Health Information Exchange in Finland: Usage of different access types and predictors of paper use

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1 Abstract

Introduction: Timely, complete and accurate patient data is needed in care decisions along the continuum of care. To access patient data from other organizations, there are three types of regional health information exchange systems (RHIS) in use In Finland. Some regions use multiple RHISs while others do not have a RHIS available. The recently introduced National Patient Data Repository (Kanta) is increasingly used for health information exchange (HIE).

Objectives: The purpose of this study was to assess usage of paper, RHISs and Kanta by context in 2017; evolution of paper use over the years; and predictors of paper use in 2017 among Finnish physicians for HIE system development.

Methods: Data from national electronic health record (EHR) usage and user experience surveys were taken from 2010 (prior to ePrescription system implementation), 2014 (prior to implementation of Kanta) and 2017 (Kanta was in full use in the public sector and in large private organizations). The web-based surveys were targeted to all physicians engaged in clinical work in Finland.

Results: Kanta was the most frequently used means of HIE in 2017. Paper use had reduced significantly from 2010 to 2014. The trend continued in 2017. Still, up to half of the physicians reported using paper daily or weekly in 2017. There were great variations in paper use by healthcare sector, available RHIS type and EHR system used. In multivariable analysis (with all other variables constant), predictors of more frequent use of paper than electronic means for HIE were: private sector or hospital, access to Master Patient Index RHIS (type 1), multiple RHIS (type 4) or no RHIS (type 5), two particular EHR systems, older age, less experience, operative, psychiatric or diagnostic specialties, and male gender.

Conclusions: Usability of HIE systems including EHRs as access points to HIE need to be improved to facilitate usage of electronic HIE. Usage ensures more timely and complete patient data for safe, coordinated care. Specialty-specific needs and requirements call for more user participation in HIE design. Especially older professionals need training to better exploit HIS for HIE.

Keywords: electronic health record, health information exchange, communication, physicians, usability, technology acceptance

1 Introduction

Timeliness and completeness are dimensions of data quality. Access to quality data impacts all decisions made along the continuum of patient care. (1) Healthcare services are increasingly arranged in collaboration among service providers across sectors. Countries are progressing in their health information exchange (HIE) initiatives with little evidence of actual use, usability and impacts of HIE systems (2-6). In Finland, five different regional health information systems (RHISs) have been in use for over 10 years. They have offered three different ways to access patient information with patient consent across registrars, with minor changes in user organizations over the years. Some regions use multiple RHISs while some have no RHIS available, amounting to five different RHIS types. Definitions of the types are presented in Annex 1.

A national ePrescription service was implemented between 2011–2016 in Finland to improve patient and medication safety and prescribing efficiency. Systems implemented in Sweden, Denmark, Germany, and England were used as references (7). In 2014, the service was fully implemented in the public sector. National Patient Data Repository (Kanta) implementation started in 2014 to enhance efficient handling of patient information and patient safety. Systems implemented in Belgium, England, Netherlands, Austria, Sweden, Denmark and the United States were used as references (8). In 2017, Kanta was in full use in the public sector and major private organizations.

According to our earlier HIE study (9), information from other organizations was available, but it was not necessarily utilized. In regions with type 2 HIE access, electronic HIE was more common than elsewhere. Primary care physicians used electronic HIE to a larger extent than physicians in specialized care. Electronic health record (EHR) brand was associated with electronic HIE usage. Moreover, users of three particular EHR brands were most active in electronic HIE use.

Usability of HIE systems is a crucial element in improving usage. Access to more complete patient data is a factor for safer, more coordinated care. Earlier studies (Annex 2) show that:

- Usage rate of HIE after implementation is often low, even if clear benefits can be shown (10)
- Usability (11-14) and practice setting (15-17) predict usage of the HIE
- Specialty, satisfaction with push HIE and improved access to complete info (17) predict overall satisfaction with HIE (15,18)

Earlier studies focus mainly on use and user satisfaction in the US. Many studies are local, focusing on intention of use. There is paucity of comprehensive, nation-wide follow-up studies comparing variation in usage of different types of HIE systems.

The objectives of this study are to assess: usage of paper, RHIS and Kanta in 2017; evolution of paper use over the years; predictors of paper use in 2017 among Finnish physicians. The study has implications on furthering usability of HIE and EHR systems,

via which the HIE systems are mainly used. Good usability improves usage. Usage of timely and complete data is an important element in safe, coordinated care.

2 Research methods

Experiences on eHealth systems have been monitored on a regular basis in Finland from 2010 using a nationwide survey to physicians (19-22). A web-based survey was conducted in the beginning of 2010, 2014, and 2017, targeted to all physicians aged less than 65 years of age and engaged in clinical work (https://www.laakariliitto.fi/site/assets/files/1266/lomake_laakarit_2017.pdf). This study utilizes a combined data set including the 2010, 2014, and 2017 nationwide surveys.

The questionnaire was sent to physicians with an e-mail address in the Finnish Medical Association register. In 2010, 3929 physicians responded to survey, 3781 in 2014, and 4018 in 2017 giving response rates 27.2%, 23.1%, and 23.4%, respectively. The questionnaire from 2010 was used in all three data collections, with clarifications to some questions and pre-tested with five physicians in 2010, eight physicians in 2014 and six physicians in 2017. In this study, the outcome variable was:

> Year 2017: **To what extent** do you use the following methods to retrieve patient information from another organization (Does not concern referrals and feedback)? 1) Papers or fax 2) RHIS (Regional Health Information System) 3) Kanta. Response alternatives: Daily, weekly, seldom, never[1].
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> Year 2010 and 2014: Which of the following do you **mainly** use in searching for patient information from ANOTHER organization; for example, between the hospital and primary care? (Does not concern referrals and feedback) Papers, Fax; RHIS A; RHIS B; RHIS C; RHIS D; RHIS E; Other, please specify.

The controlling variables - gender, age, experience in EHR use, working sector, hospital district, HIE access type, and EHR system used – were selected based on earlier studies. HIE access type variable was generated by grouping the respondents by hospital district to 5 groups according to HIE access type implemented in each hospital district. Information on the availability of various RHISs was obtained from a separate survey (23), conducted at the same time as the physician surveys in 2010, 2014, and 2017. Respondents of nine of the most frequently used EHR systems (over 30 respondents) and a group 'Other systems' including respondents of EHR systems with less than 30 respondents were depicted in the analysis.

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[1] The question about means of HIE was changed from 2010 and 2014, since we wanted more precise information about frequency of HIE use by different means. Also Kanta had been introduced, and the old question format did not work anymore. For comparability, an additional variable was built from the 2017 variable, depicting relative use of paper compared to e-means: Respondents, who used paper more frequently than RHIS or Kanta were grouped into "More paper"-users for short. Due to new format of the question statistical differences between the variables 'More paper' and 'Mainly paper' were not calculated.

Representativeness was assessed by comparing age and gender distributions between respondents to the registry of the Finnish Medical Association. Overall, the target population was every year slightly younger, slightly more often male than the respondents of our survey (19,20). As the differences were insignificant, the findings can be generalized to all physicians in clinical work in Finland.

The controlling variables were analyzed by year. We used the Chi-square Test to test associations between the categorical (control and outcome) variables and the Kruskal-Wallis Test for association between experience statement in EHR and year. We used multivariate logistic regression analysis to study which variables predicted physicians' use of paper in 2017. Stepwise selection method was used for selecting independent variables for the logistic regression models using a significance level of 0.05 for a variable to stay in the model. The statistical analysis was carried out with SAS (SAS Institute Inc., Cary, NC, USA) version 9.3.

3 Results

3.1 Demographics

Mean age was 47.9 (men 49.6, women 46.6) in 2010, 47.7 (men 49.5, women 46.6) in 2014, and 47.7 (men 48.5, women 47.2) in 2017. The proportion of respondents working in health centers and private sector increased during the study period and respondents from hospitals and other contexts decreased (Table 1, p-values show significance of differences between years). The proportion of the youngest and the oldest age groups and female respondents and the proportion of respondents working in areas with RHIS type 2 increased. (RHIS types defined in Annex 1). Of the EHR systems, the proportion of respondents using EHR-systems 'a' and 'b' increased while system 'h' became less popular. Responses from different hospital districts showed no significant differences between years (p=0.243).

Table 1 Demographics of the respondents

	2010	2014	2017	p
Target population N	14411	16350	17210	
Questionnaire sent (% of target population)	87	91	93	
Respondents N	3924	3775	4009	
Gender %				<.001
male	42.2	38.1	35.1	
female	57.8	61.9	64.9	
Age group %				<.001
-34	12	16.9	16.7	
35-44	23.6	21.2	21.9	
45-54	33	28.4	26.7	
55-	29.1	33.6	34.7	
Working sector %				<.001
Hospital	47.3	45.1	45.2	
Health centre	24.1	24.9	25.5	
Private	12.2	12.6	15	
Other	16.4	117.3	14.3	
Experience in EHR use %				<.001*
Novice	1.2	0.9	0.9	
2	7.1	4.8	3.7	
3	26.5	22	23.3	
4	42.2	45.2	41.4	
Very experienced	23.1	27.1	30.8	
Means of electronic HIE in use %				<.001
Type 1 (Master patient Index) RHIS +Kanta in 2017	32.4	30.1	31.5	
Type 2 (Virtual regional EHR) RHIS+Kanta in 2017	14.8	16.1	19.9	
Type 3 (Web distribution) RHIS+Kanta in 2017	9.9	10.1	10.8	
Type 4 (multiple) RHIS+Kanta in 2017	4.8	3.3	0	
Type 5 (no) RHIS+Kanta in 2017	38.2	40.4	37.8	
EHR system used %				<.001
System a (Private care)	0	3.3	4.7	
System b (Private care)	9.9	11.7	12	
System c (Public primary & special. care)	25.7	24.1	25.9	
System d (Public special. care)	5.7	5.4	5.8	
System e (Public primary care)	1.3	1.3	1.3	
System f (Public primary and special. care)	4.3	3.9	5.6	
System g (Public primary and special. care)	14.1	13.4	14.4	
System h (Private care)	2.7	3.1	2.1	
System i (Public special. care)	25.5	24.7	23.6	
Other systems (j)	10.8	9.7	5.7	
*Kruskal-Wallis test				

EHR (Electronic health record), HIE (Health information exchange), RHIS (Regional health information system), Kanta (National patient data repository)

3.2 Use of paper, RHIS and Kanta by context of use in 2017

Up to half of the respondents still used paper daily or weekly in 2017 with significant working sector-specific differences (Table 2). RHISs were used daily or weekly mainly in the public health centers, least by users from the private sector, whereas daily or weekly users of Kanta were mainly respondents from the public health centers and private sector.

Table 2 Use of paper, RHIS and Kanta by working environment in 2017

		Working sector				
		Hospital	Health centre	Private	Other	p
Using paper	Total N	1717	967	571	545	0.001
	Daily/ weekly %	33.9	35.5	43.1	37.6	
	Less frequently/ not at all %	66.1	64.5	56.9	62.4	
Using RHIS	Total N	1711	996	510	513	<.001
	Daily/ weekly %	38.1	68.3	7.7	24	
	Less frequently/ not at all %	62	31.7	92.4	76	
Using Kanta	Total N	1747	1005	582	547	<.001
	Daily/ weekly %	38.8	59.3	55.8	34.7	
	Less frequently/ not at all %	61.2	40.7	44.2	65.3	

Differences in usage of paper by available RHIS type were significant($p<0.001$): paper was used daily or weekly most frequently by those with RHIS type 5 in use (42%), least by those with RHIS type 2 in use (25%) and by one third of those with RHIS types 1, 3, and 4 in use (37%, 30% and 33% respectively). EHR system ‘a’ and ‘h’ users responded using paper daily or weekly most frequently (53% and 52% of respondents respectively) ($p<0.001$).

3.3 Evolution of paper use by year, working sector, RHIS system and EHR-system in use

Between 2010–2014, there was a significant shift from ‘mainly paper’ to ‘mainly electronic’ means of HIE (Table 3). The shift was also seen when looking at paper users by working sector, with biggest decreases in paper use among physicians working in hospitals and health centers. In 2017, less than fifth of all respondents reported using ‘more paper’ than RHIS or Kanta, with significant differences by working sector.

Table 3 Main means of HIE, and use of paper by working sector in 2010, 2014 and 2017

Year	2010	2014	p	Year	2017	p
Means of HIE %			<.001	Means of HIE %		
Mainly e-means	37	47		More e-means	82	
Mainly Paper	64	47		More paper	18	
Total N	3644	3375		Total N	3800	
Mainly paper/ working sector %			<.001	More paper / working sector %		<.001
Hospital	68	47		Hospital	19	
Health centre	39	20		Health centre	5	
Private	89	87		Private	26	
Other	68	55		Other	31	
Total N	2259	1574		Total N	685	

Reduction in 'mainly paper' use from 2010 to 2014 was evident also by RHIS type used, with biggest reduction (from 42% to 14%) in responses from regions using type 2, and smallest from regions using type 5 RHIS (from 85% to 74%). In 2017, significant differences remained: proportions of users of 'more paper' by RHIS types 1-5 were 18%, 6%, 9%, 13%, and 25% respectively ($p<0.001$).

The proportion of 'mainly paper' users remained very high in 2010–2014 for users of EHR system 'b' (90–86%), 'd' (79–66%), 'h' (83%–81%) and 'i' (77%–62%). Users of EHR system 'c' (from 39% to 16%), 'f' (from 75% to 35%), and 'g' (from 55% to 29%) showed over 20 percentage unit reductions in paper use. For EHR system 'e', the proportion of physicians using mainly paper remained low from 2010 to 2014 (13% to 2%). In 2017, the lowest rates of 'more paper' responses were from users of EHR system 'e' (2%), 'g' (5%), 'c' (9%), and 'd' (13%), and highest for systems 'h' (39%), 'i' (27%), 'f' and 'b' (23%), with statistically significant differences between systems ($p<0.001$).(Annex 3 table 6)

3.4 Predictors of paper use in 2017

Access to RHIS types 1 and 5 increased the odds for using 'more paper' than RHIS or Kanta compared to access type 2, controlling for age, gender, working sector, EHR system used, experience in EHR use, and specialty (Table 4). The odds for using more paper than RHIS or Kanta was higher among physicians working in private sector (OR 11.0, 95% CI 4.8–25.1) and specialized care (OR 1.7, 95% CI 1.1–2.8) compared to those working in health centers. EHR system 'f' users' odds for using more paper was higher, whereas system 'a', 'b' and 'g' users' odds was lower compared to the reference system (system 'c'). The odds for using more paper among physicians working in operative, diagnostic and psychiatric specialties as well as those without specialization was higher compared to physicians working in general medicine specialty. For older physicians and male gender the odds for using more paper was higher. Increase in number of years of using the EHR system decreased the odds.

Table 4 Predictors of using more paper than RHIS or Kanta in 2017

Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Limits	
rhietype 1 vs 2	2.1	1.3	3.4
rhietype 3 vs 2	0.9	0.4	1.8
rhietype 5 vs 2	2.1	1.3	3.5
Age group 2 vs 1	1.6	1.1	2.3
Age group 3 vs 1	2.9	2.0	4.1
Age group 4 vs 1	2.8	1.9	3.9
workings hospital vs health centre	1.7	1.1	2.8
workings private vs health centre	11.0	4.8	25.1
workings other vs health centre	4.4	2.5	7.6
ehr 1 vs 3	0.3	0.2	0.6
ehr 2 vs 3	0.2	0.1	0.5
ehr 4 vs 3	1.4	0.6	3.1
ehr 5 vs 3	0.2	0.0	1.3
ehr 6 vs 3	1.9	1.2	3.2
ehr 7 vs 3	0.5	0.3	0.8
ehr 8 vs 3	0.7	0.3	1.6
ehr 9 vs 3	1.5	0.9	2.5
ehr 10 vs 3	0.9	0.5	1.6
Experience 1 vs 5	3.0	1.3	6.9
Experience 2 vs 5	2.2	1.4	3.5
Experience 3 vs 5	1.4	1.1	1.8
Experience 4 vs 5	1.2	1.0	1.5
Operat vs general	2.9	2.1	4.1
Conservat vs general	1.4	1.0	2.0
Diagnost vs general	3.7	2.3	5.9
Psychiatr vs general	1.9	1.3	2.9
Not known vs general	1.5	0.4	5.8
Nonspecial vs general	1.8	1.2	2.7
male vs female	1.3	1.1	1.6

With ‘use of paper daily or weekly’ variable as the independent variable, access to RHIS types 1 (OR 1.6, 1.2–2.1) and 5 (OR 1.9, 1.4–2.5) remained as significant predictors. The use of EHR system ‘a’ increased the odds for frequent paper use (OR 1.6, 1.1–2.3).

4 Discussion

4.1 Discussion by key results

Up to half of the Finnish physicians still used paper for HIE daily or weekly in 2017. This can at least partially be explained by system and data availability: RHISs were not available in all regions, most of the private providers could not access RHISs and all had not joined Kanta. All pertinent patient data are not yet available via Kanta, with up to five days’ delay in storing it there, which can be considered too long also in non-

urgent cases. Also, daily nursing documentation and medication administration data are not yet stored in Kanta, but are available via RHIS types 2 and 3. In addition, by autumn 2017, only half of patients had given consent to view their data across registrars (https://yle.fi/uutiset/3-9867258): without consent the data are archived in Kanta, but not disclosed. Trust in privacy has been emphasized in previous literature as prerequisite for HIE (24).

Working sector was a strong predictor of more paper use in 2017 as in our previous study (25). Availability as well as different HIE needs may explain the result: The largest private providers have patient data documented within the same organization available nationally within the same EHR system. In most hospital districts, physicians have had access to regional radiology and laboratory information systems for nearly two decades, which may reduce the need for viewing RHIS or Kanta in the public sector. Also, pertinent patient information is usually provided in the referral to hospital, sent via point to point connection. Moreover, in cases of inpatient transfers between organizations, information is usually printed to be brought along with the patient. During the hospital stay or consecutive visits to outpatient departments, there is obviously less need for HIE.

Significant differences in paper use by RHIS type and EHR system (cf. (10)) suggest differences in usability of information retrieval as a likely explanation. In the 2010 analysis (9) type 1 predicted lower likelihood of experiencing RHIS support for cross-organizational collaboration and higher likelihood of usability problems, which may explain the higher use of paper in these regions still in 2017 (Types 4 and 5 were not assessed in the earlier analysis). According to previous studies, usability (11-14) and practice setting (15,16) predict usage, and specialty, satisfaction with push HIE, improved access to complete info (15,18,26) predict overall satisfaction with HIE.

The results show great reduction in paper use between 2010 and 2017. Implementation of the national Kanta system after 2014 is the most feasible explanation. It has offered the private sector and regions without RHIS access to patient data across registrars for the first time. However, for physicians who already had access to RHIS, Kanta has offered less added value.

Specialty, age and gender predicted more paper than RHIS or Kanta use in addition to the working sector, HIE access type and EHR system used. Working sector as controlling variable divides respondents also by specialty. Operative, diagnostic and psychiatric specialties as predictors of more paper use may also indicate specialty-specific HIE needs: In operative specialties, relevant information is usually provided in the referral. Diagnostic specialties have dedicated HIE systems (PACS and LIS). In psychiatry, some patients may be more hesitant in giving consent for HIE, however, we found no studies assessing this. Also data of psychiatric patients are in some cases protected with additional access control, which may make its electronic usage more difficult than in other specialties. Operative specialties and psychiatry have been also slower in EHR adaptation than conservative specialties (27-29). Our finding of males being more likely to use paper for HIE than females is supported by a study showing women being more likely than men to use computers at work (30). A study on predictors of EHR use showed no gender-specific differences (31). Age increased the

likelihood of using more paper in our study, reducing likelihood of using EHR also in an earlier study (31).

4.2 Limitations

Questionnaires are suitable for gathering an overview of a situation and current problem areas from a large group of users. Results don't reveal the causes of problems, but a national survey to users to monitor eHealth policy implementations gives direction to problem solving. Extent of HIE could also be studied using access logs from various HIE systems. However, they do not reveal whether the user actually found the information she/he needed, what proportion of this information was considered useful and what other means for HIE were used. Subjective questionnaires add to our knowledge of actual HIE usage patterns.

The generic survey method reliability and validity questions also apply in this study (32), and were considered when formulating the survey. Three members in our research group were practicing primary and secondary care physicians. This allowed us to fit the questions to respondents' everyday practice, language and understanding of HIE and formulate introductory text.

Selection bias may also occur. In 2010, register information on the physicians' working sector was used to include only physicians working in the clinical work into the target population. In 2014 and 2017, this information was no longer available. Therefore the questionnaires were sent to all working aged physicians (i.e. to a larger target population, with a cover letter calling for responses from physicians in clinical work). Based on the results, only physicians working in the clinical work responded the survey each year. Also the register of e-mail addresses was not totally comprehensive, which may have caused additional selection bias.

Grouping respondents by available HIE type was not straightforward: ways that physicians can access data from other organizations and data contents available for them varies, and physicians may not be aware of types of HIE they use. Therefore we used information from an organizational survey for grouping.

We were not able to statistically compare 'mainly paper' variable from 2010 to 2017 due to change in questions. We calculated a proxy variable 'more paper' to serve in the place of 'mainly paper' in the 2017 data, not including it in statistical comparisons.

Questionnaires focus on subjective experiences, which 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 (33). A carefully planned questionnaire may offer the respondents unique means of communicating their experiences of ICT usage offering invaluable state-of-the-art data from end-users' viewpoint

5 Conclusions

Physicians use paper if they cannot achieve their goals with information systems. Results call for improvements in EHR- and HIE-system usability to increase usage. Timely access to more complete patient data facilitates safer and more coordinated care of patients. Type 2 RHIS predicted less paper use, providing a good reference point for development.

Results related to specialty- and user-specific differences in HIE pinpoint the urgency to develop deeper understanding of differences in needs and requirements of HIE. Developing information contents of national information services (e.g. Kanta in Finland) for added value to the physicians at point of care across specialties requires more collaboration with users. Attention needs to be paid in older professionals' skills in exploiting the electronic means of HIE.

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Annex 1 The Finnish context of HIE

Between the three data collection points, several changes in the Finnish health care and health information infrastructure have taken place, which need to be accounted for as they may impact the results.

1.1.1 Physicians in Finland

There are a few demographic changes in the target group from 2010 to 2017. The number of physicians engaging in the clinical work has increased by 2700 since 2010, and also the proportion of the youngest and the oldest age groups has grown. Relatively there are now more female physicians in the labor market than in 2010. The context of work has also slightly shifted from public to private care.(19,20,34)

1.1.2 Local government reform

The administrative environment has also changed. Even if there is no change in the Finnish public health system as such (primary health and social care are provided by municipalities or associations of municipalities and specialized care by special organizations (hospital districts) owned by the municipalities), a local government reform led to reduction of numbers of municipalities from 342 in 2010 to 320 in 2014. Historically the municipalities and hospital districts have built their own EHR systems and health data repositories.

The current Prime Minister Sipilä's government (from 28.5.2015) has decided to give the responsibility of social and health care service provision to 18 autonomous provinces by 2019. The aim is a full horizontal and vertical integration of health and social care and the primary and secondary levels of services. The reform will set requirements for easier data exchange between primary and specialized care, whereby it is of utmost importance to monitor the HIE-situation prior to the reform. In future, it is not enough to exchange data only between primary and specialized care, because a great emphasis of the forthcoming reform will be in the free choice of care between private and public care. Without well-functioning HIE-systems, previous patient information will not be available in these situations

1.1.3 A new Finnish e-health and e-welfare strategy

E-health and e-welfare systems have been identified as important tools in modernising social and health care services. The Ministry of Social Affairs and Health upgraded the Finnish national e-health and e-welfare strategy in 2015. Of the six main target areas two are especially relevant for this study: 1) aim to ensure that the systems are usable, support professionals' work and operating processes and electronic applications are in use and 2) aim to have client and patient information is accessible to professionals and clients irrespective of changes in organization structures, services and information systems. (35) These goals underline further the need to monitor their attainment.

1.1.4 Implementation of new RHISs and NHIS

There have been different Regional Health Information Systems (RHIS) in different regions in Finland long before implementation of the National Health Information System (NHIS, with patient data archive Kanta and ePrescription). The RHIS availability for different hospital districts has changed somewhat during the seven years. The different RHIS types and changes in RHIS availability are depicted in table 5 (23).

Table 5 Types of regional information exchange systems in different hospital districts from 2010 to 2017. (23,28,29)

	RHIS type used		
Hospital district	**2010***	**2014***	**2017***
Helsinki ja Uusimaa	Type 1	Type 1	Type 1
Varsinais-Suomi	Type 1	Type 1	Type 1
Satakunta	Type 1	Type 2	Type 2
Kanta-Häme	Type 2	Type 2	Type 2
Pirkanmaa	Type 5	Type 5	Type 5
Päijät-Häme	Type 2	Type 2	Type 2
Kymenlaakso	Type 2	Type 2	Type 2
Etelä-Karjala	Type 2	Type 2	Type 2
Etelä-Savo	Type 2	Type 2	Type 2
Itä-Savo	Type 2	Type 2	Type 2
Pohjois-Karjala	Type 2	Type 2	Type 2
Pohjois-Savo**	Type 5	Type 5	Type 5
Keski-Suomi***	Type 4	Type 4	Type 2
Etelä-Pohjanmaa	Type 2	Type 2	Type 2
Vaasa	Type 3	Type 3	Type 3
Keski-Pohjanmaa	Type 4	Type 2	Type 2
Pohjois-Pohjanmaa	Type 3	Type 3	Type 3
Kainuu	Type 4	Type 2	Type 2
Länsi-Pohja	Type 3	Type 3	Type 3
Lappi	Type 3	Type 3	Type 3
Ahvenanmaa	Type 2	Type 2	Type 2

*Depicts situation with patient data produced by specialized care. Does not include laboratory- or imaging data repositories nor patient data exchange within the primary care data repositories.

Compared to the situation in 2010, some changes have happened in the available RHIS in hospital districts, allowing access to detailed clinical notes between primary and specialized care in Finland. In 2010, we limited the analysis to only those hospital districts, which had RHISs access type 1, 2 or 3 in use. In this article, we used the full data by forming two new RHIS types; one with hospital districts using mixed RHIS and

one with hospital districts and private organizations without RHIS access. Thus, the following RHIS -types were formed:

- **RHIS type 1**: Hospital districts using the **Master Patient Index-type RHIS**. In this type, authorized users access an index of the original data from a centralized reference database via a separate user interface. Each of the indexed data items must be viewed (pulled or queried) separately. The users of practically all EHR system brands and organizations have access to RHIE, but only to selected information such as notes and laboratory results i.e. not the whole patient record. Users at primary and secondary care have an equal access to data, which is structured according to care episodes.
- **RHIS type 2**: Hospital districts using a **regional virtual EHR –type RHIS**. In this type, the physician has direct access to the electronic patient record of another organization. Users at primary and secondary care are using a common EHR user interface to a regional patient data repository, which can be a single repository or virtual combination of repositories. Diagnostic images and laboratory data may still have separate regional archives, which may be presented as part of the same EHR-system (integrated functionality) or as a separate regional data repository which the user launches through a separate interface (36)
- **RHIS type 3**: Hospital districts using the **Web distribution -type RHIS**. In this type, authorized users from primary care have full access to a web based electronic patient record from specialized care. In 2010, primary care physicians could see all the information from the specialized care hospital only for those patients who they had themselves referred to specialized care. By 2014, however, this restriction/constraint had been suspended. This model is asymmetric: while all data form specialized care is available, no text data from primary care is exchanged. There are however separate common repositories for imaging and laboratory data.
- **RHIS type 4**: Hospital districts using **multiple RHIS systems** to exchange patient documentation between primary and specialized care. There are multiple patient data repositories for text data in the region and their contents is viewed using various user interfaces. Typically imaging and laboratory data exists in separate repositories which might or might not be connected to those user interfaces.
- **RHIS type 5**: Hospital districts have **no RHIS system** for EHR text data exchange. In these areas separate systems for laboratory and radiology data exchange however exist. The exchange of text data has been paper based until our 2017 study, when Kanta-system was fully implemented in the public sector. Respondents from private organizations were included in this group. They have had no access to any type of public sector RHIS, thus relying to the paper-based HIE up until 2017, when for the first time, the HIE functionalities through the national Kanta-system was available (during the

2017 data collection Kanta was in use in the public sector and biggest private sector organizations)

NOTE: while RHIS systems are mainly for information pull from other organizations or from previous visits, Finnish healthcare has an extensive electronic referral – discharge letter system that is used in nearly all hospital districts and also between private care and public care. This pushes electronic information to another care provider, when care responsibility is transferred to another institution.

In addition to the RHISs, a national level HIE-system (Kanta) has gradually been implemented during our study: During the first national survey in 2010, no national means for HIE were implemented. By the time of the repeated data collection in 2014, all the public health care organizations had joined the ePrescription service allowing access to prescriptions made in other joined organizations as well as to dispensing information. In 2014, the national Kanta-archive implementation had just started, but practically no data had been exchanged by our survey. By 2017 data collection, all public organizations and the largest private organizations had also joined the Kanta-system. The Kanta system consists of a patient data archive, electronic identification and signature-service for user authentication, a code service to ensure harmonious coding of stored information, and MyKanta pages for citizens' access to their data. The characteristics of the Kanta-service are depicted below:

- The national HIE system (Kanta and ePrescription) is integrated to primary and specialized care EHR systems (as in RHIS type 2). Whereas type 2 RHIS (the virtual EHR-model) has an internal database and direct user interface common to all EHR-users, Kanta is used via local EHRs, and has a national database with security rules and message interfaces which respond to a request sent from an EHR (there is search functionality as in RHIS type 1). Kanta returns the requested data in a predefined 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 RHIS-systems. A web-interface is also available for professionals. The Kanta system will provide a specialty-specific continuous medical record (features of RHIS type 3 - web distribution model). It is different from RHIS type 3 in that technically it will operate using similar messages as the current EHR systems. The Canadian, North American, Scottish, Welsh, Irish, Dutch, Estonian, French, Swedish and Danish HIE models have been analyzed for the basis of Kanta-development. The comparison concludes that the Estonian HIE architecture is closest to the Finnish Kanta architecture (with a centralized repository (as in RHIS types 2 and 3) for textual data, and a separate user interface (as in RHIS type 3). 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 RHIS type 1). The RHIS systems are joined to the national Kanta archive.

1.1.5 Changes related to the Health Care Act

The new health care act took force on May 1st 2011. The act aims to improve co-operation between primary, secondary and tertiary levels of care, to put the citizen in the center and to strengthen the primary care level. The legislation gave for the first time, patients right to select their point of care – first care center within own municipality, later within the region. It also made it possible to administratively form a single register of the patient information generated by different public service providers within a hospital district. In practice, this has meant right to access patient data from different public organizations without patient's specific consent. Technically the access has meant querying patient information from other organizations on paper or viewing patient data via regional health information systems.

Annex 2 Results of previous literature

Ref/ year	Types of HIE	Setting	Indicators	Data sources	Results
(37) review	electronic sharing of health related information according to US standards	US, primary care	HIE usage Benefits Barriers	peer reviewed and gray literature, all types of designs (N=64)	Improved access to test results and other data, decreased staff time for handling referrals and claims processing. Barriers: implementation cost, privacy and liability concerns, organizational characteristics (lack of strategy support), and technical barriers (lack of interoperability).
(38) review	Various HIE-tools facilitating provider-provider communication	Mainly US, outpatient setting, different diseases	Health service utilization disease-specific clinical outcomes, process-of care, efficiency	4 RTCs and 7 observational studies (N=11)	no evidence on most of the measures, except moderate evidence on reduction of hospitalizations, hospital length of stay and ED visits due to sharing of laboratory information
(39) review	electronic sharing of health related information according to US standards, modes of access not described	US, all organisation types	HIE usage, Patient/provider satisfaction, Attitudes Health care utilization, Efficiency Clinical outcomes, Financial sustainability	peer reviewed descriptive qualitative, quantitative, hypothesis-testing studies and reviews (N=87)	HIE is believed to bring value, concerns about disruptions in workflow, technical problems, and cost
(40) original study	region-wide electronic patient record systems	Sweden	user adoption	observation, interview, questionnaires of users of 3 wards (N=?)	Large variations in the units' adoptions due to expectation and attitude, management and steering, end-user involvement, EPR learning, and usability. Changes in work processes need to be considered in development and deployment, in order to achieve the potential benefits.
(41) review	Challenges and opportunities for HIE	Saudi Arabia		Review (6 studies)	Three primary challenges for HIE were identified including data formatting, semantic ontology, and building the HIE infrastructure. Saudi Arabia is advancing in the electronic medical record (EMR) implementation especially with current changes on the level of authority and ministry structure. Building an EMR foundation will make the HIE simpler to implement for the Saudi Arabian Ministry of Health.
(42) review	Barriers to HIE assimilation process			Review (44 studies)	The findings show the importance of raising national awareness of HIE potential benefits, financial incentive programs, use of standard guidelines, implementation of certified technology, technical assistance, training programs and trust between healthcare providers. The study highlights deficiencies in the current policy
(13) original study	a statewide HIE	US, Colorado	interest in and preferences in HIE of primary care and specialist practitioner	Self-constructed questionnaire (N= 621 primary care physicians and 611 specialists)	clinical data were commonly missing during clinic visits. "Clinical notes/consultation reports," "diagnosis or problem lists," and "hospital discharge summaries" were considered the three most useful data types exchanged, but opinions differed by specialties.
(10) original study	Regional HIE	US, Tennessee	User perspectives on usability	QUIS 0.7 survey for different professional groups	43% of respondents had used the implemented HIE system less than one hour per week. The reactions to system usability (effort required to learn the system, system functionality) were good predictors of the average weekly time that they engaged

				(N=345)	with the system.
(12) original study	a secure online platform for health information exchange	US	physician's pre-implementation attitudes and preferences towards health information exchange	Self-constructed questionnaire (N= 328)	physicians who believed that financial incentives would be helpful, that HIE would be easy to use, or who preferred viewing patient health information electronically were found to be at least three times more likely to indicate they would adopt and use HIE.
(14) original study	transmission of CDA-format documents between clinics and hospitals	South Corea	physicians' perceptions and use of a health information exchange	Self-constructed questionnaire (N=197)	Perceptions were positive, concerns about information safety and security, system costs, and disputes between care providers in cases of malpractice. More information came from the tertiary-care hospital to the clinics compared with the information flow in the opposite direction.
(15) original study	push- and pull-mechanism health information exchange	New York state	physician usage of and satisfaction	Self-constructed questionnaire (N= 584)	A greater proportion of physicians very satisfied with push HIE compared to pull HIE, difference not statistically significant (p=0.148). Improvement in access to timely information (73%) and complete information (60%). Three predictors of satisfaction with HIE ($p < 0.05$): being a pediatrician (OR 4.90); being very satisfied with push HIE (OR 7.99); and identification of improved access to complete information through HIE (OR 15.69).
(3) review	electronic sharing of health related information according to US standards, modes of access not described	US, all organisation types	HIE Barriers over time	peer reviewed and gray literature, all types of designs (N=28)	Main barriers listed in 2014 were efficiency/ workflow and usability. In earlier years, cost, workflow, lack of technical support, impeding competition were mentioned more often.
(18) original study	web-based, view-only system to support information sharing across organizational boundaries and disparate clinical information systems	Canada	adoption, user satisfaction and impact to patient care	Self-constructed questionnaire (N=?)	The majority of users agreed the system improves information sharing and continuity of care. System security access issues hindered adoption and reduced user satisfaction. Users also reported low workflow integration and having to use multiple systems as concerns.
(4) review	electronic sharing of health related information, modes of access not described	Mainly US, All organisation types	HIE usage Costs Quality	peer-reviewed empirical articles (N=27)	57 percent of the studies reported some benefit from HIE, but in controlled design studies evidence was mixed.
(11) original study	electronic medical records exchange between hospitals	Taiwan	physicians' acceptance	Theory of planned behaviour-based survey (N= 191)	Attitude, subjective norm, perceived behavior control, institutional trust and perceived risk have a significant influence on the physicians' intentions to use EMR exchange systems (predict perceived usefulness and ease of use)
(17) review	electronic transfer of patient data and health information between healthcare	US, International literature	HIE adoption, implementation, usage and assimilation"	20 surveys, of which 5 were targeted to clinicians (+24 other types of studies,	Of the 5 reviewed surveys to clinicians, 1 was the Finnish survey, 1 reported start-up costs and resources to select and implement a system as major barriers for implementation and use of HIE. 1 reported low overall usage rate of the HIE, calling for more understanding of organizational and social context during the HIE design and implementation. 1 reported patient summary data displayed by default. as

	providers			N=44)	important feature of query-based HIE systems is User role, practice site type, and patient consent workflow may affect patterns of query-based HIE web portal system usage. 1 study reported Use of an HIE resulting in reduced use of hospital resources, noteworthy cost savings, decreased length of stay, and improved quality of care

Annex 3 Additional tables

Table 6 Mainly paper users n (%) by EHR-system used in 2010, 2014 and 2017

	Mainly paper users (n (%)) by EHR-system			
EMR system	2010	2014		2017
System a	0 (0)	71 (61.7)		32 (17.9)
System b	320 (89.9)	320 (86.25)		105 (22.8)
System c	377 (38.7)	138 (15.4)		92 (9.4)
System d	157 (78.5)	119 (66.1)		28 (12.5)
System e	6 (12.5)	1 (2.08)		1 (2.0)
System f	118 (78.7)	48 (34.8)		39 (22.9)
System g	295 (55.0)	137 (29.2)		29 (5.38)
System h	78 (83.0)	78 (81.3)		32 (38.6)
System i	706 (76.7)	509 (62.2)		243 (26.73)
Other systems (j)	256 (71.9)	153 (56.0)		88 (39.5)

Authors' contributions

Hannele Hyppönen, Jarmo Reponen, Tinja Lääveri, Jukka Vänskä and Johanna Kaipio contributed to the questionnaire development, as well as revisions and approval of the manuscript.

Hannele Hyppönen had main responsibility for the manuscript. She was responsible for the study questions, the study outline and main author of the results and discussion. Sonja Lumme acted as the statistician, planning the statistical analyses together with Ms Hyppönen, being responsible of the methods-section, conducting the analyses and co-authoring results.

Jarmo Reponen had the main responsibility for describing the types and functionalities of RHIS systems in Finland and the contextual changes from 2010 to 2017 in Finland, as well as co-authoring discussions.

Johanna Kaipio conducted the search and review of previous literature on the subject. She had main responsibility for the related research chapter. She also participated in modifying other parts of the article.

Tinja Lääveri reviewed the literature together with Johanna Kaipio, acted as a co-author in results and discussion section and checked the overall article for terminology.

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Statement on conflicts of interest

No reported of conflicts of interest