Factors Influencing User Satisfaction in Electronic Health Record Systems

A Regression Analysis and its Relevance to the Valkyrie Project

[a] Ove Lintvedt[1,2], [b] Espen S. Nordheim[1], [c] Terje Geir Solvoll[1,2], [d] Rune Pedersen[1,2]

[1]Norwegian Centre for E-health Research,
University Hospital of North Norway,
Tromsø, Norway
[2]Norway Faculty of Nursing and Health Sciences
Nord University
Bodø, Norway

e-mail: [a]ove.lintvedt@ehealthresearch.no, [b]espen.solbakken.nordheim@ehealthresearch.no,
[c]terje.solvoll@ehealthresearch.no, [d]rune.pedersen@ehealthresearch.no

***Abstract*—User satisfaction with Electronic Health Record (EHR) systems is critical for ensuring efficiency, usability, and quality of healthcare services. This study examines how training satisfaction, functional satisfaction, and general satisfaction influence overall satisfaction with an EHR system. Using regression analysis, we identify key predictors of user satisfaction and provide recommendations for system improvement. Results indicate that efficiency, usability, and workflow optimization are the most significant determinants of overall satisfaction, with training having a secondary but notable effect. Furthermore, the findings are linked to the Valkyrie project, a distributed service-oriented architecture designed to enhance healthcare coordination and data sharing. We explore how insights from this study can inform the development of the Virtual Health Record (VHR) in Valkyrie, highlighting the need for data accessibility and user-centred design.**

Keywords-electronic health records; usability; workflow optimization; healthcare efficiency; Valkyrie project; virtual health record; interoperability; healthcare coordination.

I. INTRODUCTION

EHR systems are widely implemented to improve healthcare documentation [1], patient safety [2], and workflow efficiency [3]. However, user satisfaction remains a challenge, as healthcare professionals often encounter usability issues [4], workflow inefficiencies [5], and training limitations [6]. This study explores the relationship between training, functional, and generic satisfaction with EHR systems and their impact on overall user satisfaction.

The relevance of this study extends to the Valkyrie project [7], which aims to enhance healthcare coordination through a VHR that integrates data across multiple healthcare providers. The Norwegian government has promoted the development of EHRs that improve information flow [8]. Healthcare professionals frequently encounter challenges in navigating and interpreting the extensive volumes of patient data within EHR systems [9]. These challenges are often related to data overload and fragmentation, complicating the diagnostic process. Additionally, the design of many EHRs has been criticized for not adequately considering the complex cognitive and collaborative aspects of healthcare delivery. This oversight can lead to cumbersome systems for clinicians, further hindering efficient data navigation and interpretation [10].

A VHR is an extension of EHR systems, focusing on interoperability, real-time data access, and comprehensive patient insights. It represents a shift from institution-centric record-keeping to a patient-centred, data-driven approach, enabling improved clinical decisions and patient outcomes. The Valkyrie project and VHR have the same aims as the Patient-Centered Data Home (PCHD) [11], which aims to improve healthcare interoperability and patient data accessibility, but they differ in their architecture, implementation, and scope. The PCDH is a Health Information Exchange (HIE) model designed to facilitate the secure and automated exchange of patient health records across regional and national HIE networks. When patients receive care outside their primary healthcare system, the PCDH framework ensures that their home HIE automatically provides relevant medical history to the treating provider, enhancing care continuity and reducing duplication of tests and treatments. VHR and PCHD address healthcare interoperability challenges and improve patient-centred care by ensuring critical patient information is accessible across healthcare institutions. However, VHR is a broader system, dynamically aggregating real-time data from multiple sources, while PCHD is a structured, federated exchange model designed explicitly for secure HIE-based data sharing when patients move across different care settings. By leveraging VHR's real-time data accessibility and PCHD's structured HIE-based data exchange, healthcare systems can create a more interconnected, efficient, and patient-centred health information ecosystem.

By examining the key factors influencing EHR user satisfaction, this research provides insights regarding the improvement of user experiences in distributed electronic health record systems like Valkyrie.

This paper is structured as follows: Section II presents the methods, including setting, study design and data collection, variables and measures, and analysis techniques. Section III

presents the results. Section IV discusses the findings. Finally, Section V is the paper's conclusion, with recommendations for future research.

II. METHOD

A. Related Work

Numerous studies have explored user satisfaction in EHR systems. Lintvedt et al. [12] investigated satisfaction post-deployment in Northern Norway, emphasizing usability and clinical documentation. Other research has focused on the influence of training and technical support on satisfaction [6] or explored how EHR systems affect patient safety and workflow efficiency [2][5].

Despite this, few studies have simultaneously analysed training, functionality, and general satisfaction as separate constructs feeding into overall satisfaction. Moreover, no prior work has used this regression framework to connect findings directly with a future system architecture like Valkyrie. Our contribution thus lies in identifying practical satisfaction predictors and applying them to ongoing system design.

B. Setting

Norway's hospital sector is governed by four Regional Health Authorities (RHA), which oversee healthcare services in the South-East, West, Central, and North regions. In 2021, all RHAs were transitioning to a new EHR system. However, the Northern Norway Regional Health Authority (Helse Nord RHA) was the first and only region to fully implement the new EHR system, transitioning from DIPS Classic to DIPS Arena across its hospitals.

This study focuses on the hospitals within Northern Norway, specifically the University Hospital of North Norway (UNN), Nordland Hospital (NLSH), and Finnmark Hospital (FSH). This region was selected based on its unique status as the only RHA that had fully implemented the new EHR system in 2021 and that prior user satisfaction research was carried out in this RHA. No additional selection criteria were applied. However, the findings should be interpreted considering the specific characteristics and operational context of hospitals in Northern Norway.

C. Study Design and Data Collection

This study employs a cross-sectional survey-based approach. The hospitals wanted to send the survey to all employees, with no possibility to find who many respondents that got the invitation. Of the 629 total respondents, only 407 indicated active use of the EHR system and completed the satisfaction sections. Responses from non-EHR users were excluded from the satisfaction and regression analyses, ensuring that all reported findings reflect the experiences of active EHR users. Data were collected from the healthcare professionals using a standardized questionnaire measuring satisfaction with different aspects of the EHR system. The survey used Likert scale responses (1 = total disagree to 5 = total agree). The participants were recruited through emails, with each hospital responsible for extending the invitation to all their employees. This method was considered as the most suitable solution as it used existing administrative structures. The hospitals did not want to send any reminders.

D. Variables and Measures

The study analyses three primary categories influencing Overall Satisfaction (OS):

- Training Satisfaction (TS): Satisfaction with training (TS1), Perceived adequacy of training time (TS2), and Generic assessment of training quality (TS3).
- Functional Satisfaction (FS): Workflow and efficiency (FS1), Customization (FS2), Documentation and record-keeping (FS3), and Communication and patient interaction (FS4).
- Generic Satisfaction (GS): EHR efficiency for patient work (GS1), Clinical Quality Support (GS2), Automated Information Integration (GS3), Ease of use (GS4), and Support for clinical documentation (GS5), Clinical Documentation Support (GS6), Care Coordination Support (GS7).

In addition, data related to respondents' profession (physicians, nurses, and other professions), affiliation (three hospitals), gender, age, and clinical experience were collected.

E. Statistical Analysis

Regression analyses were conducted to determine the relative contributions of TS, FS, and GS to OS. Stepwise regression was used to identify the most significant predictors. In addition, a regression was conducted to find a model for Overall Satisfaction based on the significant variables from the individual analyses. The statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) 29.02 (IBM Corp., Armond, NY), with statistical significance set at $p < 0.05$.

There were missing data for the FS variables. For other variables, there were no missing values, as responses were mandatory. Missing values were addressed by applying the Missingness Completely At Random (MCAR) assumption by Little [13] and confirmed it (χ^2=48.27, DF=47, p=.42). Expectation-Maximization (EM) analysis that estimates the means, covariances, and correlations was used to input missing values. The missing values were moderate, n=254 (15.60%), as some questionnaire items depended on the profession.

The statistical methodology aligns with prior studies on EHR user satisfaction [14][15], which employed regression analysis to identify key factors influencing user satisfaction in recently deployed EHR systems in Northern Norway. The use of regression to reduce satisfaction dimensions and assess overall usability effectiveness parallels our approach, reinforcing the robustness of our findings.

F. Ethics

The study was presented and approved by the data-protection officer at the University Hospital of North Norway.

G. Limitations

This study is subject to several limitations. Firstly, the voluntary nature of survey participation, the unknown number of invitees, and the absence of reminders may have led to self-selection bias, potentially attracting participants with strong opinions. Secondly, as the survey was distributed through hospital email systems without individual tracking, it is not feasible to verify the exact delivery rate or follow up on non-responses. Lastly, the study concentrates on hospitals within a single regional healthcare area, which limits the generalizability of the findings to other healthcare contexts.

III. RESULTS

A. Descriptives

The number of participants completing the primary survey was n=629, and participants who completed the satisfaction survey and were EHR users were n=407 (61.71%). Of this group, 63.30% were female. The average years of clinical experience was 18.03 years (sd=11.03), and the mean age of EHR users was 46.32 years (sd=11.42). In terms of professional roles among EHR users, physicians constituted n=101 (24.80%), nurses n=150 (36.90%), and other clinicians n=156 (38.30%). Age distribution within the EHR users was as follows: 6.60% (n=27) were between 18-29 years, 24.10% (n=98) were between 30-39 years, 25.6% (n=104) were between 40-49 years, 29.20% (n=119) were between 50-59 years, and 14.50% (n=59) were 60 years or older. The distribution among hospitals and professions is in Table I. The statistics for the satisfaction constructs is in Table II. A follow-up regression analysis was performed including covariates such as profession, gender, age, and clinical experience. Among these, clinical experience showed a weak positive correlation with overall satisfaction ($\beta = .12$, $p = .048$), while profession and age were not statistically significant. These findings suggest user satisfaction is primarily shaped by EHR functionality rather than demographic differences.

B. Training Satisfaction and Overall Satisfaction

A linear regression was used to test if TS significantly predicted OS. The overall regression was statistically significant ($R^2 = .257$, $F(3, 403) = 46.378$, $p = <.001$).

Regression analysis of TS variables revealed that satisfaction with training quality (TS1) had the strongest impact on OS, see Table III. The R^2 value indicates a moderate explanatory power. The overall explained variance was modest, indicating that training alone does not sufficiently predict OS.

TABLE I. HEALTH REGION AND CLINICAL PROFESSIONS

Health Region	Clinical profession			
	Physicians, n	*Nurses, n*	*Other, n*	*Total, n (%)*
FSH	6	8	7	21 (5.26%)
NLSH	37	77	75	189 (46.4%)
UNN	58	65	74	197 (48.4%)
Total, n (%)	101 (24.8%)	150 (36.9%)	156 (38.3%)	407 (100%)

TABLE II. DESCRIPTIVE STATISTICS FOR SATISFACTION CONSTRUCTS

Satisfaction type	Descriptive statistics	
	Mean	*SD*
Training Satisfaction (TS)	3.36	1.12
Functional Satisfaction (FS)	3.34	.69
Generic Satisfaction (GS)	3.65	.79
Overall Satisfaction (OS)	3.53	.99

C. Functional Satisfaction and Overall Satisfaction

A linear regression was used to test if FS significantly predicted OS. The overall regression was statistically significant ($R^2 = .508$, $F(4, 402) = 103.687$, $p = <.001$). The significant predictors are listed in Table III. The strongest predictors were FS1, FS2 and FS3. The FS4 standardized coefficient ($\beta = -.151$) indicates a weak negative effect, meaning Communication and patient interaction have a small but statistically significant negative impact on OS compared to the other predictors.

D. Generic Satisfaction and Overall Satisfaction

A linear regression was used to test if GS significantly predicted OS. The overall regression was statistically significant ($R^2 = .617$, $F(7, 399) = 92.011$, $p = <.001$). GS variables were highly predictive of OS ($R^2 = .617$). The significant variables were EHR efficiency for patient work (GS1), Ease of use (GS4), and Support for clinical documentation (GS5), see Table III. Other GS variables were not significant.

TABLE III. REGRESSIONS PREDICTING OVERALL SATISFACTION (OS)

Satisfaction	Regression statistics		
	Variable	*β*	*p*
FS	FS1	.459	<.001
	FS2	.383	<.001
	FS3	.332	<.001
	FS4	-.151	.003
TS	TS1	.276	<.001
	TS2	.183	.029
	TS3	.069	.006
GS	GS1	.334	<.001
	GS4	.282	<.001
	GS5	.288	<.001

TABLE IV. REGRESSIONS MODELL PREDICTING OVERALL SATISFACTION (OS)

Satisfaction	Regression statistics			
	β	*Std. β*	*se*	*p*
GS1	.261	.262	.041	<.001
GS4	.190	.197	.038	<.001
GS5	.198	.177	.044	<.001
FS1	.201	.147	.054	<.001
FS3	.133	.114	.048	.006
FS2	.141	.107	.060	.019
TS1	.067	.066	.034	.049

E. Stepwise Regression Model for Overall Satisfaction

Multiple linear regression was used to test if the significant TS, FS, and GS variables significantly predicted the OS. The overall regression was statistically significant (R^2 = 0.682, F(7, 399 = 122.362, p = < .001). The final model incorporating significant TS, FS, and GS variables is presented in Table IV and Figure 1. FS4, TS2, and TS3 were insignificant and excluded from the final model. There are no major multicollinearity issues (VIF < 2.591).

IV. DISCUSSION

The findings of this study show that key factors influencing overall satisfaction with the EHR, represented by factors related to improving system efficiency and usability (GS1, GS4), enhancing support for clinical documentation and workflow (GS5, FS1, FS3), developing better customization options (FS2), and improving training (TS1). Addressing these areas can lead to a more user-friendly, efficient, and adaptive EHR system.

The results of this study emphasize several critical factors that determine overall satisfaction with the Electronic Health Record (EHR) system. These factors include improvements in usability and system efficiency (GS1, GS4), support for clinical documentation and workflow (GS5, FS1, FS3), customization capabilities (FS2), and comprehensive training programs (TS1).

A. Implications for EHR System Improvement

Maximizing EHR systems' effectiveness and enhancing user satisfaction will lead to enhanced usability and workflow efficiency. Streamlining workflow processes and optimizing documentation tools can significantly improve user satisfaction. Implementing intuitive navigation, reducing redundant data entry, and integrating Artificial Intelligence (AI) assisted automation for repetitive tasks can enhance efficiency, minimize cognitive burden, and allow healthcare professionals to focus more on patient care.

While EHR system training moderately impacts overall satisfaction in our study, improving training methodologies can lead to better user adoption and experience. Personalized, role-specific training modules, hands-on simulations, and continuous learning opportunities can help users adapt more

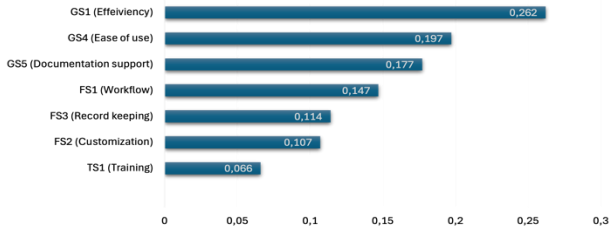

Figure 1. Predictor Importance in Overall Satisfaction (Standardized β).

effectively to system functionalities and leverage advanced features to improve productivity. Although training appears to have a minor effect in this study, it has been three years since a major upgrade of the EHR system was implemented. Training is a significant factor in user satisfaction with the implementation and major upgrades of EHR systems. Furthermore, training can be crucial for new EHR system users, regardless of when they start using it.

Providing greater flexibility in system configuration allows users to tailor the interface and workflows to align with their clinical routines. Offering customizable dashboards, adaptable templates, and user-defined shortcuts will enhance usability, reduce frustration, and improve overall engagement with the system.

Actively collecting system users feedback will ensure that the system evolves in response to user needs. Feedback could be done by incorporating user feedback through regular surveys, usability testing, and iterative design refinements. Establishing a feedback loop between clinicians and developers can drive enhancements that address real-world challenges and usability pain points.

By focusing on these areas, EHR systems can become more adaptive, user-centred, and conducive to efficient healthcare delivery, ultimately improving clinician satisfaction and patient outcomes.

The role of nonsignificant factors in EHR user satisfaction is important. While considerable attention has been given to factors that significantly impact overall satisfaction, it is equally important to consider factors that were not statistically significant. These elements still have the potential to improve satisfaction if they are better integrated or optimized within the EHR system. Possible reasons for nonsignificant factors could be: 1) Limited usage or awareness. Some features may not contribute to satisfaction simply because they are underutilized or not well-known among users; 2) Lack of adaptation to clinical workflow. If a feature is not intuitive or well-integrated, users may avoid it, leading to lower satisfaction scores; and 3) Technical limitations or interoperability issues. Poor implementation or lack of seamless integration with other systems can reduce the perceived value of a feature. It could be the cause of nonsignificant factors, such as Communication and patient interaction (FS4) and Care Coordination Support (GS7). EHR systems can enhance user engagement and functional satisfaction by addressing these gaps through usability improvements, workflow integration, and better user training, even for currently nonsignificant factors.

B. Implications for Valkyrie Project

The findings from this study carry significant implications for the Valkyrie project, particularly in enhancing user experience and optimizing system functionality. Prioritizing usability and workflow efficiency should be a foundational goal in Valkyrie's development to ensure a seamless and intuitive interface that meets the needs of healthcare professionals. Variables such as GS5 (Support for Clinical Documentation) and FS1 (Workflow and Efficiency), both statistically significant predictors of overall satisfaction, directly inform key design goals of Valkyrie's VHR, such as seamless documentation and efficient data navigation. By aligning system development with these empirically identified needs, Valkyrie can proactively enhance clinician satisfaction and usability.

Valkyrie's success will rely on the support of comprehensive clinical documentation, enabling effortless and timely access to health data across systems. Ensuring interoperability and real-time data integration will improve decision-making and reduce administrative burdens.

The insights gained from this study can serve as a valuable framework for implementing user-centred design strategies to develop Valkyrie's VHR. Adaptive user interfaces, streamlined navigation, and intelligent data retrieval will enhance system usability and efficiency.

Additionally, pre- and post-implementation studies or similar evidence-based methodologies will be essential for evaluating Valkyrie's impact on user satisfaction. Continuous assessment and iterative improvements based on user feedback will contribute to a more responsive and effective system, ultimately leading to improved clinical workflows and patient care outcomes.

C. Addressing Challenges in Accessing Large Journal Data

Healthcare professionals face significant challenges in efficiently accessing and interpreting large volumes of patient data stored in EHR systems. Data prioritization should be implemented to improve data usability and retrieval. This could be intelligent filtering mechanisms that dynamically highlight the most relevant clinical data by implementing context awareness. Implementing context-aware data prioritization could be an intelligent filtering mechanism that dynamically highlights the most relevant clinical data based on user roles, patient conditions, and clinical context. By leveraging real-time data analysis and AI-driven recommendations, the system can adapt to different care scenarios emphasizing acute conditions in emergency settings, chronic disease history in primary care, and clinical context. Context awareness ensures that clinicians receive the most relevant information when they need it, thereby reducing information overload and, at the same time, enhancing decision-making.

Further, in line with Valkyries VHR, a dynamic interface design could provide a user-friendly dashboard with structured overviews that categorize data by priority, timeline, and relevance. Customizable widgets and role-specific views should be integrated to improve the visualization of relevant data and thereby help to reduce cognitive overload.

Finally, focus on a context-aware optimized documentation retrieval process that transitions from free-text search dependency to structured data retrieval methods that use standardized terminologies and metadata indexing. Natural Language Processing (NLP) and semantic search functions should be incorporated to refine search accuracy and relevance, ensuring faster access to vital clinical documentation.

By integrating context-aware prioritization, role-specific interfaces, and advanced search capabilities, EHR systems can become more efficient and user-centred, improving clinical workflows and reducing the time spent navigating complex datasets.

V. Conclusion and Future Work

This study highlights the key factors influencing user satisfaction with EHR systems, emphasizing the importance of usability, workflow efficiency, and clinical documentation support. Training was found to have a secondary but meaningful impact, especially during system transitions and for new users.

The findings provide several strategic recommendations for improving EHR systems, including the need for optimizing efficiency and usability by streamlining workflows and integrating intelligent automation, strengthening clinical documentation and workflow support to minimize administrative burdens, enhancing training strategies for better adoption and long-term satisfaction, providing flexible customization options to align with diverse clinical needs, and implementing continuous feedback mechanisms for iterative system improvements. These insights are directly applicable to the Valkyrie project, where user-centred design and seamless data accessibility will be crucial for the successful implementation of the VHR.

Future research should focus on longitudinal studies to assess how satisfaction evolves and how emerging technologies, such as AI-driven data filtering and real-time interoperability, can enhance EHR usability. Continuous evaluation and iterative improvements will ensure that EHR systems remain effective, responsive, and beneficial to healthcare professionals and patients. By applying these principles, existing EHR systems and new initiatives like the Valkyrie project can foster more intuitive, efficient, and user-centred digital healthcare environments, ultimately benefiting healthcare professionals and patient outcomes.

References

[1] L. Poissant, J. Pereira, R. Tamblyn, and Y. Kawasumi, "The impact of electronic health records on time efficiency of physicians and nurses: a systematic review", J Am Med Inform Assoc., 12(5), pp. 505-16, Sep-Oct 2005, doi:10.1197/jamia.M1700.

[2] C. Tanner, D. Gans, J. White, R. Nath, and J. Pohl, "Electronic health records and patient safety: co-occurrence of early EHR implementation with patient safety practices in primary care settings", Appl Clin Inform., 11;6(1), pp. 136-47, Mar. 2015, doi:10.4338/ACI-2014-11-RA-0099.

[3] E. Li, J. Clarke, H. Ashrafian, A. Darzi, and A. Neves, "The Impact of Electronic Health Record Interoperability on Safety and Quality of Care in High-Income Countries: Systematic

Review", J Med Internet Res, 24(9):e38144, 2022, doi:10.2196/38144.

[4] J. L. Howe, K. T. Adams, A. Z. Hettinger, and R. M. Ratwani, "Electronic Health Record Usability Issues and Potential Contribution to Patient Harm", JAMA, 27;319(12), pp. 1276-1278, Mar. 2018, doi:10.1001/jama.2018.1171.

[5] K. Zheng, R. M. Ratwani, and J. Adler-Milstein, "Studying Workflow and Workarounds in Electronic Health Record-Supported Work to Improve Health System Performance", Ann Intern Med., 2;172(11 Suppl), pp. S116-S122, Jun. 2020, doi: 10.7326/M19-0871.

[6] T. Heponiemi et al., "Electronic Health Record Implementations and Insufficient Training Endanger Nurses' Well-being: Cross-sectional Survey Study", J Med Internet Res., 23;23(12):e27096, Dec. 2021, doi:10.2196/27096.

[7] T. G. Solvol, C. Granja, S. Cassidy, Ø. S. Solvang, and O. Lintvedt, "Valkyrie: A Distributed Service-Oriented Architecture for Coordinated Healthcare Services", pp. 42-46. International Conference on eHealth, Telemedicine, and Social Medicine (eTELEMED), 2023. Retrieved: April, 2025, https://hdl.handle.net/11250/3125119.

[8] Ministry of Health and Care Services, "One citizen – one Health Record", Whitepaper. no. 9 (2012-2013). "Én innbygger - én journal". *St.Meld. nr. 9* (2012–2013), 2012. Retrieved: April, 2025, https://www.regjeringen.no/no/dokumenter/meld-st-9-20122013/id708609/

[9] M. Quinn et al., "Electronic health records, communication, and data sharing: challenges and opportunities for improving the diagnostic process", Diagnosis (Berl). 27;6(3), pp. 241-248, Aug. 2019, doi:10.1515/dx-2018-0036.

[10] J.H. Holmes et al., "Why Is the Electronic Health Record So Challenging for Research and Clinical Care?", Methods Inf Med., 60(1-02), pp. 32-48, May 2021, doi:10.1055/s-0041-1731784.

[11] K. S. Williams and S. J. Grannis, "Patient-Centered Data Home: A Path Towards National Interoperability", Frontiers in Digital Health, 4, Jul. 2022, doi:10.3389/fdgth.2022.887015.

[12] O. Lintvedt, L. Marco-Ruiz, and R. Pedersen, "User Satisfaction with Recently Deployed Electronic Health Records", Studies in Health Technology and Informatics, vol. 302, pp. 192–196, May 2023, doi:10.3233/SHTI230101.

[13] R. J. Little, "A Test of Missing Completely at Random for Multivariate Data with Missing Values", Journal of the American Statistical Association, 83:404, pp. 1198-1202, Jul. 1988, doi: 10.1080/01621459.1988.10478722.

[14] O. Lintvedt, L. Marco-Ruiz, and R. Pedersen, "User Satisfaction with Recently Deployed Electronic Health Records", Stud Health Technol Inform., 18;302, pp. 192-196, May 2023, doi:10.3233/SHTI230101.

[15] O. Lintvedt, E. S. Nordheim, T. G. Solvoll, R. Pedersen, "Evaluating Usability and User Satisfaction in Hospital-Based EHR Systems: A Comparative Study of SUS and NuHISS in the Context of the Valkyrie Project", 2025, in press.