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Electronic Patient Care Report in Pre-Hospital Emergency Care: Stakeholder Perspective

Master's thesis

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Tallinn 2023

TALLINNA TEHNIKAÜLIKOOL
Infotehnoloogia teaduskond

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Elektrooniline patsiendi hoolduse aruanne haiglaeelses erakorralises abis: sidusrühmade vaatenurk

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Tallinn 2023

Author's declaration of originality

I hereby certify that I am the sole author of this thesis. All the used materials, references to the literature and the work of others have been referred to. This thesis has not been presented for examination anywhere else.

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08.05.2023

Abstract

Background: Electronic patient care report (ePCR) systems have been increasingly implemented in ambulance care. However, there is a paucity of research into the ePCR implementation in emergency medical services involving ambulance clinicians' perspectives, hence, further research is necessary. **Aim:** This study aims to examine the perceptions of key stakeholders towards the ePCR system and to identify areas that need further attention to enhance user experience and maximize the system's full potential. **Methods:** The study used a mixed-method design. The main emphasis was given to qualitative inquiry in line with the constructivist philosophical foundation and to address the problem. Descriptive statistics and qualitative content analysis were used to analyse the results. **Results:** Participants expressed mixed attitudes concerning their user experience with the ePCR. Several pain points were revealed, including the transition period, lack of customization, issues with the transmission of information, and challenging ergonomics. Nevertheless, the ePCRs offered benefits, such as improved legibility and detailed account of the emergency incident, integration with Lifepak 15, as well as easy access to patient care records stored electronically. Overall, while the ePCR presented challenges, it was perceived as a beneficial tool. Participants expressed optimism about the potential of the ePCR technology. **Conclusion:** The findings reveal areas that require further attention to enhance user experience and maximize the system's full potential. Drawing from stakeholders' perspectives, the study offers fourteen key insights that provide valuable recommendations. The findings suggest the ePCR system's design and functionality should be re-evaluated to address the challenges associated with its use. Further development and improvement of the ePCR system, accompanied by the development of interoperability in Irish healthcare, are needed to ensure that the ePCR system realises its full potential and meets the needs and expectations of ambulance clinicians. This would enhance the overall user experience of ambulance staff while also potentially enhancing patient care.

This thesis is written in English and is 68 pages long, including 8 chapters, and 3 figures.

Annotatsioon

Elektrooniline patsiendi hoolduse aruanne haiglaeelses erakorralises abis: sidusrühmade vaatenurk

Taust: Kiirabis on üha enam rakendatud elektroonilisi patsiendiraportite (ePCR) süsteeme. Siiski on tehtud vähe uuringuid ePCRi rakendamise kohta erakorralise meditsiini teenistuses, mis hõlmaksid kiirabi arstide vaatenurki, seega on vaja täiendavaid uuringuid. **Töö eesmärk:** Käesoleva uuringu eesmärk on uurida peamiste sidusrühmade taju ePCR-süsteemi suhtes ning tuvastada valdkonnad, mis vajavad täiendavat tähelepanu, et parandada kasutajakogemust ja maksimeerida süsteemi täielikku potentsiaali. **Meetodid:** Uuringus kasutati segameetodilist disaini. Tulemuste analüüsimiseks kasutati kirjeldavat statistikat ja kvalitatiivset sisuanalüüsi. **Tulemused:** Osalejad väljendasid erinevaid hoiakuid seoses ePCRi kasutamiskogemusega. Ilmnesid mitmed valupunktid, sealhulgas üleminekuperiood, kohandamise puudumine, probleemid teabe edastamisega ja keeruline ergonoomika. Sellest hoolimata omavad ePCRid eeliseid, nagu parem loetavus ja üksikasjalik kirjeldus hädaolukorra kohta, integratsioon Lifepak 15-ga, samuti lihtne juurdepääs elektrooniliselt salvestatud patsiendi ravidokumentidele. Üldiselt, kuigi ePCR tekitas probleeme, peeti seda kasulikuks vahendiks. Osalejad väljendasid optimismi ePCR-tehnoloogia potentsiaali suhtes. **Järeldused:** Tulemustest selguvad valdkonnad, mis vajavad täiendavat tähelepanu, et parandada kasutajakogemust ja maksimeerida süsteemi täielikku potentsiaali. Sidusrühmade seisukohti arvesse võttes pakub uuring neljateistkümne peamist teavet, mis annab väärtuslikke soovitusi. Tulemused näitavad, et ePCR-süsteemi ülesehitust ja funktsionaalsust tuleks uuesti hinnata, et lahendada selle kasutamisega seotud probleeme. Selleks, et ePCR-süsteem kasutaks oma potentsiaali täielikult ära ja vastaks kiirabibrigaadi arstide vajadustele ja ootustele, on vaja ePCR-süsteemi edasi arendada ja täiustada ning arendada koostalitlusvõimet Iiri tervishoius.

Lõputöö on kirjutatud inglise keeles ning sisaldab teksti 68 leheküljel, 8 peatükki ja 3 joonist.

List of abbreviations and terms

CAD	Computer Aided Dispatch
CFIR	Consolidated Framework For Implementation Research
CPG	Clinical Practice Guideline
DOI	Diffusion of Innovation
ECG	Electrocardiography
ED	Emergency Department
EHR	Electronic Health Record
EMS	Emergency Medical Services
EMT	Emergency Medical Technician
ePCR	Electronic Patient Care Report
GDPR	General Data Protection Regulation
GP	General Practitioner
HCI	Human-Computer Interaction
HIQA	Health Information and Quality Authority
HSE	Health Service Executive
ICT	Information and Communication Technology
KPI	Key Performance Indicator
MeSH	Medical Subject Heading
MDT	Mobile Data Terminal
NAS	National Ambulance Service
PCR	Patient Care Report
PHECC	Pre-Hospital Emergency Care Council
UCD	User Centred Design
UX	User Experience
UXR	User Experience Research

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1 Introduction

Pre-hospital emergency care service (ambulance) plays a significant role in the overall provision of healthcare. Ambulance care, tended by trained and certified clinicians such as paramedics and emergency medical technicians (EMTs), is an integral and crucial part of pre-hospital emergency care. It is a critical component of the health system aimed at improving outcomes of injuries and other time-sensitive illnesses. Due to population ageing in industrialized countries, the demand for pre-hospital emergency medical services (EMS) such as ambulance care is rapidly accelerating [1]–[3]. Therefore, there is an acute need for pre-hospital emergency care research, including studies on ambulance care digitalization [4].

Digital transformation of ambulance care is a growing trend [5]. There is an ongoing transition from paper-based to electronic patient care report (ePCR) documentation in pre-hospital emergency care. Nevertheless, the digital transformation of healthcare services is often accompanied by challenges [6]–[9]. In particular, complications may arise due to a lack of research into stakeholder, especially end-user, perspective [10]–[13]. As indicated by recent studies [14]–[17] and corroborated through the author's research into the scientific literature scope, there is a scarcity of research on the Electronic Patient Care Report in pre-hospital emergency care. Furthermore, an even smaller number of studies include qualitative feedback and insights from end-users such as ambulance professionals [15], [16], [18], [19]. Hence, it is a **problem** that little is known about the ambulance professionals' perspective on the ePCR system.

In this master's thesis, the author used a mixed-methods study design, surveying, and interviewing ambulance clinicians and other key informants. The research **aims** to examine the perceptions of key stakeholders towards the ePCR system and to identify areas that need further attention to enhance user experience and maximize system's full potential.

2 Background

2.1 Electronic Patient Care Report (ePCR)

Electronic patient care report (ePCR) systems have been increasingly implemented in ambulance care to provide a digital platform for recording patient care reports [16]. Presently available ePCR systems often replicate existing paper-based patient care reports with electronic fields to capture history, physical exam, assessment, and treatment rendered [14]. The ePCR system software is typically loaded on rugged tablet computers that EMS providers take with them in the field to capture data in real-time as the call progresses [15], [16], [19]. However, the process of submitting the ePCR documentation to the ED varies significantly. For instance, the ePCRs can be provided to the receiving hospital as a hardcopy printed in the ambulance or hospital and then passed to the ED's nurse, or ePCRs can be wirelessly transmitted directly into the hospital's information system after report completion [15], [16].

A limited number of studies have explored the objectives and challenges of implementing ePCR systems in healthcare organizations, mainly in North America (see Appendix 2). Improved billing and quality assurance were found to be the primary motivating factors behind the implementation of an ePCR system, according to Baird and Boak [19]. In a qualitative study, Landman et al. [18] found a similar objective for the implementation of an ePCR system, namely, improved quality assurance through the increased availability of patient records and improved reporting functionality. Also, the implementation was motivated by the state mandates requiring emergency services to adopt ePCRs. A qualitative observational study in Denmark by Jensen et al. [16] concluded that most ambulance clinicians reported increased collaboration efforts with ED clinicians following the implementation of the ePCR. In the 2020 study conducted by Porter et al. in the United Kingdom (UK) [15], all surveyed emergency medical services seemed to use electronic health records produced by ambulance clinicians primarily as a repository for patient data. The study concluded that there was little evidence of the full potential of EMS' electronic health records being realised to rapidly transfer information, enhance decision-making, or alter patient treatment. Thus, even

though the adoption of the ePCR systems on electronic devices has opened up numerous possibilities to provide greater support to ambulance clinicians and patients, and potentially to improve the quality of care provided by EMS, the primary use case for the ePCR was 'data dump' [15].

Several challenges were identified in the ePCR's implementation. According to Landman et al. [18] these challenges include poor usability of software, concerns about privacy and security, concerns about increased ambulance run times and other service disruptions, and concerns about difficulty integrating systems within existing ED or hospital systems. In Baird and Boak's study, 67% of participants reported frustration with a tablet stylus interface used for ePCR recording. According to Katzer et al. [20] another challenge of the ePCR implementation was an increase in the total quantity of exam information documented. Moreover, in the descriptive study, Broussard [21] found that paramedics had difficulty adapting to the new technology, and reported that on the introduction of alternative options through which information could be recorded onto ePCR, 70% of staff preferred entering reports on a laptop or computer during downtime or after shifts and emailing them to dispatch centres. Similarly, in a Danish study by Jensen et al. [16] documentation was seen as a secondary priority, and ambulance clinicians have struggled to complete documentation in the ePCR before arriving at the receiving hospital due to short distances. In Baird and Boak's study [19], 86% of ePCR users found the system easier to use with the addition of extra hardware tools. Moreover, in Landman et al.'s [18] and Baird and Boak's [19] studies, findings emphasise the value of assistance and training in facilitating adoption. Furthermore, one of the key findings in Porter et al. [15] study suggests that ambulance clinicians may find it difficult to fit real patient encounters into the structured, sequential format of the ePCR.

In conclusion, the ePCR systems have been found to have several benefits for ambulance care service, including improving the legibility of clinicians' records and enhancing the quality assurance process. However, challenges remain in their implementation, such as the poor usability of software and hardware, difficulty with adapting and integrating ePCR systems within emergency medical care settings and workflow, and lack of integration with existing ED or hospital systems. Also, as many researchers observed in the identified studies, there is a paucity of research into the ePCR implementation in emergency medical services involving ambulance clinicians'

perspective (see Appendix 2). Hence, further research is necessary to examine the implementation of the ePCR systems in pre-hospital emergency care from the ambulance professionals' perspective.

2.2 Organisation of Pre-Hospital Emergency Care in Ireland

The Republic of Ireland **National Ambulance Service** (NAS) is the authorized provider of pre-hospital emergency and intermediate care in Ireland. The NAS, which is a division of the Health Service Executive (HSE), was founded in 2005. It is operating from 102 locations throughout Ireland [22], covering a population of 5,123,536 (as of the 2022 Census) [23] across an area of 68,893 square kilometres. According to the National Ambulance Service Employment Report: January 2023, the NAS employs 1980 ambulance staff of which there are **1511** pre-hospital care (ambulance) professionals [24]. The NAS provides the Intermediate Care Service, which predominantly focuses on the inter-facility transfer of patients, and is staffed by a crew of Emergency Medical Technicians (EMTs), and the Pre-hospital Emergency Care services staffed by Paramedics and Advanced Paramedics [22].

The **Pre-Hospital Emergency Care Council** (PHECC) is an independent statutory agency responsible for setting standards, education, and training in the field of pre-hospital emergency care in Ireland. PHECC acknowledges organisations that provide pre-hospital emergency care training and education and publishes clinical practice guidelines (CPG). Additionally, to execute the clinical practice guidelines, PHECC keeps a legal registry of accredited practitioners and approves pre-hospital emergency care service providers [25].

The **Health Information and Quality Authority** (HIQA) is an independent agency established to improve the quality and safety of health and social care services in Ireland. HIQA develops standards, inspects and reviews health and social care services, and provides support for informed decisions on service delivery [26].

2.3 Documentation in Pre-Hospital Emergency Care in Ireland

In compliance with Irish legislature and standard operating policies, pre-hospital emergency care providers, such as registered NAS Practitioners (and certified

Responders handing over care to a Practitioner), must keep accurate and thorough records of clinical care provided to a patient. This record is called a **Patient Care Report** (PCR) [27]. It consists of the national standard PCR document as formulated by the PHECC. The most recent revision of the PCR Information Standard was published by the PHECC in 2018 [28]. The **PCR Information Standard** [29] consists of data elements that are grouped into 14 sections:1) Incident data, 8) Medication treatment, 2) Patient demographics, 9) Continuity of care, 3) Patient clinical assessment, 10) Clinical audit, 4) Clinical status, 11) Declined treatment and/or transport, 5) Vital observations, 12) Cardiac arrest, 6) Clinical impression, 13) Doctor in attendance, 7) Care management, 14) Cardiac First Response (CFR) Report handover. Those data elements include but are not limited to, information about the patient's name and address, date of birth, key provider response times to the patient, chief complaint, vital observations, clinical impression, and care delivered. The latest, 5th edition, of a PCR template published by the PHECC in 2018 [30] is provided in Appendix 3.

The **PCR Guidebook** [31] published by the PHECC in 2018 to provide clear directions for the accurate completion of a PCR states that the main purposes for filling out a PCR are 'clinical', 'legal protection' and 'organisation information'. The 'clinical' purpose is aimed at recording the pre-hospital care, interventions and medications administered to patients. Stating that the information listed on the PCR is crucial for the patient handover process at the destination facility. Where lack of current information can cause needless, repeated patient assessments and delay the delivery of critical, timely treatments. The 'legal protection' purpose is reportedly to use PCRs as legal documents if required as evidence to aid a legal process. And the 'organisation information' is purported to provide information on the quality of the healthcare and to, subsequently, inform and support decision-making by licenced ambulance clinicians, policymakers and patients.

Moreover, the PCR Guidebook 2018 mentions that PCR's data regarding critical clinical and support functions that affect patient outcomes are tracked and evaluated using key performance indicators (KPIs). Thus, the gathering and aggregation of patient data through PCR records make it possible to measure PHECC KPIs.

Furthermore, per **NAS Management of Patient Care Records Policy** (revision date 31.12.2020, Document Ref No. NASCG001) [27], a PCR includes forms in which

information is held or stored manually, mechanically or *electronically*. This Policy states that the main reasons for storing PCRs are to provide evidence of patient treatment, to inform management/staff of significant clinical events, to provide evidence of completed ambulance calls, and to provide for legal compliance requirements.

Noteworthy, the 'Clinical Information Management' section of the PHECC's 'Clinical Resources' published on their official website includes the abovementioned PCR Information Standard (2018), the NAS Management of Patient Care Records Policy (2020), the PDF template of a PCR (5th edition, 2018), and the PCR Edition 5 Guidebook (2018). However, no references or additional information is provided about the ePCR apart from the note in the NAS Management of Patient Care Records Policy referring to a PCR as a form which can also hold information electronically.

2.4 Transition to an ePCR in Pre-Hospital Emergency Care in Ireland

According to Goal 2 of the National Ambulance Service Strategic Plan 2016 – 2020, the NAS was envisioned to move from a paper-based patient data reporting to an ePCR system starting from Q1 2016, and finishing the transition in Q4 2018 [32]. As announced in 2019 on the official website of eHealth Ireland – the HSE division responsible for the delivery of technology to support healthcare across the Irish health service, the NAS and the HSE's Office of the Chief Information Officer (OoCIO) are collaborating to enable the delivery of the NAS Vision Strategy 2020 and to implement its Digital Plan to technologically enable Emergency Ambulances. Furthermore, it is stated in a 2019 news release on the official website of eHealth Ireland under the Digital Ambulance Project that this plan has led to the implementation of three key ICT systems: 1) ePCR system, 2) mobile data terminal (MDT), and 3) communications hub [33].

Thus, according to the 2019 announcement by eHealth Ireland the introduced ePCR system enables paramedics to consistently record the care provided to patients including recording of patient condition, vital signs, medications, and other relevant information using a handheld (touchscreen) computer tablet. Additionally, the complete ePCR report is accessible to the receiving hospital while the patient is being transported allowing for more coordinated and effective care. This function is enabled by the communications hub fitted in each Emergency Ambulance which allows for patient information to be

transmitted between the ICT systems onboard the ambulance and the ICT systems at the National Emergency Operations Center offering rapid, secure, and reliable communication [33].

Furthermore, in the same 2019 press release, eHealth Ireland advised that the NAS and OoCIO have completed a roll-out of these three aforementioned digital ambulance technologies, including ePCR, to 77 of the 90 NAS ambulance stations, namely, all ambulance stations in the South (Oct 2018) and North Leinster (Jun 2019) regions of Ireland, with roll-out to the West region expected to be completed by the end of 2019.

3 Problem Statement, Aim, and Research Questions

Problem statement: The paucity of research regarding the ePCR system and lack of user feedback from primary stakeholders like ambulance clinicians who frequently interact with the system is a significant issue. This lack of feedback may hinder efforts to enhance the user experience and fully optimize the system's potential.

Aim: This study aims to examine the perceptions of key stakeholders, such as ambulance clinicians, towards the ePCR system and to identify areas that need further attention to enhance user experience and maximize the system's full potential.

Research questions:

RQ1: What are user attitudes and the perceived challenges and benefits of the ePCR?

RQ2: What is the perceived potential of the ePCR from key stakeholders' perspectives?

4 Theoretical Framework

The theoretical foundation of this study is grounded in a holistic approach that encompasses various frameworks for eHealth systems research, development and evaluation [34]–[36]. Digital Health or eHealth is characterized by interrelationships where technology, people, and context are intertwined, hence epistemological flexibility appears to be an appropriate approach. Thus, according to a holistic approach, multidisciplinary theoretical frameworks and methodological approaches should be combined and integrated to account for interdependencies [37]–[39].

4.1 Paradigm

Overall, a conceptual construct for the study design was influenced by the literature overview, pragmatic considerations, and the author's alignment with a **constructivist worldview**. John Dewey's works published at the beginning of the 20th century gave rise to what is known as Dewey's transactional constructivism: interaction, cooperation, coordination, and communication, through which we construct an intersubjective world out of our individual, subjective worlds, or in other words, individual *perspectives* [40]. Dewey's transactional constructivism, arguably, could also be considered a form of realism, demonstrating that objectivity is not attainable and that subjectivity is not problematic in itself [41]. Transactional constructivism is a paradigm that offers a researcher a philosophical foundation that helps to overcome the impasse between objectivism and subjectivism.

4.2 Human-Computer Interaction: User Experience

This study drew on **Human-Computer Interaction** (HCI) theory – an intersectional theory that on the one hand, integrates psychology and the social sciences, and on the other, computer science and technology, highlighting the importance of user experience [42]–[45]. The HCI theory bore the **User Centred Design** (UCD) framework that is focused on taking the users into account in the process of products and technologies design and evaluation. Furthermore, in pursuit of a more complete, holistic HCI the

concept of **user experience** (UX) emerged as a countermovement to the dominant, task- and work-related 'usability' paradigm in HCI [46]. Thus, UX is aimed at designing technology that goes beyond functionality and considers the user's subjective, complex, and dynamic experience. In other words, unlike conventional HCI, UX considers the user's subjective perspective, the design of the system, and the context in which the interaction occurs such as the social or organizational setting [46]. Moreover, UX focuses not only on the immediate consequences of use (perceptions and responses) but also introduces the concept of anticipated or imagined use [47]. Enhancing the effectiveness and enjoyment of product use and associated user experiences is a key goal of UX [48].

One of the methods to assess UX is to conduct **user experience research** (UXR), including in the form of questionnaire surveys and post-experience interviews [49]–[51]. The UXR can be in a form of a formative evaluation (during the development process) or a summative evaluation (on the final product) [52]. In UXR, user feedback is the information gathered regarding customers' attitudes, beliefs, opinions, and sentiments towards a product or service [51]. This form of qualitative feedback is frequently acquired through interviews and surveys [53]. It can be used to pinpoint aspects of the product that users particularly enjoy or appreciate as well as pain points and areas of confusion [54]. The user expectations and aspirations that are revealed through feedback can be utilised to guide design decisions [54]. Hence, product designers and researchers may create more useful and user-centered products and services by knowing users' experiences.

4.3 User Attitudes in Digital Health Studies

It is proposed that research, especially qualitative, into users' perspectives, examining users' attitudes and opinions is a crucial part of assessing eHealth or Digital Health systems [34], [35], [48], [55], [56]. Furthermore, it is suggested that users are the most important stakeholder group because assessing the eHealth system from the users' perspective should allow for addressing all the key factors including the design and implementation of the digital system in specific contexts [55], [56].

Users' attitudes are an important factor influencing the success of digital innovation, including in eHealth. Attitudes and beliefs can act as both facilitators and barriers to the

implementation of digital systems across all eHealth domains [6], [7]. A systematic review of systematic reviews summarized several important attitudes that can act as either facilitators or barriers, of which positive were: belief in the system's benefit for the patients, motivation, interest in technology, and individual opinions on usefulness; and negative: perceived disruption of care, doubt of positive impact on patients care quality, resistance to change [7]. Among other factors concluded to be barriers influenced by attitudes and beliefs are fears over a loss of autonomy, concerns over patient privacy and security being compromised, worries about liability, and perceived threats to the patient-physician relationship [7].

4.4 CFIR Framework: Stakeholder Perspective Approach

Several research models have adopted the stakeholder's perspective approach in the studies focused on understanding a multidimensional digital system implementation. While different stakeholders evaluate new practices on an individual and group level, the end-users, for instance, clinicians, through the contextualization of use and communication with peers, define the system use [19], [57]. Therefore, exploring the importance of users' participation in the post-implementation period is crucial. Some research has shown that the use of off-the-shelf software solutions rather than custom software solutions gave a false impression that installation would be simple and straightforward [58]. However, in reality, the system/innovation adoption required adaptation through the method of a continuous cycle of configuration, customisation, and implementation based on user input [59].

Thus, in 2009 Damschroder et al. [60] published a comprehensive literature review of implementation research that resulted in the **Consolidated Framework for Implementation Research** (CFIR), which is seen as an extension of Rogers' Diffusion of Innovation (DOI) theory [61], [62] and a continuation of Greenhalgh et al. comprehensive review that delivered an influential implementation framework in service organizations [63], [64]. Some of the DOI related variables applied in 2009 CFIR are Relative Advantage (comparing the innovation to current practice), Compatibility (the extent to which the innovation conforms to the needs, values, and experiences of potential users.), Trialability (ability to test and reverse the innovation, if

necessary), and Complexity (examining how difficult the innovation is to understand and/or use) [62].

The CFIR is a 'meta-theoretical framework' that includes 39 'constructs' from a synthesis of existing theories, without preconditioning specific hypotheses [60]. These standardized constructs are organized across five domains, all of which interact to influence implementation and implementation effectiveness [65]. The five major domains within the 2009 CFIR framework are as follows [66]: 1) intervention characteristics, 2) outer setting, 3) inner setting, 4) characteristics of the individuals involved, and 5) the process of implementation.

Damschroder proposed that the researchers can select constructs from the CFIR that are most relevant for their study setting and suggested that the CFIR can be applied at any phase of the study. For instance, the CFIR is used to develop data collection approaches and/or as a guide for analysing, interpreting, and/or reporting implementation-related findings [65]. Thus, in this study, the CFIR is also incorporated to examine the stakeholders' perspectives (see Figure 1).
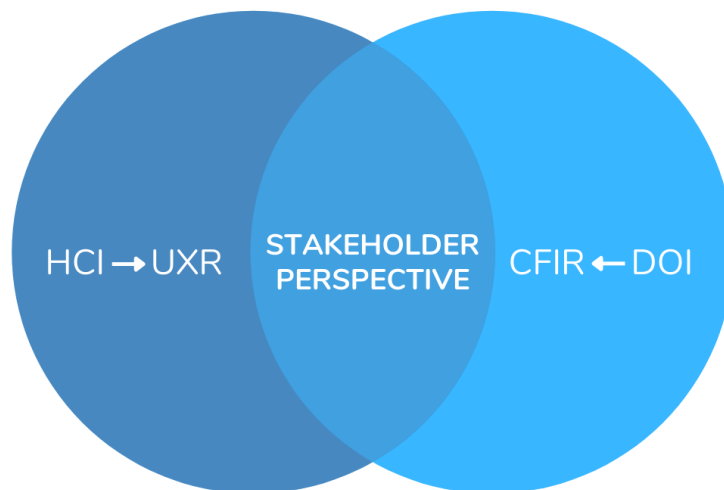
Figure 1. Venn diagram of the multidimensional continuum of overlapping theoretical approaches.

To summarize, a multidimensional continuum of overlapping theoretical approaches is seen as a holistic approach to research [67], [68]. Thus, studies that employ such an approach and include research into stakeholder perspectives, especially end-users, are recommended for researching eHealth systems because they provide added value and context for users [34], [69]–[71].

5 Methodology and Methods

5.1 Primary Research Design

The study combined both qualitative and quantitative methods. It is suggested that combining the qualitative and quantitative methods, through *convergence* at various stages of research such as data collection or data analysis, helps to overcome some study limitations, triangulate the results, get a better understanding of the issues, and contextualization [72]–[77]. The main emphasis was given to the qualitative inquiry in line with the constructivist philosophical foundation and due to the paucity of qualitative studies on the Electronic Patient Care Report in prehospital emergency care involving primary users – ambulance clinicians.

To define the participants, gather initial information on the ePCR system, recruit participants for the interviews, and quantify the informants' attitudes and opinions, a questionnaire was distributed online via LinkedIn. It is relatively straightforward for the researchers operating within the constructivist paradigm to include the technological context as a situating factor when undertaking research, namely, using digital tools to conduct research to answer the research objectives [78]. Moreover, online surveys are often used in UXR as those can reach across time zones and target the user population [79]. Additionally, in the scoping review of methods and their mix for Human-Centered eHealth studies by Kip et al. [34] it was concluded that several authors have suggested that an online questionnaire, is an appropriate means of research to efficiently and effectively gather information from key informants and stakeholders and to assess variances among groups, such as their opinions and/or understanding.

Furthermore, semi-structured interviews, with ambulance professionals and other key informants were conducted in a reflective and iterative manner to get a thorough knowledge of how the ePCR system is perceived by the end-users and, to get expert opinions. The iterative approach was chosen to minimize the chance of having a research outcome that was too restricted by allowing fresh facts and inputs to emerge throughout the study [80]. Furthermore, the scoping review by Kip et al. [34]

summarized, that interviews – as a method, can be employed to identify points of improvement for methods prototypes or existing eHealth systems according to end-users or design experts. Also, the review pointed out, that what makes interviewing an especially useful method is that it can be applied at any point in the eHealth system's development and evaluation process.

Non-probabilistic sampling strategy was employed for the study with inspiration from the constructivist grounded theory method of inquiry [81], [82]. Non-probabilistic sampling allows for the flexibility that is required by the mixed-methods iterative study designs rooted in constructivism, where the blending of qualitative and quantitative methods allows the researcher to go where analysis indicates would be the most effective and useful place to collect more data that will answer the questions that arise during enquiry and analysis [75], [76]. Subsequently, the saturation point was deemed as achieved in line with the grounded theory approach when no new ideas or information surfaced [82].

To conclude, this study is founded in a holistic multi-modal theoretical framework and situated within a constructivist philosophical paradigm and has a convergent mixed-method design employing quantitative and qualitative techniques.

5.1.1 Ethical Considerations

This master's thesis does not contain any biomedical research involving human participants, sensitive patient information/data, or personal identifiable information of participants; the participation in the study was voluntary and the respondents willingly consented to partake in the study, hence, this project does not require ethics committee approval or review. The principles of confidentiality of the participants were followed and the guidelines of the General Data Protection Regulation (GDPR) [83] were taken into account accordingly.

5.2 Data Collection

5.2.1 Web-based Questionnaire

The web-based questionnaire was employed as one of the primary research methods in this study. The questionnaire was designed and published online using Qualtrics online

survey software [84]. It consisted of quantifiable Likert-scale questions, where the 5-point scale included 'strongly disagree', 'somewhat disagree', 'neither agree nor disagree', 'somewhat agree', and 'strongly agree' response options. Also, the questionnaire included multiple-choice and open-ended questions. The questions were modelled on the previous studies [15], [16] and developed in line with UXR methods [51]. Questions were adapted to the context of this study to define the participants, gather initial information on the ePCR system, recruit interview participants, and quantify the EMS professionals' attitudes and opinions. Qualtrics software was chosen as it is a well-recognised survey platform which offers a questionnaire assessment tool and provides built-in analytics tools [79]. To validate the questionnaire, the Qualtrics questionnaire assessment tool was utilised.

The questionnaire's front page provided a summary of the reasons for launching the survey, the author's contact details, as well as the invitation to contact the author to participate in the face-to-face interview, and the appeal to refer colleagues to participate in the survey/interviews, ergo employing virtual snowball sampling technique of the non-probabilistic sampling strategy [82], [85]. The questionnaire was made available online and distributed via LinkedIn, employing both convenience and purposeful sampling variants of the non-probabilistic sampling strategy [82], [85].

No demographic characteristics were surveyed to avoid the data potentially becoming identifiable and falling under the scope of the GDPR with all the ensuing consequences. Moreover, a systematic review of systematic reviews on the factors influencing the implementation of eHealth summarized that most reviewed studies concluded that no clear relationship between demographic characteristics and attitudes could be established [7]. All questionnaire responses were anonymous.

5.2.2 Semi-structured Interviews

Another primary research method employed in this study was semi-structured interviewing. The interview technique that draws on the UX, and thus, is utilized by the UXR practitioners [51], [86], was used to inform the author's interviewing style. The interview questions were developed based on prior research on the subject of the ePCR implementation [15], [16], the questionnaire results, and the CFIR concepts [87]. The iterative interview process was applied to allow for new information to emerge in line with the grounded theory approach [80], [82], [88]. The face-to-face interviews were

conducted virtually via MS Teams, utilizing the Team's built-in auto-transcription tool and the online transcription software Otter.ai [89] as a backup.

All the participants were assured of confidentiality, briefed on the study, informed of the application of the auto-transcription tool, and asked for consent. The opportunity to contact the researcher was provided via LinkedIn or email.

The interviews took place between August 2022 and December 2022. Virtual face-to-face interviews were conducted with stakeholders such as ambulance clinicians and with key informants who held various roles: academician of paramedic studies, ICT manager and change and innovation manager in HSE (see Appendix 4). Twelve interviews were included in the study and analysed.

5.3 Data Analysis Methods

Descriptive statistics were used to analyze the results of the questionnaire. Descriptive statistics, which showcases quantifiable data using practical graphical representations, frequently serves as the basis for quantitative analysis [90]–[92]. Qualtrics software's built-in analytics tools were utilized for the descriptive statistical analysis. The qualitative data obtained from the expert interviews provided a more in-depth exploration of the numerical and statistical results obtained through the questionnaire.

The dualistic technique of inductive and deductive qualitative content analysis was utilized in this study. Qualitative content analysis is a research method that aims to understand the subjective interpretations of individuals [93] and thus, fits with the overall constructivist philosophical foundation of this study. This mode of analysis involves examining textual data in a semi-structured way to derive knowledge from the field. The investigator's insight is essential in qualitative content analysis, and an enormous amount of work is required during the process, as it is more complex and challenging than quantitative analysis because it is less standardized and formulaic [82], [94].

The qualitative content analysis method can be used with both qualitative and quantitative data, and either or both, an inductive and/or deductive manner, can be applied [95]. The deductive component involved utilizing existing theories and frameworks, including HCI, DOI and the CFIR, and formulating and mapping

concepts/themes based on the research questions, the initial analysis of the literature, the quantitative survey, and a preliminary scan of the raw interview data. On the other hand, the inductive approach allowed for unexpected themes to emerge during the analysis process. Combining these approaches enabled the development of patterns from the unknown parts that may fall outside the predictive codes of deductive reasoning, resulting in a more comprehensive analysis [94]. Thus, this combination of inductive/deductive qualitative content analysis is appropriate for mixed methods methodology [93]. During the initial stages of analysis the qualitative research software Taguette [96] was used to highlight and tag quotes, however, later on, Microsoft Word was mostly used in the process of qualitative content analysis.

5.4 Secondary Research

To research methodology techniques, theoretical frameworks, and philosophical paradigms, and scope the scientific literature, the primary database sources were used, including TalTech's PRIMO portal, PubMed, Google Scholar, SAGEPub's 'SAGE Knowledge' portal that provides encyclopaedic knowledge and authoritative Handbooks, and ScienceDirect which provides (AI-generated) summaries about key elements with extracts from books and articles. Additionally, extensive research of grey literature was performed to review documents, such as the information standards, and other relevant documentation.

To conduct thorough research the reviews, overviews, systematic reviews, and scoping materials were analysed first, before delving into the primary sources to cover the fundamentals and expand the literature. A 'footnote chasing' technique which involves searching the citation indices, and browsing through the bibliographies of selected articles to identify further resources were utilized to reach data sufficiency.

Keywords as well as medical subject headings (MeSH) terms were used to scope the scientific literature. Search terms included 'electronic patient care report', 'ePCR', 'electronic patient report form', 'ePRF', 'electronic prehospital medical record, 'ePMR', 'electronic record', 'electronic medical records', 'prehospital care', 'prehospital medical care', 'emergency medical service', 'ambulance', 'emergency medical technician' and 'paramedic'.

6 Results

This chapter provides the results of the questionnaire and semi-structured interview data using descriptive analysis and qualitative content analysis. Some of the 2009 CFIR concepts [66] were utilized during the initial stages of qualitative content analysis (see Appendix 5). A total of eight themes emerged through the qualitative content analysis of the questionnaire and interview results.

6.1 Questionnaire Participants

Questionnaire data cleaning was performed to identify eligible responses for data analysis (see Figure 2).
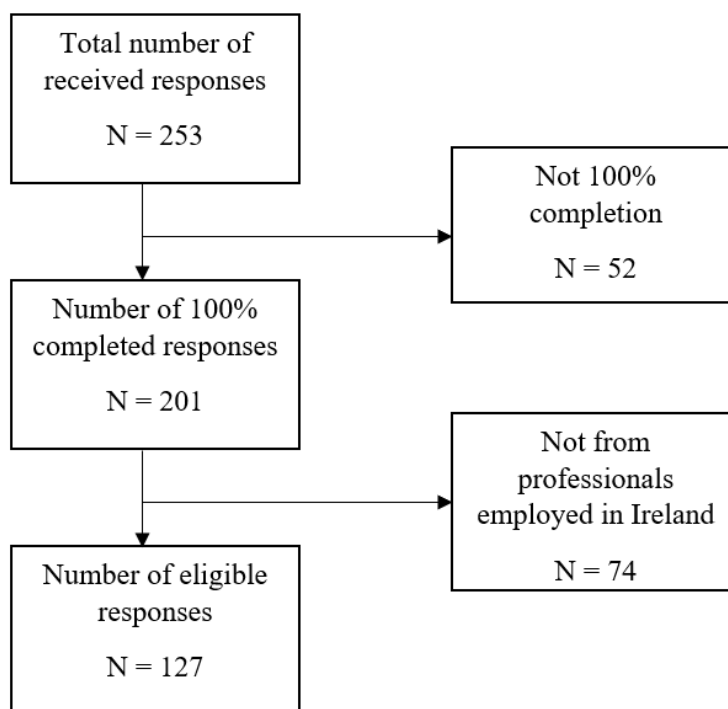
Figure 2. Representation of survey data cleaning process.

Out of 127 eligible survey responses, 83% of participants self-identified as paramedics, 12% – as advanced paramedics, 3% – as EMTs, and 2% – as others, which included: "Advanced paramedic educator/ PhD" and "Doctoral student 25 years as advanced

Paramedic." Furthermore, the survey respondents were asked about the duration of an ePCR use. The majority of the respondents (80 participants) indicated the duration of an ePCR use is between three to four years.

6.2 Interview Participants

A total of 12 semi-structured interviews were carried out with ambulance clinicians and other key stakeholders (see Appendix 4). The mean of the professional experience years for the 12 participants is 15 years. The spectrum ranged between 2 – being the lowest, and 32 – being the highest number of years. The estimation was performed based on the participants' answers regarding their work experience.

6.3 Themes

6.3.1 Training and Learning Curve

One of the topics that were explored to examine the experiences of the ambulance clinicians was the training and transitioning from paper PCR to the ePCR.

According to the questionnaire results, 66% of the questionnaire participants strongly agreed with the statement that they "received training on an ePCR use in ambulance care", while 26% somewhat agreed with this statement. Nevertheless, 84% of respondents strongly agreed with the statement "I understand what an ePCR is" and 79% – strongly agreed with the statement that they are "an experienced user of an ePCR" (see Appendix 6). Only one answer could be chosen from the 5-point Likert-scale that included 'strongly disagree', 'somewhat disagree', 'neither agree nor disagree', 'somewhat agree', and 'strongly agree' response options.

The ambulance clinicians that participated in the interviews indicated that they have received training during the transition from paper-based PCR to the ePCR. As per the participants' recollection, the training was provided during either a one-day or a two-day course, with the majority of participants having had a two-day training when the ePCR was rolled out. The majority of participants indicated that the training they received was deemed by them sufficient to transition to electronic reports.

However, when asked to describe their experience transitioning from paper PCR to the ePCR, most indicated that there was a learning curve and that they have been learning how to use the ePCR efficiently through practical application. During the adjustment period, the initial ePCR use was slower for most participants than the paper PCR as it took time to get used to the layout and to find the required fields in the drop-down menus. One of the interviewees noted that "*transitioning to the ePCR was quite difficult for the first couple of weeks, definitely. We would have found we were spending a lot of time focused on the digital ePCR and it was often quite distracting for patient care.*" Also, one participant noted that some of the practical advice that was given during training on how to use the ePCR when it is docked to the keyboard in the ambulance car may not have been appropriate for when the ambulance car is moving, however, the interviewee noted in defence of the trainers that "*they were sort of given the system and they were told to adapt the training around that rather than the whole system being developed together.*" Additionally, one interviewee indicated that they would have preferred a refresher course for the ePCR use, to be more prepared for situations when some rarely used features are required, like Bluetooth sharing with other tablets, which is not used on a day-to-day basis but can turn out to be crucial for some cases hence require fast implementation.

Noteworthy, the staff in a more senior position pointed out during their interviews that they have noticed that the newer staff who are only familiar with the ePCR may experience difficulty using the paper PCR in circumstances when the ePCR is not available. One participant expressed that the staff that is unfamiliar with paper PCR tend to "*panic*" in such situations. Moreover, it was commented by the senior ambulance staff that "*there's still some younger paramedics who will hide behind the ePCR when they don't know what to do next*" during interactions with the patient. While the newer staff indicated that they preferred the electronic system as it was more familiar to them, hence they found the use of the ePCR system intuitive during their training process.

Nevertheless, despite these initial challenges, participants reported that with more experience, the ePCR use became faster. As one participant noted, "*We used to spend about an hour filling up the ePCR to the minimum standard. But now, I know where the box is and my fingers go very quickly.*" Another ambulance clinician noted that once they became accustomed to the electronic system, it was easier to use than the paper version, saying "*It took a little while to get used to it, but now I actually find it the*

opposite, that it would be harder to do a paper one than the ePCR." On the other hand, another participant expressed that even though the ePCR's "*flow became a lot easier [to navigate]… It can be still a little bit distracting. It's not always easy to fill in.*"

Overall, the initial use of electronic patient care reports (ePCR) in ambulance care appears to have a learning curve to overcome. Study participants highlighted that comprehensive training on the system was important, but also that a lot of the learning occurred through practical trial and error.

6.3.2 Balancing Patient Care and Record-Keeping

The challenge of balancing patient care with record-keeping emerged as one of the prominent themes of the study.

When responding to the Likert-scale survey statement: "ePCR causes ambulance staff to give less time to quality patient care", 43% of the questionnaire participants somewhat agreed with this statement, and 30% – strongly agreed. Only one answer could be chosen from the 5-point Likert-scale that included 'strongly disagree', 'somewhat disagree', 'neither agree nor disagree', 'somewhat agree', and 'strongly agree' response options. Moreover, in the free-text box of the multiple-choice survey question on the ePCR features that in their view "improve the work of ambulance staff and the overall quality of patient care", one of the survey respondents left the following comment about the ePCR: "*Time consuming, much prefer the paper PCR, same information is given to receiving hospital. I understand the data format and the reasoning but it takes away from patient communication.*"

Furthermore, several interview participants indicated that the amount of information required in the ePCR increased compared to paper PCR and may contribute to longer completion times and work duplication, hence the emphasis on detailed documentation may take away from patient care. One participant described the ePCR as "machine-oriented" and noted that "*treating a patient with the ePCR has so many disadvantages because it takes longer. And that's my main obstacle is that it means less time for the patient.*" Moreover, one participant negatively described user experience with ePCR as "*sort of cognitive overload where you can be overwhelmed by the amount of technology and trying to fit everything into the right box.*" Also, one of the interview participants remarked that "*for the really sick patients, I always found the paper-based PCR is*

easier because you could just grab your pen, write down the vital signs, and go back to patient care." Another interview participant highlighted the work duplication by stating that "*many of our colleagues, including myself, what we do is we go into the patient's house, we write everything on our gloves, like patient's date of birth etc. And then we transferred the handwritten one onto the ePCR.*"

Thus, the time-consuming nature of the ePCR documentation was emphasised by most interview participants. One of the interviewees commented that "*it could be 45 minutes to an hour sometimes completing the ePCR after a cardiac arrest for example, whereas the paper-based PCR not so much.*" Another interview participant expressed that "*Digital ePCR tends to be a little bit time-consuming to navigate through and complete your information… I would say that building in detailed history information is a little bit more challenging.*" Another ambulance clinician noted that "*We find filing cardiac arrest, you're often completing stuff in triplicate.*" On the other hand, the interviewee who described themselves as "young in the service" and "digital" expressed that it takes them 15 to 20 minutes to complete the ePCR documentation for most emergencies. While major trauma – "*could take up to 30 minutes.*" Adding that "*you try and balance it [record-keeping] with patient care… if you're in a situation where there's too much emphasis on patient care, you'd leave the ePCR to the end. You would have to leave it.*"

Therefore, the participants noted that the ePCR is often filled in retrospectively. Several interview participants remarked that completing the ePCR simultaneously with patient care during complex cases, such as, for example, cardiac arrest incidents is challenging. One ambulance clinician expressed that "*The issue comes in complicated cases… if you're trying to do too much at once, you get this cognitive overload.*" Another ambulance clinician also noted that "*There's so much going on and it's taking up so much of your mental bandwidth that I really, I genuinely don't even bother. I don't even bother anymore trying to do the ePCR. I just write down the main events on a bit of paper, because I know I'm just gonna have to do it afterward.*" Hence, it appears that ambulance clinicians often take hand-written notes during a call and carry a small notepad or use a whiteboard at the back of an ambulance to make notes of times of interventions and drug administrations. One interviewed ambulance clinician described that "*there are usually 2 practitioners [on-scene] and you have to be hands-on and it [ePCR] often now will stay either with the vehicle until the third person or fourth person arrives, at which point it's filled in then. ePCR is often filled in retrospectively at*

the hospital." Therefore, it appears that after the patient is handed over to the ED staff, the ambulance clinicians transcribe, often hand-written notes, onto the ePCR. The call/run is not officially over until the ePCR is finalised and submitted: "*It's all retrospective, but within the confines of the call, the call is not finished until the ePCR is filled up*." One participant describes the process as follows: "*You do all your interventions get the patient in the hospital, handover, get the signature, and then go back out to the ambulance [car] then and write in your ePCR... And not at the time when the patient is deteriorating, so you'd leave it [documentation] to the end at the hospital*." Importantly, as one of the participants pointed out, "*The ePCR is done later so that filling in the ePCR doesn't take me away from the patient*."

Nevertheless, the majority of the interview participants noted that despite the time-consuming nature of the ePCR, it provides more space than the paper PCR for a detailed account of the incident and patient data. As one ambulance clinician put it, "*The free text where you insert the narrative, I think, that's the most useful*." Participants also reported that the quality of information gathered with ePCR was significantly improved compared to paper-based PCR because "*electronic patient care report allows you to have much more detailed information*" and record more vital signs and assessments. The same was expressed by a participant of the survey who commented in the free-text box that the ePCR offers "*enough areas to comment on social setting, vulnerable persons, details cardiac arrest reports, ability to state whether an intervention made an improvement or if there was an adverse effect,*" when replying to the multiple-choice survey question on the ePCR features that "improve the work of ambulance staff and the overall quality of patient care". One of the interview participants pointed out that "*for the end-user, it is, takes longer to fill the ePCR. Yes, it is longer. But [on] ePCR I have more space to write down what I want, where are the paper PCR was restricted with the amount of information that could be written down.*"

Noteworthy, another comment left in the free-text box of the aforementioned survey question, indicated that the ePCR "*forces crew to full set of vitals every time*." Similarly, several interview participants expressed the same sentiment, describing how the ePCR effectively serves as a reminder to check and record all necessary data. One ambulance clinician noted that "*ePCR will remind you to complete things [during assessment] that you haven't done. So that's very good… because you can't remember everything off-script. That's why we have checklists*." However, the same participant shortly added that

"*I don't feel that it flows. And it repeats itself a lot, so for example… say the patient has a chest pain, so we have to type 'chest pain' into five separate boxes, which just takes a lot of time. The interface is absolutely awful*," echoing the sentiment about the time-consuming nature of the ePCR documentation.

Overall, while the ePCR's seemingly time-consuming nature and perceived machine-orientation may have led to frustrations and concerns about over-documentation, the ePCR serving as a reminder to check all the necessary vitals during patient assessment and the ability to record more detailed information was perceived as valuable benefits compared to paper PCR. Despite the challenges, participants emphasized that they do not compromise patient care by filling out the ePCRs.

6.3.3 Legibility and Audit

Improved legibility and accessibility of electronic records for audit emerged as one of the themes of the study.

One of the survey participants wrote in the free-text box of the multiple-choice survey question on the ePCR features that in their view "improve the work of ambulance staff and the overall quality of patient care," that the ePCR is "*More legible than handwritten PCR.*" Also, one of the comments left in the free-text box of the same survey question, mentioned the "*Audit of practitioner and patient care*" as a useful feature of the ePCR. Additionally, one of the interview participants described the benefit afforded by an electronic system as follows: "*most useful in ePCR is that you can read ePCR better… You can go back to it yourself to change something… Before, you have to scratch it out [on paper PCR]. Now you can just change it on the ePCR so that helps a lot as well*." Moreover, another of the interview participants commented that even though "*ePCR does take longer… But on the other hand, my handwriting is illegible, so the fact that now patient care report is typed on ePCR means people after me can read my PCR where they couldn't read the paper-based format.*"

The electronic system was also noted by study participants to have features that made it more user-friendly compared to a paper-based PCR. For example, several participants appreciated the spell-checker and the ability to easily query a medication name. One participant stated that "*I love that the ePCR has a spell-checker and for example, that it gives medications that you can, you know, easier to find.*" Also, the drop-down menus

and ability to simply 'tap' rather than write were perceived by one participant as most beneficial because "*instead of writing everything it's just tapping and drop-down boxes... So it is a lot easier to use now.*"

Additionally, it was acknowledged that the thorough documentation facilitated by the ePCR improved the legal defensibility of paramedic actions and the ability to provide a step-by-step account of an incident for audit. As one participant mentioned, "*From a medical-legal point of view, in my opinion, the electronic patient care report made it a lot easier to make paramedic's actions more defensible because the majority of the entries that you make are time stamped so it could give you, step-by-step account of an incident.*" On the other hand, one participant expressed the view that "*[ambulance clinicians] shouldn't treat lawyers. We should treat patients.*" The participant made an assumption that it might be due to general concerns of possible legal actions that the ambulance staff tend to write down lots of information on the ePCR.

Finally, it was proposed that the ePCR offered advantages in terms of data storage and security. As one participant pointed out, "*The difficulty with the paper PCRs was retaining that information... you're outsourcing the storage of them to security companies to make sure that they were there and they were retrievable so that in the event of a court case, you could go back to paper PCR and retrieve that, but there were costs associated with that.*" Thus, the participant purported that with the introduction of the ePCR, it appears there is no longer any need for outsourcing storage, which made the process seemingly more efficient and cost-effective compared to paper PCR.

Overall, the improved legibility and the facilitation of efficient audit by the accessibility of electronic patient care report (ePCR), as well as the usefulness of detailed electronic records in case of legal matters, and other user-friendly functions that were not available when using paper PCR, were perceived as beneficial by the study participants.

6.3.4 Information Exchange and Paper Printouts

The perceived impact of the ePCR on the information exchange, in particular, concerning the clinical handover at ED appeared as one of the prominent themes of the research. The topic of the absence of rapid electronic transmission of information between the ePCR system and hospital information systems (HIS), and subsequent use

of paper printouts, as well as the topic of patient ID look-up and health information query emerged.

When answering the Likert-scale question of the questionnaire on whether an "ePCR improves clinical handover from ambulance to the hospital's Emergency Department (ED)" 18% of the survey respondents neither agreed nor disagreed, 31% – somewhat agreed, and 24% – strongly agreed with this statement. However, even though 30% of the questionnaire participants strongly disagreed with the statement that an "ePCR causes a decrease in communication between ambulance and hospital staff", 25% – somewhat disagreed with the statement, nonetheless, 28% – neither agreed nor disagreed. Only one answer could be chosen from the 5-point Likert-scale that included 'strongly disagree', 'somewhat disagree', 'neither agree nor disagree', 'somewhat agree', and 'strongly agree' response options. One of the comments left in the free-text box of the multiple-choice survey question on the ePCR features that in the participants' view "improve the work of ambulance staff and the overall quality of patient care", pointed out that "*there is no integration with existing systems in other domains, the ePCR currently functions as a computer-aided paper PCR.*" This ambiguous topic was further explored during the semi-structured interviews.

Thus, the interview participants indicated that the ambulance staff provide a verbal account of the incident and the interventions to the ED staff during the patient handover process. The information recorded in the ePCR is printed out using a printer located in the ambulance car, upon the documentation completion by the ambulance clinicians. Thereafter, this paper printout of the patient care report is handed in at the hospital. Depending on the case, the filling out of the ePCR is done either at the scene or on the way to the hospital, or during the triage, while ambulance staff are waiting to handover the patient or sometime after, therefore the printout could be handed in either simultaneously with the patient or later. One participant described the printout for complex cases as akin to a "toilet roll" due to its considerable length. One of the participants indicated that "*most of the time I have at least 4 pages*" and raised a concern that such use of paper is not environmentally friendly: "*I'm destroying the Amazon forest by printing and printing.*" Another interviewee's description resonates accordingly: " *If I was at cardiac arrest once you hit the print button on that [ePCR], this produces meters and meters and meters of paper, which typically is not really reviewed by the emergency department.*" Moreover, it was noted by one of the interview

participants that "*It would be rare for Emergency Department doctors or nurses to read our ePCR printout. The layout of the ePCR printout doesn't marry up with the ED floor patient care because it's black and white. It can take a while to find where the medications were given and at what time*". Another participant described the printout as "confusing." Hence, some participants expressed doubts that the ePCR printouts are read at all by the hospital staff and questioned the usefulness of the longwinded printouts that are not perceived as user- or eco-friendly. On the other hand, several interview participants expressed an opinion that even though they assume that the ePCR printouts are usually not read by the hospital staff, they believe the hospital clinicians might occasionally read them when reviewing a case.

Therefore, the majority of the interview participants expressed that, from their perspective, the switch to the ePCR from paper PCR did not have a significant impact on the patient handover at the hospital's ED as it remained somewhat similar to how it was done with paper PCR because "*Person-to-person interaction didn't really change during the handover process at Emergency Department.*"

However, it emerged during the study that a patient's identification (ID) and health record look-up feature were also not fully facilitated by the ePCR system. Namely, the ePCR system did not seem to have access to or exchange information with any centralized information system that might hold the demographics and health data of Irish residents. Nevertheless, participants reported that the information recorded during a previous ambulance call to the same patient could be repopulated when the patient's date of birth and name were queried through the ePCR. However, it was noted by the interview participant that some of the repopulated data, such as the name of a GP or a next of kin were often erased, hence needing to be queried from the patient and recorded again. Moreover, as indicated by one of the participants, the repopulation works if the spelling of the patient's name and the date of birth match exactly. According to the interviewee, "*The last encounter with the same patient erases, override anything else that was done previously.*" Adding that this should be improved: "*It should be an additive rather than starting from scratch again.*" In other words, if one of the ambulance crews did not or could not properly look up the patient information for a recurring patient and began the record anew, the previous record(s) may no longer be available for repopulation of the ePCR fields through the available to the on-scene ambulance clinicians ePCR interface. Thus, a continuous documentation chain may not

be available for the next encounter with the recurring patient. The overall situation was explained further by one of the key informants: "*there's no access to patient records, or there are no electronic patient records that we can access either through ePCR… but… we can populate the information coming from our communication center onto the ePCR. We can mine that data from the ePCR within the service, but in relation to working with other departments, it's not good.*" Therefore, the ePCR appears to be an isolated information system, forming its own data silo.

Noteworthy, in the questionnaire, when replying to the multiple-choice survey question, respondents indicated the patient ID look-up as the top ePCR feature that in their experience potentially "improves the work of ambulance staff and the overall quality of patient care" (see Figure 3).
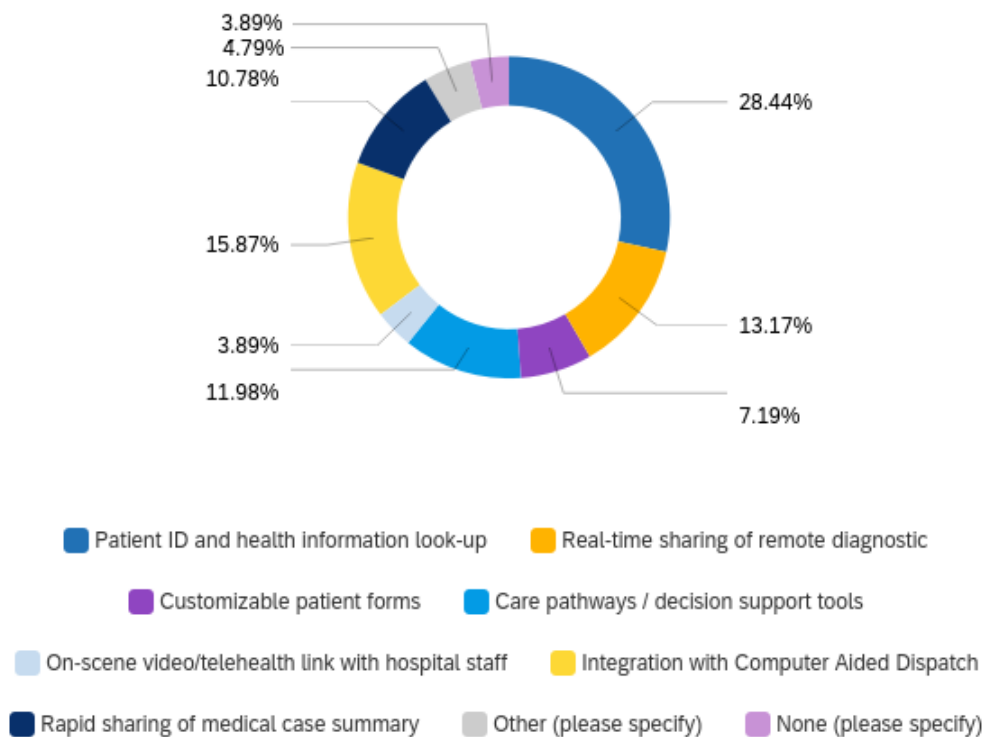
Figure 3. Pie chart illustrating survey respondents' perception of beneficial features of an ePCR.

To summarize, study results indicate that, at the time, there was no electronic information exchange between the ePCR system and the HIS or any other centralized information system that holds demographic or health data. Hence, paper printouts were reportedly used during the clinical handover process. Thus, participants did not perceive any significant impact on the handover process in relation to the ePCR use.

6.3.5 Integration with Lifepak 15

While exploring the information exchange and perceived benefits topics, the theme of integration with Lifepack 15 emerged. Integration with Lifepak 15 – an automated external defibrillator, was perceived as a significant benefit of the ePCR use in ambulance care by study participants. Real-time sharing of remote diagnostics is in the top three choices of the survey respondents to the multiple-choice survey question on the ePCR features that in their experience potentially "improve the work of ambulance staff and the overall quality of patient care" (see Figure 4).

According to the interview participants, the devices can communicate with each other via Bluetooth, therefore, potentially, the ePCR can automatically populate some of the fields with the information from the Lifepak 15, which can "*take some of the pressure off*" by automating part of the record-keeping and reducing the potential for errors. One participant noted that "*because we can transmit vitals from the Lifepak 15 onto the ePCR, you don't have to record all the vitals. You can just send them over before you print.*"

However, when exploring the subject further, another participant commented that "*paramedic could download the information gathered on the Lifepak 15 down onto the electronic patient care report with time stamps. But in complex cases, ePCR completion is done after the event, after paramedics handed over the patient to the hospital's ED. You get your paperwork in order and then you would go clear.*" Therefore, the transmission from Lifepak 15 is not autonomous of human action. As one of the interview participants described it, in cardiac arrest situations whilst ambulance clinicians "*can mark events on the Lifepak 15 that will then transmit certain events across [to the ePCR]*", however, "*it won't [do it] if you don't have someone doing that [marking events on the Lifepak 15], it won't transmit, so you're trying to remember times*" by writing down on the whiteboard. Adding, that "*usually, there may only be two people or three people responding to a cardiac arrest, in which case all that stuff would be filled in post-event.*"

Furthermore, it was pointed out by several participants that sometimes the Bluetooth connection between the ePCR device and the Lifepak 15 fails. One interview participant described a situation when data between the devices fails to transmit. In short, to record drug administration an ambulance clinician can click the drug on the screen of the

Lifepak 15 and then select 'enter' to record which drug was given to the patient and the time of the event which will be time-stamped. However, as pointed out by the interviewee, when the ambulance clinicians press the button to transmit the same information from Lifepak 15 to the ePCR system, the data appears to be either partial or entirely missing in the 'vital sign' section on the ePCR. "*So we might get something, we might get times, but there's not the correspondent event that happened, so we might get at 10:21. All we get the time, not what drug was given at 10:21. Was it adrenaline? Was it amiodarone? Was it an accident? I find that there's definitely a problem with the transmission of information from Life Pack 15 to the ePCR*". To overcome this problem, the participant indicated that what "*I [the participant] and a lot of my colleagues do is press the code summary on Lifepak 15 which… summarizes the whole event with all the times*. Thus, it appears that the Lifepak 15 device prints out what was described as a "*massive code summary*" which is then used to manually transcribe the data onto the ePCR. Thus, some participants expressed frustration with transmission failures, with one participant adding that they are "*doing a lot of stuff manually… So it's hybrid at the moment.*"

Hence, it appears that the Lifepak 15 integration still required manual operation by one of the attending ambulance clinicians, with the ePCR serving as a data repository for the Lifepak 15 data.

6.3.6 Challenging Ergonomics

The results of the study indicate that the current (at the time of the study) ergonomics of the ePCR device may pose significant challenges for ambulance clinicians. The theme of challenging ergonomics promptly emerged during the qualitative research. This topic resonated strongly with the interview participants.

Participants expressed frustration with the placement of the docking station/terminal for the ePCR tablet, located at the back of the ambulance car near the pilot chair. The docking station/terminal allows for the use of a keyboard for typing on the ePCR. Due to such position of the docking terminal, when sitting in the chair in front of the stretcher the ambulance clinicians "*have to twist [their] back almost 180 degrees*" to type the electronic patient care report using the keyboard of the docking station. One of the interview participants when asked to offer an opinion on the ergonomics of the ePCR's tablet and the placement of the terminal with the keyboard in the ambulance car

described it as "*Well, it's awful. Like, it's awful. Zero. It's terrible. And I'm sure the other participants have said the same thoughts*." Another participant commented that "*ergonomically it's not very good if you're turned trying to type.*"

Moreover, one of the interviewees expressed that, "*It's actually much easier to use the keyboard [to fill in the ePCR], but the keyboard is up, out of the way, and not supposed to be used while the ambulance is moving*." Also, another participant noted that the ambulance clinicians are encouraged to use the keyboard to fill in the ePCR, however, due to the challenging position of the docking terminal "*during training, we were told when we're typing to face forward and… put one knee on the chair and this allows you to face directly*." However, when asked whether this method to type is used when the ambulance car is moving, the participant replied that "*strictly speaking, you should not be doing this when the ambulance is moving you. We don't all the time. But yeah, during training that's what we were told to have to type and it's ridiculous*." Hence, there appears to be conflicting advice given to the ambulance clinicians on how to use the keyboard terminal when the ePCR is docked in the ambulance car.

Overall, the interview participants explained that using the keyboard while seated in the ambulance chair required twisting their back almost 180 degrees, which could be uncomfortable and potentially harmful.

6.3.7 User Preferences and Expectations

This section presents results on user preferences and expectations. When responding to the Likert-scale statement of the questionnaire: "I object to the use of ePCR in ambulance care", 54% of the survey respondents strongly disagreed with this statement, and 17% – somewhat disagreed. Moreover, 34% of the survey respondents indicated that they 'strongly agree' with the statement "I would recommend the use of ePCR in ambulance care" and a further 30% somewhat agreed with this statement. Furthermore, 52% of survey respondents strongly agreed with the statement: "I see the potential of ePCR use in ambulance care," and 32% – somewhat agreed. However, as one of the survey participants commented, "*We don't get to use it [ePCR] to its full capability yet*." Only one answer could be chosen from the 5-point Likert scale that included 'strongly disagree', 'somewhat disagree', 'neither agree nor disagree', 'somewhat agree', and 'strongly agree' response options.

A similar sentiment was echoed by the stakeholders who participated in the semi-structured interviews. As one participant put it, "*There are potential benefits that were not used.*" Thus, in terms of future improvements, participants expressed a desire for access to the collected ePCR data for educational and training purposes as "*it could inform our own clinical practice.*" However, at the moment, it appears, the ambulance clinicians "*don't really have any access to it [data].*" For instance, as one ambulance clinician noted, the access to the ePCR's historical data could show the clinicians which skills they need to practice or retrain, based on their past performance, bringing as an example, an IV cannulation and intubation. Another ambulance clinician described the expectation of ePCR's data use in (re)training skills for medication administration: "*I see the benefits of the electronic version, particularly for identifying training needs and where there might be, where things are not done. For example, we have quite a long list of medications we can administer, but if we aren't administering those medications over a long period of time, you know, staff would probably need retraining on them, and that's what the electronic version will be useful because it'd be easy to identify things like that.*"

Additionally, several participants expressed a desire for access to the patient's medical history and demographics data as soon as the call comes in, to adequately prepare equipment and plan the treatment. And, as one of the interviewees put it, to "*Have some idea… if they've called frequently. Perhaps they're COPD patients or they've had a long history of cardiac problems. I could start to get a picture based on what they've called in for this time as what their management has been for the last X number of call-outs, so I could start planning my treatment and go well [prepared]… we probably need to go in with a couple of extra bits of equipment. So I think there's potential there.*" Another participant mentioned that prepopulated demographics and medical data would save time on record-keeping.

Furthermore, several participants expressed a strong desire for a dedicated cardiac arrest functionality with the ePCR system. One participant noted that "*So I think definitely they're going to have to improve the current ePCR. The cardiac arrest section of the ePCR especially. And maybe even have a separate section for that maybe.*" This interviewed ambulance clinician added that having a separate section/box for a cardiac arrest incident with dedicated screen flow could be beneficial as it could save time: "*I'm just thinking if a separate box for cardiac arrest was on the ePCR and then it clicked on*

it and then boom. It was like a nice flow, especially for cardiac arrest, because you just don't have the time to be going from box to box to box all the time. If there was a separate box, that would be nice." Another interviewed participant also suggested a separate, dedicated button on the ePCR for cardiac arrest cases, that would expedite the documentation process, and expressed that as an attending ambulance clinician, "*I should be able to just hit a cardiac arrest button… Now I've got a shortened document. Designed specifically for cardiac arrest.*" One other participant also noted that "*It would be lovely to get patient's previous ECG had they been done… But we don't get that kind of information. So the potential for it is huge.*"

Several participants expressed a desire to utilise the ePCR data for research, analysis and prediction. One of the survey respondents commented, that "*If used correctly [ePCR] can aid in research and reviews*" when replying to the free-text box of the multiple-choice survey question on the ePCR features that "improve the work of ambulance staff and the overall quality of patient care." As one interviewed stakeholder summed it up: "*I think the potential for ePCR is massive… It's unfortunate that it's being limited and treated only as a form of documentation as opposed to an adjunct for patient care.*" Thus, the interviewee expressed the view that the ePCR's data analysis could potentially aid in managing chronic patients: "*We assign them to the community paramedic based on this information, we could probably intervene before they become so unwell they require an ambulance. So [if] we're looking at smart data now and we're almost preventing them to have the need for an ambulance.*" Moreover, the stakeholder also suggested that the currently gathered data should be then analysed to potentially improve stock and medication management, especially during winter months.

Also, one of the ambulance clinicians suggested to "*split the ePCR into two versions: short for the hospital, and the rest stored [electronically] for the ambulance service,*" to compromise on data gathering requirements and expediency, adding that hospitals "*don't care about long narratives… But the ambulance service does.*" Additionally, one participant suggested placing a printer for the ePCR in the hospital: "*I'd like to have a keyboard station and a printer.*" In the interviewee's opinion, this addition could reduce the time ambulance clinicians spent going between the hospital and the ambulance car, hence may reduce the overall time spent on documentation.

Furthermore, while some participants appreciated the bulky design of the ePCR table that can withstand dropping, others expressed a desire for a more compact and portable device, akin to a phone, that could fit in the trouser pocket, just like a paper PCR used to fit. One participant noted that "*it would be handy to have a slot on the stretcher to place the ePCR because at the moment we sort of slot it in between the patient's leg and the stretcher, which I don't think it's very professional.*" Another ambulance clinician speculated that what could improve current challenges with ergonomics is "*if it [ePCR tablet with docked keyboard] could be put on a swing arm or something to bring it out in front of you when you're using it [in ambulance car].*"

Finally, some study participants expect improvements in ePCR's user interface: "*ePCR has to improve its usability and the interface.*" One suggestion was to "condense" the patient assessment to fewer screen tabs: "*On the electronic version that's [patient assessment] broken over several different pages within the software… So I think trying to condense it down into fewer pages and fewer dropdown menus will probably be a lot more beneficial.*" This comment resonates with the one left on the questionnaire, that suggested the "*ePCR software needs to flow like Apps on a phone and have AI that can be overridden if required.*" Also, one of the interview participants expressed a desire for a built-in decision support system that could alert an ambulance clinician about a patient's allergies and previously prescribed medications.

Overall, most questionnaire and interview participants expressed a preference for continuing the use of the ePCR in ambulance care. However, they also communicated their expectations towards future improvements to the system. To sum up, with the direct quote by one of the interview participants, the ePCR system is "*brilliant for data collection… So, I do think it's good, but it's got a long way to go yet.*"

6.3.8 Interoperability in Irish Healthcare

To fully comprehend some of the results, the topic of interoperability in Irish healthcare was explored through interviews with key informants.

One key informant described the interoperability in Irish healthcare as "*digitally immature*" and noted, "*There's legacy stuff in place… there's modernization that's rapidly needed in our health service.*" Another participant expressed that the state of interoperability was "*not great, it couldn't be better.*" Moreover, one of the interviewed

key informants noted that Irish healthcare still has "*a long journey to go*" in terms of interoperability.

Moreover, one of the interviewees expressed that the Irish healthcare system is "*very system-orientated and not really integrating the systems.*" Another participant elaborated that, "*In some areas, we have a lot of siloed systems or stand-alone systems that are meeting our clinical colleagues' needs. But there's very limited interoperability amongst the systems, so there is a drive from within the HSE to make sure these systems are starting to talk to each other.*" However, the participant noted that "*everybody's trying to make things, interoperability, in a local sense… but there is no national direction there or policy.*" Hence, the key informant emphasised the need for a national standard or policy to drive interoperability. Thus, the interviewee suggested that the Health Service Executive (HSE) needs to make the systems 'talk' to each other to harness the data – "*a very valuable commodity,*" to make better decisions in managing the complex Irish healthcare service. The interviewed key informants shared a view on the value of interoperable health data in quality care and service management.

When exploring the potential of interoperability concerning emergency care, one of the participants elaborated that, "*If an ambulance had access to summary information about say, a kidney patient or a haemophilia… some of the key things, that the patient is a dialysis patient for example, or a transplant patient, that could significantly improve the patient's journey or quality of service. Because in the end, this man is typically at the point of emergency, and if the paramedics had that information they could make more accurate clinical decisions.*" Hence, once more accenting the importance of interoperable data, that can be converted to knowledge and result in a better overall service, starting from pre-hospital emergency care: "*If we have the data, we have the knowledge and we have a quality service.*" Furthermore, the same interviewee suggested that there was a strained availability of hospital wards and staff, thus congestion when getting from the ED to the ward. Hence, the participant suggested that if the ambulance service would have had access to the patient's last assessment by the GP, they could be "*well armed going into the situation,*" and then they could do their on-scene assessment and sent it to the ED, enabling the receiving hospital staff to perform their assessment before ambulance's arrival and prepare all the necessary to efficiently transfer the penitent to the ward. Additionally, another key informant suggested that if the pre-hospital emergency service would have had a "*synopsis of who*

that person is, what that person needs, and what medications [they] are on," the ambulance crew might be able to treat patients at home more, instead of bringing to the hospital, and thereby "*reducing demand in our hospitals*." However, one of the interviewees acknowledged that for the ambulance service to have access to the patient's prior medical history, such as, for example, summary information from the GP "*we'd have to figure out a national identity number*," meaning there would need to be a common national identity number linked to all patient's health data and available to query for related health services, such as ambulance service. One participant suggested linking the patient's PPS number (unique reference number that helps holders to access social welfare benefits, public services and information in Ireland) with the ePCR.

Most interviewed stakeholders expressed views that interoperability between the ambulance's ePCR system and HIS holds great potential. As one of the participants described it, the direct communication between the ePCR system and HIS may potentially reduce the waiting time for the patient to receive time-sensitive treatment: "*What would be nice is if there was a linked-up system with A&E. So paramedics could send ePCR data directly to the hospital staff online… so that at least they would have a lot of information prior to our arrival. There is a pre-alert on the radio but sometimes that's lost… [when] we arrive it's not the patient that they directly expected because it's just been some information lost in translation… To send this information on to the hospital prior to ambulance arrival and they can have the CT scan booked prior our arrival and that's just chipping away at the time that it takes for the patient to receive their clot-busting therapy. It's just about little marginal gains.*" Another participant remarked that even though the integrated approach where the information from the ePCR is sent live to the ED ahead of ambulance arrival "*would be great*", however, "*there needs to be joined-up thinking between the ambulance service and the hospitals what is an accepted format for the delivery of that information, because I don't think that is the case right now.*"

Overall, participants described the current state of interoperability in Ireland as limited, with many siloed systems that did not exchange valuable information with each other. Participants noted that gathered data is a valuable commodity in the health service. Despite the challenges, there was a shared belief in the potential for ICT, including the ePCR, to positively impact the healthcare system's overall quality and patient care, if full interoperability of data would be attained.

7 Discussion

This chapter discusses the findings of the study and attempts to address the research questions and reach the aim of the study while illustrating the interrelation with a broader research corpus. Also, the study's limitations and possibilities for future research are presented.

7.1 Summary of User Attitudes and Perceived Challenges and Benefits

The findings of this thesis provide valuable insights into user attitudes and the perceived challenges and benefits of using the ePCRs in ambulance care in Ireland. The use of electronic patient care records (ePCR) in pre-hospital emergency care in Ireland has elicited both positive and negative views from key stakeholders, as revealed in qualitative content analysis of several interviews. Positive attitudes appeared to stem from the perceived usefulness of some of the ePCR features compared to paper PCR. However, despite the benefits afforded by the ePCR, not all participants were enthusiastic about the implementation of the ePCR system. Some individuals demonstrated ambivalence toward and even aversion to the ePCR system when compared to the paper-based system. As individual attitudes and enthusiasm play an important role in the adoption and successful implementation of new technologies in healthcare [6], [7], [60], it is paramount for the decision-makers and change managers to take these factors into account.

In particular, the transition period from paper PCR to the ePCR prompted negative attitudes, implying that ambulance clinicians experienced challenges adapting to new technology, similar to the findings in the Broussard study [21]. Hence, the availability of more hands-on training opportunities could help to facilitate a more favourably viewed transition to the ePCR. This coincides with the findings in Landman et al.'s study which emphasised the value of assistance and training in facilitating adoption [18]. Moreover, a more flexible approach to implementation during the transition period could induce a more positive attitude from ambulance clinicians. As indicated in Baird and Boak's study [19], after the introduction of flexibility, instead of an initial strict

mandatory implementation of the ePCR, both individual and collective ability to make sense of the change was enhanced improving acceptance of the innovation. These insights may be of particular importance to the decision-makers and change managers when evaluating ePCR's implementation in ambulance care.

Furthermore, the results indicate that the ePCRs presented numerous other challenges. One of those challenges stemmed from technical issues that prevented an effective integration with Lifepak 15. In fact, the ability to transmit vital signs directly from the Lifepak 15 to the ePCR was perceived by the study participants as one of the benefits of the ePCR, as it can eliminate the need for manual recording and reduce the potential for errors. However, failure to transmit information from Lifepak 15 to the ePCR, prompting manual transcription of the same data, defeated the purpose of the transmission and negated the perceived benefit. Thus, further improvements to the integration may be necessary to address any technical glitches and ensure that the two devices communicate effectively. This aspect may be of particular interest to the quality assurance specialists and ICT and programme managers conducting a post-implementation audit.

The results indicate that the ePCR implementation increased the total quantity of exam information documented, as perceived by the participants. Therefore, this factor was perceived by some participants as a challenge of the ePCR compared to paper PCR, which aligns with the finding in Katzer et al. study [20]. Moreover, the issue of duplication of recorded information may be occurring in the work of ambulance clinicians regularly, and possibly results in the duplication of work, and therefore, is perceived by some participants as machine-oriented over-documentation taking away the focus from patient care. It was reported that the ePCR's flow required repetition of the same information, and navigation through multiple screen tabs, causing frustration and eliciting negative attitudes. As a result, similarly to the finding in Baird and Boak's study [19], it was discovered that ambulance clinicians had distinct preferences for how and when to incorporate the ePCR into their practice while on-scene of the incident. Thus, several pain points related to UX emphasize the need for further development to improve the end-users' experience with the ePCR system in ambulance care and reduce or eliminate duplicated record-keeping, resulting in redundant work. Hence, these aspects should be considered by the product designers reviewing the future iteration of the product development.

Furthermore, retrospective record-keeping was reported, especially when dealing with complex cases, such as cardiac arrest incidents. The findings align with the literature [16] indicating that it was challenging for the ambulance clinicians to finish the ePCR filling before arriving at the receiving hospital. Thus, it appears that the verbal handover process remained the same, with no additional benefit from the ePCR system implementation. Similarly, in Jensen et al. study it was found that verbal handover was embedded in the ambulance professionals' work practice [16]. Albeit, in the Danish system, researched by Jensen et al., there was an automatic data transfer from the ePCR to HIS, therefore it was found that most of the ambulance clinicians reported improved collaboration efforts with the ED clinicians following the implementation of the ePCR [16]. In comparison, in the present study, the ePCR was not perceived by ambulance clinicians as a tool that somewhat beneficially impacted their collaboration with the ED staff during the clinical patient handover process. Moreover, in the present study, some ambulance clinicians showed unfavourable views toward printouts produced by the ePCR system, doubting their usefulness, due to their lengthy and confusing nature, compared to paper PCRs. Thus, the ePCR appeared to serve primarily as the data repository, which coincides with the findings in the Porter et al. study [15]. These insights may be of use when performing a post-implementation review.

Additionally, the challenging placement of the keyboard docking station in an ambulance car reportedly leads to ambulance clinicians' discomfort, and possibly – a health hazard. Hence, challenging, rather than convenient ergonomics, appeared to cause frustration, hence negative attitudes. Thus, this pain point needs further attention from the decision-makers and change managers, to ensure that during the system's procurement and implementation processes, the placement and overall ergonomics of the device(s) are taken into consideration.

Nevertheless, participants also expressed numerous positive opinions. Positive attitudes appeared to stem from the perceived beneficial features of the ePCR and user-friendly experiences that the participants cited, such as improved legibility, increased space for a more detailed record of the incident, accessibility of detailed electronic records for audit and legal defence, user-friendly functions such as 'tapping' and using drop-down menus instead of writing, spell-checker, medication name query function. Also, some participants reported that they perceived the ePCR as structured and methodical, with tools and aids that serve as reminders, and therefore, help clinicians with patient

assessments. Also, the participants recognized the need for effective documentation, while also prioritizing patient care. Thus, the challenge of juggling record-keeping could be seen as counter-weighted by the benefit of detailed documentation afforded by the electronic patient care report system. However, there is no definite conclusion on whether the ePCR is perceived to benefit patient care, or primarily – the administrative side of service management. These findings align with some of the previous research [15], [18] and highlight the need for ongoing evaluation of the ePCR use in ambulance care to ensure that it serves effective and efficient provision of quality patient care. The findings emphasize the need to strike a balance between the benefits of the ePCR in terms of record-keeping, and on-scene efficiency and practice. These factors may need to be considered by the pre-hospital emergency care practitioners and the paramedic studies experts in the pre-and post-implementation context.

Overall, the findings suggest that while the concept of the ePCR system is perceived as having valuable benefits, there are significant challenges experienced by ambulance clinicians that need to be addressed. Nonetheless, the findings suggest that in key stakeholders' view, the benefits of the ePCR, including improved information gathering and legibility, appear to outweigh the challenges. Since assessment of the eHealth system from the users' perspective allows for addressing all the key factors including the design and implementation of the digital system in specific contexts [55], [56], hence information gained from the present research into ambulance clinicians' perspectives offers valuable insights to the experts involved in pre-hospital emergency care service.

7.2 Summary of Perceived Potential

The ePCR is perceived by key stakeholders to have a significant potential to be a valuable tool for ambulance clinicians in Ireland. In particular, participants hoped that the system would become even more user-friendly, integrated with other health information systems, and customizable, especially for cardiac arrest cases, to better meet the needs of ambulance clinicians.

Additionally, data gathered through the ePCR is perceived as valuable and potentially useful to plan the healthcare service, improve ambulance clinicians' skills and training, and improve patient care.

However, to realise the full potential of the ePCR system, further development and improvement of the ePCR system are needed to make it more user-centred, and ergonomic, and to ensure that the ePCR meets the expectations of the end-users – ambulance clinicians. The findings suggest a need for improvements to enhance the system, with attention to the customization of user interface, the transmission of information, and ergonomics, for the system to closely align with user preferences and expectations. As the system innovation and adoption requires adaptation through the method of a continuous cycle of configuration, customisation, and implementation based on user input [59], therefore, the product designers should consider the identified in the present study user preferences and expectations for the future iteration of the product development.

Furthermore, stakeholders have identified interoperability as a critical issue that must be addressed to fully realize the potential of the ePCR system. Having demographics and medical summary information available at the point of care for ambulance services was viewed as a factor that could significantly improve the patient's journey and the overall quality of healthcare service. Establishing interoperability among healthcare systems would create a seamless information loop starting from general practitioners, continuing through the ambulance service, and ultimately reaching emergency departments, hospitals, and other healthcare and social services. This loop is expected to facilitate effective and efficient delivery of quality healthcare services. Thus, the findings suggest that there is a need for a national standard or policy to drive interoperability among healthcare systems in Ireland.

Overall, both the questionnaire and the interview participants expressed optimism about the potential of the ePCR technology. However, they also acknowledged that the current (at the time of the study) ePCR system still had limitations that needed to be addressed before it could reach its full potential, and expressed their expectations for improvements. Thus, the decision-makers and product designers may need to take into account the key stakeholders' expectations and their views on the potential of the system when reviewing the system's implementation and design.

7.3 Limitations

The study's limitations include the fact that the study was limited to the ambulance service in Ireland, hence had a limited sample pool, which may limit the generalizability of the findings to other ambulance services. Future research could involve a larger sample pool and explore the experiences of ambulance clinicians from different ambulance services and in different countries.

7.4 Future Research

Further research is necessary to determine approaches for enhancing the handover process and maximizing the potential of ePCR technology. Also, further investigation is needed to explore the potential secondary uses of ePCR data and its impact on the (re)training of ambulance clinicians. Additionally, there is a need for further research to explore the impact of the ePCR system's implementation on patient care and clinician-to-patient communication, which could potentially be conducted through observational studies. Furthermore, conducting research on the use of the ePCR during cardiac arrest incidents, combining value stream mapping tool with user experience research could provide valuable insights for improving future product design and optimizing the user interface of the ePCR.

7.5 Final Conclusions

The following study conclusions can be drawn:

1. Increasing the availability of more hands-on training opportunities could be a valuable means of promoting a smoother and more positively perceived transition to the ePCR system among ambulance clinicians.

2. Further improvements to the integration may be necessary to address technical glitches with the transmission of Lifepak 15 data to the ePCR, to ensure the benefit of the integration is realized.

3. The results suggest that there could be a recurring issue of duplicated record-keeping, resulting in redundant work. Thus, the ePCR's design may need to be

re-evaluated to emulate the benefit of a paper-based PCR of quick note-taking, to reduce or eliminate redundant work duplication.

4. No significant beneficial impact on the clinical handover process at ED was perceived by the ambulance clinicians, thus not realizing the potential benefit of having an increased collaboration between ambulance professionals and the ED staff as suggested in the literature.

5. The perceived uselessness of the paper printouts generated by the ePCR due to their lengthy and confusing nature, compared to paper PCRs, should be addressed both for environmental reasons and from the efficiency and effectiveness standpoints.

6. Challenging placement of the ePCR's keyboard docking station in ambulance car reportedly lead to ambulance clinicians' discomfort, and possibly – a health hazard, hence should be addressed accordingly to improve ambulance clinicians' efficiency and well-being in their working environment.

7. Perceived beneficial features of the ePCR and user-friendly experiences include improved legibility, increased space for a more detailed record of the incident, accessibility of detailed electronic records for audit and legal defence, user-friendly functions such as 'tapping' and using drop-down menus instead of writing, spell-checker, medication name query function. Also, the ePCR tools and aids that serve as reminders, and therefore, help clinicians with patient assessments are also perceived as beneficial. At the same time, the findings suggest that the ePCR was perceived primarily as a data repository.

8. The findings suggest that the participants recognized the need for effective documentation, while also prioritizing patient care.

9. The challenge of juggling record-keeping could be seen as counter-weighted by the benefit of detailed documentation afforded by the electronic patient care report system. The findings emphasize the need to strike a balance between the benefits of the ePCR in terms of record-keeping, and on-scene efficiency and practice.

10. There is no definite conclusion on whether the ePCR is perceived to benefit patient care, or primarily – the administrative side of service management. Hence, the findings highlight the need for ongoing evaluation of the ePCR use in ambulance care to assess its impact on clinician-to-patient communication and the provision of quality patient care.

11. Both the questionnaire and the interview participants expressed optimism about the potential of the ePCR technology. The findings indicate that the ePCR is perceived by key stakeholders to have a significant potential to be a valuable tool for ambulance clinicians in pre-hospital emergency care in Ireland.

12. There is an acknowledgement among study participants that the current (at the time of the study) ePCR system still had limitations that needed to be addressed before it could reach its full potential, and expressed their expectations for improvements. End-users' expectations include for the system/device(s) to become more ergonomic, customizable, especially for cardiac arrest cases, and integrated with other health information systems, to better meet the needs of ambulance clinicians. The findings suggest a need for improvements to enhance the system, with attention to the user interface, the transmission of information, and ergonomics, for the system to closely align with user preferences and expectations.

13. Data gathered through the ePCR is perceived as valuable and potentially useful to plan the healthcare service, improve ambulance clinicians' skills and training, and improve patient care.

14. Having demographics and medical summary information available at the point of care for ambulance services is viewed as a factor that could potentially improve the patient's journey and the overall quality of healthcare service, as suggested by the participants. Thus, the finding indicate that interoperability between the ePCR system and HIS is essential to meet user expectations and realise the perceived potential. Moreover, the findings suggest that there is a need for a national standard or policy to drive interoperability among healthcare systems in Ireland.

8 Summary

The electronic patient care report (ePCR) is a technology that has been introduced in the ambulance services in Ireland to replace the traditional paper-based patient care report system. This study aimed to examine the perceptions of ambulance clinicians towards the ePCR system and to identify areas that need further attention to enhance user experience and maximize system's full potential. The study used a mixed-methods design, combining a survey and interviews with key stakeholders.

The study's findings suggest that the availability of more hands-on training opportunities could help facilitate a more favourably viewed transition to the ePCR by ambulance clinicians. Further improvements to the integration may be necessary to address technical glitches with the transmission of Lifepak 15 data to the ePCR to ensure that the integration's benefits are realized. The study revealed that there could be a recurring issue of duplicated record-keeping, necessitating the re-evaluation of the ePCR's design to reduce or eliminate redundant work. Additionally, the placement of the ePCR's keyboard docking station in ambulance cars reportedly caused discomfort and may pose a health hazard, requiring improvement to enhance ambulance clinicians' efficiency and well-being.

The ePCR's system was found not to have any significant beneficial impact on the clinical handover process at the ED form ambulance clinicians' perspective. Nevertheless, participants recognized the need for effective documentation afforded by the ePCR's while prioritizing patient care, albeit the ePCR was perceived primarily as a data repository. Thus, there is no definite conclusion on whether the ePCR benefits a clinician-to-patient communication. Therefore, ongoing evaluation of the ePCR use in ambulance care is necessary to assess its impact on the provision of quality patient care.

This study concludes that ePCR technology has significant potential to be a valuable tool for ambulance clinicians in pre-hospital emergency care in Ireland, but improvements, including interoperability between Irish health information systems, are needed to enhance user experience and realise the ePCR's full potential.

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Appendix 2 – Summary of ePCR studies that include ambulance professionals' perspectives (2012 – 2022)

AUTHOR	TITLE	COUNTRY	YEAR	DESIGN	SAMPLE SIZE	MAIN FINDINGS
LANDMAN ET AL.	Prehospital Electronic Patient Care Report Systems: Early Experiences from Emergency Medical Services Agency Leaders	USA & Canada	2012	Qualitative study: web-based survey & semi-structured interviews	N = 13 key informants	1) Adoption was primarily motivated by the promise of e-PCR systems to benefit quality assurance measures. 2) The adoption of e-PCR systems encountered a number of obstacles, such as worry about possible increase in ambulance waiting times, difficulty integrating with current hospital information systems, and lack of funding.
BAIRD AND BOAK	Leading change: introducing an electronic medical record system to a paramedic service	USA	2016	Semi-structured interviews followed up with electronic survey	N = 4 (interviews with paramedics); N = 29 (survey /paramedics)	1) It was discovered that each paramedic had distinct preferences for how and when to incorporate the EMR/ePCR into their practice. 2) Adoption was significantly influenced by the EMR's/ePCRs user interfaces and perceived ease of use. 3) After the introduction of flexibility, instead of an initial strict mandatory implementation, both individual and collective ability to make sense of the change was enhanced and barriers to acceptance were removed.
PORTER ET AL.	Electronic health records in ambulances: the ERA multiple-methods study	UK	2020	(1) Rapid literature review; (2) Telephone survey; (3) Detailed case studies; (4) Knowledge-sharing	Package 2: N = 22 middle and senior managers interview sessions. Package 3: N = 30 middle and senior managers interview sessions.	1) There is a very limited range of published literature specifically on EHRs in ambulance services. 2) Participants reported benefits to the accuracy of record-keeping and the ease of extracting data. However, many potential advantages of EHRs identified were not realised yet. 3) Very limited evidence of patient records' electronic sharing. 4) Benefits in terms of data storage; challenges included interoperability and technical issues.
JENSEN ET AL.	Understanding the Effect of Electronic Prehospital Medical Records in Ambulances: A Qualitative Observational Study in a Prehospital Setting	Denmark	2021	Qualitative observational study	N =26 (ambulance clinicians), N = 42 (ambulance runs)	1) Observations confirm that documentation was a secondary concern and that due to short distances, the ambulance clinicians had trouble finishing their ePMR forms before getting to the ED. 2) Ambulance clinicians found utilizing the ePMR/ePCR a good tool for actively collaborating in a prehospital setting. 3) However, in life-threatening situations ambulance clinicians communicated information via telephone rather than ePMR/ePCR.

Appendix 3 – PCR Template Edition 5 2018

Page 1:

Page 2:

Out-of-Hospital Cardiac Arrest

Chest Pain

Yes ☐ No ☐ Unknown ☐ Time of Chest Pain HH | MM

Collapse

Yes ☐ No ☐ Time of Collapse HH | MM

Category of person who witnessed collapse

Citizen	Not dispatched by ambulance control
Responder on duty	Dispatched by ambulance control
Responder other	Not dispatched by ambulance control
Responder auxiliary/voluntary service	On duty at or near the scene
Practitioner	Dispatched by ambulance control
Doctor or off-duty practitioner	Not dispatched by ambulance control
Doctor or off-duty practitioner	Dispatched by ambulance control
Nurse	
Fire	
Garda	

Chest Compressions

Yes ☐ No ☐ IF NO ADD REASON NOT COMMENCED

Time chest compressions commenced HH | MM Dispatcher aided Yes ☐ No ☐

Total duration of chest compressions HH | MM

Mechanical cardiopulmonary device was used Yes ☐ No ☐

Category of person who commenced chest compressions

Citizen	Not dispatched by ambulance control
Responder on duty	Dispatched by ambulance control
Responder other	Not dispatched by ambulance control
Responder auxiliary/voluntary service	On duty at or near the scene
Practitioner	Dispatched by ambulance control
Doctor or off-duty practitioner	Not dispatched by ambulance control
Doctor or off-duty practitioner	Dispatched by ambulance control
Nurse	
Fire	
Garda	

Defibrillator

Yes ☐ No ☐ PIN/HSPI

Category of person who first applied defibrillator pads

Citizen	Not dispatched by ambulance control
Responder on duty	Dispatched by ambulance control
Responder other	Not dispatched by ambulance control
Responder auxiliary/voluntary service	On duty at or near the scene
Practitioner	Dispatched by ambulance control
Doctor or off-duty practitioner	Not dispatched by ambulance control
Doctor or off-duty practitioner	Dispatched by ambulance control
Nurse	
Fire	
Garda	

Initial Arrest Rhythm

Shockable ☐   Unshockable ☐

Specify: (if known)

Specify rhythm What was first cardiac rhythm recorded prior to defibrillation

Ventricular fibrillation	Ventricular tachycardia
Unknown rhythm – shock advised	Asystole
Unknown rhythm – no shock advised	Pulseless electrical activity

Time First Arrest Rhythm Analysis HH | MM

Shock

Was shock advised ☐ Yes ☐ No ☐ N/A PIN/HSPI

Was shock delivered ☐ Yes ☐ No Defibrillator malfunction ☐

Total shocks delivered NUMBER   Time of first shock delivered HH | MM

Category of person who delivered first shock

Citizen	Not dispatched by ambulance control
Responder on duty	Dispatched by ambulance control
Responder other	Not dispatched by ambulance control
Responder auxiliary/voluntary service	On duty at or near the scene
Practitioner	Dispatched by ambulance control
Doctor or off-duty practitioner	Not dispatched by ambulance control
Doctor or off-duty practitioner	Dispatched by ambulance control
Nurse	
Fire	
Garda	

Return of spontaneous circulation (ROSC) at any stage Yes ☐ No ☐

Did rearrest occur Yes ☐ No ☐ no. of times

Category of person who first achieved return of spontaneous circulation (ROSC)

Citizen	Not dispatched by ambulance control
Responder on duty	Dispatched by ambulance control
Responder other	Not dispatched by ambulance control
Responder auxiliary/voluntary service	On duty at or near the scene
Practitioner	Dispatched by ambulance control
Doctor or off-duty practitioner	Not dispatched by ambulance control
Doctor or off-duty practitioner	Dispatched by ambulance control
Nurse	
Fire	
Garda	

CPR in progress when transporting Yes ☐ No ☐

Spontaneous circulation on arrival to hospital Yes ☐ No ☐

Doctor in attendance MCRN Yes ☐ No ☐

Cardiac First Response (CFR) Report handover Yes ☐ No ☐

SIGNATURE/PIN/HSPI

NOTES

Declined Treatment and/or Transport

Practitioner aid to determine patient "decision making capacity"

A person lacks of capacity to make a decision if he or she is unable to:

- Understand the information relevant to the decision ☐ YES ☐ NO

- Retain the information long enough to make a voluntary choice ☐ YES ☐ NO

- Use or weigh that information as part of the process of making the decision, or ☐ YES ☐ NO

- Communicate decision by any means (including sign language/assistive technology) or if the implementation of the decision requires the act of a third party ☐ YES ☐ NO

I/We witness that the patient has declined treatment/transport to the Emergency Department.

I/We have advised the patient to consult with his/her own doctor as soon as possible or should his/her condition deteriorate to call 999/112 for emergency medical assistance.

PIN/HSPI (1)

PIN/HSPI (2)

Report to the EMS Control Centre ☐ YES ☐ NO

Additional Information

Additional Information

Pupil Size Chart

● ● ● ● ● ● ● ● ● · 2 · 1
8 7 6 5 4 3

Incident Information Abbreviations

NTT: Not treated/Not transported
TR: Treat & refer
VOD: Verification of death
PC: Palliative care
DOA: Dead on arrival

Cardiac Rhythm Abbreviations

Atrial Fibrillations	AF	Ventricular Fibrillation	VF
Supraventricular Tachycardia	SVT	Pulseless Electrical Activity	PEA
Junctional Rhythm	JR	Idioventricular	IDIO
Ventricular Tachycardia	VT	Asystole	ASY
Premature Ventricular Contraction	PVC	Third Degree Heart Block	THB
Premature Atrial Contraction	PAC	Second Degree Heart Block Type II	SHBT2
Sinus Tachycardia	ST	Second Degree Heart Block Type I	SHBT1
Sinus Bradycardia	SB	First Degree Heart Block	FHB
Normal Sinus Rhythm	NSR	Atrial Flutter	AFL

Route Abbreviations

Buccal		SL	Sublingual	IV	Intravenous
Subungual	SG	Subcutaneous	SC	Intranasal	IN
Inhalation	INH	Intramuscular	IM	Per Rectum	PR
Oral		IO	Intraosseous	ETT	Endotracheal	IO

Additional Information

Appendix 4 – Interview schedule and participants' occupation

#	DATE OF THE INTERVIEW	PARTICIPANT'S PROFESSIONAL ROLE
1	23.08.2022	Advanced paramedic, Supervisor (NAS)
2	31.08.2022	Paramedic (NAS)
3	22.09.2022	Paramedic (NAS)
4	26.09.2022	Advanced paramedic (NAS)
5	28.09.2022	Advanced paramedic (NAS)
6	29.09.2022	Advanced paramedic (NAS)
7	29.09.2022	Advanced paramedic (NAS)
8	03.10.2022	Paramedic (NAS)
9	26.10.2022	ICT Programme Manager (HSE)
10	07.11.2022	Sr. Lecturer in Paramedic Studies, registered paramedic
11	29.11.2022	Advanced paramedic (NAS)
12	09.12.2022	Change & Innovation Manager (HSE)

Appendix 5 – 2009 CFIR constructs used during initial analysis stage

Description of some of the 2009 CFIR domains and constructs within each domain used during the initial stages of the qualitative content analysis

Domain 1: Intervention – characteristics of the intervention itself (4 concepts)
- Relative Advantage: Advantages of using the intervention over other options, as perceived by the target population   - Adaptability: How well an intervention may be adapted to a certain organization's demands   - Complexity: Perceived difficulty of implementation   - Design Quality & Packaging: Perceived packaging and presentation
Domain 2: Outer Setting – factors external to the organization (1 concept)
Cosmopolitanism: Network and connectivity
Domain 4: Individuals - characteristics of the individuals involved in the implementation (3 concepts)
- Knowledge and Beliefs about Intervention: Individual staff members' awareness of and attitudes about the intervention   - Self-efficacy: An individual's belief in their ability to use the implementation   - Individual Stage of Change: The stage a person is in as they develop their ability to apply the intervention with competence, enthusiasm, and persistence.
Domain 5: Process – processes of implementation (2 concepts)
Engaging: Engaging individuals in implementation processes, including training

Appendix 6 – Survey responses illustrating opinions and attitudes

#	Field	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Total
1	I see the potential of ePCR use in ambulance care.	3.15% 4	5.51% 7	6.30% 8	32.28% 41	52.76% 67	127
2	I object to the use of ePCR in ambulance care.	54.33% 69	17.32% 22	14.96% 19	9.45% 12	3.94% 5	127
3	ePCR improves clinical handover from ambulance to the hospital's Emergency Department.	11.81% 15	15.75% 20	18.11% 23	30.71% 39	23.62% 30	127
4	ePCR causes a decrease in communication between ambulance and hospital staff.	29.92% 38	25.20% 32	27.56% 35	10.24% 13	7.09% 9	127
5	ePCR in ambulance care helps to provide a better quality of care to the patients.	19.69% 25	30.71% 39	17.32% 22	19.69% 25	12.60% 16	127
6	ePCR causes ambulance staff to give less time to quality patient care.	11.02% 14	11.81% 15	3.94% 5	43.31% 55	29.92% 38	127
7	I would recommend the use of ePCR in ambulance care.	10.24% 13	7.87% 10	18.11% 23	29.92% 38	33.86% 43	127