valuable","4","5 -
Extermely Valuable"))

Clin_or$`Overall Perception` <- factor(Clin_or$`Overall Perception`, levels = c(0,1), labels =
c("Negative","Positive"))
Clin_or$Province <- factor(Clin_or$Province, levels = c(0,1,2,3,4,5,6,7,8,9), labels = c("NL","NS",
"PEI","NB","QC","ON","MB","SK","AB","BC"))
Clin_or$Gender <- factor(Clin_or$Gender, levels = c(1,2,3,4,5), labels = c("Non
Binary","Woman","Man","Perfer Not to Say","Perfer to Self Describe"))
Clin_or$`Area of Practice` <- factor(Clin_or$`Area of Practice`, levels = c(0,1,2), labels =
c("Remote","Urban","Rural"))
Clin_or$`Frontline Staff` <- factor(Clin_or$`Frontline Staff`, levels = c(0,1), labels =
c("Other","Frontline Staff"))

Pep_or <- ordianldf[,c(27:32,62:68)]
names(Pep_or) <- gsub("\\.", "",names(Pep_or))
Pep_or$Support <- factor(Pep_or$Support, levels = c(1,2,3,4,5), labels = c("1 - Not Important",
"2", "3 - Somewhat Important","4","5 - Extermely Important"))
Pep_or$`Patient Interaction` <- factor(Pep_or$`Patient Interaction`, levels = c(1,2,3,4,5), labels
= c("1 - Not Important", "2", "3 - Somewhat Important","4","5 - Extermely Important"))
Pep_or$Training<- factor(Pep_or$Training, levels = c(1,2,3,4,5), labels = c("1 - Not Important", "2",
"3 - Somewhat Important","4","5 - Extermely Important"))
Pep_or$`Operation Levels` <- factor(Pep_or$`Operation Levels`, levels = c(1,2,3,4,5), labels =
c("1 - Not Important", "2", "3 - Somewhat Important","4","5 - Extermely Important"))
Pep_or$Stakeholders <- factor(Pep_or$Stakeholders, levels = c(1,2,3,4,5), labels = c("1 - Not
Important", "2", "3 - Somewhat Important","4","5 - Extermely Important"))
Pep_or$Customization<- factor(Pep_or$Customization, levels = c(1,2,3,4,5), labels = c("1 - Not
Important", "2", "3 - Somewhat Important","4","5 - Extermely Important"))

Pep_or$`Overall Perception` <- factor(Pep_or$`Overall Perception`, levels = c(0,1), labels =
c("Negative","Positive"))

```

```

Pep_or$Province <- factor(Pep_or$Province, levels = c(0,1,2,3,4,5,6,7,8,9), labels = c("NL","NS",
"PEI","NB","QC","ON","MB","SK","AB","BC"))
Pep_or$Gender <- factor(Pep_or$Gender, levels = c(1,2,3,4,5), labels = c("Non
Binary","Woman","Man","Perfer Not to Say","Perfer to Self Describe"))
Pep_or$` Area of Practice ` <- factor(Pep_or$` Area of Practice ` , levels = c(0,1,2), labels =
c("Remote","Urban","Rural"))
Pep_or$` Frontline Staff ` <- factor(Pep_or$` Frontline Staff ` , levels = c(0,1), labels =
c("Other","Frontline Staff"))

modelnull <- clm(as.factor(Integration)~1,data=Hware_or,link="logit")
modelA <- clm(as.factor(Integration)~Age,data=Hware_or,link = "logit")
modelY <- clm(as.factor(Integration)~Years,data=Hware_or,link = "logit")
modelO <- clm(as.factor(Integration)~` Overall Perception ` ,data=Hware_or,link = "logit")
modelR <- clm(as.factor(Integration)~` Frontline Staff ` ,data=Hware_or,link = "logit")
modelAY <- clm(as.factor(Integration)~Age+Years,data=Hware_or,link = "logit")
modelAYO <- clm(as.factor(Integration)~Age+Years+` Overall Perception ` ,data=Hware_or,link =
"logit")
modelAYOR <- clm(as.factor(Integration)~Age+Years+` Overall Perception ` +` Frontline
Staff ` ,data=Hware_or,link = "logit")
modelYOR <- clm(as.factor(Integration)~Years+` Overall Perception ` +` Frontline
Staff ` ,data=Hware_or,link = "logit")
modelOR <- clm(as.factor(Integration)~` Overall Perception ` +` Frontline
Staff ` ,data=Hware_or,link = "logit")
modelAR <- clm(as.factor(Integration)~Age+` Frontline Staff ` ,data=Hware_or,link = "logit")
modelAOR <- clm(as.factor(Integration)~Age+` Overall Perception ` +` Frontline
Staff ` ,data=Hware_or,link = "logit")
modelAO <- clm(as.factor(Integration)~Age+` Overall Perception ` ,data=Hware_or,link = "logit")

anova(modelnull, modelA)
summary(modelA)
confint(modelA)
exp(coef(modelA))

anova(modelnull, modelY)
summary(modelY)
confint(modelY)
exp(coef(modelY))

anova(modelnull, modelO)
summary(modelO)
confint(modelO)
exp(coef(modelO))

anova(modelnull, modelR)
summary(modelR)
confint(modelR)
exp(coef(modelR))

```

```
anova(modelnull, modelAY)
summary(modelAY)
confint(modelAY)
exp(coef(modelAY))
```

```
anova(modelnull, modelAYO)
summary(modelAYO)
confint(modelAYO)
exp(coef(modelAYO))
```

```
anova(modelnull, modelAYOR)
summary(modelAYOR)
confint(modelAYOR)
exp(coef(modelAYOR))
```

```
anova(modelnull, modelYOR)
summary(modelYOR)
confint(modelYOR)
exp(coef(modelYOR))
```

```
anova(modelnull, modelOR)
summary(modelOR)
confint(modelOR)
exp(coef(modelOR))
```

```
anova(modelnull, modelAO)
summary(modelAO)
confint(modelAO)
exp(coef(modelAO))
```

```
anova(modelnull, modelAOR)
summary(modelAOR)
confint(modelAOR)
exp(coef(modelAOR))
```

```
anova(modelnull, modelAR)
summary(modelAR)
confint(modelAR)
exp(coef(modelAR))
```

```
modelt <- polr(as.factor(Ergonomics)~ Age+Years+Province, data=Hware_or, Hess = TRUE)
library(brant)
```

```
summary(modelt)
brant(modelt)
```

8.8 Appendix 8

Table 8.11. List of questions, short forms and abbreviations.

Short Title	Abbreviation	Full Question
Hardware		
Ergonomics	Ergo	Ergonomics - The comfort of the Earpiece/Headset/Device that is worn to interface with the speech recognition software.
Durability	Dura	Durability - Sturdiness of the device, ability to easily sanitize, battery life, weatherproofing, etc.
Customizability	Cust	Customizability - Ability to change/reshape or have an individual device created.
Local Processing	LocPro	Local Processing - Ability to use speech recognition software without cellular or Wi-Fi connection.
Interoperability Devices	InterOpD	Interoperability (Devices) - Ability of software to interact with other devices (e.g., EKG monitor, IV Pump, laptop) and issue commands to devices.
Communication	Comms	Communication - Ability to use the device for dual purposes, speech recognition documentation and communication with dispatch/receiving ED.
Integration	Integrat	Integration - The ability of the device to be integrated into the ePCR system that is currently in use. I.e. not requiring a new ePCR system to use the SR device.
Clinical Context		
Medication History	MedHis	Medications - Ability to record patient medications through spelling name/DIN/Rx number.
Vocabulary	Vocab	Vocabulary - A robust and paramedicine-specific vocabulary and the ability to store and record context/regionally specific terms.
Dictation	Dict	Dictation - Ability to dictate narrative documentation to the device and have that transcribed into an ePCR.
Vital Sign Recording	VitSigRec	Vital sign recording - Using a voice command to import vital signs from an active monitor with a timestamp.
Intervention Timestamp	InterTimes	Interventions - Timestamping interventions using voice commands using speech recognition to record details about the intervention (e.g., record placement, size, and IV flow rate).
Medication Administration Timestamp	MedAdTime	Medication Administration - Timestamping medication administration using voice commands and speech recognition to record details about

		the medication administration (e.g., record time, route, dose, lot, and exp date).
Medication Scanning	MedScn	Medication scanning - Scan the medication barcode prior to administration to automatically record information or record a patient's medications automatically.
Capture Images and Video	CapImgVid	Capture Images or Videos - Capture photos or videos of patient injuries
Telemedicine	Telemed	Telemedicine - Ability to stream video directly to consultation physician or paramedic from the device.
Feedback Display Smart Glasses	FeedDSG	Feedback Display - (Smart Glasses Only) Ability to receive live feedback in heads up display (e.g., CPR rate and rhythm feedback, live vital signs, recorded interventions, etc.)

Human-Computer Interface

Editing	Editing	Editing - The ability to manually edit speech recognition entries using a keyboard or digital interface.
Calibration	Calib	Calibration - The ability to calibrate the device to your specific speech patterns, thereby increasing accuracy.
Accuracy	Accuracy	Accuracy - High word recognition rates, and ability to select a best fit word from a paramedicine specific vocabulary.
Minimal Interface	MinInter	Minimal Interface - Interface, either screen (smart glasses) or headset is small and does not pose a barrier to patient interaction.
Voice Command Operation	VocComOp	Voice Commands - Voice commands to navigate ePCR, or activate accessory equipment.
Feedback	Feedback	Feedback - Ability of device to provide either audio or visual feedback for interventions (CPR rate & depth, medication timings, etc.).
Conversational Processing	ConvPro	Conversational Processing - Ability of the speech recognition technology to decipher conversational language into the ePCR. (e.g., "Okay Ms. Smith I am going to give you a medication, 2.5 mg of Morphine through the IV line we started, you may feel nausea or a warm sensation" translates to Medication -> Morphine -> Dose: 2.5mg ->Route: IV -> Timestamp).
Closed Loop	Clsdloop	Closed Loop - The device provides a repeat of what information was recorded, or an audio or visual cue that recording was completed.
Hands Free Operation	HFOps	Hands-Free Operation - Technology can be fully operated hands free using commands or gestures (Smart glasses).

People		
Support	Supp	Support - Easily accessible technical support for troubleshooting issues.
Patient	Patient	Patient - The device used to interact with speech recognition must not interfere with patient interaction.
Training	Train	Training - Adequate training is provided including time to practice, learn the interface.
Operation levels	OpLvls	Operation Levels - Account for users' technological abilities. Basic - intermediate - advanced settings for a user's comfort or ability with the technology.
Stakeholders	StakeHo	Stakeholders - Involvement of receiving hospital/health authority, knowledge and systems in place to receive incoming information. Examples include, dedicated parallel repository systems in the emergency department, in hospital EHR that can receive some basic amount of paramedic data.
Customization	Custom	Customization - Ability to make adjustments to the interface that suit the users' particular needs.

Workflow and Communication

Dual Users	DualUse	Dual Users - The ability for both paramedics to record information on an ePCR simultaneously.
Differentiation	Differ	Differentiation - The ability of the speech recognition technology to differentiate between active patient care and conversation between paramedic partners.
Adaptability	Adapt	Adaptability - The ability for the speech recognition technology to be integrated into existing paramedic workflows (e.g., the technology works on current ePCRs, and can be used with existing communications systems).
Interoperability Institutional	InteropIns	Interoperability (Institutional) - Ability to use speech recognition to transmit recorded patient information to the receiving facility (e.g., voice command to transmit vitals, EKGs, recorded interventions and medications).

Organizational Policies, Procedures, and Culture

Training Support	TrainSup	Training Support - Policies to support adequate time and training on use of the speech recognition devices.
Stakeholder Engagement	StakHEng	Stakeholder Engagement - The organization engages hospitals, health authorities and other response agencies and creates policies to allow the integration of the technology.

Organizational Buy In	OrgBuyIn	Organizational Buy-In - Leadership within the organization has committed to the use of speech recognition technology and recognizes the benefits and time savings.
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External Rules, Regulations and Pressures

Compliance	Compl	Compliance - The speech recognition device meets all required medicolegal requirements for recording audio and video of patients.
Storage	Storag	Storage - The speech recognition service stores all recorded conversations in a cloud service for required period for recall when required or mandated.
Deletion	Delet	Deletion - The speech recognition software deletes all recordings from the local device as the user logs out from the system.

System Measurement and Monitoring

Published Use Studies	PublishUS	Published Use Studies - Test group studies to determine the efficiency and effectiveness of the speech recognition technology in a live environment.
Continuous Improvement	ContinImp	Continuous Improvement - Regular feedback session to determine areas of improvement, or identify areas for further expansion.
User Testimonials	UserTest	User Testimonials - The ability to hear from other paramedics/paramedic services who have used similar devices or technologies.

Technology Familiarity

Speech to text	StTFam	Speech to text - Function on smartphones (For text messages or search functions)
Voice Assistants	VcAssFam	Voice Assistants - (e.g., Siri, Alexa, Google Home)
Medical Dictation	MedDicFam	Medical Dictation - (e.g., Dragon ONE Nuance medical dictation, Deepscribe)
Vehicle Systems	VhclSysFam	Vehicle Systems - (e.g., OnStar, BMWs MBUX)
Voice Command Appliances	VoComAppFam	Voice Command Appliances - (e.g., Xbox Kinect, Whirlpool smart oven)
Smart Glasses	SmrtGFam	Smart Glasses - (e.g., Google glass, Vuzix M400, Microsoft hololens)

Technology Use

Speech to Text	StTUse	Speech to Text function on Smartphone
Voice Assistant	VcAssUse	Voice Assistant
Medical Dictation 1	MedDicUse	Medical Dictation
Vehicle System	VhclSysUse	Vehicle System
Voice Command Appliances 1	VoComAppUse	Voice Command Appliances
Smart Glasses 1	SmrtGUse	Smart Glasses

Perceptions (What is your perception of speech recognition technology?)

More Accurate	MoAcc	Speech recognition documentation is more accurate than typed documentation.
More Efficient	MoEff	Speech recognition documentation takes less time to complete than typed entry.
Not Disruptive	NotDis	Speech recognition documentation would not be disruptive to my patient interactions.
More Complete Notes	MoCompN	Speech recognition documentation would help me produce more complete and accurate notes at handover that will increase patient safety.

8.9 Appendix 9

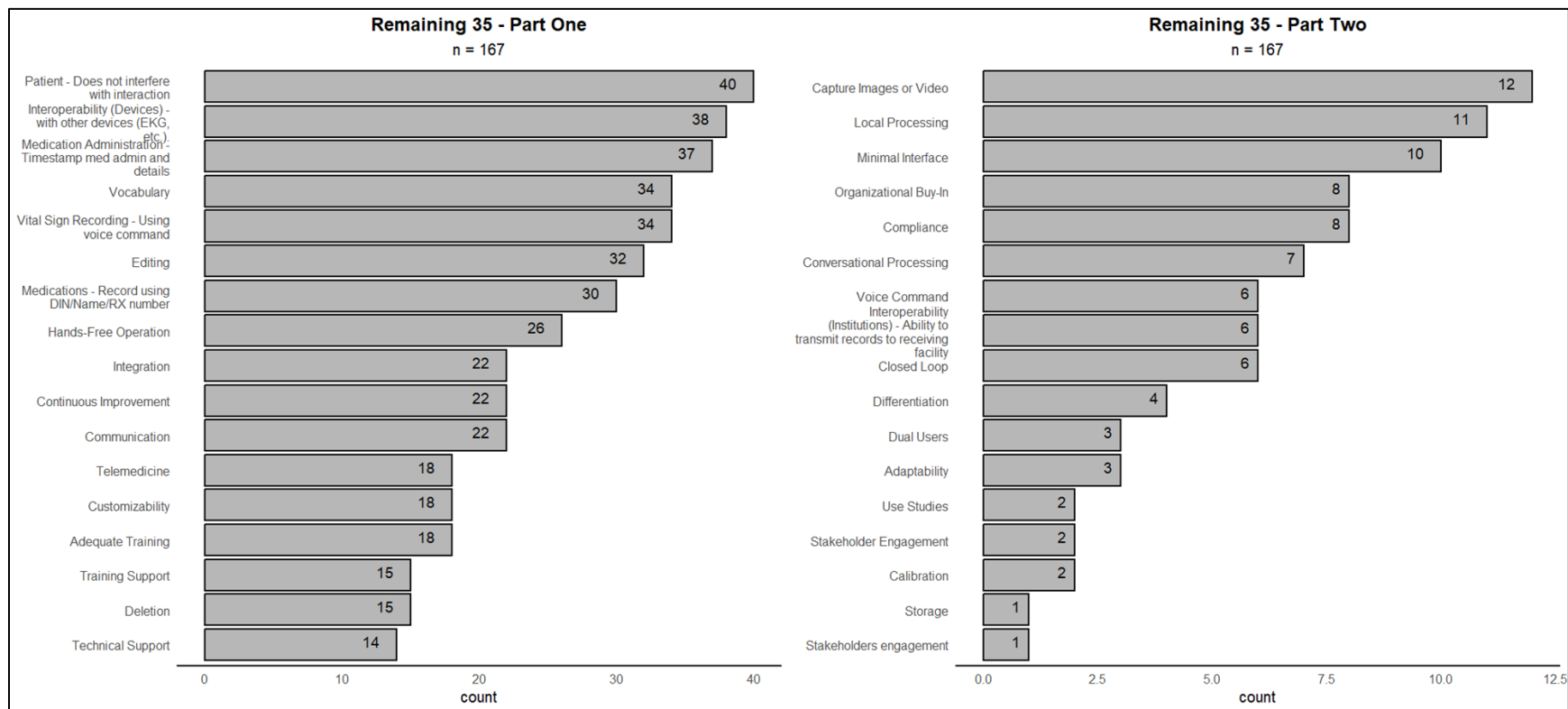


Figure 8.3. Remaining 35 minimum set features.