User Experience of an Electronic Medical Record:
A Cross-Sectional Study in the Public Health Sector of the Western Cape, South Africa

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Background and Purpose: The Electronic Continuity of Care Record (eCCR) is a web-based Electronic Medical Record commissioned and implemented by the Western Cape Government Health and Wellness department in 2015 for all 53 public hospitals in the province to capture medical records of patients. While there has been previous research into the quality of clinical coding capture within the eCCR, there has not yet been a formal evaluation of end users' experience (UX) of the application. This study is the first formally to evaluate the user experience of an eHealth application in the public sector in the Western Cape.

This study which evaluated the user experience of the eCCR end users in terms of its *attractiveness*, pragmatic qualities (*efficiency*, *perspicuity*, *dependability*) and hedonic qualities (*stimulation*, *novelty*), describes the characteristics of end users and explores associations between user characteristics and the UX of eCCR.

Methods: A validated UX Questionnaire survey was made available online to evaluate the eCCR user experience. An invitation and link to the survey was added on the eCCR landing webpage specifically to target users of the application. Response data were collected over three months from June to August 2023 using 26 UEQ questions that comprised Lickert-type scales of 1-7 to rate experience. The mean was determined for each scale. Mean scale values > 0,80 represented a positive experience. Values between -0.80 and 0.80 represented neutral experience while values < -0,80 represented a negative experience.

Results: There were 201 participants in this study. The question (item) response means were combined per scale: attractiveness=0.87, perspicuity=1.32, dependability=0.88, stimulation=0.76, efficiency and novelty reported low means of 0.55 and 0.30 respectively.

Conclusion: The User Experience UX evaluation indicated that the eCCR was an easy-to-learn and understandable web-based application, the end users reported it was valuable, secure, enjoyable, and met user expectations. The overall *attractiveness* of application was positive. The pragmatic qualities of the eCCR were rated higher than the hedonic qualities. The study indicated that the eCCR can be strengthened with regard to its innovative and creative features to improve upon the experience scales related to *novelty,* as well as its *efficiency*.

Keywords: user experience, electronic medical record, public health

1   Introduction

User Experience (UX) was defined by International Organisation for Standards, as "users' perceptions and responses that result from the use and/or anticipated use of a system, product, or service. Users' perceptions and responses include the users' emotions, beliefs, preferences, perceptions, comfort, behaviours, and accomplishments that occur before, during and after use. UX is a consequence of brand image, presentation, functionality, system performance, interactive behaviour, and assistive capabilities of a system, product, or service. It also results from the user's internal and physical state resulting from prior experiences, attitudes, skills, abilities and personality; and from the context of use [1][2]."

The World Health Organization developed a global strategy on digital health with the purpose of increasing access to information and communications technology in least developed countries [3]. While the strategy does not explicitly mention "user experience" it does, however, propose the following as a policy option and action: "ensure that institutions, decision-makers and personnel involved in the provision of health care services and all end-user communities and beneficiary populations are adequately engaged in the design and development phases [3]."

Taking UX into consideration is key to delivering products that meet the users' needs and are easy to use or understand with the aim of giving users a positive experience [4][5]. Research in UX can help improve the design of healthcare technology and end user satisfaction, while enhancing the wellbeing of staff [4][6]. It is also useful in planning new developments on health technology software and applications. Literature in UX has demonstrated that engaging users at development stages of the Electronic Medical Records (EMR) improves the adoption of the applications [7][8][9].

An EMR is the digital equivalent of paper patient records or charts [10]. It typically contains information such as medical history, investigation results, treatment and plans for continuity of care of a patient as it is collected by the health service provider [10]. The EMR enhances and supports continuity of care, access to quality care, patient safety and health care productivity while indirectly enabling a better experience of the health service by patients [7][11][12].

The user experience questionnaire (UEQ) was developed by Martin Schrepp in 2005 [13]. There have since been several translations and validations of the tool [13][14]. The use of the UEQ to evaluate EMR systems in health has successfully been used in developed country settings [7,11]. In Canada, researchers conducted a UX survey in six public hospitals to explore the experiences and perceptions of healthcare providers using the existing EMRs. The participants reported that they experienced positive outcomes, quality patient care and improved productivity. They also observed that the longer end users use an EMR system the more the adoption and user experience improve [11].

Laugwitz et al, reported the UEQ in its standard form appears to be an easy to apply, reliable and valid measure for user experience that can be used to complement data from other evaluation methods with subjective quality ratings [14]. However, some limitations include that the items on questionnaires cannot be changed or removed, as this will influence the results.

A South African UX study conducted in 2014 reported that end users interacting with government websites often found that they did not meet their user needs [15]. The 2019-2024 National Digital Strategy for South Africa states that user experience of systems is a critical factor in the systems' success [16]. Additionally, the National Development Plan has a vision for a single cohesive digital strategy where existing information systems for patient care will be centrally coordinated at national and provincial levels [3][16].

Though the use of EMRs has increased over the years in both developed and developing countries, in Africa there is limited literature on UX of EMRs. Most of the literature on EMRs in the Sub-Saharan Africa focuses on the factors that hinder implementation [17][18]. A study conducted in Khayelitsha Hospital in the Western Cape reported that the failures of current EMRs are leading to ineffective capturing of patients' information. It also highlighted the need for a national comprehensive EMR [19].

A systematic review assessing usability on the implemented EMR systems in Africa reported that less attention was given to user satisfaction during implementation, and this impacted the usability of EMR systems [20]. Hassenzahl stated that there tends to be greater emphasis on usability and utility of applications than giving end users a rich user experience [5]. Furthermore, they recommended designers and developers should consider the gathering and analysis of hedonic requirements in addition to usability and functional requirements [5].

The Western Cape Government Health and Wellness (WCGHW) department developed a web-based application called the Electronic Continuity of Care Record (eCCR) to improve the UX of the digital aspects of the patient discharge process as part of its Strategic Information and Communications Technology Plan for Health [21]. The eCCR is used by clinicians, nurses, allied health workers and clerical staff in all public hospitals in the Western Cape Province to integrate and improve discharge processes for in-patients, referrals for outpatients, electronic prescriptions, clinical concept coding, procedure lists, the generation of medical certificates, and ultimately to improve continuity of care. At the time of this research, the eCCR had approximately 900 active users. Since the launch of eCCR in 2015 there has been previous research into the quality of International Classification of Disease (ICD) code data but there has not yet been a formal

evaluation of end users' experience of the application [22][23]. This study is the first formally to assess the UX of the eCCR or any eHealth system in the Western Cape public health sector.

This study being the first UX research for this application, it is anticipated that the results will contribute to future developments or improve the current UX of the eCCR. The UX research can be used to understand user needs in order to deliver informed, relevant and innovative design solutions, that meet users' needs [24]. The study assessed the experiences of eCCR end users in the Western Cape public sector hospitals in terms of overall attractiveness, pragmatic, and hedonic qualities of the eCCR application. Furthermore, it explored the association between the number of months end-users used the application and their user experience.

2   Materials and Methods

The study method comprised a cross-sectional survey method in the form of an electronic self-administered validated UX questionnaire [25]. The study was conducted over a three-month period from June to August 2023.

2.1   Study Criteria

The study participants included eCCR end users in Western Cape public hospitals. Users included clinicians, allied health workers, nursing staff and administration staff. The study targeted end users with more than one month's experience of using the eCCR to participate in this survey. Users with read-only access and inactivity of more than 60 days were excluded from the study.

2.2   Sample Size

At the time the study was conducted there were approximately 900 active users of the eCCR. A standard value of population proportion of 50%, 95% confidence level, and a margin of error of 5% was used to estimate the required *n* of 270 participants, due to the global tendency of low response rates to survey invitations [26].

2.3   Recruitment Strategy

A hyperlink to invite eCCR users to participate in the UX survey was added to a splash screen when users logged into the application. Printed Quick Response (QR) codes were posted in hospital wards to encourage participation in the survey. The questionnaire was structured to exclude and automatically exit users that did not meet the study inclusion criteria.

2.4   Data Collection Instrument

This study used a standardized UEQ long questionnaire by Martin Schrepp et al [13]. The questionnaire included 26 questions where the participants had to rate their experience on a scale 1-7. Each question could be ascribed to broader scale categories (Fig. 1).
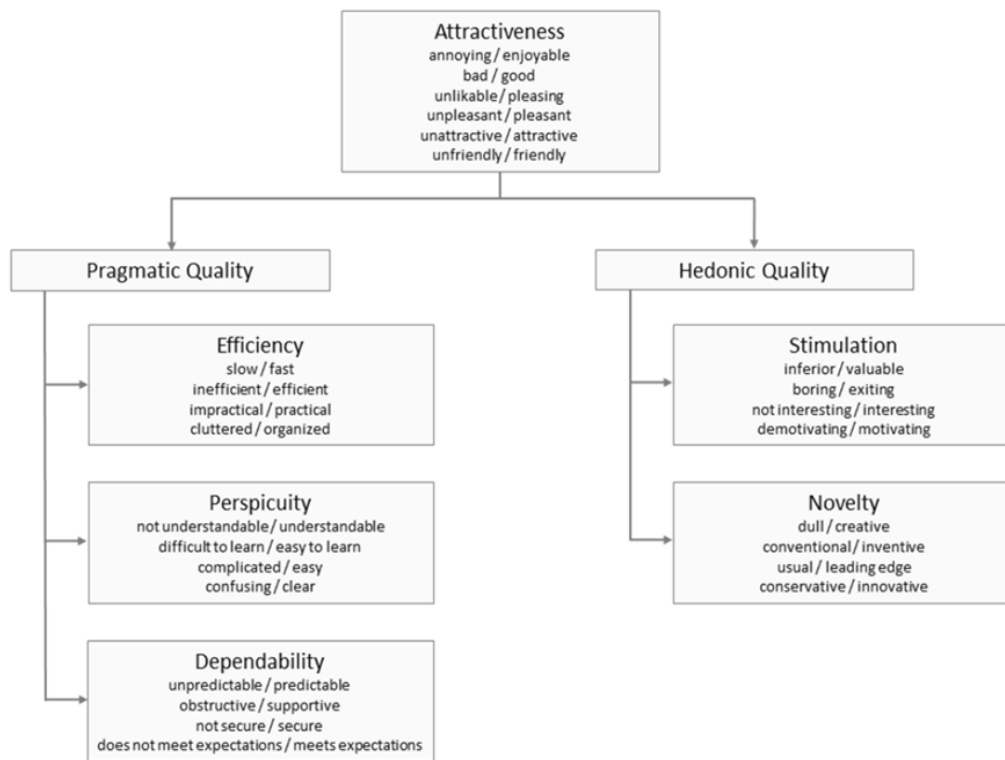
Figure 1. User Experience Questionnaire scale structure (Source: UEQ Handbook, 2008)

Figure 1 elaborates on the meaning of each score. The response scores were grouped according to *pragmatic* and *hedonic* qualities, where pragmatic quality described task related quality aspects, hedonic quality, and the non-task related quality aspects such as originality and innovativeness. *Attractiveness* referred to users' overall impression of the product while efficiency measured whether users could solve their tasks without unnecessary effort. *Perspicuity* measured how easy it was to become familiar with the product. *Dependability* measured whether users felt in control of the interaction. *Stimulation* measured how exciting and motivating it was to use the product. *Novelty* measured whether the product was creative [13][20].

The questions or items had two terms with opposite meanings to describe the user's experience. The questions were randomly organized. Half of the questions started with the positive term and the other half started with the negative term. These were then shuffled to reduce a tendency towards either end of the scale. The UEQ used a seven-point scale to reduce the well-known central tendency bias for these type of questions [14].

2.5   Data Collection

Data were collected using a self-administered electronic questionnaire developed in Microsoft Forms™. This was accessible online via a link on the eCCR website or by scanning a QR code posted in the wards. The survey allowed participants to use mobile phones or computers to participate. In addition to the questions on the validated UEQ tool, occupational data (job position and experience using eCCR) were collected to classify the end users. Two open ended questions were also included asking participants what aspects of the eCCR they disliked and if they had any suggestions. The data collected were kept in a private access-control computer where only the supervisor and investigator had access.

2.6   Data Analysis

Data from the electronic questionnaire was directly entered into UEQ data analysis tool, embedded with a Microsoft Excel™ spreadsheet. Themes were identified from the comments to the open-ended questions.

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The UEQ tool included functions to automate and analyse the data returned from Microsoft Forms™. It used six scores for *attractiveness*, *efficiency*, *perspicuity*, *dependability*, *stimulation*, and *novelty* to evaluate UX (Fig.1). Descriptive statistics were used to report the mean, variance, and standard deviation of scores and per item asked. The data on occupational roles and months of experience were presented using frequency tables, bar, and pie charts. The UEQ analysis measured the means of grouped UEQ scale qualities and individually scales, reported standard deviation (SD), 95% confidence intervals (CI) and benchmarks. Furthermore, the participants were grouped in the months of using eCCR Group 1-6 months, Group 6-12 months, and Group >12 months. The association between the months (experience) of using eCCR and UX was analysed using the ANOVA F-test. A p-value of <0.05 was considered statistically significant.

2.7   Ethics considerations

This study was conducted according to accepted and applicable national and international ethical guidelines and principles, including those of the international Declaration of Helsinki, seventh revision of 2013 [27]. Health Research Ethics Committee at Stellenbosch University provided ethics approval (S22/08/155). Furthermore, the WCGHW Provincial Health Research Committee granted permission to conduct the research (WC_202212_015), as well as the joint proprietors of the eCCR application.

A consent form was integrated into the online survey. After informed consent was obtained, the participants were enrolled into the study and had access to the UEQ. Personal details were stored separately from questionnaire responses according to South Africa's Protection of Personal Information Act of 2013.

3   Results

There were 208 respondents to the survey, of which five did not meet inclusion criteria and two declined providing consent. Therefore 201 participants were analysed. Participant professional roles and demographic characteristics are outlined in Table 1.

Table 1. Participant roles and demographics (n = 201)

Professional roles	Frequency	Percentage
Senior Clinicians	98	48.75%
Junior Clinician	82	40.79%
Nurse	6	2.99%
Allied Health Worker	5	2.49%
Clerk	3	1.49%
Case Manager	2	1.00%
Administrator	5	2.49%
Age Range	Frequency	Percentage
24-30	77	38.31%
31-40	69	34.33%
41-50	32	15.92%
51-60	19	9.53%
61-65	4	1.99%

The sample had 157 (77%) participants with more than 12 months using the application, 6 to 12 months 19 (9%), 1 to 6 months 23 (11%). The participants were aged between 22 to 64.

Figure 2. Healthcare workers' experience in using eCCR (months)

3.1   User Experience Questionnaire results

The UEQ toolkit includes a Microsoft Excel™ based analysis formulas to analyse the data. The results below were outputs of UEQ analysis tool. The table below presents the means of UEQ scales grouped into pragmatic and hedonic quality, pragmatic quality (Perspicuity, Efficiency, Dependability) and hedonic quality (Stimulation, Novelty). The mean values between -0.80 and 0.80 represent neutral experience of the corresponding scale, values > 0,80 represent a positive experience and values < -0,80 represent a negative experience.
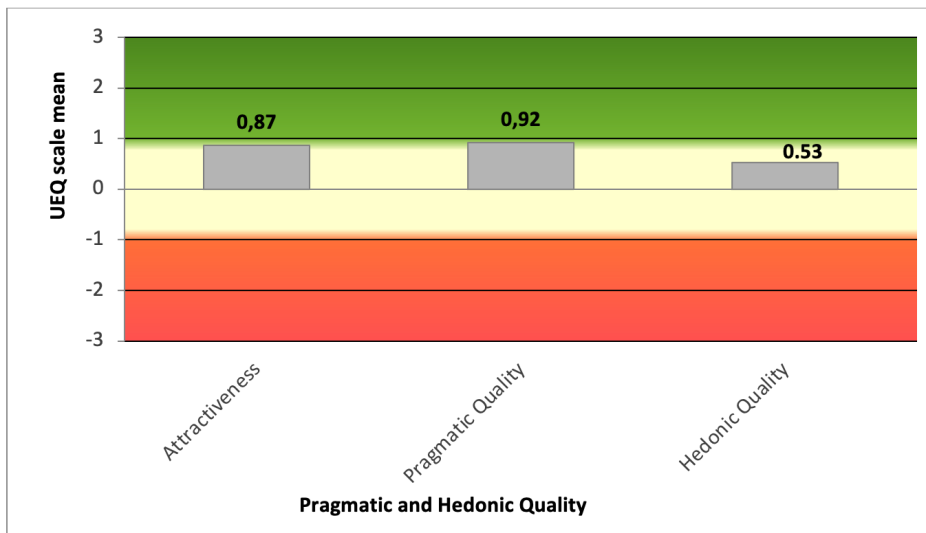

Figure 3. Grouped User Experience Questionnaire scale

The analysis of the means of the six scores found *perspicuity* (1.32) had a highest mean, followed by *attractiveness* (0.87) and *dependability* 0.89, indicating positive experiences. The *stimulation* 0.76, efficiency 0.55 and *novelty* 0.30 had means below 0.80, indicating a less than neutral experience.

Table 2. User Experience Questionnaire descriptive statistics (n = 201)

Scale	Mean	Std. Dev.	95% Confidence Interval
Attractiveness	0.87	1.30	0.69 − 1.05
Perspicuity	1.32	1.10	1.17 − 1.48
Efficiency	0.55	1.23	0.37 − 0.72
Dependability	0.89	1.17	0.73 − 1.05
Stimulation	0.76	1.21	0.59 − 0.93
Novelty	0.30	1.13	0.14 − 0.45

The 95% confidence intervals for the six scales are presented on the table above, including means and standard deviation. The confidence interval is a measure for the precision of the estimation of the scale mean.

The UEQ analysis performs a benchmark comparison of the quality of the product evaluated compared to other products. The benchmarks allow conclusions about the relative quality of the evaluated product compared to other products. Below are the results of how the eCCR compared to other products tested using UEQ.

The eCCR benchmarks ranged from above average to bad. Four of the scales ranked below average. *Perspicuity* was the only scale that ranked above average, while *efficiency* had the lowest benchmarking rank.
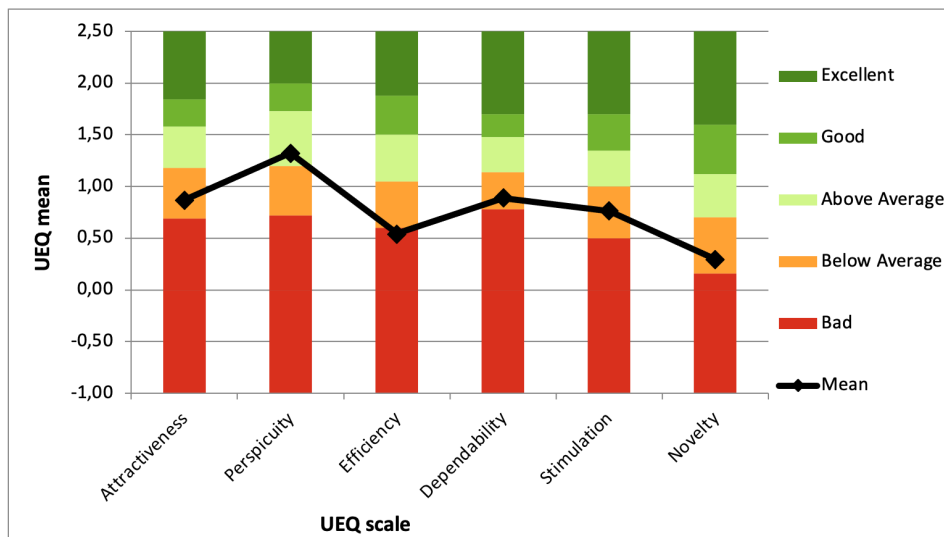

Figure 4. eCCR Benchmark when compared to other applications that were assessed by the UEQ.

3.2   Association between user characteristics and the UX of eCCR.

Further statistical analysis was done to assess the association between months of using eCCR and UX (UEQ scale means between the three groups. The table below presents the means, SD, and 95% confidence intervals within each group. The difference in the UEQ means between the three groups had no statistical significance.

Table 3. ANOVA descriptive analysis between the three groups of months using eCCR.

	Months using eCCR	n	Mean	SD	95% confidence interval of mean	p-value
Attractiveness	1 – 6 months	23	0.79	1.36	0.20 – 1.38	
	6 – 12 months	19	0.43	1.20	-0.15 – 1.01	
	>12 months	159	0.93	1.30	0.73 – 1.14	
	Total	201	0.87	1.30	0.67 – 1.05	0.27
Perspicuity	1 – 6 months	23	1.27	0.87	0.88 – 1.64	
	6 – 12 months	19	1.35	1.21	0.77 – 1.94	
	>12 months	159	1.33	1.12	1.15 – 1.50	
	Total	201	1.32	1.10	1.17– 1.48	0.96
Efficiency	1 – 6 months	23	0.43	1.32	-0.13 – 0.99	
	6 – 12 months	19	0.53	1.33	-0.11 – 1.17	
	>12 months	159	0.56	1.21	0.37 – 0.75	
	Total	201	0.54	1.23	0.37 – -0.72	0.89
Dependability	1 – 6 months	23	0.71	1.22	0.18 – 1.23	
	6 – 12 months	19	0.64	1.31	0.01 – 1.28	
	>12 months	159	0.94	1.15	0.76 – 1.12	
	Total	201	0.89	1.17	0.72 – 1.05	0.42
Stimulation	1 – 6 months	23	0.49	0.99	0.06 – 0.92	
	6 – 12 months	19	0.34	1.44	-0.35 – 1.03	
	>12 months	159	0.85	1.19	0.66 – 1.03	
	Total	201	0.76	1.20	0.59 – 0.93	0.12
Novelty	1 – 6 months	23	0.34	0.84	-0,03 – -0,70	
	6 – 12 months	19	0.18	0.93	-0.27 – 0.63	
	>12 months	159	0.30	1.19	0.11 – 0.49	
	Total	201	0.29	1.13	0.14 – 0.45	0.90

3.3   Suggestions to Improve the User Experience of the eCCR Application

In response to the open question about what research respondents dislike about the application, they reported that the eCCR application was slow, that they were frustrated with the use of ICD codes and disliked having to manage multiple sets of credentials across the various clinical applications available to them. They suggested improving the eCCR application's speed, improving the ICD coding user experience, and enabling integrated access to all clinical information about their patients.

4   Discussion

Although the eCCR was available to a diverse range of health professionals in the public hospitals, the study appealed to younger professionals between the ages of 20 to 40. This is likely because discharge summaries were commonly prepared by the younger junior clinicians. Previous surveys have also reported decreased survey response rate from the clinicians as their age increased. One study suggested that the higher workload could be forcing them to prioritize their clinical duties and postpone other activities, like answering surveys [28].

This finding from this UX evaluation suggests that the longer the users use an application, the more their UX improves [11]. In this study participants with less than one month's experience were excluded. 11% of the participants had used the application for between one and six months. More than 75% of the participants had used eCCR for more than 12 months. Since three quarters of the sample had more than 12 months of experience, we can assume that these users were more familiar and comfortable with the eCCR.

End users rated the *attractiveness* as a positive experience, meaning that they perceived the eCCR to be pleasant, good, user-friendly, and enjoyable to use.

4.1   Pragmatic quality

The UEQ scale means, grouped into pragmatic quality, indicated an overall positive experience by users. The participants indicated the application was easy to use and understandable as the *perspicuity* had a highest mean. This is a good finding, since the WCGHW department has been using and improving this application for more than eight years and has eliminated the need for special training that would draw clinicians away from their core clinical duties. The *dependability* scale also had a positive finding. The eCCR proved to meet the expectations of the end users. Users perceived the web-based application to be predictable and secure.

Regarding the *efficiency* of the eCCR, the results indicated participants had a neutral experience when looking at whether the application was fast or slow, efficient, or inefficient, or practical or impractical. The *efficiency* scale had the lowest mean in the pragmatic quality group. Additionally, when compared to other applications, the *efficiency* was reported as bad. While users reported that the application was slow, it may have been difficult for them to distinguish between the overall network speed and the eCCR responsiveness. Similarly, the eCCR *dependability* scored below average. Only *perspicuity* scored well compared with other applications.

Hassenzahl stated that, if end users perceive a product or application to be effective and efficient, they will be satisfied with their UX [5][6]. Although the participants reported positive experiences for *perspicuity* and *dependability*, *efficiency* of this application did not meet end users' expectations. However, the adoption of the eCCR in the Western Cape has been good despite literature that suggests that poor aspects of systems features would slow down the adoption of the EMR [29].

4.2   Hedonic quality

The hedonic quality of the eCCR had a low UEQ scale mean. The participants found the sensational aspects of the eCCR to be a neutral rather than a positive experience. The analysis outputs indicate that the eCCR is not very interesting, creative, and innovative. Although the pragmatic quality was rated better than the hedonic quality of this application, users will benefit from further development focusing on improving hedonic quality. The *stimulation* was rated better than the *novelty*. The application is valuable to the end users. The eCCR has a valuable function in the health system, and the healthcare professionals value its role.

The *novelty* scale had the lowest UEQ scale mean of all the six scales. The end users reported this web-based application was not very innovative, creative, or leading-edge. When compared to other applications on the UEQ, benchmarks *stimulation* and *novelty* were reported to be below average. There is a significant requirement for the eCCR developers and management to reevaluate the hedonic features of this application.

4.3   End users grouped by months using eCCR

The ANOVA test did not demonstrate statistically significant findings between the different groups of the UEQ scale means, but the study may have been underpowered for this as a secondary objective. This study excluded end users who had not used the application for longer than one month.

4.4   Limitations

The study was impacted by a lower-than-expected survey response rate which is a common limitation in surveys in general [26][28]. The inability to remind participants to take the survey made it difficult to motivate participants. The investigators emailed hospital managers with requests to encourage their clinical staff to participate and posted study promotion posters in areas that would be visible to clinicians.

In terms of the internal validity, the inherent design and layout of the UEQ, as a validated questionnaire, was to reduce respondent bias. However, there may have selection bias as this survey primarily targeted current users of the application and inadvertently excluded past eCCR end users who may have disengaged from the application due to poor UX.

Regarding external validity, the findings of this study are specific to the eCCR application. However, custodians of similar applications within South Africa's expanding digital health space may take heed of potential pitfalls as they strengthen their respective applications. While this study focussed on the UX of a specific EMR application in the Western Cape, it provides proof of concept for use of the UEQ within the South African public health sector.

4.5   Recommendations

For future enhancements to this eCCR, the developers should focus on improving the hedonic qualities of the application to make it more innovative, creative, and interesting. Attention should be given to the speed and responsiveness of eCCR and/or the network infrastructure on which the application runs.

5   Conclusion

Overall, the users perceived the UX of the eCCR application as a positive experience. This UX evaluation indicated that the eCCR was an easy-to-learn and understandable web-based application. The end users reported that it was valuable, secure, enjoyable, and met most of their expectations. The overall attractiveness of application was positive.

Although the benchmarking scores of the UX of eCCR were positive, some of the scales were below average with efficiency reported as poor. There were aspects in need of strengthening to make the application more efficient, innovative, and creative to improve the UX.

The findings of this study will guide the future developments of the eCCR in the Western Cape and assist other health organisations in developing or improving their EMRs. Furthermore, this research demonstrates the value of evaluating UX in multi-dimensional and constructive manner with a view to strengthening EMR applications within South African digital health ecosystem.

Acknowledgements

Declarations

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Conflict of Interest

None.

Author Contributions

SG and RD conceptualised the study. SG conducted the data collection, analysis and drafted the manuscript. RD supervised the research. Both authors critically reviewed the manuscript and approved the final version for publication.

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