

---

This is an electronic reprint of the original article.  
This reprint may differ from the original in pagination and typographic detail.

Martikainen, Susanna; Kaipio, Johanna; Lääveri, Tinja

## End-user participation in health information systems (HIS) development

*Published in:*

International Journal of Medical Informatics

*DOI:*

[10.1016/j.ijmedinf.2020.104117](https://doi.org/10.1016/j.ijmedinf.2020.104117)

Published: 01/05/2020

*Document Version*

Peer-reviewed accepted author manuscript, also known as Final accepted manuscript or Post-print

*Published under the following license:*

CC BY-NC-ND

*Please cite the original version:*

Martikainen, S., Kaipio, J., & Lääveri, T. (2020). End-user participation in health information systems (HIS) development: Physicians' and nurses' experiences. *International Journal of Medical Informatics*, 137, Article 104117. <https://doi.org/10.1016/j.ijmedinf.2020.104117>

---

This material is protected by copyright and other intellectual property rights, and duplication or sale of all or part of any of the repository collections is not permitted, except that material may be duplicated by you for your research use or educational purposes in electronic or print form. You must obtain permission for any other use. Electronic or print copies may not be offered, whether for sale or otherwise to anyone who is not an authorised user.

# End-user participation in health information systems (HIS) development: Physicians' and nurses' experiences

## *Authors*

Susanna Martikainen<sup>1</sup> PhD, Johanna Kaipio<sup>2</sup> D.Sc.(Tech.), Tinja Lääveri<sup>3</sup> MD

<sup>1</sup> University of Eastern Finland, Kuopio, Finland

<sup>2</sup> Aalto University, Espoo, Finland

<sup>3</sup> Helsinki University Hospital, and University of Helsinki, Helsinki, Finland

## *Contact details of the corresponding author:*

- susanna.martikainen@uef.fi
- P.O. Box 1627, FI-70211 Kuopio, Finland
- Mobile +358 443242455

## **Keywords**

Participation, end-user, health information system, health information system development, electronic health record, nurse, physician, usability

## **Abbreviations**

Electronic health record (EHR); Health information system(s) (HIS); Information system (IS)

## Abstract

**Background:** End-user participation is essential to the development of health information systems (HIS) that are useful for clinicians and support their routine work. However, few studies have investigated end users' experiences with HIS development and their preferred ways of participation in it.

**Objectives:** This study examined the participation experiences of physicians and nurses with HIS development.

**Methods:** National cross-sectional surveys on end users' experiences with HIS development were conducted in Finland among physicians in 2010, 2014, and 2017 and nurses in 2017. For the purposes of this study, we selected and analyzed the statements concerning participation and end users' experiences on HIS development and their preferred ways of participation in it.

**Results:** A total of 3013 physicians and 2685 nurses working in public hospitals and health centers were included in this study. In total, 48.4% of physicians and 45.4% of nurses reported that they had participated in HIS development; however, 85.1% of respondents regarded that software vendors are not interested in end users' viewpoints and development ideas. Most respondents (53.4%) preferred to participate by communicating with a person responsible for HIS development within the organization. Few participants reported that the proposed improvements took place in the desired manner (10.0%) or quickly enough (6.9%). Younger clinicians were more willing to participate in HIS development than older clinicians. During the follow-up period (2010, 2014, 2017), the physicians' experiences did not improve.

**Conclusions:** While physicians and nurses are willing to participate in HIS development, suitable methods to effectively include them and their feedback seem to be lacking or underutilized. Crucially, physicians and nurses, who make up the largest groups of end users, are not able to influence HIS development in their preferred ways. Healthcare organizations must recognize the importance of clinician participation; these clinicians should have the opportunity to continue clinical work.

# 1. Introduction

Several studies have reported poor usability and user satisfaction for health information systems (HIS) [1-9]. Notably, user participation in HIS development is considered to be an important factor contributing to system success [10-13]. As Ratwani et al. [14] have highlighted, software designs and development processes that promote usability and greater collaboration between vendors and clinicians are crucial to improving the quality of HIS.

User participation refers to the various activities that end users perform during information system (IS) development [15,16]. User participation is considered to contribute to IS success [17], which is difficult to achieve, by improving software quality and increasing satisfaction [17-19]. In 1996, Damodaran described the related benefits of user participation in IS development: avoidance of costly system features unwanted by the users or considered unusable, improved acceptance of the system, more effective use of the system derived from the users' better understanding of it, and increased user participation in decision-making within the organization [19]. Moreover, users should have greater involvement in systems that are very complex and used for difficult tasks [18].

To help end users participate in HIS design and evaluation, various quantitative and qualitative approaches have been used [20,21]. Surveys, usability tests, and interviews are the most commonly used methods [21,22]. Developers may also observe and interview clinicians on site [23]. To involve large groups of participants, developers typically form end-user focus groups [24]. End-user feedback, such as system error reporting, can also be collected with websites [25,26]. Today, many organizations train and employ physician or nurse informaticists, who engage in both clinical work and HIS development [27-31].

This study analyzed the experiences of Finnish physicians and nurses with HIS development. Our research questions were as follows:

- RQ1. What experiences do physicians and nurses have with giving feedback to HIS developers?

- RQ2. Have they participated in HIS development?
- RQ3. How would physicians and nurses prefer to participate in HIS development?
- RQ4. Do the ages of physicians and nurses relate to their participation experiences with HIS development?
- RQ5. Have the physicians' experiences with providing feedback to HIS developers changed between the three timepoints of 2010, 2014, and 2017?

## **2. Materials and methods**

### **2.1. Surveys for Finnish physicians and nurses**

National usability-focused cross-sectional monitoring studies were conducted in 2010, 2014, and 2017 among Finnish physicians [7,32-35]. In 2017, a similar study was conducted among Finnish nurses [36]. The surveys were based on the validated National Usability-Focused HIS Scale (NuHISS) [37] and included a section on end users' participation experiences with HIS development.

The survey method and the questionnaire have been described in detail previously [2,7,37]. An invitation to the web-based survey was emailed to all working-age physicians in Finland, the members of a nurses' labor union, and the members of a professional nurses' association [36]. The physicians' participation experiences from the 2010 survey have been published previously [35].

Already in 2010, all Finnish public health centers and hospitals used electronic health record (EHR) systems [38,39]. By 2015, the national Patient Data Repository and an electronic prescription system had both been deployed [38,39,40,41]. During 2017, five hospital and three larger health center EHR brands were in wide use.

### **2.2. Questionnaire statements on participation in HIS development**

The section that addressed end-user participation in HIS development (Table 1) was identical for the nurses and the physicians apart from the questions about their preferred ways of participation (Q3), which were not included in the physicians' 2017 questionnaire; for these comparisons, we used the 2014 physicians' questionnaire instead.

**Table 1.** Statements on participation in HIS development used in the surveys of this study.

|   |  |
|---|--|
| <p><b>Q1.</b></p>   | <p><b>Think of the experiences you have had in providing feedback about your HIS. Please indicate your responses to the following statements.</b><br/> <i>Scale: Fully agree / Somewhat agree / Neither agree nor disagree / Somewhat disagree / Fully disagree</i><br/> <b>A.</b> I know how and to whom I can send feedback about the system if I wish to do so.<br/> <b>B.</b> The system vendor is interested in feedback about the system provided by the end users.<br/> <b>C.</b> The system vendor implements corrections and change requests according to the suggestions of the end users.<br/> <b>D.</b> Corrections and change requests are implemented within a reasonable time frame.</p>  |
| <p><b>Q2.</b></p>   | <p><b>Have you participated in systems development work?</b><br/> <b>A.</b> A lot<br/> <b>B.</b> A little<br/> <b>C.</b> Not at all</p>  |
| <p><b>Q3.</b></p>   | <p><b>In which ways would you be interested in participating in systems development work in the future? You may choose one or more alternatives.</b><br/> <b>A.</b> I'd be interested in showing software developers how I work and describing my software-related needs.<br/> <b>B.</b> I'd be interested in participating in a development work group made up of other system end users.<br/> <b>C.</b> I'd be interested in providing suggestions and feedback about how the software can be designed and changed to the vendor using a website.<br/> <b>D.</b> I'd be interested in providing suggestions and feedback about how the software can be designed and changed to the vendor using email.<br/> <b>E.</b> I'd be interested in telling the physician/person* in charge of information systems development for the organization about usage-related problems.<br/> <b>F.</b> I am not interested in participating.<br/> <b>G.</b> How else would you like to participate? _____</p> |
| <p>* = "physician" in the physicians' questionnaire, "person" in the nurses' questionnaire.</p> |  |

The user-participation methods targeted with these statements were as follows (Table 1; Q3): observing/shadowing users (Q3.A), forming end-user focus groups (Q3.B), collecting feedback (Q3.C and Q3.D), and end-user representative in the organization (Q3.E).

### 2.3. Study population

In 2017, 4018 physicians (approximately 20% of all physicians in Finland) and 3607 nurses (5% of the theoretical target group, 12% of the sample, and 35% of all recipients who opened the email) participated in the 2017 survey [32,36].

We chose to focus on public sector respondents who constituted the final study population (n= 3013 physicians and 2685 nurses); in Finnish private and social care sectors both the used EHR brands and working environments differ considerably between nurses and physicians. Most nurses employed in either sector work in long-term elderly care, while physicians employed in the public sector provide care for the clients of these facilities. In contrast, most physicians employed in the private sector work in occupational health care or for private outpatient clinics [42].

Public health centers provide outpatient primary care. The public-sector nurses and physicians who work in home care use the same EHR system as their colleagues at the health centers. Within a hospital, the same EHR system is used in both inpatient and outpatient care. While most of a hospital's physicians work in both the outpatient clinics and the wards, its nurses work mainly in either.

Depending on where the public sector respondents worked, their responses were categorized as either "hospital" or "health center." The frequencies of the responses to Q3.A-E were calculated from those respondents who had responded to at least one of the other questions (physicians n=3013; 75.0%; nurses n=2685; 74.4%).

## **2.4. Analysis**

To analyze the responses to Q1.A-D (Table 1), the five-point Likert scale assessments "Fully agree" and "Somewhat agree" were combined into "Agree" and "Somewhat disagree" and "Fully disagree" into "Disagree".

Statistical analyses were carried out with SPSS 22 (IBM Corp, Armonk, NY). The chi-squared test or Fisher's exact test were used to compare categorical variables when applicable. Statistical significance was determined to be  $p < 0.05$ . The means were calculated from the 5-point Likert scale responses. Analysis of variance (ANOVA) and Bonferroni's post-hoc tests were also used to compare the physicians' responses between 2010, 2014, and 2017.



## **2.5. Study outline**

This study comprised of four parts. First, to compare the participation experiences of the nurses and the physicians (Q1-2), we used the responses to the 2017 survey. Second, to analyze the preferred ways of participation (Q3), we used the responses to the physicians' 2014 survey and the nurses' 2017 survey. Third, to determine the impact of age (Q1-3), the responses to the 2017 surveys were combined. Fourth, to assess the change over time (Q1), the data from the physicians' 2010, 2014, and 2017 surveys were compared.

### 3. Results

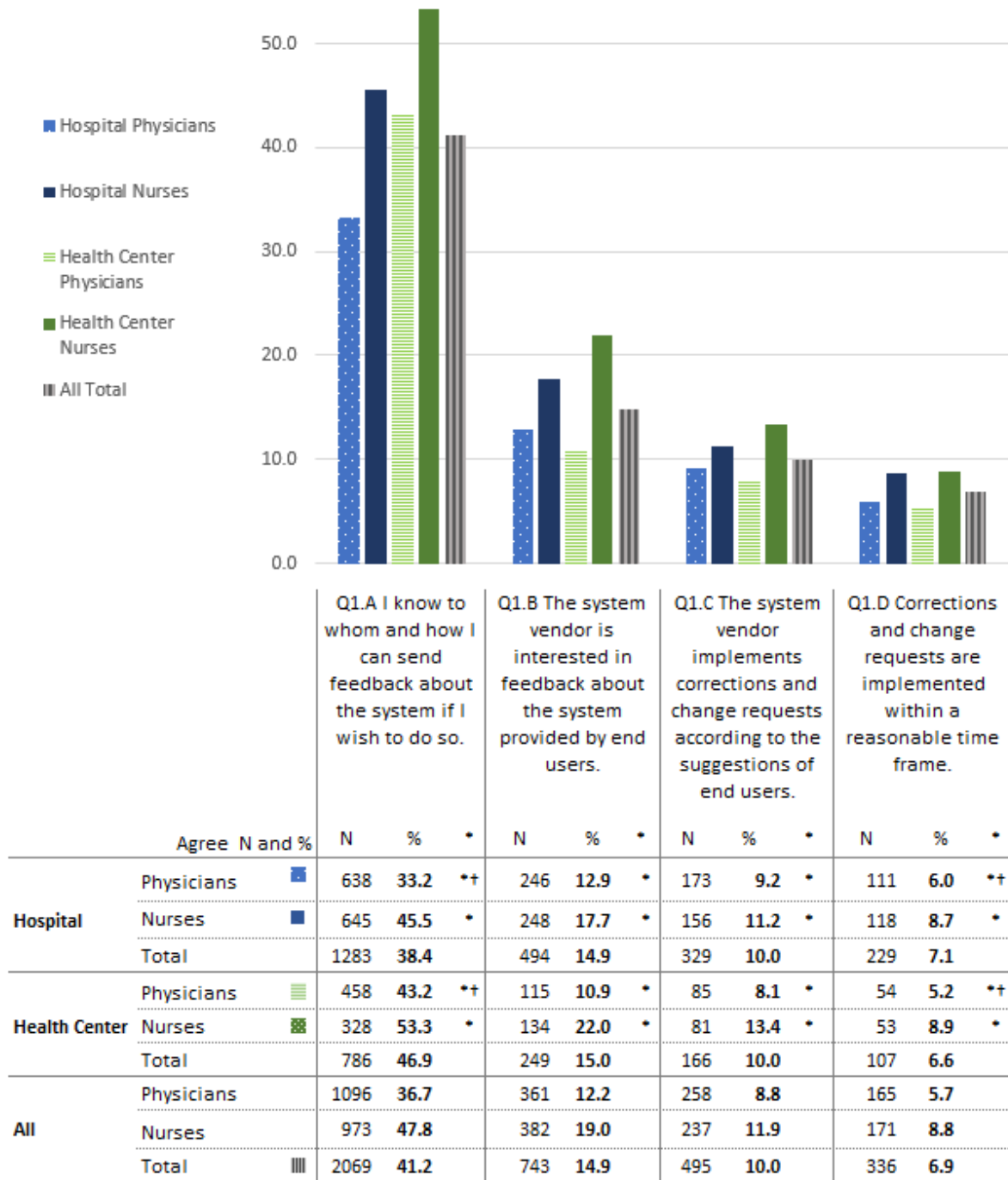
The demographics of the respondents to the 2017 surveys are provided in Table 2, and they correspond with those of Finnish physicians and nurses in general [32,36,43].

**Table 2.** Demographics of the respondents to the 2017 survey.

|                      | 2017        |             |
|----------------------|-------------|-------------|
|                      | Physicians  | Nurses      |
| <b>Hospital</b>      | 1943        | 1861        |
| <b>Health center</b> | 1070        | 824         |
| <b>Female</b>        | 1975        | 2508        |
| <b>Male</b>          | 1005        | 132         |
| <b>Under 35yrs</b>   | 711         | 514         |
| <b>35-44yrs</b>      | 713         | 580         |
| <b>45-54yrs</b>      | 787         | 806         |
| <b>55-64 yrs</b>     | 789         | 749         |
| <b>Total</b>         | <b>3013</b> | <b>2685</b> |

#### 3.1. Comparison of participation experiences between physicians and nurses

Compared to the physicians (33.2–43.2% agreeing with Q1.A), the nurses, particularly those who worked in health centers (53.3% agreeing vs. 45.5% of hospital nurses agreeing), were more knowledgeable about how to provide HIS feedback (Figure 1). All respondent groups were critical about the system vendors' interest in end users' feedback, compliance with their suggestions, and the speed of corrections. As seen in Figure 1, the physicians were more critical than the nurses.



**Figure 1.** The physicians and nurses who agreed with the statements about giving feedback and participating in HIS development. Statistically significant ( $p < 0.05$ ) differences between professional groups within working sector are marked with \* and hospital vs. health center within professional group marked with †.

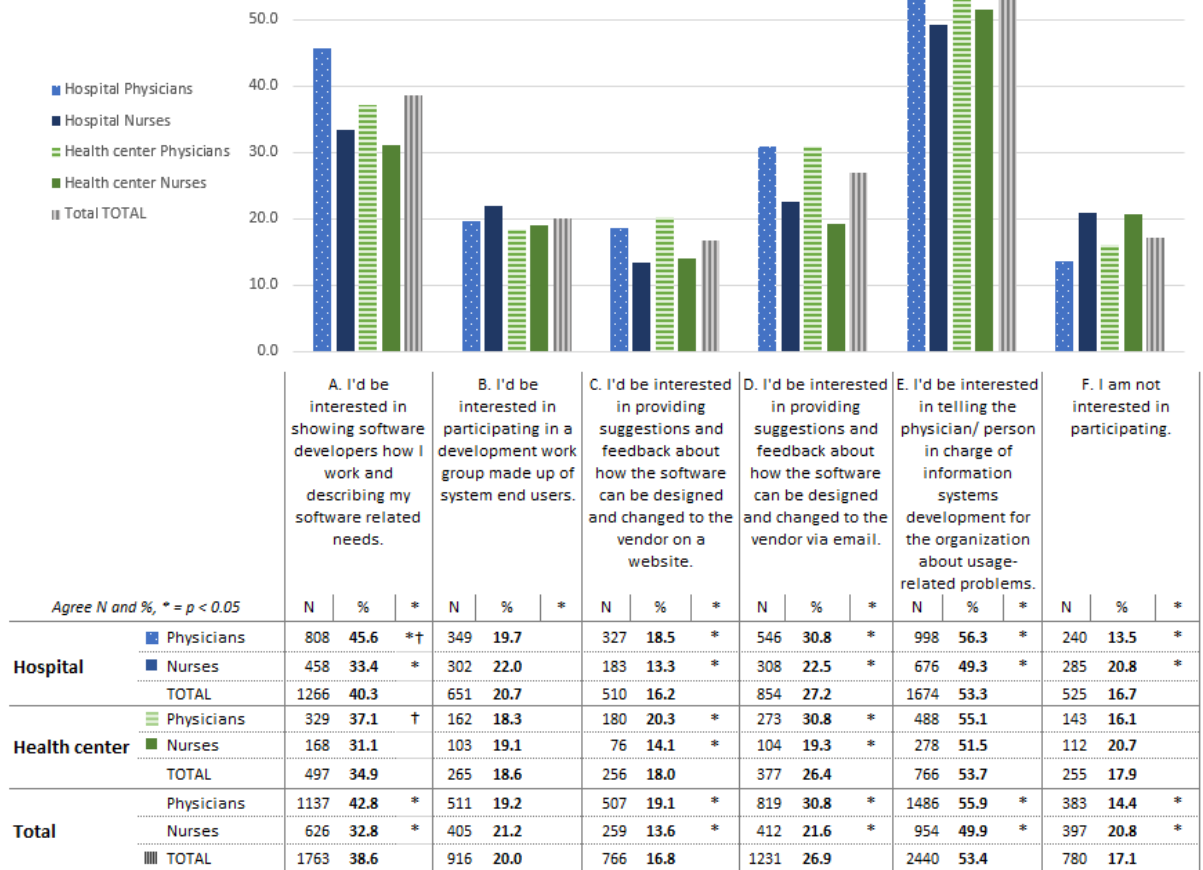
Approximately half of the respondents (49.6-57.6%) had never participated in HIS development (Figure 2). Particularly physicians working in hospitals had participated more than their colleagues in health centers.



**Figure 2.** The physicians' and nurses' responses to statements about their participation in HIS development. Statistically significant differences are marked with \* and hospital vs. health center within professional group marked with †.

### 3.2. Preferred ways of participation in HIS development

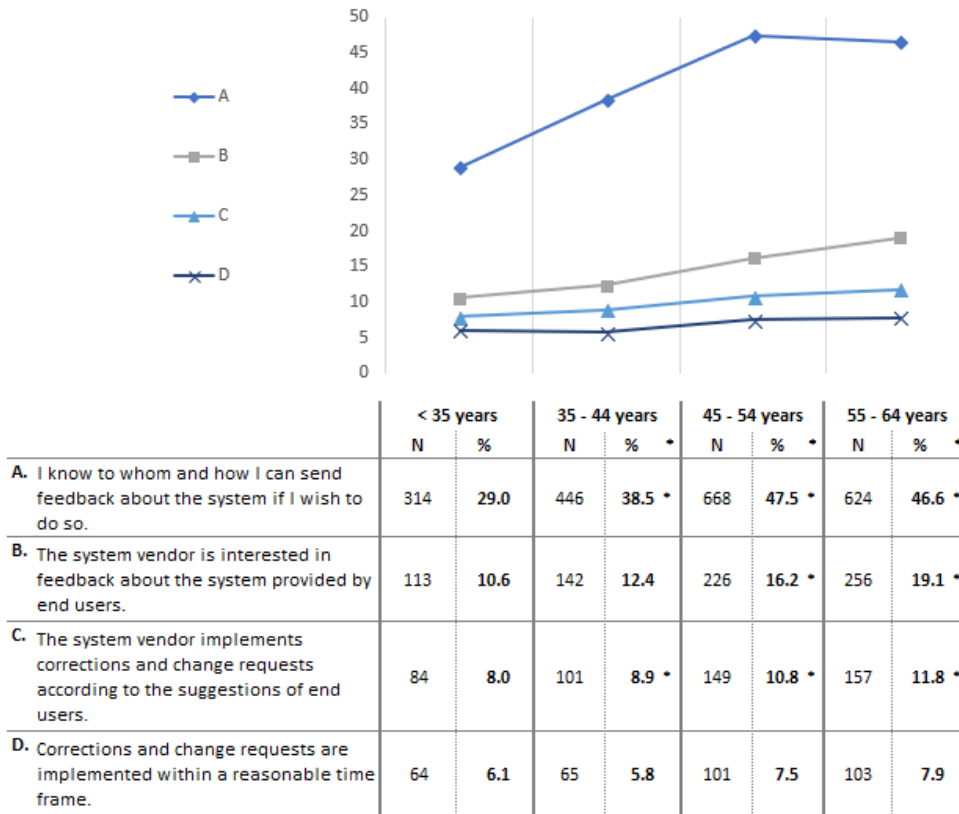
For all respondent groups, communicating problems with a person responsible for HIS development within the organization (Q3.E.) was the most favorable (total 53.4%) way of participating (Figure 3). Particularly physicians working in hospitals were interested in showing software developers how they work (45.6%). Providing suggestions and feedback with a website (Q3.C.) was the least preferable (total 16.8%). Of nurses who worked in hospitals, 20.8% but only 13.5% of physicians working in hospitals responded that they were not interested in participating in HIS development (Q3.F.).



**Figure 3.** The preferred ways of participation for physicians and nurses who worked in hospitals and health centers. Statistically significant differences are marked with \* and hospital vs. health center within professional group marked with †.

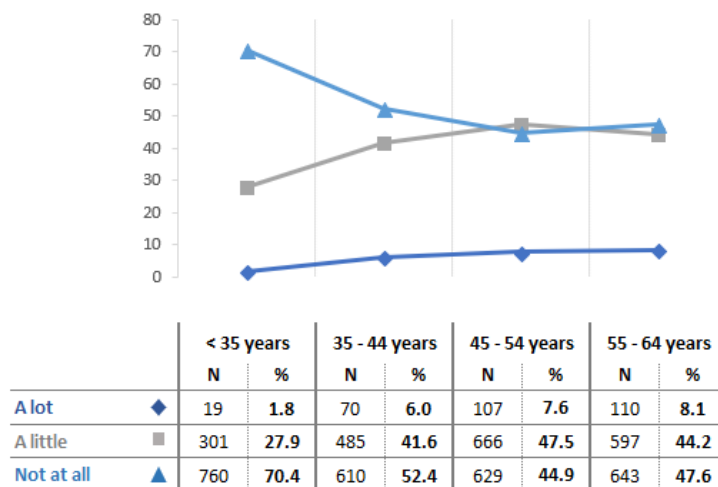
### 3.3. Impact of age on the physicians' and nurses' experiences

The older (>45 years) physicians and nurses were more knowledgeable than the younger ones on how and to whom they could provide feedback about the HIS (46.7–47.5% older vs. 29.0–38.5% in the other age groups, Figure 4). Moreover, 19.1% of the respondents in the oldest age group and only 10.6% in the youngest agreed that the system vendor is interested in the feedback provided by end users. The differences in their responses to the other statements were not as apparent.



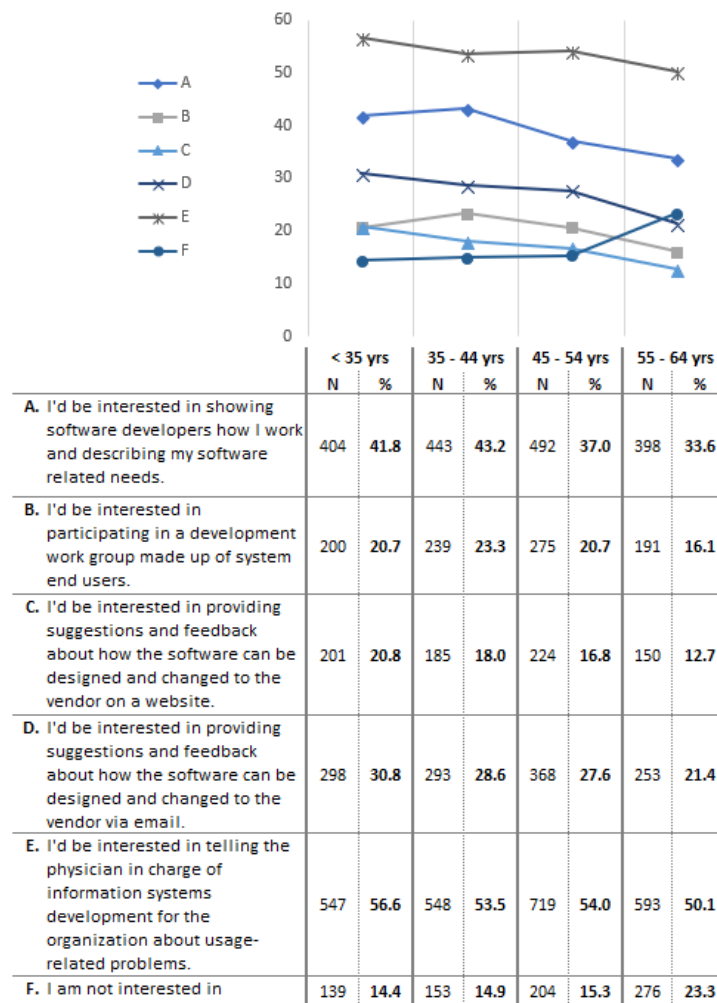
**Figure 4.** The experiences of physicians and nurses in providing feedback, sorted by age group. Statistically significant differences are marked with \* and relative to the youngest age group.

In the youngest age group (<35 years), 70.4% of the physicians and nurses had never participated in HIS development. The respective figures were 44.9–52.4% in the older groups (Figure 5).



**Figure 5.** The participation of physicians and nurses in HIS development, sorted by age group.

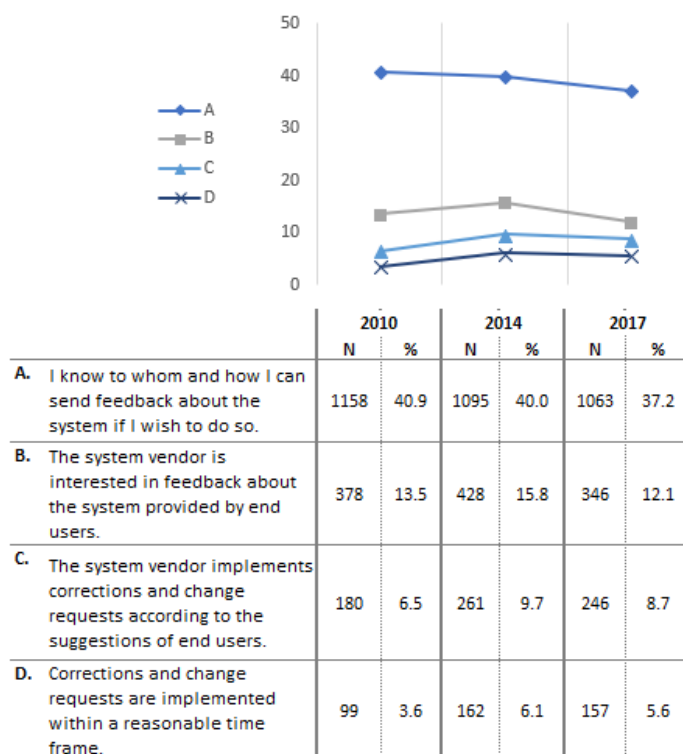
The two youngest age groups were the most welcoming (41.8–43.2%) to on-site developers (vs. 33.6% in the oldest age group; Figure 6). The youngest were more willing to provide feedback with a website (20.8%) or email (30.8%) than the oldest (12.7% and 21.4%, respectively). Communicating with a person in charge of HIS development was the most popular option for providing feedback for all age groups (56.6% for <35 years and 50.1% for 55–64 years). Only 14.4–23.3% of respondents were not interested in participating.



**Figure 6.** The impact of age on favorable ways to participate among physicians and nurses, sorted by age group.

### 3.4. A time series of physicians' experiences with HIS development

No major improvements were observed between the physicians' responses from 2010, 2014, and 2017 concerning their experiences with providing feedback to system vendors (Figure 7, Appendices A,B). The proportion of respondents knowledgeable of how and to whom they could give their feedback had decreased from 40.9% to 37.2% between 2010 and 2017 ( $p < 0.001$ ). The physicians' views of the system vendors' interest in end-user feedback remained stable (13.1–12.5%). The physicians did not feel that their configurations and corrections were implemented as requested, and they found this process to be slow.



**Figure 7.** A comparison of the physicians' positive responses to statements A-D from 2010 to 2017.



## 4. Discussion

To our knowledge, this is the first study to compare how physicians and nurses view HIS development participation. Moreover, we provide an analysis of the participation experiences of different age groups and report the results of a seven-year follow-up study on the physicians' experiences. The data were collected between 2010 and 2017 in Finland, where EHR are widely used [38,39].

### 4.1. Vendors were considered unresponsive to HIS-related feedback (RQ1)

Physicians and nurses reported similar experiences regarding their feedback to HIS developers and vendors. While less than half knew how and to whom they could send their feedback, only a few participants believed that vendors are interested in end users' viewpoints (14.9%) or that corrections and change requests are implemented according to their suggestions (10.0%) or quickly enough (6.9%). While we found no studies that would explain why clinicians working in health centers were more knowledgeable about sending feedback, our perception is that in Finland, local superuser support is better organized in health centers than in hospitals.

Interestingly, in our earlier study, the developers considered the development speed to be reasonable [44]. From their perspective, the change management and development processes provide clear timeframes. Nevertheless, the end users may feel ignored if the timespan between providing feedback and possible correction is too long. This dynamic may also explain the discrepancy between the end users' and the developers' perceptions of development speed and the quality of system corrections [45]. Therefore, these processes should be more visible to the end users [45]. The developers must also consider how their changes impact the whole system and other users, however, post-go-live customization should be possible on organization-, context- and end-user-specific levels [46, 47]. National treatment guidelines may assist in focusing the local customization efforts on regional care pathways and differences in task allocation between professional groups instead of disease-specific discussions.

## **4.2. Roughly half of respondents had participated in HIS development (RQ2)**

A relatively high proportion (47.2%) of respondents had participated in HIS development. However, clinicians interested in HIS development might also be more willing to take HIS monitoring surveys than those who are not. Indeed, few (17.1%) were unwilling to participate. It is possible that clinicians, particularly physicians working in hospitals, have more time dedicated to improving processes of their specialties than in primary care. Evidently, many willing clinicians remain underutilized. Barriers to participation include physicians and nurses having insufficient working time dedicated to HIS development, earlier negative experiences may render end users not prioritizing their time to HIS development.

## **4.3. On-site developers and physician/nurse informaticists were highly valued (RQ3)**

Lack of end user engagement has been identified as one of the main barriers of successful HIS implementation [48, 49]. End-user participation also increases acceptance of the HIS implementation [50]. While half of our respondents had participated in HIS development at least to some extent, this participation does not appear sufficiently impactful. Roughly half of all respondents (53.4%) preferred reporting their ideas to a physician or nurse responsible for HIS development in the organization. Indeed, physician/nurse champions/informaticists are crucial to HIS-related change management and system development [28,51,52]. In Finland, a subspecialty for eHealth was established for physicians in 2012 [53]; such programs are available in other countries for both physicians and nurses [30,31].

Having developers on site to observe workflows and hear development needs is a well-described method for improving HIS [54-57]; it was preferred by 38.6% of our respondents. However, end users may simply describe their current workflows to developers instead of innovating new solutions or analyzing their work [57]. Furthermore, they may not be aware of an organization's strategic goals or

the workflows of other professionals. Regardless, without seeing the system and these workflows in a real use context, developers may not have enough data to improve usability.

The nurses appeared more willing than the physicians to participate in user groups. Because there are more nurses than physicians in healthcare organizations, it may be easier for them to find substitutes and dedicate time to participation. Considering their clinical role as having main responsibility on patient care and thus making most clinical decisions, physicians may also find the decision-making process in consensus-driven user groups too slow.

Collecting web-page-based feedback is the least interactive participation method. It is low-cost and easy for vendors, but documenting needs and ideas may require a considerable amount of time from end users. This may explain its low popularity among our respondents.

Since the preferred methods are all relatively resource intensive, there is an apparent need for optimizing user participation methods for better fit in the healthcare IT system development.

Moreover, more flexible and light-weight usability testing methods are needed for the complex HIS contexts. Collaborative development of user interface design patterns and user-centered design and agile development methods could be utilized.

#### **4.4. Younger physicians and nurses were more willing to participate in HIS development (RQ4)**

Older respondents appeared more knowledgeable than the younger ones on how and to whom they could send their feedback; moreover, they were more satisfied with how vendors responded to their feedback. They also had participated more often in HIS development, which is logical as older physicians and nurses tend to hold more managerial positions than their younger colleagues. Moreover, due to the complexity of HIS, participation in HIS development often requires a thorough understanding of the domain itself and several years of work experience. The younger respondents, in contrast, appeared more willing to participate in HIS development.

Our results suggest that the younger respondents were interested in all kinds of development activities. While this interest in HIS development is encouraging, the end-user representatives of development teams should always be carefully selected [19]. System-related functional expertise, communication skills, computing backgrounds, and personality traits can be used as selection criteria [58].

#### **4.5. Physicians' experiences with HIS development did not improve between 2010, 2014, and 2017 (RQ5)**

The physicians' experiences with HIS development did not improve between 2010, 2014, and 2017. It is possible that neither customer organizations nor the vendors have been able to identify suitable ways of taking their end users' feedback into account. Another explanation is that the implementation of the national Patient Data Repository and the e-prescription system, which took place between 2014 and 2016 [40,41], may have encouraged vendors to focus on building integrations and data structures rather than developing other functionalities.

#### **4.6. Limitations**

Our study has some notable shortcomings. Firstly, the respondents may have been more active in HIS development than those end users who did not respond. Secondly, the response rate for nurses is relatively low. This may be because the survey was conducted for the first time among nurses, although the response rates have remained rather stable among physicians [2,7,32,43]. Regardless, the comparisons with the target population had good representativeness [2,7,32,43]. Nurses may also not consider HIS development to be an essential part of their work. Unfortunately, to our knowledge, no previous studies have assessed this issue. Thirdly, we did not address all participatory methods of user-centered design, such as usability testing. Fourthly, we did not ask how and during which software development phase the respondents had participated in HIS development. This should be included in future studies. End users tend to be more involved with error reporting and problem

solving at the implementation phase of a new EHR [59]. During our study period, there were no major changes to the distribution of the EHR brands used by healthcare organizations in Finland [60].

## **5. Conclusion**

The physicians and nurses reported that they were not able to influence HIS development and were not listened to by developers. Participatory methods in HIS development appear underutilized or suitable methods are lacking. Overall, the end users, particularly the younger clinicians, were willing to participate in HIS development.

Healthcare organizations need to recognize the importance of clinicians participating in HIS development, such as by enabling career paths for physician and nurse informaticists. These clinicians should also have the possibility to continue their clinical work and thus maintain their awareness of the working contexts for their systems.

## Summary table

### What was already known on the topic?

- End-user participation in HIS development is essential.
- Physicians are willing but not able to participate in HIS development.
- Research on end users' participation experiences with HIS development is scarce, particularly that targeting nurses.

### What has this study added to our knowledge?

- This study is one of the first to report both physicians' and nurses' experiences with giving feedback to HIS developers and participating in HIS development.
- Although physicians and nurses were willing to participate, they could not influence HIS development in their preferred ways.
- Younger clinicians were more willing to participate in HIS development than older ones, whereas older clinicians had participated more often in HIS development than younger ones.
- Health care organizations must recognize the importance of clinicians participating in HIS development while also continuing their clinical work.

# References

- [1] D. Hudson, A. Kushniruk, E. Borycki, D.J. Zuege, Physician satisfaction with a critical care clinical information system using a multimethod evaluation of usability, *Int. J. Med. Inform.* 112 (2018) 131–136.
- [2] J. Kaipio, T. Lääveri, H. Hyppönen, S. Vainiomäki, J. Reponen, A. Kushniruk, E. Borycki, J. Vänskä, Usability problems do not heal by themselves: national survey on physicians' experiences with EHRs in Finland, *Int. J. Med. Inform.* 97 (2017) 266–281.
- [3] M. Topaz, C. Ronquillo, L.M. Peltonen, L. Pruinelli, R.F. Sarmiento, M.K. Badger, J.L. Tayaben, Nurse informaticians report low satisfaction and multi-level concerns with electronic health record: results from an international survey, *AMIA Annu. Symp. Proc.* 10 (February (2017)) (2017) 2016–2025.
- [4] S. Vainiomäki, A.M. Aalto, T. Lääveri, T. Sinervo, M. Elovainio, P. Mäntyselkä, H. Hyppönen, Better usability and technical stability could lead to better workrelated well-being among physicians, *Appl. Clin. Inform.* 8 (4) (2017) 1057–1067.
- [5] Wehlou, *Rethinking the Electronic Healthcare Record*, Man In the Middle Books AB, Uppsala, 2014.
- [6] P.H. Jones, *Design for Care: Innovating Healthcare Experience*, Rosenfeld Media, New York, 2013.
- [7] J. Viitanen, H. Hyppönen, T. Lääveri, J. Vänskä, J. Reponen, I. Winblad, National questionnaire study on clinical ICT systems proofs: physicians suffer from poor usability, *Int. J. Med. Inform.* 80 (10) (2011) 708–725.
- [8] S. Culler, J. Jose, S. Kohler, K. Rask, Nurses' perceptions and experiences with the implementation of a medication administration system, *Cin Comput. Inform. Nurs.* 29 (5) (2011) 280–288.
- [9] J. Nielsen, *Medical Usability: How to Kill Patients Through Bad Design*. Jakob Nielsen's Alertbox, Retrieved from (2005) <http://www.nngroup.com/articles/medical-usability/>.
- [10] M.E. Huang, IT is from mars and physicians from venus: bridging the gap, *PMR* 9 (2017) S19–S25.
- [11] A. Kushniruk, C. Nøhr, Participatory design, user involvement and health IT evaluation, *Stud. Health Technol. Inform.* 222 (2016) 139–151.
- [12] M.A. Harris, H.R. Weistroffer, Does User Participation Lead to System Success? Proceedings of the Southern Association for Information Systems Conference, (2008), pp. 1–6 Retrieved from <http://sais.aisnet.org/2008/1BHarrisWeistroffer.pdf>.
- [13] W.T. Lin, B.B.M. Shao, The relationship between user participation and system success: a simultaneous contingency approach, *Inf. Manag.* 37 (6) (2000) 283–295.
- [14] R.M. Ratwani, J. Reider, H. Singh, A decade of health information technology usability challenges and the path forward, *Jama* 321 (8) (2019) 743–744.

- [15] H. Barki, J. Hartwick, Measuring user participation, user involvement, and user attitude, *MIS Quart.* 18 (1) (1994) 59–82.
- [16] H. Barki, J. Hartwick, Rethinking the concept of user involvement, *MIS Quart.* 13 (1) (1989) 53–63.
- [17] R. Subramanyam, F.L. Weisstein, M.S. Krishnan, User participation in software development projects, *Commun. ACM* 53 (3) (2010) 137–141.
- [18] J.D. McKeen, T. Guimaraes, Successful strategies for user participation in systems development, *J. Manag. Inf. Syst.* 14 (2) (1997) 133–150.
- [19] L. Damodaran, User involvement in the systems design process—a practical guide for users, *ehav. Inf. Technol.* 15 (6) (1996) 363–377.
- [20] P.Y. Yen, S. Bakken, Review of health information technology usability study methodologies, *J. Am. Med. Inform. Assoc.* 19 (3) (2011) 413–422.
- [21] M.A. Ellsworth, M. Dziadzko, J.C. O’Horo, A.M. Farrell, J. Zhang, V. Herasevich, An appraisal of published usability evaluations of electronic health records via systematic review, *J. Am. Med. Inform. Assoc.* 24 (1) (2016) 218–226.
- [22] S. Ghulam Sarwar Shah, I. Robinson, User involvement in healthcare technology development and assessment: structured literature review, *Int. J. Health Care Qual. Assur.* 19 (6) (2006) 500–515.
- [23] J. Niès, S. Pelayo, From users involvement to users’ needs understanding: a case study, *Int. J. Med. Inform.* 79 (4) (2010) e76–e82.
- [24] A. Bruseberg, D. McDonagh-Philp, Focus groups to support the industrial/product designer: a review based on current literature and designers’ feedback, *Appl. Ergon.* 33 (1) (2002) 27–38.
- [25] A. Fabijan, H.H. Olsson, J. Bosch, Customer feedback and data collection techniques in software R&D: a literature review, *International Conference of Software Business*, Springer, Cham, 2015, pp. 139–153.
- [26] J. Hess, D. Randall, V. Pipek, V. Wulf, Involving users in the wild—participatory product development in and with online communities, *Int. J. Hum. Stud.* 71 (5) (2013) 570–589.
- [27] AMIA, American Medical Informatics Association. History of the Clinical Informatics Subspecialty, Retrieved from: <https://www.amia.org/clinicalinformatics-board-review-course/history> . Referenced August 26th, 2019 (2019).
- [28] J.S. Singer, E.M. Cheng, K. Baldwin, M.A. Pfeffer, UCLA Health Physician Informaticist Committee, The UCLA health resident informaticist program—A novel clinical informatics training program, *J. Am. Med. Inform. Assoc.* 24 (4) (2017) 832–840.
- [29] A. Sieja, K. Markley, J. Pell, C. Gonzalez, B. Redig, P. Kneeland, C.T. Lin, Optimization sprints: improving clinician satisfaction and teamwork by rapidly reducing electronic health record burden, *Mayo Clinic Proceedings*, (Vol. 94, No. 5, Pp. 793-802). Elsevier, 2019.



- [30] C.U. Lehmann, A.V. Gundlapalli, J.J. Williamson, D.B. Fridsma, W.R. Hersh, M. Krousel-Wood, et al., Five years of clinical informatics board certification for physicians in the United States of America, *Yearb. Med. Inform.* 27 (01) (2018) 237–242.
- [31] M.R. Cummins, A.V. Gundlapalli, P. Murray, H.A. Park, C.U. Lehmann, Nursing informatics certification worldwide: history, pathway, roles, and motivation, *Yearb. Med. Inform.* 25 (01) (2016) 264–271.
- [32] P. Saastamoinen, H. Hyppönen, J. Kaipio, T. Lääveri, J. Reponen, S. Vainiomäki, J. Vänskä, Lääkärien arviot potilastietojärjestelmistä ovat parantuneet hieman, *Finnish Medical Journal* 73 (34) (2018) 1814–1819.
- [33] J. Vänskä, J. Viitanen, H. Hyppönen, M. Elovainio, I. Winblad, J. Reponen, T. Lääveri, Lääkärien arviot potilastietojärjestelmistä kriittisiä, *Finnish Medical Journal* 65 (2010) 4177–4183.
- [34] J. Vänskä, S. Vainiomäki, J. Kaipio, H. Hyppönen, J. Reponen, T. Lääveri, Potilastietojärjestelmät lääkärin työvälineenä 2014 : käyttäjäkokemuksissa ei merkittäviä muutoksia, *Finnish Medical Journal* 69 (49) (2014) 3351–3358.
- [35] S. Martikainen, J. Viitanen, M. Korpela, T. Lääveri, Physicians' experiences of participation in healthcare IT development in Finland: willing but not able, *Int. J. Med. Inform.* 81 (2) (2012) 98–113.
- [36] H. Hyppönen, T. Lääveri, N. Hahtela, A. Suutarla, K. Sillanpää, U.-M. Kinnunen, O. Ahonen, E. Rajalahti, J. Kaipio, T. Heponiemi, K. Saranto, Kyvykkäille käyttäjille fiksut järjestelmät? Sairaanhoidtajien arviot potilastietojärjestelmistä 2017, *FinJeHeW* 10 (1) (2018) 30–59.
- [37] H. Hyppönen, J. Kaipio, T. Heponiemi, T. Lääveri, A.M. Aalto, J. Vänskä, M. Elovainio, Developing the national usability-focused health information system scale for physicians: validation study, *J. Med. Internet Res.* 21 (5) (2019) e12875.
- [38] J. Reponen, M. Kangas, P. Hämäläinen, N. Keränen, Tieto- Ja Viestintäteknologian Käyttö Terveystieteiden Vuonna 2014 (2015). Tilanne Ja Kehityksen Suunta. (In English: Use of Information and Communications Technology in Finnish Health Care in 2014. Current Situation and Trends.) Report 12/2015, The Finnish Institute for Health and Welfare (THL), Helsinki, Finland, 2015.
- [39] J. Reponen, M. Kangas, P. Hämäläinen, N. Keränen, J. Haverinen, Use of information and communications technology in Finnish health care in 2017, Current Situation and Trends, The Finnish Institute for Health and Welfare (THL), Helsinki, Finland, 2018 Report 5/2018. (In Finnish with English abstract).
- [40] Kanta - Patient Data Repository, (2019) Available in <https://www.kanta.fi/en/professionals/patient-data-repository> . Referenced April 29th, 2019.
- [41] V. Jormanainen, Large-scale implementation and adoption of the Finnish national Kanta services in 2010–2017: a prospective, longitudinal, indicator-based study, *Finn. J. Ehealth Welfare* 10 (4) (2018) 381–395.
- [42] P. Metsäniemi, H. Hyppönen, S. Vainiomäki, J. Kaipio, P. Saastamoinen, J. Reponen, T. Lääveri, Yksityissektorin lääkärit kokevat potilastietojärjestelmien hidastuneen, *Finnish Medical Journal* 44 (73) (2020) 2570–2580.

- [43] U.M. Kinnunen, T. Heponiemi, E. Rajalahti, O. Ahonen, T. Korhonen, H. Hyppönen, Factors related to health informatics competencies for nurses—results of a national electronic health record survey, *Cin Comput. Inform. Nurs.* 37 (8) (2019) 420–429.
- [44] S. Martikainen, M. Korpela, T. Tiihonen, User participation in healthcare IT development: a developers' viewpoint in Finland, *Int. J. Med. Inform.* 83 (3) (2014) 189–200.
- [45] S. Martikainen, M. Korpela, I. Luukkonen, V. Vainikainen, Where does the interaction break down? The stakeholder map of health IT systems development and use in Finland, *Finn. J. Ehealth Ewelfare* 7 (4) (2015) 192–209.
- [46] D. Benyon, Adaptive systems: a solution to usability problems, *User Model. Useradapt. Interact.* 3 (1) (1993) 65–87.
- [47] M. Hertzum, J. Simonsen, Configuring information systems and work practices for each other: what competences are needed locally? *Int. J. Hum. Stud.* 122 (2019) 242–255.
- [48] K. Cresswell, Z. Morrison, S. Crowe, A. Robertson, A. Sheikh, Anything but engaged: user involvement in the context of a national electronic health record implementation, *Inform. Prim. Care* (2011).
- [49] A. Boonstra, A. Versluis, J.F. Vos, Implementing electronic health records in hospitals: a systematic literature review, *BMC Health Serv. Res.* 14 (1) (2014) 370.
- [50] A. Tariq, M. Baysari, C.H. Pedersen, M.V. Andersen, M.M. Larsen, M. Shahi, et al., Examining barriers to healthcare providers' adoption of a hospital-wide electronic patient journey board, *Int. J. Med. Inform.* 114 (2018) 18–26.
- [51] J.S. Ash, P.Z. Stavri, R. Dykstra, L. Fournier, Implementing computerized physician order entry: the importance of special people, *Int. J. Med. Inform.* 69 (2-3) (2003) 235–250.
- [52] K.A. Poterack, R.H. Epstein, F. Dexter, The anesthesiologist-informatician: a survey of physicians board-certified in both anesthesiology and clinical informatics, *Anesth. Analg.* 127 (1) (2018) 115–117.
- [53] The Finnish Medical Association, Terveystieteiden Tietotekniikka, Retrieved from <https://www.laakariliitto.fi/palvelut/koulutukset/erityispatevyydet/tietotekniikka/> . Referenced September 29th, 2019 (2012).
- [54] A. Holzinger, Usability engineering methods for software developers, *Commun. ACM* 48 (1) (2005) 71–74.
- [55] K. Holtzblatt, J.B. Wendell, S. Wood, *Rapid Contextual Design: A How-to Guide to Key Techniques for User-centered Design*, Elsevier, 2004.
- [56] H. Beyer, K. Holtzblatt, *Contextual Design: Defining Customer-centered Systems*, Elsevier, 1997.
- [57] S. Kujala, Effective user involvement in product development by improving the analysis of user needs, *Behav. Inf. Technol.* 27 (6) (2008) 457–473.
- [58] N. Saleem, An empirical test of the contingency approach to user participation in information systems development, *J. Manag. Inf. Syst.* 13 (1) (1996) 145–166.

[59] B. Rahimi, R. Safdari, M. Jebraeily, Development of hospital information systems: user participation and factors affecting it, *Acta Inform. Med.* 22 (6) (2014) 398.

[60] H. Hyppönen, P. Hämäläinen, J. Reponen, *E-Health and E-Welfare Of Finland-Check Point 2015*, (2015).

# Appendices

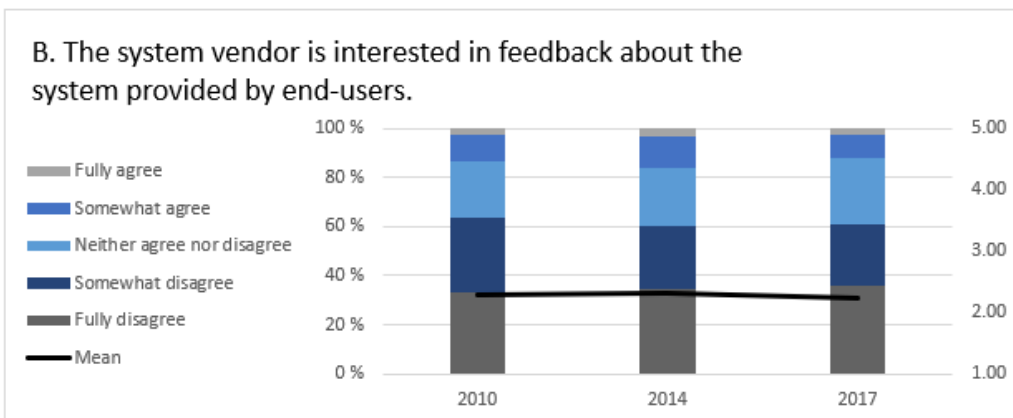
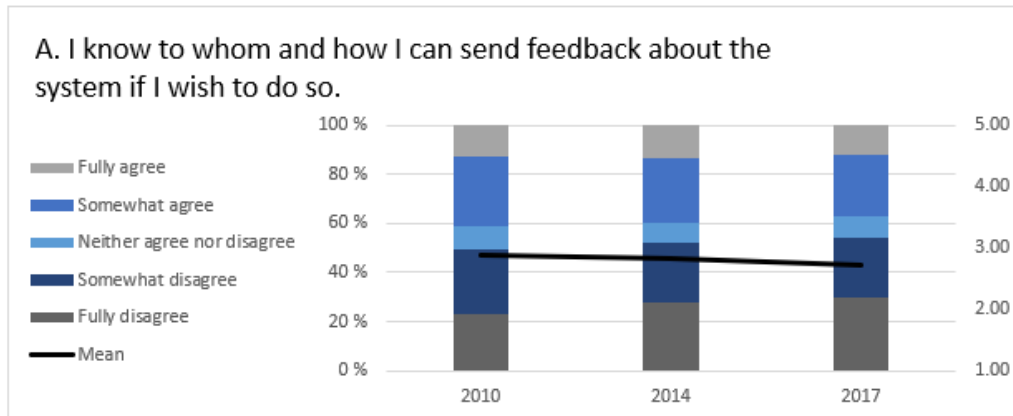
## Appendix A.

Comparison of physician's mean opinion scores with scale from 1 (Fully disagree) or 5 (Fully agree) for four development-related statements in 2010, 2014 and 2017.

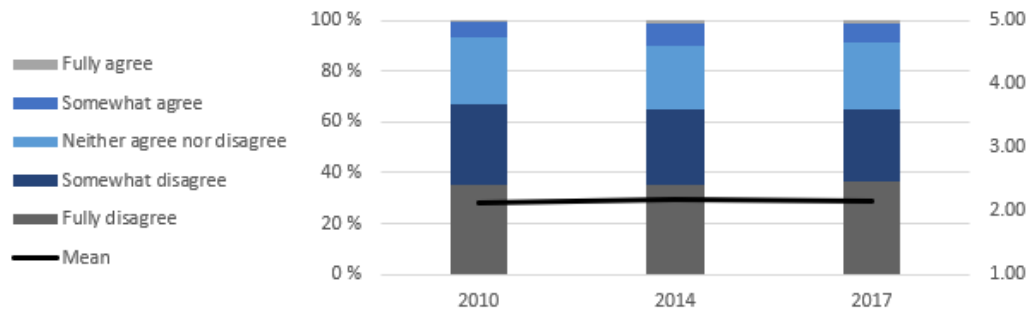
| Year        |  | 2010 | 2014 | 2017 | p between 2010 and 2014 | p between 2010 and 2017 | p between 2014 and 2017 |
|-------------|--|------|------|------|-------------------------|-------------------------|-------------------------|
| <b>Q1.A</b> | <b>I know to whom and how I can send feedback about the system if I wish to do so.</b>                         |      |      |      |                         |                         |                         |
|             |  | 2,88 | 2,83 | 2,72 | 0.328                   | 0.000                   | 0.002                   |
| <b>Q1.B</b> | <b>The system vendor is interested in feedback about the system provided by end-users.</b>                     |      |      |      |                         |                         |                         |
|             |  | 2,27 | 2,32 | 2,23 | 0.274                   | 0.325                   | 0.003                   |
| <b>Q1.C</b> | <b>The system vendor implements corrections and change requests according to the suggestions of end-users.</b> |      |      |      |                         |                         |                         |
|             |  | 2,14 | 2,18 | 2,16 | 0.150                   | 1.000                   | 0.652                   |
| <b>Q1.D</b> | <b>Corrections and change requests are implemented within a reasonable time frame.</b>                         |      |      |      |                         |                         |                         |
|             |  | 1,88 | 1,89 | 1,88 | 1.000                   | 1.000                   | 1.000                   |

## Appendix B.

Physicians' responses of the development-related statements in all three questionnaires (2010, 2014 and 2017). Trendlines (black line) of the mean response value and proportions of the responses (coloured areas) in all three years, scale from 1 = Fully disagree to 5= Fully agree.



**C. The system vendor implements corrections and change requests according to the suggestions of end-users.**



**D. Corrections and change requests are implemented within a reasonable time frame.**

