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# How to improve communication using technology in emergency medical services? A case study from Finland

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## Abstract

The field of emergency medical services (EMS) is a challenging environment for ensuring fluent information exchange between stakeholders because several different kinds of organizations are involved in EMS missions. Solutions for information and communication technology can vary significantly depending on the organization. This study aims to identify current communication bottlenecks between EMS professionals, understand the technological challenges behind them, and describe technologies that can improve EMS communication in the future.

Information for the study about current EMS processes, technologies, and technology needs was collected from EMS professionals during three workshops, five personal interviews, and one email questionnaire. All surveyed health care professionals were working in the county of Northern Ostrobothnia. Information about proposed technologies for EMS was obtained from literature and interviews with five technology companies.

The principal problem in EMS communication is scattered health data. This leads to a lack of common situational awareness for professionals and incomplete medical histories for patients. The reasons behind those problems are different information systems which do not communicate with each other and the lack of a common electronic patient care record for use by stakeholders. National projects have been launched in response to these problems, but further development is needed to ensure that all information needed for decision-making can be deployed effectively. Personal health measurements, sensors, telemedicine, and artificial intelligence will create opportunities for further improving the flow of communication, provided those tools can be integrated into decision-making systems.

**Keywords:** emergency medical services, electronic health records, personal health records, artificial intelligence

## Introduction

Healthcare services in Finland are broadly divided into primary health care and specialized medical care. Municipalities are responsible for organizing primary healthcare services by offering local health centers, which are typically citizens' primary contact for healthcare services. Specialized medical care is the

responsibility of hospital districts, which also oversee emergency medical services (EMS) in their respective regions. [1] Several stakeholders, such as emergency response centers (ERC), rescue departments, EMS, and on-duty care providers, are involved in communications during EMS missions in Finland [2].

There were about 700,000 EMS missions in Finland in 2015, two thirds of which were classified as non-urgent [3]. Between 2012 and 2014, the number of EMS missions increased by 1.3% to 8.5% depending on the district surveyed, and the annual total was 30–40% higher than that of other comparable countries [3,4]. In Northern Finland, 40% of EMS missions did not result in ambulance transport, and no medical treatment was indicated for one third of non-transport patients [5]. For these reasons, there is a need for processes and technological solutions that can more accurately determine the urgency of EMS missions. Potential ways to reduce the number of non-emergent EMS missions is to improve the dispatch process and provide better access to patients' medical histories [6].

The Finnish national EMS survey underscored the need for a national data repository to provide reliable operational data to EMS stakeholders, from which a good basis for data management can be created [3]. In response to this need, the common field command system for authorities (KEJO) was established to overhaul the information exchange process. The main goal of KEJO is to enable close cooperation and situational awareness between all EMS stakeholders. In EMS missions, the main document in which to record patient data (e.g., vital signs, medications etc.) is an electronic patient care record (ePCR). The key to achieving fluent information exchange is to provide ePCR access to all EMS stakeholders, regardless of location. Under the KEJO system, ePCRs are stored in the Patient Data Repository within Finland's Health Information Exchange (HIE) and are therefore accessible to all EMS personnel. The primary aim is to eliminate duplicate recording of patients' health data by providing consultant physicians direct access to ePCRs. [7] According to the latest information, the introduction of the KEJO system will happen during the year 2020 [8].

The aim of this study was to find technological solutions to improve the flow of communication in EMS. The main aims of the study were as follows:

1. Identify current communication bottlenecks between EMS professionals and understand technological challenges behind them.

2. Describe new technologies that could improve EMS communication in both the short (within three years) and long term (over three years).

## Material and methods

The research concerning the perspective of EMS professionals was conducted in the county of Northern Ostrobothnia, which was the fourth largest county in Finland in the year 2017, with a population of 411,856 [9]. To place this into the perspective of national provision of EMS, a short description of stakeholders is presented here. There are six ERCs in Finland that are responsible for the dispatch of EMS units [10]. Paramedic field supervisors have a role as both operative on-duty leaders for EMS and medical incident commanders [11]. Arranging on-duty care services is the responsibility of municipalities and hospital districts and the 24-hour on-duty service is provided in conjunction with major health care centers and hospitals [12]. Finnish helicopter emergency medical services (FinnHEMS) is responsible for arranging helicopter emergency medical services (HEMS) [13]. However, HEMS doctors also provide telephone consultations for EMS units in critical conditions. In non-critical situations, EMS units consult the doctor in the nearest hospital or health care center.

The information from the professionals was collected during three workshops held during January and February of 2017, five structured interviews held in March and October, and one email questionnaire done in February. The data on information and communication technology (ICT) solutions used in EMS units (ground ambulances) was collected from key personnel of Oulu-Koillismaan's Department for Rescue Services using a structured email questionnaire.

The aim of the workshops was to deepen the understanding of EMS processes and technologies and to collect ideas for future improvements. In the first two workshops, the participants (6+2) consisted of emergency care specialists and on-duty care specialists from the Northern Ostrobothnia Hospital District. In the third workshop, six key personnel from the Oulu City Consortium and the Hospital District participated.

The aim of the personnel interviews was to collect specific information concerning the ICT solutions used in the participants' daily work. Three paramedics, one physician from the on-duty care unit, and one EMS physician participated in the personal structured interviews.

The information related to current and future technology solutions for EMS was obtained from five structured interviews conducted with technology companies and from literature review. The interviews were conducted during April and May of 2017. The interviewees' job titles ranged from technology specialists to project managers.

The objective of the literature review was to find state-of-the-art technologies and future technology solutions from an EMS perspective within the following areas: EHRs, telemedicine, personal health measurement, wireless technologies, IoT, and analytics for healthcare. The data was gathered mainly from ScienceDirect, IEEE Xplore, and Oulu University Library databases, as well as the web pages of the Finnish authorities. The key words for search were: KEJO, ERICA, UNA, Apotti, ensihoito, Kanta, openEHR, analytics healthcare, IoT healthcare security, IoT healthcare interoperability, My Data, 5G healthcare, LTE Public Safety and VIRVE. The number of selected documents was 124, of which 27 were journal papers, 77 were reports, 10 were conference proceedings, six were theses, four were books, and 32 were webpages. The documents and webpages were categorized according to the themes that emerged in the interviews and workshops. Documents were selected to only include those relevant from an EMS and Finnish national perspective. There was no theoretical framework for selection criteria, but the aim was to find essential discussion perspectives and acute needs for development, as well as to identify future trends.

The collected information was analyzed manually using qualitative methods. Current communication bottlenecks and the technologies behind them were identified based on the analysis. Short- and long-term technology solutions that are intended to improve the flow of communication were presented in the final phase of this study.

### *Ethics*

The interviewees were asked to consent to the research and were informed about the use of the data.

## Results

### *ICT solutions currently used in EMS in the Northern Ostrobothnia Hospital District region*

Based on personal interviews, email questionnaire, and workshops, the study identified four different kinds of in-hospital information systems, three different kinds of pre-hospital information systems, and one national database for information exchange in use in the Northern Ostrobothnia Hospital District region.

According to the personal interviews, *electronic health records (EHR)* are used primarily by the personnel of on-duty care units and consultant physicians in hospitals. Oulu University Hospital (OUH) and the on-duty care unit at OUH currently use an EHR named ESKO [14]. HOITU, an electronic nursing platform, is used by the on-duty care unit of OUH and is an extension of the ESKO product family [15]. Based on information from on-duty care personnel, the administrative registration of patients is done using a Uranus Oberon patient management system [16]. Effica is the main EHR brand used in municipalities in the Northern Ostrobothnia Hospital District region [17].

*Kanta Services* is the National HIE service for Finnish citizens, healthcare providers, and pharmacies. It includes electronic prescriptions, a pharmaceutical data-

base, “My Kanta" pages, and the Patient Data Repository. [18]

The *FinnHEMS* database is used to record urgent EMS missions and telephone consultations where HEMS doctors are involved [19]. According to the EMS physicians, the stored information includes the patient's prerequisites, vital signs, and care instructions, and information about the EMS unit requesting consultation. The system supports structured recording, which is crucial during a consultation phone call.

*Merlot Medi* is the system used by paramedics to create and record ePCRs [20]. According to the interviews and workshops, ePCR is available in electronic format for paramedics only; others parties can receive only a printed copy. Based on information from rescue departments’ personnel, the system supports automatic transfer of certain vital signs (e.g., EGC, blood pressure, and oxygen saturation) via wireless local area network (WLAN) link from a defibrillator/monitor to ePCR. Sending electrocardiography (ECG) directly to cardiologists in electronic format is a special case. It can be performed using Bluetooth and a mobile data connection. Data from previous EMS missions are available from the Merlot Medi database only to paramedics.

According to the interviewed paramedics, the vehicle-mounted computer PEKE features an integrated global positioning system (GPS) receiver and an administrative security radio network (VIRVE) modem for EMS units. All EMS missions are sent via wireless VIRVE data connection to PEKE by ERC, and then the EMS unit acknowledges the assigned task.

Based on information from EMS professionals, wireless communication is performed using Global System for Mobile Communications (GSM) and VIRVE phones. The VIRVE network, based on terrestrial trunked radio (TETRA) technology, is the foundation of wireless speech communication among authorities in Finland [21,22]. According to the interviewed EMS professionals, prior notification to hospitals for urgent tasks and calls to consultant physicians are handled mainly with GSM phones. All other tasks are handled with VIRVE phones.

Figure 1 presents the current flow of communication between stakeholders using ICT solutions in EMS in the Northern Ostrobothnia Hospital District region.

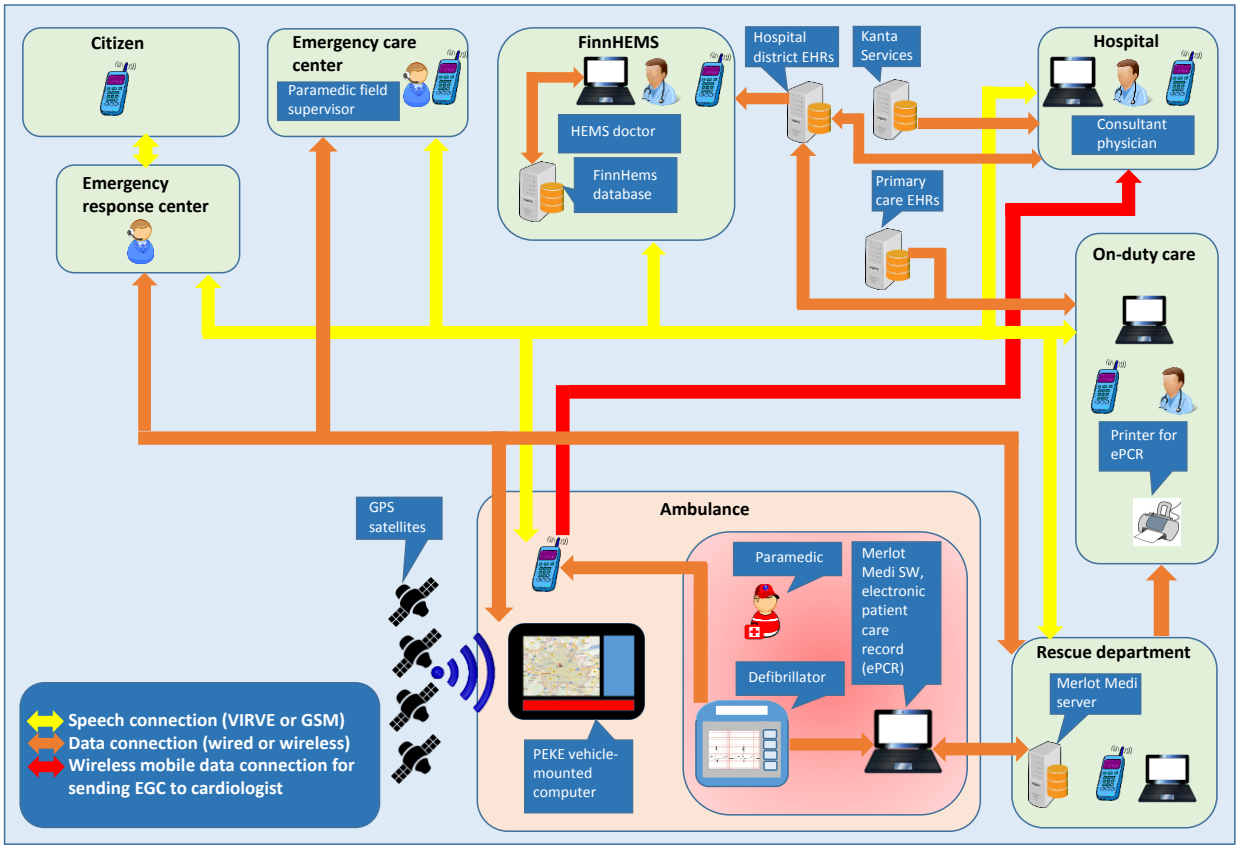


**Figure 1.** The current flow of communication between stakeholders and used ICT solutions in EMS in the Northern Ostrobothnia Hospital District region.

***Information flow bottlenecks and needs for improvement for the future***

Based on workshops and personal interviews, the following issues have emerged as the main constraints on information flow and needs for improvement for the future (Table 1).

**Table 1.** Information flow bottlenecks and needs for improvement for the future.

| Issue | Description |
|---|---|
| Several ICT systems | • Information about the patient is located in many databases.<br>• Not every stakeholder can access all the needed systems.<br>• Systems don't support single sign-on.<br>• The systems don't communicate with each other.<br>• The medical history of the patient is incomplete and is not up to date. |
| Information only in paper format | • The ePCR is available in electronic format to only to paramedics.<br>• ECG can be delivered to electronic format only to the cardiologist. |
| Data is transmitted orally | • There are possibilities for misunderstandings, and the system is time consuming when doing the prior notification orally by using GSM-phone.<br>• The interviewees wish that the prior notification could be performed electronically by pressing only one button. |
| Double records of the patient | • The consultant doctor makes the same records as in the ePCR to their own organization's EHRs.<br>• When the patient is registered to on-duty care unit, the same things are recorded twice because only a paper copy of ePCR is available.<br>• It is not possible for the consultant physician to enter records directly into the ePCR. |
| No access to EHRs in the field | • EMS physicians and paramedics have no access to primary care and hospital district EHRs in the field.<br>• The current systems don't support wireless access. |
| The patient vital signals from the field cannot be accessed | • The patient's vital signals are stored to the ePCR of the Merlot Medi, which is visible in electronic format only to rescue departments. Other stakeholders can only get paper copies.<br>• At the moment it is not possible to send vital signals to a consultant physician in real time. |
| Clear common situation view is needed | • There may be many cases ongoing at the same time, so better visibility is needed to understand the urgency. |
| Better use of home care and patient's own health measurements | • Currently, the measurements are not used systematically.<br>• The measurements could be a part of the patient's medical history. |
| There is no real-time visibility of the patient and the EMS mission | • With video, the consultant physician could more easily evaluate the patient's healthcare needs. For example: stroke, need for advanced analgesics or anesthesia, respiration problems, need for non-invasive ventilation etc.<br>• The color of the patient can indicate the severity of their condition, and in a critical situation, live video helps with triage. |
| The possibility of combining the history of citizen's personal records from ERC, Rescue department, social and health service databases is needed | • High-risk cases can be better identified (e.g. the patient may have a certain disorder that requires urgent treatment).<br>• To sort out the cases, which do not in practice need EMS. There could be people who call ERC several times a year with no real need for EMS. In these cases, the person in question can be guided to social welfare services. |

***Technology solutions***

The information related to technological solutions was mainly collected from literature review. The interviewed technology companies typically had solutions for personal health measurements, analytics, and telemedicine applications, so their offerings are more applicable to long-term communication solutions.

***Finland's ongoing projects to improve information exchange in the healthcare sector.***

Better availability of ePCRs to all stakeholders will be possible when the KEJO system is introduced. The current field command system for Finnish police, as well as the current PEKE, Codea, and Merlot Medi field systems, will ultimately be replaced by KEJO [7,23]. The data repository and archive location of ePCRs in EMS will be the Patient Data Repository of Kanta Services. In addition, KEJO is able to display all patient record documents saved in the Patient Data Repository to EMS personnel. KEJO allows for all stakeholders to add notes to the same record if they are working within the KEJO system, which will eliminate the need for double recording. If the consultant physician is not using the KEJO system, then paramedics can save the ePCR as incomplete or use a versioned format in Kanta Services, which allows the consultant physician to see the patient's information. Then care instructions can be provided through another system like GSM or VIRVE phones. [7]

Better information exchange between ICT systems will be needed in the future. This is true for all Finnish social and healthcare organizations, not just EMS [14,24]. For that reason, the national-level UNA project was created to ensure that future social and healthcare ICT systems provide up-to-date information that is seamlessly available to all stakeholders [25]. The project includes eighteen hospital districts and seven cities [26,27]. It will be based on a modular architecture supporting supplier-independent connections to the UNA kernel. The key functions of the kernel will be customer relations and operations management. Patient information from primary care and hospital district organizations, as well as from private sector service providers, will be transferred to the UNA kernel through Kanta Services, and from there it can be forwarded wherever necessary. [25,27] The UNA kernel procurement process was started at the end of 2017 [28]. Another approach to providing future ICT solutions is the Apotti project, which includes the hospital district of Helsinki and Uusimaa (HUS) together with five nearby cities [29]. Apotti will also support modularity; however, its approach is different than that of the UNA project because a company called EPIC will implement the system to all the stakeholders inside the Apotti consortium [29].

***The technological solutions to improve information exchange in EMS in the long term.***

Wireless broadband services are needed for real-time transfer of vital signs, real-time video feeds, and fluent mobile use of EHRs [30,31]. The highest data rate requirements for sending vital signs is 15kbit/s, so 2G transmission speeds are sufficient for that purpose [32-34]. A real-time video stream (HD720i) needs 3-4Mbits/s, a transmission speed that in practice requires 4G network coverage [35,36]. The current wireless VIRVE network does not provide high enough data rates for all requirements even with upcoming TETRA enhanced data service (TEDS) enhancement [21,37]. A potential solution could be to use voice communication over the VIRVE network and utilize commercial networks for broadband services alongside VIRVE. Future commercial networks like Long Term Evolution (LTE) Public Safety, which offers Private Mobile Radio (PMR) features, could develop more permanent wireless solutions [38,39].

Better utilization of citizens' self-disclosed health data can be accomplished by using people's own health measurements either as part of their medical histories or for remote monitoring of their health status. The feasibility of this approach grows each year as the number of personal health measurement devices and applications increases [40]. However, professionals need ready access to these measurements if they are be used in urgent EMS situations. Typically, health measurement devices store data on manufacturers' own cloud services, which can create challenges for

EMS personnel who need to access the data. In Finland, Kanta Services will administer the Personal Health Record (PHR) database for storing citizens' own health measurements in the future [41]. Social and healthcare professionals will be able to check those measurements, provided they have a professional application authorized by PHR, the patient's consent, and an established treatment relationship [41].

Better analyzed and personalized health data can be provided to EMS professionals using artificial intelligence (AI) solutions. AI can help in forming an overall picture of the citizen's health profile by combining and analyzing the data from EHRs, social departments' ICT systems, sensors, and health measurement devices. The aim is to sort out which citizens really need EMS, predict diseases, and react early enough if something critical happens. [42-44] If predictive analytics can show that a citizen's health risk level is rising, a physician can recommend at-home care and start appropriate treatments before something critical happens [45]. The analyzed data can also show when a citizen does not need EMS and should instead be guided to social welfare services for the help they need [46]. Automatic alarms can be generated using AI and sensor data to activate EMS as early as possible [47]. A practical example of using AI can be triage based on large-scale EHR data. [48].

Figure 2 presents a vision for future technologies and flow of communication in EMS. In this figure, as compared with the current situation, more information is available to all stakeholders even with a mobile connection. Information exchange between different kinds of information systems works seamlessly. KEJO terminals connect to Kanta Services through the Turvaväylä (TUVE) network [7]. Analytics can combine analyzed data from several different sources and provide it to all stakeholders who need it.

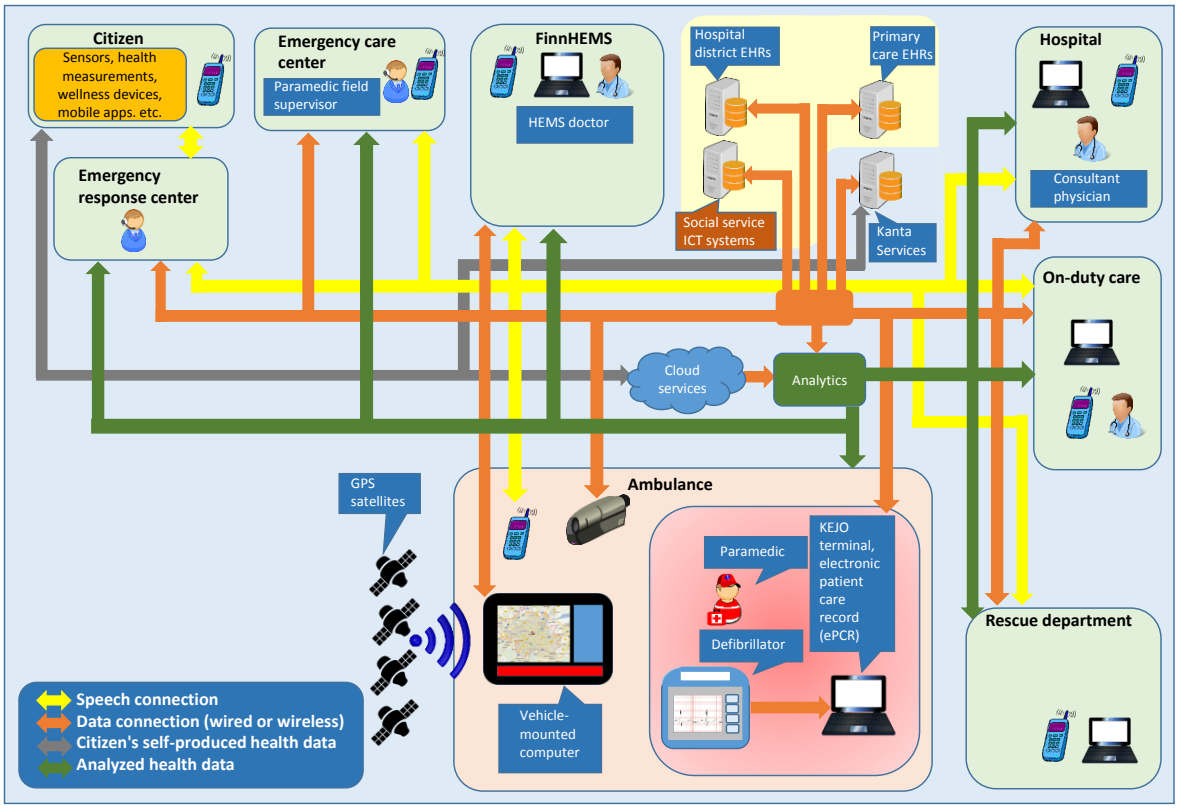


**Figure 2.** Vision for future ICT solutions and increased communication flows between ICT systems in EMS in Finland.

***A dashboard for future EMS***

This increased amount of information creates new requirements for how it will be presented to EMS professionals. The introduction of the KEJO system will allow EMS personnel to access ePCR regardless of their location. However, the situation is problematic if the consultant physician needs the patient's information from primary healthcare services or specialized medical care while simultaneously checking the patient's data on the ePCR. In practice, another terminal is needed, because the KEJO system is operating in a secured TUVE network to which other systems do not have access. [7]. Based on information collected in this study, a common dashboard will be required in order to get a simplified view of all data. Optimally, all the information needed for decision-making and patient care will be presented in the same view, which will be available to all stakeholders regardless of location.

One possible future user interface (UI) for EMS professionals is presented in Figure 3. The usability of the user interface is important to avoid the risk of patient safety [49]. The features presented in the UI are those that healthcare professionals indicated as the most important in interviews. The UI is easy to use and provides a comprehensive view of patient information such as medications, medical history, treatment constraints, living will, and an analyzed personal health profile. The location of EMS unit can also be presented. There is easy access to the EHRs of primary care and hospital districts as well as the patient's ePCR. Patients' vital signs can be visualized in real-time. Treatment guidelines for diseases are available. The system also enables real-time video conferencing between EMS units and consultant physicians.


**Figure 3.** A dashboard for future EMS from consultant physician view.

## Discussion and conclusion

In this study, current barriers to the EMS information flow in the Northern Ostrobothnia Hospital District region were identified, and underlying technological or functional issues were presented. This study shows that it is very challenging to ensure fluent information flow in EMS because several different kinds of organizations, each having their own ICT solutions, participate in EMS missions. The use of different healthcare ICT systems which do not communicate with each other results in scattered health data and double recording of patient data. Surveyed professionals are typically satisfied with their own organizations' ICT systems, but professionals outside of those organizations have no access to the systems and the data stored there. The availability of ePCRs to all stakeholders is limited because electronic access is available to paramedics only, while others can only get paper copies.

Similar observations have also been made at the Finnish national level, leading to the creation of the KEJO project to create a common field command system for authorities [3]. The main improvement is related to ePCRs, which will be stored in the Patient Data Repository in Kanta Services [7,23]. All professional who use the KEJO system can create and read records of ePCRs. Others may apply for an intermediate-level ePCR to their own EHR from the Patient Data Repository to check patients' EMS mission records [7].

Scattered health data is a common problem in Finnish healthcare and EMS [14,24]. National projects such as UNA and Apotti have been set up to overhaul social and healthcare ICT systems in order to facilitate better information exchange and keep patients' health data up to date [25-29].

The above-mentioned national projects will increase the availability of ePCR and improve the exchange of information between healthcare information systems, but further development is needed to ensure that all information needed for decision-making can be deployed effectively.

Among EMS professionals, there is a need for real-time video streaming from emergency scenes as well as from the patient. It provides a better understanding of patients' conditions, and real-time video consultation is well suited for sparsely-populated areas, as shown in a study from rural western Australia [50]. A pilot study form United States shows that in mass casualty incidents, real-time video assists in triaging patients [51]. Implementation of real-time video for EMS using current technology is feasible, since real-time video streaming is already in use in the field (e.g. in Latvia, where ambulances are equipped with two video cameras) [30]. A pilot study has also been conducted in Finland on how EMS and the patient safety can be improved with wireless video connection [31].

The real-time video and mobile use of EHRs sets new broadband requirements for authorities' wireless networks [21,32]. The current wireless VIRVE network does not provide the data rate required by such applications, which means new solutions are needed [21]. One approach could be to provide wireless broadband services using commercial networks alongside VIRVE or to rely solely on future commercial networks that support PMR features [21,38,39].

The functionality of Kanta Services will play a crucial role in future EMS missions in Finland because with the introduction of the KEJO system, the information will be shared through the Patient Data Repository to all stakeholders [7]. In addition, the UNA kernel will share patients' information with other EHRs through Kanta Services [7,25,26]. Health records produced by citizens themselves will also be stored in the PHR of Kanta Services and from there can be further distributed to healthcare professionals [41]. Currently, the utilization rate of Kanta Services is very low among EMS personnel. The main reasons, according to interviewed professionals, are that the user interface is clumsy and that updating the database is too slow for urgent work. These issues demonstrate that when designing ICT solutions for healthcare, system usability should be considered from the beginning of product development to avoid any risk to patient safety [49].

In the long term, personal health measurements, sensors, and AI solutions for healthcare offer potential improvements to EMS communications. Health data from devices and sensors could become part of patients' medical histories and could be used for remote monitoring of patient status. The goal of remote monitoring is to ensure that EMS reacts quickly to critical situations. In the best cases, the need for EMS can be avoided altogether [46]. More personalized and predictive healthcare for citizens can be achieved if health data from several databases can be combined and analyzed using AI solutions [45]. Experiments by the city of Espoo show that personal treatment plans can be successfully developed using social and healthcare data, along with early education and client relationship data [52]. This kind of approach will help EMS providers form an overall picture of patients' health profiles and identify potential risk factors. If needed, patients will be directed to appropriate healthcare or social services, which could reduce the need for EMS in the future. Another approach to using AI in EMS could be to automate alarms based on sensor data, thus leading to earlier EMS activation when needed.

The study presents the overall flow of information in EMS—including all ICT solutions—in contrast to previous studies and surveys focusing solely on the technology of a specific subfield such as the EMS national data repository, wireless technologies, or EHRs [3,21,24]. The findings in this study are comparable to those of previous subfield studies, such as the availability of ePCR to all stakeholders, the better integration of healthcare information systems, and the need for broadband wireless solutions for authorities. Although the KEJO system improves access to ePCR for all stakeholders, and national projects improve the exchange of information between healthcare ICT systems, this study also highlights the need to integrate information from ePCR, EHRs and all other necessary information sources in order to support rapid decision-making. The process of combining all data does not just present technical problems; it could also depend on the identity and access rights policies of different organizations. However, these issues are not the focus of this research. This study has also revealed that AI, sensors, personal health measurements, and telemedicine offer potential ways to further develop EMS communication in the long term if the abovementioned current problems can be solved first. The results of the study can be used by decision makers in EMS and may also be beneficial for professionals developing and integrating data systems. To our knowledge, this is the first study in Finland investigating technological barriers in EMS. Our results are applicable to other regions in Finland.

The material for this study was collected from January 2017 to October 2017. Since then, the biggest change in the Northern Ostrobothnia Hospital District region has been the implementation of ePCR in PDF format. This implementation was done due to the delay of the introduction of the KEJO system until 2020 [8]. Now physicians, as well as paramedics, can see ePCR in electronic format, but recording patient data directly to ePCR during a consultation process is still a problem for physicians. In other respects, the information exchange of EMS has remained the same as during this study.

The use of many different healthcare ICT systems which do not communicate with each other is currently the biggest communication bottleneck between EMS professionals. In the short term, the introduction of the KEJO system will improve the availability of ePCRs to all stakeholders and reduce the amount of double recording. In the long term, the integration of AI with EMS decision-making systems will provide huge potential for improved flow of communication and, in the best cases, reduce the need for EMS. For that reason, future studies should be done on the topic.

### *Limitations*

The data collected in this study is based on the subjective opinions of EMS professionals. We suppose that the results are broadly indicative of the current information exchange situation in EMS because the findings are very similar among professionals. This study was performed only in one Finnish's county. However, we believe other areas in Finland and the Nordic countries are facing the same problems.

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***Declaration of conflicting interests***

None.

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