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User experiences with different regional health information exchange systems in Finland

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ABSTRACT

Purpose: The interest in cross-organizational Health Information Exchange (HIE) is increasing at regional, national and cross-European levels. The purpose of our study was to compare user experiences (usability) of different regional health information exchange system (RHIE) types as well as the factors related to the experienced level of success of different RHIE system types.

Methods: A web-based questionnaire was sent to 95% of Finnish physicians aged between 25 and 65 years of age. RHIE systems were mainly available in the public sector and only in certain regions. Those 1693 physicians were selected from the 3929 respondents of the original study, who met these criteria. The preferred means (paper/fax vs. electronic) of cross-organizational HIE, and replies to the 11 questions measuring RHIE success were used as the main dependent variables.

Results: Two thirds (73%) of the primary care physicians and one third (33%) of the specialized care physicians replied using an electronic RHIE system rather than paper or fax as a primary means of cross-organizational HIE. Respondents from regions where a regional virtual EHR (type 3) RHIE system was employed had used electronic means rather than paper HIE to a larger extent compared to their colleagues in regions where a master patient index-type (type 1) or web distribution model (type 2) RHIE system was used. Users of three local EHR systems preferred electronic HIE to paper to a larger extent than users of other EHR systems. Experiences with an integrated RHIE system (type 3) were more positive than those with other types or RHIE systems.

Conclusions: The study revealed User preferences for the integrated virtual RHIE-system (type 3) over the master index model (type 1) or web distribution model (type 2). Success of individual HIE tasks of writing, sending and reading were impacted by the way these functionalities were realized in the EHR systems. To meet the expectations of increased efficiency, continuity, safety and quality of care, designers of HIE systems also need to take into account the

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different HIE needs of primary care clinicians and their secondary care colleagues in hospitals. Both national legislation and local interpretations of data protection possibly hinder the full use of any RHIE systems. These findings should be taken into account when designing usable HIE systems. More qualitative research is needed on specific features of those local systems that are associated with positive or negative user experience.

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1. Introduction

The Organization for Economic Co-operation and Development (OECD) has defined a Health Information Exchange (HIE) as follows: “HIE refers to the process of electronically transferring (or aggregating and enabling access to) patient health information and data. Exchange may take place between different types of entities – for example, e-messaging between patient and provider, e-transfer of patient data between ambulatory care providers, or e-transfer of data at the regional level”. [1] The interest in the exchange of patient information between different healthcare providers is growing rapidly. A number of countries (e.g. England, Netherlands, Finland and the USA) are progressing in their regional and national health information exchange initiatives. Many have been conducting their first evaluations in order to determine the next steps, obtain policy information, and outline future directions [2–5]. An inter-organizational exchange of information has become increasingly important in Finland following the new Health Act 1326/2010 that came into force on 1st May 2011, which has extended the patients’ ability to choose their place of treatment (see Appendix 1 for the Finnish context of HIE).

The health information exchange (HIE) systems are expected to give clinicians access to patient information at the point of care regardless of where the patient has been treated previously and thereby improve the efficiency, continuity, safety and quality of care [6,7]. The systems promise to connect patient data from primary, secondary and tertiary care providers from the public and private sector [8,9], as well as to improve the coordination of care and information among hospitals, laboratories, physician offices, and other ambulatory care providers [10]. Further, the HIE systems are expected to enhance practices of physicians, administrative personnel, as well as empower the patients. Among expected benefits are also improvements in statistical, monitoring and research processes [11].

It has been argued that in order to be more successful, the HIE implementation process (including the selection and the tailoring of the information technology system as well as the implementation strategy) needs to be more flexible by nature and consider how to adapt to local needs both in primary and specialized care organizations [2]. Rudin et al. [14] have suggested integrating HIE into the clinical workflow. Moreover, user satisfaction has been found to correlate with the use of HIE systems [15]. Arising from this, Gadd et al. [15] has proposed that consolidation of information is a key to success, not the availability of information per se.

According to Delone and McLean’s information system success model [16], information system quality, information quality and support service quality have a strong correlation

with actual use and user satisfaction. These in turn, have a strong correlation with variables measuring information system benefits.

Numerous studies have been conducted on the success of individual health information systems from the end-users’ viewpoint (e.g. [17–21]), but to this date, there is very little research on success of complex HIE systems, in particular comparisons of the success of different types of HIE solutions in fulfilling the expected benefits.

This study is a continuation to two previously published studies from the same data [17,22]. The first study presented the theoretical grounds for the contextual nature of usability as a key element to success of information systems, focusing on the generic state of computer-supported patient information processing and associated communication among clinical physicians in Finland [17]. The article discussed differences between the traditional concept of usability (associated with interaction between a human and a computer system) and user experience (UX, a new concept that emphasises the emotional aspects resulting from the use of a system, referring to a person’s perceptions and responses resulting from the use and/or anticipated use of a system).

The second study was conducted from the viewpoint of information-technology-enhanced collaboration in clinical work [22]. The results of the study showed that the main concern of physicians is the time-consuming nature of cross-organizational patient information exchange. Problems in information management were particularly emphasized among those physicians working in hospitals and in-patient wards.

The previously published studies on the same data have not made a distinction between experiences of users of different types of regional health information exchange (RHIE) systems in Finland, or examined factors behind the experienced HIE success. Therefore, we wanted to analyze the data further to compare the success of different types of RHIE systems, and determine factors associated with the success. The study questions are:

1. What are the respondents’ primary means of RHIE in different regions?
 - 1.1 To what extent do primary means of RHIE vary depending on the working sector?
 - 1.2 To what extent do primary means vary depending on an Electronic Health Record (EHR)-system used?
2. How do respondents’ experiences of HIE success vary, and which factors are related to the experiences?
 - 2.1 How do experiences of HIE success vary between primary and specialized care RHIE system users?

2.2 How do experiences of HIE success vary among primary care clinicians using a specific local EHR type in different RHIE regions?”

The scientific outcomes of this study will benefit further research on HIE success. The practical outcomes are targeted mainly to decision-makers about user preferences of different ways of realizing specific HIE system functionalities, not only in Finland, but also in other countries where similar systems are being developed and deployed. In Finland, the results provide a picture of the baseline situation on the eve of implementation of the national HIE system. The results will also contribute to the further development of EHR systems, since regional systems are often used via an array of local EHR-systems, and the HIE problems experienced may also reflect problems in the EHR systems.

1.1. Types and functionalities of RHIE systems in Finland

In the Finnish public health system, primary care is provided by municipalities and specialized care is provided by special organizations (hospital districts) owned by municipalities. Historically these organizations have built their own EHR systems and health data repositories.

With most of collaboration in patient care taking place at the regional level, the smooth communication of electronic patient data has become necessary. Today, inter-organizational data exchange is increasing rapidly in Finland. This is due to the fact that digital data depositories in individual physician institutions are in active clinical use, and secure data connections (different kinds of intranet solutions and secure internet connections) enable the communication of electronic patient information [23].

1.1.1. Health information exchange in this study

The OECD HIE definition [1] takes information system functionalities as a starting point, not the information systems themselves. This increases feasibility given the variations in systems and terminology used in different countries (i.e. EHR can mean very different things in different countries). This study focuses on HIE as the e-transfer of patient data between care providers at regional level.

In the Finnish case of RHIE, functionalities are offered by different mechanisms, either with point-to-point messages or different RHIE system types. The point-to-point functionalities include *Electronic referrals*, messages sent to another institution, in order to transfer the responsibility of patient care. *Electronic discharge letters* are then returned to the sending institution once the patient's treatment is finished. The referral can evolve into an *electronic consultation letter*, if neither responsibility for the patient nor the actual patient is transferred, but where professional advice for treatment is sought or professional opinions are given. For collaboration between primary and a specialized physician, the most important messages are referral letters, consultation letters, and feedback or discharge letters. In addition to a narrative text, the letters can include results of laboratory tests and radiological examinations [23]. There are also point-to-point messaging services for teledistribution of radiology and laboratory results. These

point-to-point mechanisms that require the active pushing of information by the provider are not included in this study.

Different types of more comprehensive RHIE systems can exchange many different types of patient data, such as electronic laboratory and imaging results, medical images, and bio signals and narrative texts from different specialties. They can thus provide a source of reference information for past treatment, form a basis for current patient data distribution in a geographically distributed physician environment, as well as constitute a data repository for consultation services and workload distribution. These RHIE systems where the user side is active are the target of this study.

1.1.2. Types of RHIE systems in Finland

Three major different types of comprehensive RHIE systems can be identified in those hospital districts which have entered the clinical phase of RHIE usage [23], which are compared in this study:

- (1) The *master patient index model*, called a “type 1” RHIE system in this study. This type has a centralized reference database of available selected information from user organizations. Authorized users have access via a separate user interface to an index of the original data. Each of the indexed data items must be viewed separately. The contents of the original selected data include core narrative texts, digital diagnostic images, and laboratory data. Medication lists were not included at the time of this study.
- (2) The *web distribution model*, called a “type 2” RHIE system in this study. Authorized users can have full access to a web based electronic record of the patient when situated in a specialized care unit. That includes all texts, images, and laboratory data that a patient has authorized for the treating physician to see. Medication lists were not included at the time of this study. Because of web distribution, no special viewer is needed, only a secure connection. In 2010, primary care physicians could see all the information from the specialized care hospital only for those patients which they had themselves referred to the hospital. This restriction was due to a local interpretation of the national data safety legislation and an absence of a means to alter patient's consent for information review to allow access by other physicians after the referral has been sent. As a result, access to otherwise complete patient record information was available only to a limited group of referring physicians. The full potential of a type 2 RHIE system was then missed.
- (3) *Regional virtual EHR model*, called a “type 3” RHIE system in this study. If the patient grants permission, the physician has direct access to the electronic patient record in another institution. That includes all the texts, diagnostic images, and laboratory data. Medication lists are included. For outpatient and inpatient care there were separate medication lists. In this case both the viewer and the provider are using the same proprietary software, which to the clinician appears like an integrated system.

Special attention should be given to the regional distribution of diagnostic information, i.e. diagnostic images and their related requests and clinical reports as well as

laboratory data. These systems have been developed already earlier and separately from the exchange for narrative texts, sometimes consisting of their own regional archive. For users, this regional archive can be present as part of their operative health record system (integrated functionality) or as a separate regional data repository which one launches through a separate interface.

Diagnostic images are stored in picture archiving and communication system (PACS) and the associated requests and clinical reports are stored in a radiology information system (RIS) which is also the master system for information management within radiology departments. Usually only a radiology department uses these systems directly, with other departments and institutions entering and accessing the information through their local EHR or e.g. via a web-based regional system. In some regions, teleradiology services have been integrated into imaging-information delivery. Radiological studies made at a smaller hospital or a primary care institution can be medically dictated and interpreted at the main hospital of the region and the clinical reports are then made available to the imaging site through a regional RIS system.

The same principle applies for laboratory systems, which are usually more embedded into the EHR interface for users.

In a normal medical practice, the point-to-point services (described in the previous chapter) and the regional exchange type of data distribution complement each other [23]. However, not all the RHIE system types contain the same functionalities. Table 1 presents the variation of EHR systems that are used to access different RHIE systems in different hospital districts in Finland, as well as data available in different RHIE systems.

All the Finnish RHIE system types have some common features with the planned national HIE model (KanTa): KanTa is integrated to the EHR systems (as in RHIE system type 3, the virtual EHR model). The difference is that the virtual EHR model has an internal database and direct user interface common to all EHR-users, whereas KanTa has a national database with security rules and message interfaces which respond to a request from an EHR (there is search functionality as in RHIE system type 1). KanTa returns the requested data in a pre-defined format as a message to the EHR, and the local EHR processes and presents it to the users. In addition, KanTa has summaries of stored data that can be sent upon request, a functionality not existing in current RHIE-systems. A web-interface is also being planned for professionals. The KanTa system will provide a specialty-specific continuous medical record (features of the type 2 web distribution model). It is different from the RHIE system type 2 in that technically it will operate using similar messages as the current EHR systems [12].

The Canadian, North American, Scottish, Welsh, Irish, Dutch, Estonian, French, Swedish and Danish HIE models have been analyzed for the basis of KanTa-development [24]. The comparison concludes that the Estonian HIE architecture is closest to the Finnish KanTa architecture. In Estonia, there is a centralized repository (as in RHIE types 2 and 3) for textual data, and a separate user interface (as in RHIE type 2). Also the Swedish Nationell Patient Översikt (NPÖ)-system resembles the Finnish KanTa-system. The biggest technical difference is

that NPÖ does not have a centralized data archive (repository), but a router service that retrieves information on demand from local EHR systems, delivering the data to the clinician requesting it (as in RHIE type 1).

1.1.3. Ownership and usage of health data within a region

At the time of this survey, the exchange of patient information between different registrars was not possible without prior consent of the patient. The 336 Finnish municipalities – jointly owned 161 health centres. These as well as every single hospital district was regarded a separate register authority (registrar) for patient information [35]. This made the use of RHIE systems very complicated and various technical systems were implemented in order to enter and then check the existence of patient's consent. Information gathering from a RHIE system was fragmented, since multiple consents were needed, depending on which type of data was requested.

After the data collection for this survey, a new law was passed in Finland that is expected to have an impact on the usability of the HIE systems. According to the new law [25], which came into effect on May 2011, all patient record data in public (primary and secondary) care within each of the hospital districts forms one logical register irrespective of the site where it is initially stored. There is no longer distinction between data entered in primary or specialized care. That means that all professionals in the public sector involved in care of the specific patient within hospital districts are allowed to see the data. The patient has to be informed of the usage of data and the patient always has the right to deny usage of the data or part of the data. This wider access to patient information was however not in use during our survey, as already mentioned. Even after the new law, data exchange across the hospital district borders or with the private sector requires prior and specific consent from the patient.

1.2. Related research: studies on RHIE system usage and health professionals' experiences

The potential benefits of RHIE systems cannot be expected to be achieved if the physicians do not use the systems. The availability of regional systems does not necessarily result in their use.

A number of recent studies have addressed this issue. Studies conducted in the US suggest that the physicians do not use HIE in all encounters but mainly when they expect to find information from the HIE system such as a known visit to an emergency department or hospital in the recent history or the patient has prior-recognized multiple medical conditions or for the follow-up of patients after visits [26]. Johnson et al. [27] found that emergency department physicians accessed HIE system only in 7% of all encounters; the access rates were higher for patients whose missing information was believed to be present in the system e.g. repeat visits and patients with comorbidities. For primary care physicians, the use rates have been higher, 16–21% of all primary care encounters both in the USA and in Finland [26,28].

Studies on HIE system usage have not only reported the use rates but also tried to understand the challenges and benefits of a HIE implementation from the health practitioners' viewpoint. In their study of the characteristics of use and of users

Table 1 – Diverse primary care, specialized care and RHIE systems in different regions. Systems a and A (similarly, systems c and C) are from the same manufacturer.

Hospital district ID	Primary care EHR Systems and market share (%) N = 614	Specialized care EHR Systems N = 1079	RHIE system type in region	Data available in RHIE system for information exchange between specialized and primary care) ^a				
				Detailed notes	Laboratory result	Images	Imaging results	Additional information
District 1	System c 24% System e 14% System f 3% System a 0.4% System g 58% System h 0.4%	System A	Type 1	Yes	Yes	Yes	Yes	Access to patient information via reference information within the hospital district
District 2	System c 47% System f 7% System g 44% System h 3%			Yes	Yes	Yes	Yes	System A users in specialized care cannot see District 2 primary care information, but primary care system users see specialized care information. Primary care information from largest municipality in District 2 are not visible in Type 1 RHIE system
District 3	System c 76% System g 24%	System B	Type 1	Yes	Yes	Yes	Yes	Access to patient information via reference information within the hospital district
District 4	System c 100%	System C	Type 3	Yes	Yes	Yes	Yes	System in transition
District 5	System c 53% System g 47%			Yes	Yes	Yes	Yes	In implementation phase
District 6	System c 100%			Yes	Yes	Yes	Yes	
District 7	System c 94% System h 6%			Yes	Yes	Yes	Yes	
District 8	System c 69% System g 31%			Yes	Yes	Yes	Yes	Direct access to patient information in other organizations within the hospital district
District 9	System c 100%			Yes	Yes	Yes	Yes	
District 10	System c 93% System g 7%			Yes	Yes	Yes	Yes	
District 11	System c 96% System f 1% System g 3%	System D	Type 2	Yes	Yes	No	Yes	Browser-based viewing of hospital data from primary care or other hospitals within hospital district.
District 12	System g 100%			Yes	Yes	Yes	Yes	Hospitals cannot view primary care data ^b
District 13	System c 27% System f 27% System g 45.5%			Yes	Yes	No	Yes	

^a With patients' consent.^b Only viewing of patient information of physicians own referral patients.

of a successful regional HIE in both emergency departments and ambulatory safety net clinics [26,28] the authors found that discharge summaries and test reports were the most frequently accessed data in the exchange. When used, providers consistently noted retrieving additional history, preventing repeat tests, comparing new results to retrieved results, and avoiding hospitalization. Other suggested benefits include identification of drug-seeking behaviour and doctor-shopping, decrease of healthcare costs by reduced duplicate testing, and increased efficiency of clinical information gathering [29].

Studies on clinicians' experiences and attitudes towards electronic information exchange indicate that healthcare providers perceive electronic information exchange to promote the efficiency and quality of care; however, they have concerns relating to the confidentiality and safety of the exchange and the reliability and quality of patient data. This has been found e.g. by Zwaanswijk et al. [30], who researched the attitudes of healthcare providers towards HIE by interviewing 17 stakeholders about their perceptions of the benefits and problems of exchange and national EHR. Based on the results, the perceived HIE benefits include: improvements in the efficiency of healthcare and the speed of communication, access to up-to-date information about the patients, and improvements in the quality of care (e.g. prevention of medical errors). In contrast, the list of perceived problems turned out to be rather long and include the following themes: confidentiality and security of electronic HIE, reliability and quality of patient information, healthcare providers' liability and limited usefulness of protocols and guidelines, technical performance of information systems. In conclusion, the researchers suggest that the perceptions and preferences of providers, particularly those information-exchange-related problems the providers currently have, must be addressed in order to achieve successful implementation.

This conclusion has been supported by Robertson et al. [2], who conducted a longitudinal mixed-method study to describe and evaluate the implementation and adoption of detailed EHRs in secondary care in England. The researchers found that the clinicians' enthusiasm for health records particularly relate to perceived benefits in their immediate surroundings, but also to geographically widespread sharing of patient data (in the interviews the clinicians highlighted both local and national data sharing as important aspect of EHR). On the question of "how to achieve practical benefits", Rudin et al. [31] suggest considering patient visit patterns when aiming to design health data exchange functionality for meaningful use.

The importance of immediate practical benefits and successful health information exchange has been also pointed out by several studies which have researched physicians' experiences using electronic prescribing systems. Results show the following weaknesses: physicians face major barriers to electronically transmitting prescriptions to pharmacies and maintaining complete medication lists [32]. Based on their survey results, Wang et al. [33] conclude that only when the systems communicate with each other in a timely, accurate, and patient-specific manner, will the full benefits of e-prescribing be realized.

In Finland, measurement of regional HIE has been restricted to measuring connections made from individual

organizations to RHIE systems. This has been followed systematically since 2003 [34-36].

Some individual studies have also been conducted on user experiences and use of one type of RHIE system (Type 1) in Finland (e.g. [28,37,38]). These studies were not national, and covered only one regional system type. In their recently published follow-up study, Mäenpää et al. [28] showed that the regional HIE utilization rates have increased steadily in recent years (the analyzed statistical data was for 2004-2008 from primary and special healthcare). The researchers found annual increases in all 10 researched federations of municipalities, as well as increases in the viewing of reference information in each researched health professional group. The researchers also reported a significant connection to the number of laboratory tests and radiology examinations with a statistically significant increase in the numbers of viewed references and use of HIE.

Review of the HIE studies indicate a need for further research of success and practical benefits of different HIE systems - especially on regional level. The literature shows that there is an abundance of studies that describe different HIE systems [39-42], examine the HIE technology marketplace and identify challenges from policy perspective [43,44] discuss strategies for HIE development [45], analyze expected HIE benefits [46] or study single contexts or functionalities such as electronic prescription [7,32,33,47-52]. We found no studies that actually compared user experience of different HIE models. There was conceptual variation related to some of the studied functionalities (e.g. medication list vs. list of ePrescriptions). In conclusion, little research focus has been set on (a) the gathering of user experiences from different types of health organizations (specialized medical care and primary care institutions sharing the same data in the integrated EHR) as well as (b) comparisons of success of different types of RHIE systems in use from the end-users' viewpoint.

2. Research methods

A web-based survey was conducted in the beginning of 2010, targeted to all physicians aged less than 65 years, engaged in clinical work in Finland. A multidisciplinary team consisting of two practicing physicians, one usability expert and one expert in sociology of technology and eHealth evaluation designed the survey form in order to guarantee clinically as well as conceptually important issues were covered in a manner that is comprehensible to clinicians. The questionnaire was pre-tested by five clinicians.

The questionnaire was described in an IJMI 2011 article [17]. The questionnaire consisted of "three dimensions of clinical ICT system usability that reflect the physicians' viewpoint on system usage: (1) compatibility between clinical ICT systems and physicians' tasks, (2) ICT support for information exchange, communication and collaboration in clinical work, and (3) interoperability and reliability. The dimensions derive from the definitions of usability and clinical context of use analysis, and reflect the ability of ICT systems to have a positive impact on patient care by supporting physicians in achieving their goals with a pleasant user experience." These dimensions were operationalized into 32 statements with

- 1) Log in procedures in the different systems take too much time.
- 2) Results from radiological examinations are easily available..
- 3) Laboratory results are presented in a logical format.
- 4) Patient data (also from other organizations) are comprehensive, timely and reliable.
- 5) Information on medications prescribed in other organizations is easily available..
- 6) Retrieving patient information from another organization often takes too much time.
- 7) IT systems provide support for cross-organizational collaboration between the physicians.
- 8) The patient record systems help prevent errors related to medication.
- 9) The patient record systems help to avoid overlapping examinations.
- 10) The patient record systems help to ensure the continuity of care.
- 11) Patient record systems help to improve the quality of care.

Fig. 1 – Variables measuring success of RHIE-functionalities in the questionnaire.

a five-point Likert-scale [53] (completely disagree, disagree somewhat, not disagree or agree, agree somewhat, completely agree). Of the statements, 12 addressed dimension 2 (ICT support for information exchange, communication and collaboration in clinical work). The conceptual background of the questions is described in detail in a previous article [17].

For the current study, 11 of the 12 statements were selected to measure user experiences on RHIE. These are depicted below:

Fig. 2 presents the process for selecting the study respondents from the original study respondents: At the time of the survey there were 14,411 physicians in the population. Email addresses for 87% were available in the register of the Finnish Medical Association, which also participated in designing the questionnaire and analysing the results. Thus the original questionnaire was sent to 12,538 physicians, with 31.3% ($n=3929$) responding. For this study, we selected

respondents working in the 13 regions where RHIE systems type 1, 2 or 3 were in use. In some regions, either the same RHIE system type was not in use in the whole region (3 regions removed) or no RHIE system was available (4 regions removed). We also selected physicians working in the public sector; either in primary or secondary and tertiary care, since the RHIE systems are mainly used by public healthcare providers; only a nominal number of private clinics have access to these systems. In Finland, 49% of clinicians worked in 2009 in public-sector primary and secondary care organizations in the 13 hospital districts where the studied RHIE system types were in use. Based on this information, the target population for this study was approximately 6000 doctors. The responses of those not involved in clinical work were removed. After this, final cleaning of the data was performed, excluding 'false positives', i.e. public sector respondents having replied using private sector EHR systems (this group of physicians had indicated public

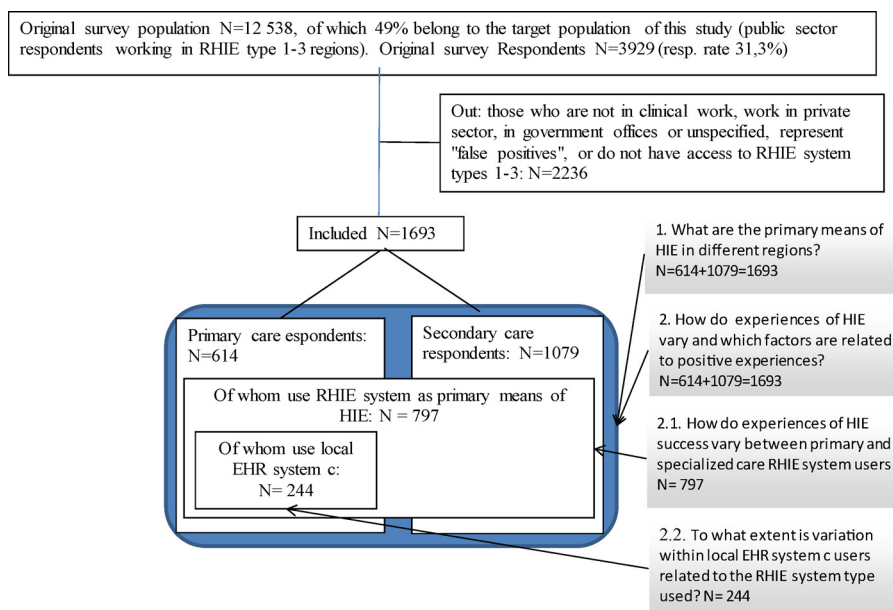


Fig. 2 – Data selection.

sector as the main working sector, but they also worked in private practices). With these criteria, we ended with a sample of 1693 respondents, whose replies we analyzed for health information exchange experiences.

The data depicted in Fig. 1 (614 primary care and 1079 specialized care responses) were used to answer the study questions. The entire data (1693 replies) were used to analyze the extent that different RHIE system types are in use (main study question no. 1), and factors related to HIE satisfaction (main study question no. 2).

The statistical analysis was carried out with SPSS 19.0.0.1 (SPSS, Inc., Chicago, IL, USA). Cross-tabulation by working sector was used to answer question 1, with the chi-square test to assess differences between groups. To answer study question 2, relations between selected independent variables (RHIE type used, local EHR system used, working sector and primary means of HIE) were first examined using Pearson correlation coefficients. Due to multicollinearity of the independent variables (predictors), they were taken alternately into the model. The internal consistency of the 11 selected dependent variables was studied with Cronbach's alpha coefficient. Due to poor internal consistency (Cronbach's alpha < 0.7), selected dependent variables were taken into the model one by one. The dependent variables were dichotomized into two categories: disagree (0) and agree (1) (Fig. 2).

To further study the working-sector-specific experiences of HIE success, only those respondents were selected from the group of 1693 respondents who replied using the RHIE system available in the respondent's region. For these, primary and specialized care respondents were compared to find out how their experiences differed.

To further study how HIE success varies among primary care clinicians using local EHR system c in different RHIE regions, we selected for analysis only primary care respondents who use EHR system c (see Table 1), which is the only primary care EHR system that can be used to access all different types of RHIE systems.

Data for study questions 2.1 and 2.2 were analyzed with cross tabulations with a Chi-square *p*-value for defining the statistical significance of differences in replies in the different groups, or alternatively, an independent group's *t*-test was used to specify the statistical significance of variation between the groups.

3. Results

Demographic features of the original study respondents (*n* = 3929) and representativeness of the sample have been depicted in detail in the IJMI [17]. The original sample was representative of the population. The subsample (public sector respondents in clinical work in the 13 hospital districts where one of the RHIE system types is used) displayed almost identical demographic features, depicted in Table 2.

The proportion of respondents representing specialized care (64%) and primary care (36%) was also identical in both the original sample and the subsample for this study. Data characteristics of our actual target population (public sector physicians from the 13 hospital districts) were not available to estimate sampling bias for the subsample more accurately.

Table 2 – Demographics of the respondents (N = 1693).

Gender	
Male	40%
Female	60%
Age	
≤34	15%
35–44	27%
45–54	32%
55>	27%

3.1. Extent of use of different RHIE system types

3.1.1. Primary means of RHIE in different regions per work sector

The primary means of RHIE is depicted in Fig. 3, where the results are presented separately for primary and specialized care respondents. The data included all the respondents for primary and specialized care, who had replied to the question.

The Pearson Chi-square significance for both primary and specialized care groups was 0.000, indicating that differences between groups are significant. As can be seen from Fig. 3, 73% of primary care respondents use an RHIE system whereas only 33% of specialized care respondents use an RHIE system as a primary means of cross-organizational HIE, and the rest of the respondents exchange health information mainly in paper format. Fig. 3 also shows differences between intensity of use of RHIE system types irrespective of working sector: In regions where a type 3 RHIE system (Regional Virtual EHR) is used, electronic HIE is used more commonly than paper-based HIE. In regions where a type 2 RHIE system is in use, paper is the most commonly used mode of RHIE.

3.1.2. What were the primary means of RHIE between users of different local EHR systems in primary care in region 1?

EHR-specific variation in the primary means of RHIE in primary care in region 1 where all major local EHR systems are used is presented in Fig. 4. EHR system e users were the most active RHIE-system type 1 users. Pearson Chi-square significance was 0.003, indicating significant differences between groups.

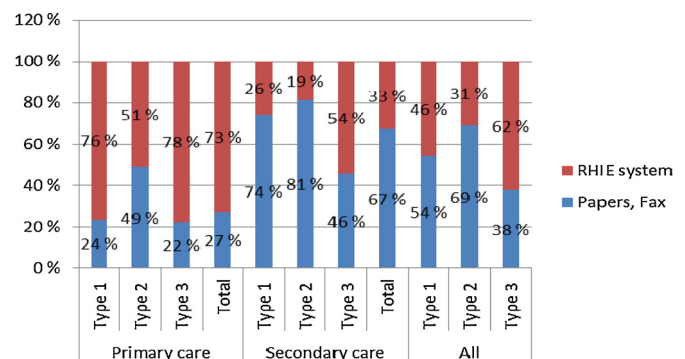


Fig. 3 – Primary means of HIE in different regions in primary and specialized care (N = 1534).

Table 3 – Variation in HIE success.

	Fully disagree	Disagree somewhat	Neither disagree or agree	Agree somewhat	Fully agree
(1) Log in procedures in the different systems take too much time	2%	9%	8%	33%	49%
(2) Results from radiological examinations are easily available	11%	25%	14%	39%	11%
(3) Laboratory results are presented in a logical format	4%	14%	14%	54%	15%
(4) Patient data (also from other organizations) are comprehensive timely and reliable	13%	33%	26%	25%	3%
(5) Information on medications prescribed in other organizations is easily available	59%	28%	9%	3%	1%
(6) Retrieving patient information from another organization often takes too much time	5%	9%	12%	29%	46%
(7) IT systems provide support for cross-organizational collaboration between the physicians	27%	39%	17%	16%	2%
(8) The patient record systems help prevent errors related to medication	22%	29%	20%	26%	3%
9) The patient record systems help to avoid overlapping examinations	16%	27%	16%	36%	6%
(10) The patient record systems help to ensure the continuity of care	9%	22%	27%	37%	5%
(11) Patient record systems help to improve the quality of care	12%	23%	30%	31%	5%

3.2. Variation in the experienced success of HIE and related factors

Variation in the experienced success of HIE as indicated by the 11 variables, is illustrated in Table 3.

There was strongest agreement (50% or over of the respondents agreed somewhat or fully) for statements 1–3 and 6, strongest disagreement with statements 5 and 7–8.

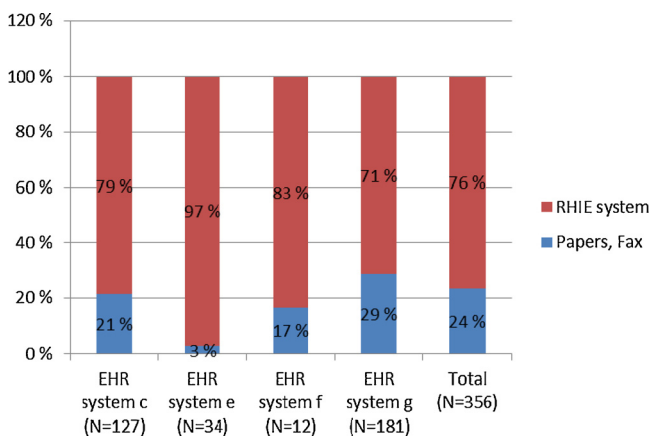


Fig. 4 – Variation in the modes of RHIE between different EHR-system users within RHIE system type 1.

Availability of radiological and laboratory results was regarded as a poor indicator of HIE success, since some of the hospital systems have this information within the EHR systems. There was almost full agreement on poor availability of medication information from other organizations, but we found no significant predictors for this statement. We selected statements 1, 4 and 6 and the RHIE – option from question “What is the most urgent focus for development?” as indicators of HIE success, for which predictors were searched. The results are presented in Table 4, where Exp(B) (Odd ratios, OR) and 95% confidence intervals for OR are reported.

The results of models A and B show that working in regions where RHIE type 1 was used.

- Increased the probability of having experienced log-in procedures taking too long, that retrieving patient information from other organizations took too much time, and that RHIE usability is the most urgent focus for development.
- Decreased the probability of having experienced the information system as providing support for cross-organizational collaboration.

Working in regions where RHIE type 2 was used.

Table 4 – Predictors of HIE success.

		Model A			Model B			Model C		
		Exp(B)	95% C.I.for EXP(B)		Exp(B)	95% C.I.for EXP(B)		Exp(B)	95% C.I.for EXP(B)	
			Lower	Upper		Lower	Upper		Lower	Upper
(1) Log in procedures in the different systems take too much time	RHIE type 1	2.051	1.540	2.731				0.277	0.161	0.477
	RHIE type 2	0.939	0.663	1.329				0.455	0.232	0.892
	RHIE type 3	1.000						1.000		
	EHR system c				0.446	0.230	0.863	0.369	0.157	0.869
	EHR system D				0.565	0.271	1.175	0.955	0.345	2.646
	EHR system A				1.504	0.747	3.030	1.247	0.614	2.531
	EHR system e				0.674	0.330	1.376	0.309	0.126	0.761
	EHR system other				0.771	0.311	1.913	0.652	0.241	1.766
	Working sector							0.773	0.496	1.206
	Primary means of RHIE							2.019	1.492	2.732
(6) Retrieving patient information from another organization often takes too much time.	RHIE type 1	1.790	1.388	2.308				1.705	1.094	2.655
	RHIE type 2	1.573	1.117	2.215				1.651	0.941	2.897
	RHIE type 3	1.000						1.000		
	EHR system c				0.591	0.337	1.038	0.955	0.452	2.016
	EHR system D				0.803	0.424	1.523	0.817	0.339	1.967
	EHR system A				0.878	0.495	1.559	0.895	0.475	1.687
	EHR system e				1.139	0.609	2.132	1.468	0.678	3.175
	EHR system other				1.649	0.680	3.996	1.972	0.742	5.238
	Working sector							1.259	0.843	1.881
	Primary means of RHIE							0.892	0.687	1.158
(7) IT systems provide support for crossorganizational collaboration between the physicians.	RHIE type 1	0.550	0.413	0.731				0.277	0.161	0.477
	RHIE type 2	0.643	0.436	0.948				0.455	0.232	0.892
	RHIE type 3	1.000						1.000		
	EHR system c				1.056	0.582	1.918	0.369	0.157	0.869
	EHR system D				1.027	0.520	2.029	0.955	0.345	2.646
	EHR system A				0.948	0.518	1.736	1.247	0.614	2.531
	EHR system e				0.441	0.216	0.900	0.309	0.126	0.761
	EHR system other				0.981	0.423	2.276	0.652	0.241	1.766
	Working sector									
	Primary means of RHIE									
Usability of the RHIE as the most urgent focus for development	RHIE type 1	1.996	1.579	2.523				2.514	1.673	3.778
	RHIE type 2	2.592	1.900	3.537				2.611	1.570	4.341
	RHIE type 3	1.000						1.000		
	EHR system c				0.941	0.595	1.487	1.506	0.795	2.853
	EHR system D				1.512	0.895	2.556	1.296	0.618	2.716
	EHR system A				1.073	0.676	1.703	0.947	0.568	1.577
	EHR system e				1.487	0.902	2.450	1.327	0.696	2.532
	EHR system other				3.258	1.618	6.560	3.362	1.499	7.541
	Working sector							0.927	0.636	1.351
	Primary means of RHIE							0.786	0.627	0.985

Variable(s) entered on Model A: RHIE type used with type 3 as the reference category. Variable(s) entered on Model B: The local EHR systems recoded into 5 dichotomized variables.

- Increased the probability of having thought RHIE usability was the most urgent focus for development based on their experience
- Decreased the probability of having experienced IT systems as providing support for cross-organizational collaboration.

Being a user of a local EHR system c decreased the probability of having experienced log-in procedures taking too much time. Being a user of a local EHR system g decreased the probability of having experienced information systems as providing support for cross-organizational collaboration. Being a user of a local EHR system other than c, g, A or D increased the probability of having thought that RHIE usability is the most urgent focus for development based on their experience. In

the full model (C), using an electronic RHIE system instead of paper increased the probability of having experienced log-in procedures being too time consuming, that IT systems had provided support for cross-organizational collaboration and that the RHIE system usability was the most urgent focus for development.

3.2.1. Working-sector-specific variation among RHIE system users

Working sector was not a significant predictor in the logistic regression analysis. Table 5 shows the working-sector-specific variation in user experiences of RHIE. The data included cross tabulation of responses of those respondents who used the RHIE system for health information exchange, and those 11

Table 5 – Working sector specific variation in user experiences of HIE. N = 797.

Variables	N	Specialized		Care Primary Care		Chi square
		Agree (%)	Disagree (%)	Agree (%)	Disagree (%)	
(1) Log in procedures in the different systems take too much time	734	86	9	75	14	0.001
(2) Results from radiological examinations are easily available	735	55	32	56	32	0.871
(3) Laboratory results are presented in a logical format	725	73	13	66	20	0.066
(4) Patient data (also from other organizations) are comprehensive timely and reliable	732	32	43	27	45	0.529
(5) Information on patient medication from other organizations is easily available	728	5	85	6	86	0.348
(6) Retrieving patient information from another organization often takes too much time	734	75	13	73	18	0.089
(7) The information system provides support for crossorganizational collaboration between the physicians	733	25	57	17	65	0.024
(8) The information system helps prevent errors related to medication	730	23	58	46	36	0.000
(9) The information system help to avoid overlapping examinations	733	51	35	36	51	0.000
The information system helps to ensure the continuity of care	732	45	30	47	27	0.632
The information system helps to improve the quality of care	730	37	35	41	26	0.018

variables that the researchers defined as key HIE variables in the survey.

Table 5 shows that the profile of the RHIE system users' replies from different working sectors is similar for some variables, but differs significantly in others. Most similarity was seen in satisfaction with access to radiological examinations and dissatisfaction with availability of medication information. The greatest difference (significant Chi square value) can be seen evaluating whether information systems were able to prevent medication errors and overlapping examinations and were efficient in log-in procedures: Specialized care respondents gave a more positive evaluation of whether the systems were able to help avoid overlapping examinations, but were more critical about whether they helped prevent medication errors and were efficient in log-in procedures.

3.2.2. RHIE system-specific variation in user experiences within EHR c users

As can be seen from Table 1, system c in primary care is the only local EHR system that exchanges data with all the three RHIE system types. We knew from previous analyses that primary care physicians are the main users of the RHIE systems, and that experiences of RHIE system users vary depending on the context of use, primary care physicians being on average slightly less critical towards RHIE systems than their colleagues in specialized care. The results for the question on how experiences of HIE success vary among primary care clinicians using the same local EHR type (type c) in different RHIE regions was further studied with a subset of data: primary care respondents who use a specific EHR-system (system c) and different RHIE systems. Results are presented in Table 6. Most similarity in replies ($p=0.792$) was found in the variable "the EHR system helps to improve the quality of care".

Very significant ($p=0.000$) differences were found in the following variables:

- Efficiency in retrieving patient info from other organizations: users of RHIE system type 3 were most satisfied, type 1 users most dissatisfied.
- Support for cross organizational collaboration: users of RHIE system type 1 were most satisfied, type 2 users most dissatisfied.

Significant ($p < 0.02$) differences were found in the following variables:

- Quality (comprehensiveness, reliability, timeliness) of RHIE system data: users of type 3 most satisfied, type 1 most dissatisfied.
- Efficiency of log-in procedures: users of type 3 least dissatisfied, type 1 most dissatisfied.

We also asked the respondents to choose from a list of items those problems they considered the most urgent in regard to their own information systems. "The usability of the RHIE system" was chosen by 25% of RHIE system type 3 users, but 68% and 66% of the type 2 and type 1 users, respectively ($p < 0.001$). This result supports the findings in Tables 4 and 5.

4. Discussion and conclusions

The most important aspect of EHR systems for the physician in charge of patient care is the availability of all relevant information at the point of care. This is mostly fulfilled in local systems, but as many institutions are involved in care, this is not enough. The more often that information from other organizations is needed, the more easily available that information

Table 6 – RHIE system -specific variation in user experiences (EHR and working sector standardized). N = 244.

Variables	N	Type 1		Type		2 Type 3		Chi square
		Agree (%)	Disagree (%)	Agree (%)	Disagree (%)	Agree (%)	Disagree (%)	
Log in procedures in the different systems take too much time	242	79	12	60	16	63	25	0.017
Results from radiological examinations are easily available	244	57	33	67	41	67	22	0.150
Laboratory results are presented in a logical format	241	70	18	81	11	62	23	0.303
Patient data (also from other organizations) are comprehensive timely and reliable	242	29	48	35	35	44	26	0.028
Information on patient medication from other organizations is easily available	241	5	89	3	81	9	79	0.189
Retrieving patient information from another organization often takes too much time	244	80	13	73	14	52	34	0.000
The information system provides support for cross-organizational collaboration between the physicians	242	81	8	14	60	34	42	0.000
The information system helps prevent errors related to medication	242	52	32	35	51	43	39	0.282
The information system helps to avoid overlapping examinations	244	34	55	38	49	37	46	0.670
The information system helps to ensure the continuity of care	244	48	32	51	14	45	26	0.155
The information system helps to improve the quality of care	241	43	25	39	19	40	28	0.792

should be. This study has compared experiences of physicians to three different types of HIE systems.

4.1. Summary of the answers to the research questions

The principal study questions were:

1. "What are the primary means of RHIE in the different regions?", and more specifically: To what extent do the primary means of RHIE vary depending on working sector and on the EHR system used? 2. "How do user experiences of RHIE success vary, and what are the factors relating to success? 2.1 "To what extent is there variation in primary and specialized care?" 2.2 "To what extent is variation related to the RHIE system type used?" These questions were answered based on data selected from a national survey to physicians that was conducted in 2010.

What are the primary means of RHIE in the different regions?

The primary means of RHIE (paper/electronic) varied at the time of study according to the RHIE system type, the working sector and the EHR system used. A total of 73% of primary care physicians replied that electronic rather than paper or fax was the primary means of cross-organizational HIE, but only 33% of the specialized care physicians used the RHIE system even though one would have been available. Respondents from regions where a type 3 RHIE system was used preferred electronic means of HIE over paper compared to their colleagues in regions where a type 1 or type 2 RHIE system was

in use. This result can reflect the completeness of data available through the different system types for the different sector respondents. The analysis of the impact of the EHR on RHIE use within region 1 showed that users of an EHR system type e used mostly electronic means for HIE, whereas usage of electronic means was found to be lower with other types of EHR. This finding may reflect the fact that these system users were most familiar with electronic communication since their EHR has the longest installation life of all the EHR systems in Finland. The EHR system itself had a statistically significant effect on the preferred means of cross-organizational HIE: paper and fax was preferred between 3% and 29% of physicians working in primary care and using the same RHIE system with an identical user interface.

Results for our first question show that even if information from other organizations is available, it may not be used to obtain inter-organizational patient data. Problems with inter-organizational data exchange are among the most important information system challenges. This explains partly the low utilization in many published studies: If the means for searching for information is regarded as too laborious and time-consuming in spite of the possible benefits, patient information is not sought. This also explains the high usage rate of paper-based HIE. There may also be other explanations for the high use of paper, such as poor interoperability, different data models, need for signatures etc., which need to be explored further. The primary obstacle for RHIE can be legislative, financial or technical. The legislative obstacle was significant in Finland during the time of our study: the

national legislation required permission from the patient for information retrieval from another organization. Primary care and specialized care even in the same geographical area were provided by different organizations at the time of the study, leading to remarkable restrictions: e.g. information through RHIE system type 2 was available only to those primary care physicians who have themselves referred a patient to the specialized care hospital. This made specialized care information more or less unusable in ad hoc consultancy situations. Another type of problem was faced with RHIE system type 1, where one could obtain permission to access any information, but the legislation had required the information to be fragmented into single inputs and this made getting an overview of patient history next to impossible. On the other hand, the users of the RHIE system type 3 did not need to take an active decision to look for the patient data from the other organizations after having patient's consent: it was readily available unlike in the other system types, where the user had to actively open a separate application for the needs of RHIE.

Both problems would not be solved with technology, but with a change in legislation, which currently permits the use of data within one regional organization.

The findings cannot be directly compared with usage rates reported by previous studies [26,28,54], since they reported the actual use of RHIE systems; our results show the preferred means of RHIE. Our study focused on three electronic RHIE systems; therefore the replies of those who had used mixed RHIE systems or no RHIE system at all were removed. However, even those classified into the "no RHIE system" group had access to the results of most of the laboratory and radiology examinations from the region as well as electronic referrals when working in specialized care and for those working in primary care physician electronic referrals, electronic discharge letters and electronic consultations were in use. These functionalities have been in wide use regionally for many years [55], so it can be assumed that many physicians do not even realize that they are using any kind of RHIE functionalities.

How do user experiences of RHIE success vary and what are the factors related to success?

Over 75% of the respondents agreed that in their experience it takes too long to log in to different systems that information on medication from other organizations is not easily available, and that retrieving patient information from other organizations takes too much time. Moreover, 50% or more of the respondents agreed that radiological and laboratory results are easily available, but that IT systems do not provide support for cross-organizational collaboration between the physicians or help prevent errors related to medication. The RHIE system type used in the region, the local EHR system in use, and the primary means of RHIE were the strongest predictors of success.

Among respondents using an electronic means for RHIE, specialized care physicians were slightly more critical of the RHIE systems and their benefits than primary care physicians. Significant differences were found in the ability of information systems to prevent medication-related errors and the efficiency of log-in procedures, but specialized care physicians were more satisfied than their primary care colleagues in considering information systems to be helpful in preventing overlapping examinations. This benefit has also

been found in previous studies, but our study adds to this knowledge by outlining differences in the views of primary and specialized care physicians. This result may reflect the fact that the examination data are already to a larger extent available in the specialized care EHR systems. The effect of regional information exchange in inhibiting unnecessary studies was also seen indirectly: laboratory and diagnostic imaging results were more readily available, while in specialized care over 50% of respondents agreed that information systems help in avoiding overlapping examinations. Interestingly, in primary care the respondents did not agree upon this. In Finland the primary care physician centres usually perform more simple types of examinations e.g. in radiology, which are precursors of more sophisticated examinations made in secondary care units. Thus, a bone radiograph already made in a primary care centre paves the way for an MRI scan made in a secondary care hospital and a repeat radiograph prior to the MRI can be avoided if the images are found in the RHIE. This may partially explain the result, but there may be many other reasons as well.

One aspect of RHIE systems is the quality of data contained in the systems. The data collected in one institution should exist in such a format and with such content that it is usable for various institutions. Already in early studies of collaborative work within teleradiology it was found that the initial storage steps in the primary site affect also the end-user of that information in the secondary site [56]. For test results this information quality is mostly well organized in RHIE systems, but medication information presents very significant difficulties related to the content of the original information or the quality of the original information system.

Within primary care respondents using the EHR system c (which can be used to access all three RHIE types), user experiences varied among respondents working in areas where different regional system types were in use. An integrated RHIE system (type 3) was preferred to other types or RHIE systems. An integrated solution was regarded as best for supporting co-operation between physicians in different organizations, but still, a larger proportion of respondents were more dissatisfied than satisfied with the availability of information. Several findings of the study can explain this: Usability of the EHR system via which the RHIE information is processed, differences in information types that are made available in different regional information systems vs. users own EHR's, usability of the RHIE system and legislative constraints on e.g. access rights. For the RHIE systems to succeed, factors such as interoperability and interface issues, technical and data standard issues as well as contextual differences in the needs have to be carefully considered when designing a HIE system.

Even though the majority of the respondents replied that the information systems do not help to prevent unnecessary (duplicate) tests, the opinions on the availability of radiology and laboratory results were mainly positive. The reason for this negative opinion on preventing duplicate tests could be that the respondents understood this question to mean the existence of a decision support system that would alert the physician that the test has already been taken.

The new legislation that came into force after the data was collected is likely to mean a remarkable change in the usability of RHIE systems, with especially the type 2 (web-distribution) model and the type 3 (regional virtual EHR) model benefitting from this change. The doctor survey will be repeated in 2014 to collect evidence on this change.

4.2. Limitations of the study

One limitation of the study is embedded in the survey (questionnaire) method: the questions may not measure what they are intended to measure, the respondents may understand questions differently than intended, respondents may not answer truthfully or may not remember the correct answer, or answer in a wrong manner, or the responses may vary due to haphazard issues (state of mind, time of day, etc.). In addition, questionnaires do not allow for reporting problems in real time and focus on subjective experiences, which reflect the respondent's previous experiences, the characteristics of the situation in which she answers the questions and the tasks she has recently performed. The second limitation is related to a possible selection bias. We do not know to what extent the characteristics of the original target population (the Finnish physicians) are similar to those of the target population of this study (public sector physicians from the 13 hospital districts where the RHIE system types 1-3 were in use). The sampling method employed and the strength of the evidence can thus be questioned, and the results may not be generalizable to the target population.

Defining cross-organizational health information exchange for the physicians replying to the questionnaire was not straightforward due to the variation in ways that physicians can access data from other organizations. In one region the physicians working in the hospitals have been able to view all regional laboratory and radiology imaging results in their own EHR system for more than a decade, but have had to use the RHIE system to view narrative parts of the electronic patient record as well as diagnosis and medications lists from other organizations. For a primary care physician in the same region, the cross-organizational HIE most likely means only a RHIE system that for them, includes also the laboratory results and radiology imaging. Those who have access to all clinical documentation and results via their own EHR system might have problems in realizing when they are using RHIE and when not. When studying user experiences of RHIE, it is important to design the survey questions so that replying does not require understanding which data comes from RHIE and which from the local EHR. It is, however, necessary that interpreters of the results have this knowledge. This weakness is seen in the published research literature: cross-organizational HIE refers to many different forms of HIE and the results on user satisfaction should be interpreted with caution. One method adopted for tackling this limitation in our study was that two members in the research group were representatives of the primary and secondary care physician practitioners. This allowed the research group to formulate the questions to fit everyday practice, language and understanding of the HIE of the respondents.

Another challenge resulted from the national approach that enforced the semi-structuring of health information

under visit-based entities, due of data protection legislation. This resulted in a concentration of regional HIE on the exchange of narrative text and semi-structuring narrative text under different titles, rather than first exchanging pre-structured pieces of information i.e. medication lists, problems lists, diagnoses lists, risk factor information etc.

The subjectivity of the questionnaire method can also be considered an advantage. Previous research shows a strong correlation between user satisfaction of the system, actual usage of it and experienced benefits [16]. A carefully planned questionnaire may provide the respondents with a unique means of communicating their experiences of ICT usage as well as for researchers to receive valuable data from the viewpoint of end-users. Also, compared to other empirical research methods, questionnaires are a suitable technique for gathering an overview of a situation and current problem areas from a large group of users.

However, it should be remembered that such studies have a low descriptive value: questionnaire results are unable to reveal the causes of problems detected. Therefore the study results provide an indication of the key development areas, but need the support of other methods of gathering information. On the other hand, with the saturation of diffusion and use rates (monitored by national surveys), a survey of user experiences provides a logical step forward in monitoring eHealth policy implementations. User experiences should in the future be monitored as regularly as diffusion and use rates.

4.3. Exploitation of the results

The study results offer three important routes for exploitation: Firstly, for researchers the study shows an example of variables used in studying user experiences at the national level. The study shows the importance of including contextual and EHR-system variables as independent variables when studying factors behind the success of RHIE systems. The study also shows the importance of having detailed enough definitions of the systems under study in order to make comparisons possible. The RHIE systems were divided into various categories according to their architecture and usage type. Our main types were the master patient index model (type 1), the web distribution model (type 2) and the regional virtual EHR model (type 3). In real life, it is difficult to find "pure" models; therefore it is important to define also the main functionalities that are included in the RHIE system. This should be noted in further studies of this subject as well as further in developing activities of the specific EHR systems.

The second audience for the study results is the eHealth system decision-makers nationally and internationally. With the increasing mobility of patients, the puzzle of patient data mobility needs to be solved. Results from comparing three different established HIE models provides a valuable benchmark for countries that are in the process of constructing HIE systems. The results offer information on user experiences and needs regarding intra-organizational patient-information-exchange at the time of the study. The results from this survey, especially the benefits of integrated (virtual) architectures and instant access to data, as well as results on the impact of EHR and experiences of HIE in real contexts are important. For Finnish decision-makers, the study also offers a

baseline measure prior to the implementation of the National Health Information System (KanTa).

The third audience are the HIE system designers. The differences in the operational and user environment and also in the information needs of HIE in the health centre and hospital, different compilations of existing systems for HIE, and the basic problems of the EHR system usability need to be taken into consideration in designing HIE systems. Designers also need to consider the national legislation, e.g. on data usage permissions as a factor that can impact user experiences of different RHIE system types.

4.4. Implications for further research

The previous HIE studies have not studied the entire complex HIE system from different users' viewpoints, comparing different system types. A systematic literature review would be required on HIE, which would cover different HIE system types as well as different contexts of use.

In the USA, it has been reported that to reach the goals set for the electronic exchange of health information and the adoption and meaningful use of health information technology in health care practices and hospitals "the use of metrics to show adoption and flow of data across parties, and evidence that care is improving, will be essential to persuade stakeholders that the initiative is progressing well and warrants continued investment" [43]. However, HIE usage and its measurements are not simple constructs. Vest and Jaspersen [57] have described the complexity as follows: First, the choice of HIE usage measurement must attend to the users, context, and objectives of the system being examined. Second, HIE usage is not immediately generalizable, but heavily context dependent. Therefore, there is a need to improve our understanding of "meaningful use" of HIE and what conceptualizations of usage might best reflect the nature and objectives of HIE.

The national survey and our subsample included users from different contexts of use. This study focused on comparison of usage and experiences of HIE success between different user groups as well as between different system types. This viewpoint has not been common in previous studies.

The national survey will be repeated in Finland in 2014 and hopefully becomes a part of national eHealth monitoring. The authors also participate in the Nordic collaboration and collaboration with the OECD in defining common indicators for monitoring HIE success. The next data collection in Finland will be conducted when ePrescription is fully implemented and the first eArchive implementations have been conducted. This will provide data to compare how the new national HIE system (KanTa) works in practice with the findings from this study.

Surveys are able to provide comprehensive but "shallow" information on any given subject. More research is needed on a comparison of the different ways to exchange health information. The research needs to specify systems and their functionalities in adequate detail to allow comparisons. Future research of information systems needs to take into account the finding that an evaluation of information system attributes needs to be set within the operational and user environment. A health centre and hospital are different contexts of use, and different regions have different compilations

of systems, which are mainly used via the EHR system. The basic problems of the EHR system, the context of use and the extent of regional information system coverage are reflected in the responses. The fact that regional information system functions are different in different areas adds further to the complexity of studying inter-organizational exchange of information. A more complete review of legislative issues and their impact on regional and national HIEs would also be warranted.

Conceptually, this study was a pilot that for the first time sought to examine the types of concepts and variables that could be used to monitor user-experience-related aspects of information systems success, particularly of national and regional information services. We see recording of user experience as a way to assess the quality of information systems and their perceived effects and benefits. However, studying user experiences of key information system functionalities is a new focus in information systems research. In addition, a well-established conceptual model for recording user experience in the context of use does not exist. Research on user perspectives of technology use seems to carry considerable cross-disciplinary interest, although the concepts and approaches used are somewhat different. For example, the reported study indicated that several items in the questionnaire could be viewed as usability attributes, user experience dimensions and information system success variables. Further conceptual analysis around the concepts of *user experience*, *usability*, *context*, *user satisfaction*, *perceived usefulness*, *perceived benefits*, and *user acceptance* should carefully consider the concepts from the perspective of different academic research fields. The conceptual work needs to continue by mapping concepts from different frameworks, comparing their definitions, searching for communalities, differences and variables used to measure them. Monitoring of information systems would also require the perspectives of those other than physicians. Research should also focus on the various business processes and IT solutions – on their impact on efficiency and their cost. Solutions should be developed to optimize business processes, not just the activity of individual users. Information stored in information systems is used for example by many administrative processes, and citizens will also be able to take advantage of it. Previous studies suggest that client or patient access to their own data will facilitate compliance with care instructions. Previous studies also provide evidence of increased efficiency in administrative processes, although the impact on clinical processes would be the opposite. Administrative viewpoint to impacts of HIE is thus one important focus for future research.

Authors' contributions

All the authors, Hannele Hyppönen, Jarmo Reponen, Tinja Lääveri and Johanna Kaipio contributed to the study design, questionnaire development, data interpretation as well as revisions and approval of the manuscript. Hannele Hyppönen, PhD, Research Manager had main responsibility for the manuscript. She was responsible for the study questions, the study outline, selection of the population for the article, and the Sections 2 and 3 of the report. She also conducted a literature search, which was used to review the previous literature

Summary points

What was known on the topic

- Several countries are implementing regional or national HIE systems.
- Earlier studies have shown rather low use rates: clinicians do not use HIE in all encounters. From the end-user perspective the main concerns relate to the confidentiality and safety of the exchange and the reliability and quality of patient data.
- Little is known about the health practitioners' experiences on HIE system usage and success of different types of HIE solutions.

What the study added to the topic

- Even if information from other organizations is available, it is not necessarily utilized; problems with usability of inter-organizational data exchange were among the most important information system challenges found in the study.
- The preferred means of RHIE (paper/electronic) was associated with the RHIE system type, the working sector and the EHR system used: In regions with type 3 (virtual integrated model) RHIE system was available, electronic HIE was more common than in other regions. Primary care physicians used electronic HIE to a much larger extent than the specialized care physicians. Users of EHR e, c and g were most active in electronic HIE.
- Strongest predictors of RHIE success were the RHIE system type, the local EHR system and the primary means of RHIE: RHIE type 3 was most successful, even if there were common problems with all RHIE types. Compared to RHIE type 3, types 1 and 2 scored poorly on support for cross-organizational collaboration, and users of these types regarded RHIE system usability as the most urgent focus for development to a larger extent than users in RHIE 3 regions. RHIE type 1 was also associated with inefficiency to retrieve patient information from other organizations
- Usability of the EHR as well as the RHIE system, information types available in the RHIE system, contextual differences in the information needs, legislative constraints on data access – along with the interoperability and interface issues, technical and data standard issues – all impact the success of a HIE.

on the subject, and help conduct the statistical analyses. The other authors contributed equally to the manuscript. Jarmo Reponen, MD, PhD, had the main responsibility for describing the types and functionalities of RHIE systems in Finland. He also had the main responsibility for the Section 4, and contributed actively in all parts of the manuscript. Tinja Lääveri, MD, specialist in Internal Medicine, had main responsibility for the statistical analyses. She also reviewed the literature together with Dr Johanna Kaipio, and contributed greatly in the Sections 3 and 4, as well as other parts in the manuscript. Johanna Kaipio, PhD, had main responsibility for the related

research chapter. She also participated in modifying other parts of the article as well as in the statistical analysis tables.

Conflicts of interest

No reported of conflicts of interest.

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Appendix 1. The Finnish context of HIE

In Finland, the expectations for regional health information exchange (RHIE) systems align with the expectations for the national HIE system (KanTa) that commenced in 2006, when the Ministry of Social Affairs and Health initiated an implementation project to build a national, centralized health information archive. KanTa consists of a national electronic archive (eArchive) of patient data, an electronic prescription system (ePrescription), a pharmaceutical database, an information management system (eManagement), and a portal allowing patients to look up their own records (eAccess) [8,9]. The eArchive serves both as a long-term archive for patient records and as a secure patient data storage, management and exchange service for organizations. The KanTa system incorporates the management of consents and living wills,¹ the provision of summaries of archived patient data and care plans, which will be available for health care organizations [8,9].

The Finnish national health information system (KanTa) will store core patient data nationally in a uniform technical format to ensure interoperability across information systems and improve their availability to healthcare providers. Patient data are generated in the uniform format, signed and viewed via the local EHR systems. The local EHR system can also offer e.g. functionality for copying of old data as a basis for new data [12,13]. At the time of the data collection for this study in 2010, the KanTa system was under construction. Implementation of ePrescription and eAccess for patients to view their prescriptions and consents started in 2011, and full public health

¹ A written document that allows a patient to give explicit instructions about medical treatment to be administered when the patient is terminally ill or permanently unconscious; also called an advance directive.

sector and pharmacy deployment will be reached in 2013. The first part of the eArchive (exchange of defined types of patient information) will be deployed starting from 2013. Public sector physicians must according to legislation start using the KanTa archive by 1 September 2014 and private service providers must be archiving their patient records in an electronic form by 1 September 2015 [12,13]. While national information services will be implemented for national level HIE, regional solutions will be further developed to support more local HIE needs.

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