Work Related Quality of Life and HIS Usability:

An Examination of Human Factors' Impact on Electronic Health Record usability during the Adoption of a New Electronic Health Record System in Norway

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***Abstract*—In this paper, we try to determine the influence of human factors, specifically Work-Related Quality of Life (WrQoL), on the usability of a newly implemented Electronic Health Record (EHR) system in Norway. We used the Work-Related Quality of Life questionnaire to measure human factors in clinical staff (physicians, nurses, and others). The National Usability-focused Health Information Systems Scale (NuHISS) questionnaire was used to measure the usability of the new Electronic Health Record. We performed a one-way Analysis of variance (ANOVA) with the NuHISS score as the dependent variable and the WrQoL score as the factor. The results show a significant effect of Work-Related Quality of Life on Electronic Health Record usability ($p < .001$), meaning that work-related quality of life significantly influences the perception of Electronic Health Record usability. The effects vary significantly depending on professional groups, ages, and genders. These findings underscore the importance of considering human factors in the usability and implementation of Electronic Health Record systems. Further research is needed to understand how human factors affect the usability of electronic health record systems.**

Keywords-Electronic Health Record (EHR); usability; Work-Related Quality of Life (WrQoL); National Usability-focused HIS Scale (NuHISS); human factors.

I. INTRODUCTION

In the past two decades, the evolution of Electronic Health Records (EHR) systems has been marked by rapid advancements [1], promising to enhance healthcare delivery efficiency. However, the transformation has shown critical implementation challenges beyond technical innovation. For example, a report from the National Audit Office of Norway on the use of information technology (IT) in hospitals in Norway highlights severe issues [2], including clinician burnout—like in other Western countries [3]. This fatigue is partly attributed to IT solutions that inadequately support clinicians' work processes and time, underscoring the critical need for EHR systems that are both effective and user-friendly [4]. Studies have shown that the lack of usability of EHR systems causes stress in healthcare workers [5]. This stress is not just a byproduct of new systems but is often rooted in the design of the system [6]. In Norway, the government has promoted the development of EHRs that improve information flow [7]. Since 2021, all the Norwegian Health Authority Regions have started implementing a new EHR system. Three health regions have been focusing on transitioning from the Distributed Information and Patient Data System in Hospitals (DIPS) Classic to the DIPS Arena EHR, and one on implementing the Electronically Published Internet Connection (EPIC) system from DocuLive. This study focuses on the transition to DIPS Arena in the Northern-Norway Health Region Authority.

Despite extensive research on the implementation and the effects on user satisfaction of EHR systems [8][9], there still exists a notable gap in our understanding of what affects the EHR usability experience of healthcare professionals. One study found that the usability experience varies by profession and EHR brand [10], and another found that comprehensive adoption and positive work environments enhance nurses' usability and quality of care [11]. Another study aims to develop virtual health records to access EHR data across healthcare levels and improve usability [19].

However, previous studies have often focused on EHR systems' technical and functional aspects and overlooked the sociotechnical interplay between the systems and the individuals using them. Moreover, the transition phase to a new EHR system is a critical period marked by challenges and steep learning curves. More research needs to be conducted in terms of how human factors influence the usability of the new system.

Recognizing such deficiency, our study aims to explore if human factors, such as Work-Related Quality of Life, can contribute to increasing our understanding of how healthcare professionals perceive the usability of newly implemented EHR systems in Northern Norway. Acknowledging the multifaceted nature of usability, which is influenced by a complex interplay of individual factors [20], system design, and organizational structures, it is necessary to explore different human factors that contribute to our perceptions of a

new EHR system. The nuanced relationship between technology and user can give us more understanding of the new system beyond the technical and operational needs and allows us to find out if the well-being of the users plays a role in the use of EHR systems.

The two research questions that guide this study are: 1) What is the effect of Work-Related Quality of Life on usability (NUHISS) and 2) Does the impact of these human factors on EHR usability vary according to demographic and professional characteristics?

To achieve these objectives, this study analyzes clinical workers effect of Work-Related Quality of Life (WrQoL) on usability, using the instrument National Usability-focused HIS Scale during the transitioning to new EHR systems. This approach can provide insights into the specific human factors that influence the success of EHR systems' implementation.

The rest of the paper is structured as follows: Section II presents the methods, including setting, data collection, 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. METHODS

A. Setting

Norway has organized the governance of the hospital sector under four regional health authorities responsible for South-East, West, Central, and North. In 2021, all these regions were transitioning towards adopting a new Electronic Health Record (EHR) system. Nonetheless, the Northern Norway Regional Health Authority distinguished itself by completing the implementation across its hospitals, shifting from the EHR system DIPS Classic to DIPS Arena. The hospitals included in the study are the University Hospital of North Norway (UNN), Nordland Hospital (NLSH), and Finnmark Hospital (FSH). The selection of the Northern Norway region was based on its position as the only region that had fully implemented the new EHR system, allowing for an examination of the post-implementation of the new system. No other selection guidelines were provided. Subjects of interest had to be selected afterwards. However, the findings need to be contextualized within the characteristics and experiences of Northern Norway's hospitals. The survey was conducted at the end of 2021, following the implementation of the new DIPS Arena EHR system.

B. Data collection

The survey is based on a previously validated questionnaire [14] distributed in 2016 and 2018. In addition to the old survey, this new survey also consists of the survey instruments Work-Related Quality of Life scale (WrQoL) and National Usability-focused HIS Scale (NuHISS). WrQoL [13] has 23 items and a six-factor structure. The instrument is a psychometric scale used to measure human factors that focus on work situations and the quality of life, including factors on General Well-Being, Home-Work Interface, Job and Career Satisfaction, Control at Work, Working Conditions, and Stress at Work. NuHISS [12] consists of 21 items with a six-factor structure. The usability questions include technical quality, Information quality, Ease of use, Benefits, Cross-organizational collaboration, and Internal collaboration. NuHISS was developed for increased knowledge of Health information systems.

Before conducting the new survey, it was piloted through six interviews to get necessary feedback on the quality of the survey. Some changes were made in 2021 to the previous questionnaire as it was reported as too time-consuming. We used the survey program LimeSurvey (LimeSurvey GmbH, Hamburg, Germany) to administer the questionnaire. Anonymity was guaranteed to all participants. The survey was dynamically designed to increase relevance for the participants so they would only answer relevant questions. The questionnaire mainly used a 5-point Likert scale ('Completely disagree,' 'Partially disagree,' 'Neutral,' 'Partially agree, 'Completely agree'). Selected items for specific queries were agree/disagree or numeric responses.

TABLE I. DATASET, BASELINE AND 2021 DATA

Health Region	Clinical profession			
	Physicians, n	*Nurses, n*	*Other, n*	*Total, n (%)*
FSH	19	18	23	60 (27.1%)
NLSH	20	32	42	94 (42.5%)
UNN	18	32	17	67 (30.3%)
Total	57 (25.8%)	82 (37.1%)	82 (37.1%)	221(100.0%)

The participants were recruited through emails, with each hospital responsible for extending the invitation to all their employees. This method was thought to be the best solution as it used existing administrative structures to facilitate the best possible. To reduce non-responses, a reminder was sent twice between September and December 2021.

The sample consisted of 603 hospital employees, of which 221 participants completed the entire questionnaire, resulting in a 36.5% completion rate. Table I shows the distribution of who answered the survey. These respondents consisted of physicians, nurses, and other professionals who comprise various working groups at the hospital that use the EHR. 25.8% were physicians, 36.2% were nurses, and 38.0% belonged to other professional groups.

The sampling method introduced some limitations. The recruitment method could have been better due to our need for more control over the distribution and limited the answers from the hard-to-contact group. Another possible bias is selection bias, where those most interested in answering such surveys are likely the most enthusiastic about responding. To mitigate these biases, we used strategies such as deploying reminders to improve the response rate.

C. Analysis/statistical methods

Analysis of Variance (ANOVA) was used to determine the dimensions of Work-Related Quality of Life (WrQoL) that significantly influence usability (NuHISS). The significance level was considered p=.05. The statistical software Statistical Package for the Social Sciences (SPSS) 29 (IBM Corp., Armond, NY) was used for the analysis. We proceeded in three steps. Firstly, we analyzed the significance for the overall groups (all age ranges, all professions, genders).

Secondly, we analyzed the significances for each of the groups. Thirdly, we studied the interactions between WrQoL and age, gender, and profession.

A minimal quantity of missing data was observed for the NuHISS variable (n=15, 6.8%), while none were found for WrQoL. Various imputation methodologies have been proposed to address data Missing Completely At Random (MCAR) and in scenarios without systematic patterns of missing data [15]. In this study, we handled missing data by presuming MCAR, as articulated by Little [16]. Our analyses substantiated the MCAR assumption ($\chi 2$=.393, df=1, p=.531). Subsequently, we utilized the Expectation Maximization (EM) algorithm within SPSS to impute missing values, which estimates the dataset´s means, correlations, and covariances. We adjusted for covariates by including possible confounders and interactions. Age was treated as an ordinal variable, while profession and gender were treated as categorical variables. The scales in WrQoL and NuHISS were treated as ordinal variables.

D. Ethics

The data-protection officer at the University Hospital of North Norway has approved the study. The Regional Committee for Medical and Health Research Ethics Northern-Norway has been consulted, but they concluded that approval was not required.

III. RESULTS

The impact of Work-Related Quality of Life (WrQoL) on the National Usability-focused HIS Scale (NuHISS) scores was examined across various professional groups, age categories, and gender. The ANOVA analysis will show if there are any significant differences in the mean scores of NuHISS across the groups of professions, age, or gender.

A. Baseline data

The number of participants who completed the survey and were EHR users was n=221 (82.5%). Of this group, 70.6% were female. The average years of experience was 17 years (sd=10.9), and the average duration in the current position was 7.6 years (sd=8.1). The mean age of EHR users was 45.7 years (sd=11.6). In terms of professional roles among EHR users, physicians constituted 25.8% (n=57), nurses 37.1% (n=82), and other clinicians also made up 37.1% (n=82). Age distribution within the EHR users was as follows: 10.0% (n=22) were between 18-29 years, 25.3% (n=56) were between 30-39 years, 23.5% (n=52) were between 40-49 years, 28.5% (n=63) were between 50-59 years, and 12.7% (n=28) were 60 years or older.

We checked interaction effects when comparing the groups of WrQoL based on profession, age, and gender. No interactions were found. Lavenes test is the test of homogeneity of variance, checking if the variance in scores is the same for each of the groups. A non-significant result does not violate the homogeneity of variance. Eta squared (Eta2) is used as an effect size measure. It quantifies the strength of the relationship between variables in the ANOVA analysis, quantifying the proportion of variance explained.

TABLE II. ANOVA RESULTS

Factor[a,b]	Subgroup	n	F	df1, df2	p[c]	Eta^2
Profession	All	203	10.441	2, 201	<.001	.093
	Physicians	56	1.313	2, 54	(.277)	.046
	Nurses	79	4.085	2, 77	.021	.096
	Other	68	6.215	2, 66	.003	.158
Gender	All	203	10.636	2, 201	<.001	.063
	Female	143	7.589	2, 140	<.001	.071
	Male	61	3.218	2, 58	.047	.044
	Other	2	-			
Age group	All	204	2.164	14, 189	.006	.074
	-29	21	.186	2, 10	(.833)	.036
	-39	49	.703	2, 15	(.510)	.086
	-49	49	2.172	2, 14	(.151)	.237
	-59	57	5.191	2, 23	.014	.311
	60+	28	2.060	1, 4	(.225)	.340

a. Lavenes test is n.s. for all factors.
b. Interaction effect is n.s. for all factors.
c. Non-significant p in brackets ().

B. Results by professions

By profession, the results show a statistically significant relationship between WrQoL and NuHISS score for all the clinical groups ($p < .001$); see Table 2. WrQoL for the specific professions, nurses ($p = .021$) and other professions ($p = .003$), significantly affect NuHISS. Physicians are the only profession that is not significant in the effect of WrQoL on NuHISS ($p = 1.313$). We combined physicians and nurses as one clinical group to overcome the small sample size of physicians. For this larger combined group, we have a significant effect for WrQoL on NuHISS ($F(2,134) = 4.808$, $p=.010$, Eta^2=.067). All significant results show that low scores on WrQoL relate to lower scores on NuHISS; see Figure 1.

The effect sizes are large (see Eta^2 in Table II) for all professions, as well as for the nurse and the other profession groups. Knowing the level of WrQoL predicts a large amount of total variance in NuHISS. The Eta^2 for the combined group of physicians and nurses has a medium effect.

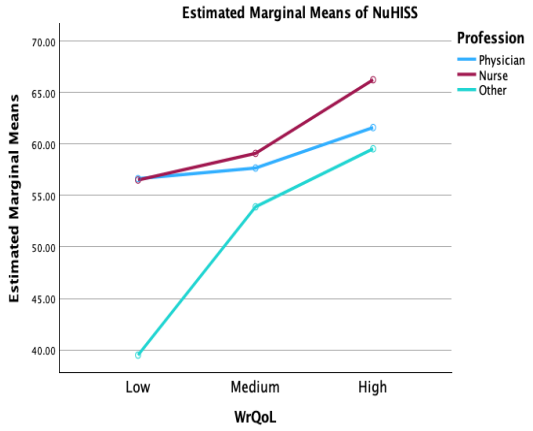

Figure 1. Estimated Marginal Means of NuHISS by profession and WrQoL

C. Results by age

Age shows a statistically significant effect of WrQoL on the NuHISS score for the overall group (all ages combined) ($p = .006$). By age groups, only the groups 50-59 ($p = .014$) were significant. All significant results show that low scores on WrQoL relate to lower scores on NuHISS; see Figure 2. Even if the groups did not reach significance, the trends for each group except the group 18-29 show the tendency that low scores on WrQoL predict low scores on NuHISS.

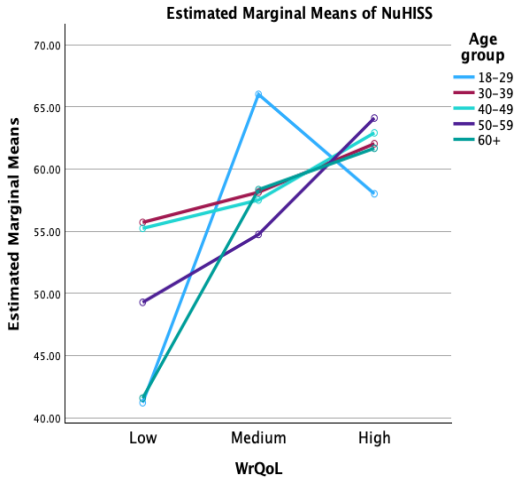

Figure 2. Estimated Marginal Means of NuHISS by age and WrQoL

D. Results by gender

Gender shows a statistically significant effect of WrQoL on NuHISS score for the overall group (all gender) ($p < .001$). When splitting the group by gender, WrQoL for both female and male had a significant effect on NuHISS ($p < .001$ and $p = .047$, respectively). All significant results show that low scores on WrQoL relate to lower scores on NuHISS; see Figure 3.

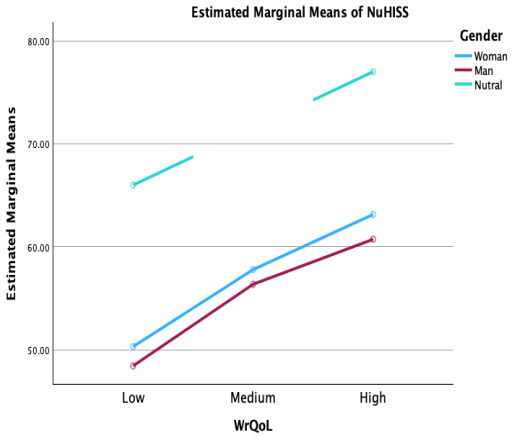

Figure 3. Estimated Marginal Means of NuHISS by Gender and WrQoL

Effect sizes is medium (see Eta^2 in Table 2) for all genders and for female, and low for male. A medium amount of total variance in NuHISS is predictable from knowing the level of WrQoL and gender.

IV. Discussion

Our study sought to explore whether there is a relationship between human factors and how healthcare professionals assess usability during the transition to a new EHR system in Norway. The findings shed some light on this theme and can give insights that can improve our understanding of the implementation process and help adopt new EHR systems.

Our analysis revealed a statistically significant relationship between Work-related Quality of Life (WrQoL) and usability, as measured by National Usability-focused HIS Scale (NuHISS) scores across the combined sample of healthcare professionals. This finding underscores the importance of considering human factors when evaluating EHR system usability. However, a more nuanced exploration could be warranted to understand the specific mechanisms through the subparts of WrQoL and how they influence usability, particularly in sociotechnical aspects and organizational factors.

Furthermore, our study identified notable differences in the impact of WrQoL on NuHISS scores across different professional groups. While nurses and other clinicians showed a significant relationship between WrQoL and NuHISS scores, physicians did not show the same association. This disparity suggests that the influence of human factors on EHR usability may vary depending on specific job roles, task requirements, and organizational contexts. To better understand these differences, future research should explore the underlying factors contributing to variations in the impact of WrQoL on usability among different healthcare professionals. When we combine the clinical groups for physicians and nurses, we have significant results. As the combined sample group is larger than the clinical groups, the non-significant result for the physician group could be due to small samples.

Additionally, our findings highlighted the effects of age and gender on the relationship between WrQoL and NuHISS scores. While the age group 50-59 showed significant results, younger age groups did not show the same patterns. Further investigation into the underlying reasons for these demographic differences is needed to understand why there are differences and ensure a high EHR system usability for all healthcare professionals. The grouping of age groups (5 groups) requires a larger sample to demonstrate if it is also significant for other groups.

By examining the relationship between human factors and usability during the implementation process, we find that human factors play a role in shaping reported EHR system usability. This finding underscores the importance of considering these elements during transitioning to new EHR systems. Our findings need further exploration and should be elucidated in a context within the socio-technical field, looking at how factors, such as context, organizational factors, and human factors, contribute to the socio-technical interplay of implementing a new EHR system.

Despite these insightful findings, our study has limitations. The setting of the study is limited to the hospitals in Northern Norway, and the findings need to be interpreted in that context. Furthermore, breaking down the groups into

subgroups makes the sample size small, while necessary for detailed analysis, introduces challenges related to sample size and increases the likelihood of potential biases. The absence of a significant effect in specific subgroups may be attributed to factors such as homogeneity of variances, small sample sizes, minimal differences between group means, considerable within-group variation, non-normality, and outliers. These factors are essential to consider as they can influence the F-value in a one-way ANOVA, affecting the interpretation of the data.

While our study uncovered several significant associations between WrQoL and NuHISS scores across different professional groups, a more in-depth examination is warranted to elucidate these findings' underlying dynamics and implications. Future research could address these limitations by employing follow-up studies or qualitative methodologies [17] to provide a more comprehensive understanding of the complex interplay between human factors and usability with EHR systems. With this regard, implementation research could help us better understand the subjective perspective of EHR users to improve their design [18].

V. CONCLUSION

The study sought to explore if we could see a relationship between reported Work-Related Quality of Life (WrQoL) and usability, as measured by National Usability-focused HIS Scale (NuHISS) score. Our findings show that there is a significant effect between the variables. Low scores on WrQoL predict low scores on usability. We also show that there are some different effects on different demographic groups and between healthcare professional groups. This should be looked at further to increase our understanding of how human factors influence healthcare professionals' views on Electronic Health Records (EHR) system usability and increase our knowledge of what needs to be considered when implementing a new EHR system. When measuring the usability of a health information system, other factors should be considered, such as organizational factors and access to patient history. In Norway, the patient's journal is not one but separate for each provider, such as hospitals and GPs. A Norwegian project, the Valkyrie project [19], intends to give access to all relevant patient data independent of where the journal is stored, and we want to see how this could impact the evaluation of the same EHR just with access to additional patient history.

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