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Technological development roles and needs in pre-hospital emergency care from the advanced level paramedics' perspective

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ABSTRACT

Introduction: The work environment of paramedics is rapidly becoming more technology-oriented, and new innovations are constantly being introduced. The aim of this study was to determine the roles Finnish advanced level paramedics identify for themselves within technological development processes in their experience and what kinds of technological development in pre-hospital emergency care are needed.
Methods: This qualitative study utilised essay material written by experienced advanced level paramedics (n = 20), which was analysed using inductive content analysis.
Results: The paramedics identified direct and indirect roles and clear obstacles. The roles were related to expertise, their own professional skills, supporting development and implementation. The obstacles to participation in technological developed were perceived as the employer's unwillingness to involve grassroots level paramedics, lack of training or expertise, and overall unrecognised role. Technological development was seen to be needed regarding information and communication technology, treatment tools, and equipment. Further, nationally homogenous technological development that supports the quality and safety of nursing work and the integration of digitalization into education were also seen as needed.
Conclusions: Paramedics can be innovative and active technology developers with extensive expertise in the technology of their field. Employers and technology developers should be encouraged to enable user-oriented product development and to involve paramedics in development work.

1. Introduction

Healthcare provides are globally facing increasing challenges with the development of technology, for example, to maintain long-distance wireless communications with increasing patient flows [1]. This poses challenges for healthcare leaders, technology designers, and policy-makers to ensure the proper adoption of technologies, staff proficiency in their use, and the continued pursuit of strategic goals [2]. Technology and digitalization in healthcare have already taken large steps forward in the last few decades [3]. Emergency medical service (EMS) systems have experienced notable changes, such as the integration of prehospital electrocardiograms, the utilisation of prehospital medication delivery, and the establishment of telecommunication connections between EMS providers and hospitals [4]. However, the need for new healthcare applications in national healthcare systems and to develop safe ways to see patients without face-to-face contact is still urgent [1]. Currently, the focus on technology development is on medical devices and healthcare-related Information and Communication Technology (ICT) [5]. For example, wireless access to patient data is an emerging area of ICT use in ambulances. In some parts of the world, EMS does not have stable wireless connectivity, while hospitals have had reliable access to wireless and paperless patient data for a longer time [6]. Nevertheless, open, accessible databases for all healthcare organisations are important for enabling a safe continuum of care [5].

In Finland, emergency rooms have been centralised, EMS operating in the pre-hospital setting is a highly critical part of out-of-hospital care [7,8], alongside, for instance, home care and social services [2]. In Finland, paramedics working in pre-hospital settings are highly educated. Advanced level paramedics (hereafter paramedics) have either a bachelor's degree in prehospital emergency care (240 ECTS (European Credit Transfer and Accumulation System); 4 years) or a bachelor's degree in nursing with additional prehospital emergency care

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studies (210 ECTS; 3.5 years), and they can start intensive care treatments in the field. The degree in prehospital emergency care in Finland is a combination of nursing and emergency care, where students graduate as registered nurses and are also certified to operate as advanced level paramedics and in a multifaceted array of nursing responsibilities. Thus, paramedics' care for patients is referred to as nursing in this study. In addition, the EMS system includes field supervisors who play a critical role in maintaining situational awareness. Field supervisors are expected to have specific qualifications, including a certification as an advanced level paramedic, and possess a wealth of operational and administrative knowledge and experience as stipulated by Finnish Government regulations. [9] However, the requirements for the EMS are still increasing, and the focus is more on systematic patient care, advanced treatment, and recognition of acute conditions [10].

In Finland, the EMS dispatch tasks are categorised into four different priority classes from A to D. Classes A to C are considered urgent, while class D is non-urgent. An A-class task is high-risk and indicates that the patient's basic vital functions are at immediate risk. For a D-class task, the patient's basic vital functions are stable, but paramedics are required to assess the need for medical care. [9] In the pre-hospital setting, the importance of new technological innovations will partly focus on non-urgent patients. For example, technological developments will help elderly people stay home and help with pre-hospital triage [8]. EMS need new resource management and technology solutions to focus ambulances where they are needed the most. One way to enable sufficient resources for urgent patients is to minimize unnecessary patient transports. With technological inventions, non-urgent patients could be diverted to other organizations operating outside hospitals, such as home care and social services [2].

Overall, paramedics are under great pressure to adapt to new technologies. Healthcare organisations are likewise under pressure to adopt new service delivery models and integrate old ones with new ones. Organizations need to ensure that employees have the knowledge and skills to safely operate with new innovations. A study by Dohan et al. suggests that healthcare organisations should use the technological knowledge of employees and utilise the available innovativeness to develop paramedic services [2]. Additionally, in the field of human–computer interaction, it is a generally accepted paradigm that better products and services are created when diverse users are involved in the development process. Furthermore, user participation can be seen as a user right to have a say in designing the systems intended for their use [11].

On the one hand, to be able to do their own work effectively, the "next generation" of paramedics needs to learn technological skills such as integrating technologies into education and clinical care, data analytics, hardware and software troubleshooting and development, data integration, and much more [5]. On the other hand, these skills would also support their competence to participate in the technology development process. Paramedics' roles in technology development can be anything from innovating to consulting and from user testing to being implementation specialists [2].

Some research on healthcare technology development among nurses, in general, exists. However, the pre-hospital emergency medical care point of view is under researched. The working environment of paramedics is becoming more technology-oriented, and employees are increasingly required to understand and know how to combine technology and nursing. The need for a technological skill set among paramedics and the specific skills essential for organisational innovation should be examined [2]. Therefore, the aim of this study was to determine the roles Finnish advanced level paramedics identify for themselves within technological development processes in their experience and what kinds of technological development in pre-hospital emergency care are needed. The research questions were: 1) what possible roles and barriers do advanced level paramedics recognise for themselves in technological development processes, and 2) what kind of technological development do advanced level paramedics consider necessary in the field of emergency care?

2. Materials and methods

2.1. Description and data gathering

A qualitative approach that utilises written texts was chosen for the current study to allow a deeper insight into a scarcely studied phenomenon regarding paramedics' experiences of technological development [12,13]. The participants of this study were experienced advanced level paramedics (n = 20) who had studied for a Master's degree in development and management of EMS in South-Eastern Finland University of Applied Sciences during the spring of 2021. South-Eastern Finland University of Applied Sciences granted a research permit for the study.

The paramedics wrote essays based solely on their own thoughts regarding their role and relationship with technology and technological development in prehospital EMS. The essays were part of the course 'Current Issues in EMS Management'. This is particularly topical due to the ongoing national-level technological reforms in Finnish EMS [14,15]. Although the essays were part of the studies, they were not graded so that the pursuit of a specific grade does not affect the nature of the research material. The design of the essay assignment (Appendix A) was a collaborative effort of the second and last authors. The second author is an experienced researcher in the fields of information systems and human–computer interaction. The last author is an experienced researcher in the fields of EMS and occupational wellbeing and the head of the Master's degree program in question.

The last author informed all the participants about the study and data protection. According to Finnish legislation and the guidelines from the Finnish National Board on Research Integrity, an ethical review was not required for this study, which involved neutral subjects and adult participants who did not belong to a vulnerable group [16]. The participants had the option to withdraw their essays from the study. When writing, the participating paramedics were aware that a researcher with a background in emergency care would analyse the material under the guidance of the second and last authors. The first author had not been named at that stage. The first author, who was selected as the researcher in question, did not have a close acquaintance with these paramedics. All the participants gave their informed consent to use their essays for research purposes. Prior to the analysis, the last author removed names, locations, titles, and layouts from the essays, forming a single document of 87 pages, in which each essay was identified only by a serial number. After this, the writer could no longer be identified from the essays. The study followed the good scientific practice defined by the Finnish National Board on Research Integrity [17].

The participating paramedics, 50/50 % women and men, were from urban and rural areas of Finland. The average age of the participants was 34.5 years.

2.2. Analysis

The data collected for the study was analysed using the inductive content analysis process [12] in order to facilitate the quantification of the data. An inductive approach was selected because there is a relatively small body of literature that is concerned with the subject of this study [18]. The analysis began with the first author, a research-oriented, experienced advanced level paramedic, reading the material several times. After the familiarisation phase, the words and phrases answering the research questions were marked separately in two colours. The marked phrases were separated from the material and grouped into subcategories, which were synthesised into upper and main categories. The second author participated in guiding the analysis from this stage on and did not handle the original data. All three authors had an ongoing discussion on the categories formed throughout the analysis phase. In the results section, the number of paramedics who wrote content classified

into different sub-categories in their essays is reported.

3. Results

3.1. What possible roles and barriers do advanced level paramedics recognise for themselves in technological development processes?

Three main categories were identified as an answer to the first research question ("What possible roles and barriers do advanced level paramedics recognise for themselves in technological development processes"): identified direct roles, identified indirect roles, and barriers to participation (Table 1). The main categories consisted of ten upper categories, composed of fourteen sub-categories.

3.1.1. Identified direct roles

The paramedics identified several direct roles in technological development processes. The expertise the paramedics gained through their daily work enabled them to see themselves potentially acting as a lived experience expert (n = 5) or a clinical expert (n = 17) in relation to technology development. The following extracts from the data illustrate this aspect:

> '(…) paramedics could be more involved in the development of first aid equipment technology. The best role for a paramedic (…) would be an expert role because the user experience and need for use are the greatest in the field, precisely with the employees at the "grassroots" level. In each project, each paramedic's own competence and substantive knowledge should also be introduced (…).' (Participant 6)

The paramedics' content of work could be linked to the experimental and final use of technological innovations. Both the experimental use of new technological innovations (n = 2) and the end use of existing technologies (n = 16) were combined with the competence of paramedics to report trial experiences. The following extract from the data illustrates this:

> 'In my experience, the best technology tester is a healthcare professional who uses the equipment in their daily work, which recognises the working and developmental features of the equipment.' (Participant 15)

One of the direct roles was also identified as emerging from the area of special expertise. These included responsibilities related to the use of ICT, such as the patient information system (n = 3) and the role of an EMT as an equipment manager at the workplace (n = 6). The following quotation explains this aspect:

> 'At the moment, at least in my own organisation, there is a device manager who acts as a contact person between the device manufacturer and the paramedics. There is no direct contact with the device manufacturer, so the role of the device manager is important in order to get the message from the field to those parties who can change things (…).' (Participant 2)

Table 1
Findings related to the first research question.

Main categories	Upper categories
Identified direct roles	Roles related to expertise gained from work experience
	Roles enabled by the content of work
	Roles related to one's expertise
Identified indirect roles	Supporting the implementation of technological innovations
	Working with medical device manufacturers
	Specialist advisory role
	Proactively supporting technology development
Barriers to participation	No role in development process
	No needed competence for participation
	Only personnel in a special position can participate

3.1.2. Identified indirect roles

The paramedics identified potential indirect roles for themselves in the technology development processes. Paramedics could support the implementation of new technological innovations in their own work, for example by training others in the use of new technologies (n = 4). Further, the paramedics were considered to be good subjects for research due to their interest and strong professional skills (n = 6). The following extract from the data illustrates this view:

> '…various studies, such as user experience, pilots and testing, are one of the biggest ways in which paramedics can participate in the development of technology in their work, or in general, the introduction of new technology in pre-hospital healthcare.' (Participant 5)

Support for technological development may be based on initiative. The paramedics considered themselves to be experts in their field. They felt that their expertise could be used, for example, for ideas for development needs based on their own initiative ideas (n = 15). The following quotation from the data expresses this sentiment:

> 'Together with other professionals, paramedics could design applications and tools to be used or tested. They could provide important and reliable information about their functionality during the pilot phase. During the testing, you would also receive information from them on how these tools could be developed or improved so that all the benefits could be used.' (Participant 3)

The paramedics could support technological development on their own initiative by identifying development needs for technology and thus making use of their own work expertise (n = 5).

Additionally, paramedics could have a role in collaborating with emergency care equipment manufacturers and acting in various expert tasks related to technologies developed for emergency care. One example of this was expressed in the following quotation from the data:

> 'The role of the paramedic is to bring up problems for which a technical or IT application could be developed to improve the operation, or, on the other hand, to give feedback to help the further development of the products.' (Participant 11)

3.1.3. Barriers to participation

The paramedics identified several barriers to participation associated with the technology development processes. They saw their opportunities to participate as limited, and the awareness of these opportunities, the existing technology, and its usability in emergency care were also felt to be limited. One participant felt that the training of paramedics did not provide competence for technology development (n = 1). The extract from the data below illustrates this view:

> 'I feel that paramedics currently have limited opportunities to participate in the development of technology required for their work. Their influence on the technology already in use and what will be acquired in the future is quite limited. The problem is that we don't know what technology already exists and how it could be utilised in emergency care (…). (…) In my opinion, the basic education of a paramedic does not provide sufficient competence for technology knowledge and skills.' (Participant 1)

Moreover, paramedics may not be given the opportunity to participate in technological development even if they have the knowledge or enthusiasm to do so (n = 9). One obstacle to participation in technology development was that the roles are given only to those in special positions rather than to those at the grassroots level. Managers (n = 2) and specialised units (n = 2), such as field supervisor units and emergency physician units, were considered to be in a special position in terms of roles. The following data extract illustrates this view:

'In the field supervisor and physician units, I think the opportunities are better because new nursing devices and research equipment are acquired more frequently for them, and thus they are better informed about what kind of opportunities are available and what is being developed.' (Participant 4)

3.2. What kind of technological development do advanced level paramedics consider necessary in the field of emergency care?

Three main categories were identified in answer to the second research question (What kind of technological development do advanced level paramedics consider necessary in the field of emergency care?): ICT/software related development needs, general pre-hospital emergency care technology-related development needs, and equipment/hardware related development needs (Table 2). The main categories consisted of nine upper categories formed from 21 sub-categories.

3.2.1. ICT/software-related development needs

The paramedics considered the development of national electronic patient information systems as an important part of the development of the information network. As part of this, an electronic emergency medical report (n = 2) and remote access to patient information systems (n = 9) were requested. In addition, mobile applications to manage patient information systems would be welcome (n = 2). Integrated systems would support faster and more efficient decision-making in the field. These options would improve patient safety as paramedics would have reliable access to updated patient records. The paramedics would also like to develop the use of video communication between the field and the hospital (n = 6). These could be used to transmit a situational picture from the field to hospitals. The following quotation from the data expresses this view:

'The weakness in information flow is often a major problem, especially in non-urgent emergency care missions. It would be great if there were a national patient information system that paramedics could easily access to obtain the patient's entire treatment history, especially regarding their previous illnesses, medications, physician visits, and home care notes.' (Participant 3)

Emergency care multi-authority mission management systems should be developed. The national emergency care field supervising system (n = 3) and other applications supporting situation management (n = 2) emerged as solutions. For example, a national system would help to standardise the content of emergency care mission messages received from the emergency centre (n = 1). The quality of multi-authority communication could also be improved through technology (n = 1), for example, using the 5G network (n = 3). The extract from the data below explains this view:

'The 5G network is marketed as fast, reliable, and secure. I would understand that safe also means information security. Therefore, the processing of patient data on the 5G network would also be safe. (…) I mentioned video consultation calls above. In addition, in the future, I would like to see a camera integrated into the work clothes of paramedics, which can be used to film the task environment and the patient, for example, for the use of physicians, rescue authorities, social authorities, police or hospitals.' (Participant 16)

The paramedics highlighted the need to develop technology to facilitate patient work, decision-making and diagnostics. They hoped that in the future, they could make more use of artificial intelligence and algorithms in their work (n = 6). Applications that reduce memory-dependent actions should be developed (n = 3). In addition, technology supporting guidance to treatment should be developed (n = 2). For example, one of the participants explained:

'What I would like is any kind of support that reduces memory-based functions and supports treatment. One example of this is the electronic patient record system, which is finally coming to our work unit as well. (…) Could artificial intelligence perhaps give support in identifying, for example, rare disease states and emergency situations that are otherwise difficult to recognise?' (Participant 17)

3.2.2. General pre-hospital emergency care technology-related development needs

The paramedics identified the need for improvement of national pre-hospital emergency care. A national development system should be compiled (n = 2), and cooperation between different emergency medical organisations should be improved for the national-level development of emergency care (n = 3) instead of small local development projects. The following extract from the data illustrates this perspective:

'The thought arises, as to whether it would be possible to build a system in Finland that would collect both information and development targets in the field of primary care from the entire country? This would partly clarify the development needs, and this could be utilised in the direction of the technology pre-hospital care, and possibly, also in unification.' (Participant 19)

The paramedics believed that technological development in support of the quality and safety of nursing work is needed. Technological innovations were considered needed, for example, in relation to the safety of medical treatment, the measures taken by paramedics, and the ergonomics of pre-hospital emergency care. Development work should be employee-oriented and specifically respond to the needs of a grassroots paramedic. The quotation below reflects this aspect:

'(…) the introduction of all kinds of checklists, specifically using technology as an aid. The fact that, for example, a resuscitation protocol could be integrated into the electronic patient record, which would work well simply by clicking on icons, would increase patient safety and reduce forgetfulness and, for example, medication dosing errors. Such an application could also automatically fill out the first aid report, recording the procedures performed and the medical treatment given with time stamps.' (Participant 20)

The training for pre-hospital emergency care was also highlighted for technological development. The training should be modernised by developing existing technologies (n = 3). Additionally, the use of virtual reality was considered a noteworthy development in the field of training (n = 5). The quotation below expresses these views:

'The use of virtual technology in healthcare seems to be the "thing" that is being developed and applied to emergency care as well. (…)

Table 2
Findings related to the second research question.

Main categories	Upper categories
ICT/software related development needs	Development of national electronic patient information systems Development of management and multi-authority mission systems Development of technologies supporting patient work, diagnostics, and decision-making
General prehospital emergency care technology-related development needs	Development of technological development processes of national emergency care Technological development in support of the quality and safety of nursing work Opportunities for digitalisation in education and training Employee-based orientation
Equipment/hardware related development needs	Technological development of emergency care equipment Development of technologies to support security and safety at work

Also, developing some kind of virtual application e.g., learning purposes would be very interesting and necessary.' (Participant 15)

3.2.3. Equipment/hardware related development needs

According to the paramedics' experiences, the equipment for paramedics should be developed. The paramedics thought that some of the equipment in use was outdated, meaning that the technological reliability of care equipment should be improved (n = 4) and automation developed (n = 6), specifically related to transferring data between care equipment and the remote monitoring of various indicators (n = 9). Data transfer between equipment could make patient monitoring and recording of data smoother and more reliable, as the quotation below outlines:

'I am particularly interested in wireless data transfer and its development. Now, from the defibrillator, information can be transferred wirelessly to, e.g., the physician's e-mail and Merlot Med. I would like to be able to develop the defibrillator's wireless data transmission, specifically from the patient to the device. Today, measuring blood pressure and saturation, as well as taking rhythm and ECG, require wireless transmitters from the patient to the defibrillator (…).' (Participant 16)

Safety-thinking emerged in the development needs. The paramedics identified the need for technological development in occupational safety. Technology supporting road safety and emergency driving should be developed (n = 4). From the perspective of safety at work, especially portable safety innovations, such as carriable body cameras, could be developed for the use of paramedics (n = 5), as the following quotation from the data describes:

'I would like to see more predictive properties for vehicles to support driving. Cars could contain technology that would tell newer cars and oncoming vehicles that an emergency vehicle is approaching. I would also like to see technology in support of our security in the near future. What would be the most reasonable solution to this is a slightly tricky problem. Of course, cameras are an opportunity, but in the shadow of privacy, they should only work in situations where we feel threatened, and we would press the cameras to record.' (Participant 10)

4. Discussion

This was the first study examining the roles and barriers that paramedics find for themselves in relation to the development of such technology that would support their work and the technological development needed in the field of prehospital emergency care. The results of this study revealed that paramedics identified direct roles for themselves at all stages of technological development, starting with innovation, continuing to design, consultation and acting as expert consultants, for example in the experimental use and reporting of technology and further development.

The need for technological development in the field of pre-hospital emergency care was strongly highlighted by the need for nationwide development. The paramedics who participated in this study hoped that ICT and nursing technology related system reforms would have at least a national impact to ensure a homogeneous EMS throughout Finland. It was felt that national patient information and recording platforms and multi-authority applications were the future and would enable better quality and safer pre-hospital emergency care work.

The development of technological solutions in the health sector is challenging due to heterogeneous user groups and highly diverse needs [19]. The involvement of users in technological development is a part of the modern technology development process. It has been identified as the best way to develop areas such as healthcare information technology [20,21]. In the development process, it is good to involve the end user group as early as possible [22]. To achieve a successful and user-friendly outcome, end users can also act as expert consultants by sharing their experience in the process [23]. This study showed that paramedics saw roles for themselves, in particular in supporting implementation in the form of training and various responsibilities related to emergency care technology. Further, the paramedics saw roles for themselves with the service of equipment and with technology manufacturers, for example, in various expert or consultant positions. The findings reflect previous understandings of the possible and desired roles of paramedics [2].

Based on the literature, participatory planning can provide roles for people who do not have the training or special skills in development work [24]. Co-design thinking sees all end users as valuable pieces of the process, and the developer is responsible for building a clear task description for all participants [25]. This study showed that paramedics also experienced direct obstacles to their participation in technology development. Some paramedics felt that they had no role in the development work. Others could see roles, but felt that the employer would not allow their participation, or that basic education would not enable development. Further, the literature supports the idea that within the development process, designers may, in making compromises, see the role of expert consultants as rather limited [19].

The fifth-generation mobile technology (5G) will significantly impact data transfer. 5G will help paramedics to access databases faster and more seamlessly. The paramedics' ability to lean on data while making diagnoses and decisions will get easier with better connections. Additionally, communication with other authorities and hospitals will be more reliable and smoother [6]. The results of this study indicate that paramedics found this to be a major issue in Finland. Paramedics operate in challenging settings all over the world. Finland is sparsely populated, with thousands of lakes and forests where distances between hospitals are long, often resulting in long transportation distances. Patient safety must be guaranteed by minimising most of the adverse events and errors. For example, by minimising the risks of technological malfunctions in challenging locations, functional data and patient record systems can aid paramedical decision making [6,26]. In this study, paramedics expressed a desire to develop technological solutions to improve patient safety for example by integrating check lists and treatment algorithms in patient record systems.

5G technology also offers new opportunities to improve the connectivity and reliability of equipment. The new generation of data transfer enables the processing of increasing amounts of data on mobile devices reliably and helps patients participate in the monitoring of treatment [27]. In the current study, the paramedics explicitly felt that there was a pressing need for development and that the reliability of the equipment should be improved. Another finding was the construction of functional network connections for pre-hospital emergency care. In the experience of the paramedics, the smooth use of patient information systems and recording platforms was dependent, for example, on the functioning of mobile data connections. Finland is currently moving towards a nationwide 5G network to provide the authorities with functional communication connections even in the event of congestion [28].

The results of the current study highlighted the will of paramedics to develop their own education by means of digitalisation. Paramedics face a continuously changing work environment and operate under random external factors with little fault tolerance. Simulation technology is under continuous development and is an important way to teach and learn paramedicine related phenomenon [29]. Virtual Reality (VR) is one of the commonly used technologies, but studies show that it needs to evolve before students can fully benefit from all its abilities [30]. Simulations allow paramedics to practice the skills and protocols they need in their work. The simulations aim to enable the student to have as realistic an environment as possible. By developing simulation technology, the learning experience and the learning environment will be brought closer to reality [29,30].

The implementation of new health technologies is a challenging and

time-consuming process. When implementing new technologies, it is important that the target organisation is in close cooperation with the technology developer [31]. The urge to implement emerging technology is strong, yet modern tele-medical technologies lack evidence of impact and further studies are recommended [32]. In light of the results of this study, it would be advisable to explore the possibility of linking technology development modules to the education of paramedics. It would be important for schools to contact equipment manufacturers and take advantage of student development interests, for example through thesis work. Overall, nurses who understand both healthcare and technology are lacking in the system, at least in the education system. The EU directive on training programmes for nurses for general care makes no mention of technological skills [33]. It will be important in the future to educate nurses who also have technological innovation capabilities [34]. Contacts and cooperation networks formed by students will be transferred to working life. Additionally, it would be useful to have similar research carried out in the opposite direction and to identify the possible roles that technology manufacturers see for paramedics in technological development processes.

4.1. Methodological considerations

The participating paramedics were experienced, had completed a bachelor's degree, and voluntarily enrolled in a master's programme. Although the target group consisted of students, they can be considered experts in their field. The target group can be described as aware, reflective, and interested in developing EMS, and thus may constitute a different group from Finnish paramedics in general. The material consisted of 20 insightful essays, which is a sufficient number for qualitative research.

Conducting content analysis is challenging and requires special precision, objectivity, and self-reflection from the researcher. The research process itself does not necessarily rely on a certain pattern, and there is a division between researchers in the implementation [35]. This study sought to achieve rigour by maintaining a precise, accurate and thorough working method. The interdisciplinary study group discussed the results intensively, and the analysis was constantly reviewed. The analysis was carried out in accordance with good scientific practice [17].

The reliability of the research results is demonstrated by the saturation of the research material towards the end. The research material was relatively extensive, and the participants had written profound essays. Some essays showed the author's personal interest in technology, but on average the results of this study could be interpreted as giving an impression of the experienced Finnish paramedic's mindset regarding this topic. The work of paramedics is similar in other Nordic countries and the results can also be transferred and utilised, at least between the Nordic countries.

A number of direct quotations from the research material were used to support the reliability of the research results. The research material was written in Finnish, and the analysis was also carried out in the original language. The results and quotes were translated into English at the end of the reporting phase. Thus, the linguistic expression of the description of the results remained both richer and more credible.

4.2. Conclusions

This study found that paramedics saw several roles for themselves in technology development processes. The roles could be applied to innovation, development, further development, feedback, and implementation. The paramedics also experienced obstacles to participation based on the employer's activities and due to a lack of specific training and know-how. The paramedics also highlighted the importance of the national patient information system for patient safety and the smooth functioning of work. New 5G network based technological innovations were expected to create new opportunities for more accurate diagnosis and communication between different authorities. Data transfer between different devices was also seen as an important development. There was also a desire to focus technology development on safety at work.

In the future, training for paramedics must be increased in the fields of technological competence. The working environment of paramedics has become surrounded by technology, and paramedics are active technology developers and innovators. Paramedics should also be more involved in technological development. On the basis of this study, organisations should see paramedics as a development resource and harness their specialist expertise in their field to develop their work. One area for further research from this study is to identify what kind of roles technology developers see for paramedics in technological development processes and compare the results with the results of this study. Another area would be to identify what kind of technological know-how is important to apply to the training of paramedics.

CRediT authorship contribution statement

Tuomo Rinkinen: Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Marianne Kinnula:** Conceptualization, Writing – review & editing, Supervision. **Hilla Nordquist:** Conceptualization, Formal analysis, Writing – review & editing, Supervision.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ienj.2024.101406.

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