Improved User Experience Design on Visualization of Cardiac Patient Monitoring System

Zainab Salma *zainabsalma12@gmail.com*
Department of Computer Science
University of Sialkot
Sialkot, 51040, Pakistan

Rizwa Arbab *rizwa.arbab12345@gmail.com*
Department of Computer Science
University of Sialkot
Sialkot, 51040, Pakistan

Abstract

Human Computer Interaction (HCI) is the study of human, computers and their interactions. It describes information exchanged through a variety of symbols and behaviours during two-way communication between humans and computers. In Cardiology, HCI plays an important role while designing interface of cardiac patient monitoring systems. Good user experience and comfortable human-computer interaction have steadily gained attention from users and designers. Poorly designed user interface can create dissatisfaction for physicians. In order to achieve the success of the underlying systems, numerous approaches could prove useful in avoiding these interaction difficulties. This study provides comprehensive study on enhancement of Cardiac Patient Monitoring systems layout, and highlights problems faced by doctors and other medical professionals and offers solutions for redesigning these systems' designs. Poor human factors design is considered the root cause of problems. Adopting HCI techniques presents a number of challenges that require in-depth research in order to be overcome. This study suggests usability and heuristic evaluation methods to aid researchers in improving the usability and efficacy of cardiac patient monitoring systems. Heuristic evaluation is one of these methods used after system usability has been assessed through questionnaire analysis. By adopting this technique HCI researchers will able to bring innovation in designing layout of these devices for Clinicians.

Keywords: Human-computer Interaction, Usability, User Experience, Heuristic Evaluation, Prototype.

1. INTRODUCTION

The human heart, a fist-sized organ that circulates blood throughout the body, has four major sections:

- Maintains blood pressure
- Speed of blood rate

In essence, the heart coordinates with other bodily systems, such as the neurological system, to regulate blood pressure and instruct the heart to pump more quickly under stress and more slowly when at rest. Cardiovascular disease is caused on by the heart's poor functioning, which affects normal cardiac function. One or more sections of the heart may be affected by cardiovascular disease, a category of illnesses that affect the heart and blood arteries. The disease includes heart or blood issues, including:

- Narrowing blood vessels, other organs throughout the body

- Heart and blood vessels problems present at birth
- Irregular heart rhythms
- Heart valves that are not working right

This disease has shown a 70% increase in frequency over the previous 20 years and is the second greatest cause of mortality for people(Feigin et al., 2021). The disease affects heart and blood vessels. It can be characterized as a heart and blood condition in which fatty deposits inside the arteries impair blood flow to the body or brain, leading to arterial hardening. It is basically caused due to unsuitable poor diet routine and other lifestyle habit (Sanchis-Gomar et al., 2022). Countries with low incomes may be more vulnerable to the harmful consequences of cardiovascular illnesses (Şahin & İlgün, 2022). In technology, Cardiology is one of the areas of healthcare where electronic devices were first used for therapy and diagnostic, providing signals give useful and crucial information regarding patient's health (Dias & Paulo Silva Cunha, 2018). Cardiac Patient Monitoring based Decision Support systems plays an important role in healthcare field to assess the health status of patients suffering from. Such systems are designed to support doctors and other medical staff in their daily activities (Ogbuabor et al., 2022). These systems constantly monitor patient's condition through various vital signs and are continuously attached to patient's body through sensors. The sensors in Cardiac Patient Monitoring Systems are able to capture bioelectric signals like ECG, saturation and pulse rate. These sensors measure a pulse wave from wrist, ear, ankle and fingertips and shows them on screen on systems. After receiving input signals from patient's body and then output the result on display screen (Azizulkarim et al., 2017). Patient monitoring system allows continuous monitoring of patient vital signs, support decision making among medical personnel and help enhance patient care. This system can consist of devices that measure, display and record human's vital signs, including body temperature, heart rate, blood pressure and other health-related criteria.

1.1 Vital Signs

Vital signs are an indication of the vital physiological functions of a live organism. Their testing and measurement are critical steps in any clinical evaluation, therefore they are termed as "vital." As part of the initial round of clinical examinations, the patient's vital signs are evaluated. At an urgent care or emergency room, patients are triaged based on their vital signs, which directs the physician on how far they've varied from their baseline. The severity of vital sign irregularities may also predict long-term patient health outcomes (Azizulkarim et al., 2017).

1.2 Display of Cardiac Patient Monitoring System

The diagram below is about Cardiac Patient Monitoring System used in hospitals of Sialkot, Pakistan.

FIGURE 1: Existing Cardiac Patient Monitoring System.

The display of Cardiac Patient Monitoring System contains following parameters:

Oxygen Saturation SpO2: This vital sign parameter is used to measure the amount of oxygen in patient's blood which is normally 95 or higher.
Blood Pressure: This vital sign parameter shows the blood pressure on display that is normally 120/80.
Heart Rate: this parameter shows heart rate, resting heart rate of a healthy adult is 60 to 100 beats per minute.
Respiratory Rate: It is reported in breaths per minutes and an adult breaths 12 to 16 times a minute.
Temperature: It shows patients body temperature normally measured in Fahrenheit or Degree Celsius, and normal range of temperature is 97.8-degree F or 36.5-degree C.

The Patients in hospitals monitored by clinician using these systems, so the visual layout of screen is important to ensure effectiveness of system. These health monitoring systems proved very useful as it reduced patients readmittance to hospital by 44% according to Geisenger Health Plan study. Another study reported decrease in heart failure related readmittance of patients by 43%(Silva et al., 2019). While interacting with these systems the clinicians confronted with unintended consequences related to the use of these systems, which led to negative impact on the design of these systems. One of these major reasons for challenges can be seen from the lack of poorly executed usability testing of these systems(Alrizq et al., 2021). Innovative patient monitoring system must meet the finest requirements for usability and human aspects in order to improve user interaction and reduce the risk of user errors. Designing medical devices with good usability is necessary to prevent dangers related to usability errors.

The important thing in healthcare is to monitor patient's condition through system installed in hospital ward. Modelling, analysing human behaviour are subject of major effort in computing field. Despite many years of development in technology, users continue to report their dissatisfaction with complicated interactions, usability of intended systems and visual representation of monitoring systems. The manufacturer of monitoring systems and user may expect the error and exclusion in the result of device so, errors can occur if usability is violated after final implementation (Rundo et al., 2020). Adverse outcomes and poor design of system can cause many issues including information retrieval of patients. A system based on HCI principles will let end user to complete a task effectively. Human Computer Interaction hold up ease of use an effectiveness for both health professional and patient. As users look for more natural interactions, further development in Human Computer application is still in great demand. While making important advances in healthcare field, the prior work offer insight into how to integrate intelligent systems into human centred design environment.

Objectives of the study:
The important objectives of the study are:

I. To identify issues faced by clinicians while interacting with Graphical User Interface of Cardiac Patient Monitoring System.
II. To develop a Visual Layout of underlying Cardiac Patient Monitoring Systems in Hospitals.

The purpose of this study is to identify factors affecting poor design, usability and presenting UX of Cardiac Patient Monitoring system in order to enhance visual layout. The research questions for this study are: 1. To what extent quality of Cardiac Patient Monitoring System be improved through HCI techniques in developing countries like Pakistan? 2. What can be achieved by involving HCI knowledge's in the hospital service system design? In order to enhance the ease of learning, effectiveness the aim is to design Cardiac Patient Monitoring System that helps the physician to interact more easily. The purpose of this study is to identify factors affecting poor design, usability and presenting UX of Cardiac Patient Monitoring system in order to enhance visual layout.

2. BACKGROUND

Comfortable Human-Computer Interaction and good user experience have gradually become the focus of users and designers. Inadequately designed graphical user interface in these Patient monitoring systems may create dissatisfaction in physicians who have difficulty using computer based technologies. Review provides overview of the study, background, matrices and applications, challenges and issues and workload in HCI for researchers and practitioners interested in evaluating interactive systems. Previous research provided different studies and user interface design models of originated from field of healthcare (Quazi & Malik, 2022).

(Stephanotis' et al., 2019) present the results of 32 expert's collective effort in community of HCI international conference series. Seven grand challenges were highlighted involving wellbeing and healthcare. The points of concern and challenges faced by health practitioners were discussed, more that main research issues relating to development of novel design, evaluation and testing for patient-centre design discussed. For designing data-driven decision-making devices in this field now focused not only on building well designed model but also on *how* their model works (Hong et al., 2020) to address this, 22 semi-structured interviews were conducted with practitioners and data was analysed. The results were achieved using three steps: (1) Roles, describing who is involved (2) Stages involving the activities and (3) Goals.

A significant category of challenges that have gained more attention throughout time is user-oriented difficulties in healthcare and medical device design. Related to this, study was presented (Bitkina et al., 2020) explaining usability and UX design issues in healthcare and medical equipment design and it was about multilateral critical evaluation of the literature on usability and user experience (UX) in the design of medical devices and healthcare, several methodologies for UX design were discussed.

Another study(Ahmad & Mozelius, 2019) proposed a design inspired by six step methods for literature review describe by authors. These methods are (1) Choosing topic (2) developing tools of argumentation (3) finding literature relevant to your topic (4) survey of that literature (5) analysis of literature and (6) writing the review. These steps were carried out by iteratively including researches on relevant topics. A portion of selected publication was also included in this study that was prove helpful in order to determine issues and challenges faced by HCI researchers. The study was also aimed to explore critical factors of HCI for e-health. Another study describes a way to examine a healthcare system that uses client-centred HCI, applying the system to field of medicine and analyse its impacts and functions using various evaluation indicators. As evaluation indicator selection was based on user objective satisfaction, teaching content, effectiveness of HCI design. As a result, a framework was designed and tests and statistics were conducted (Li & Xu, 2022).

2.1 Cardiac Patient Monitoring System

Interacting with monitoring systems in hospitals is essential and complex task that require proper knowledge and user friendly interface of system (Sowan et al., 2021). In this study, the usability of the cardiac patient monitoring systems that nurses and doctors frequently use assessed to learn more about their impressions of its usefulness. To design and evaluate **CDSS** for monitoring cardiac diseases and to support risk prevention, a preliminary investigation and prototype was designed (Kaltenhauser et al., 2020) patients and healthcare practitioners involved to conduct usability testing that contained five kind tasks for the prototype of underlying system. The purpose of this testing was to measure effectiveness and user friendliness. An approach proved helpful known as think aloud protocol having dual advantage of enable the evaluator to evaluate system learnability, providing first-hand knowledge of design issues.

Extensive research has been conducted (Sardar et al., 2019) in the fields of HCI and AI to determine how to put clinicians trust in Artificial Intelligence based systems this research can be linked back to "explainable AI" which aims to make AI more intelligible. According to a research, earlier studies on HCI for CDSS defined different types of support for clinical settings, for example the design for monitoring systems should be evidence-based and support following

phases of decision making: (1) determining appropriate interventions (2) implementing those interventions (3) monitoring the patients, a semi structured interview was also conducted (ElRashidy et al., 2021) for in-depth understanding of work, surrounding effects, interviewees and individual goals.

El-Rashidy et al., proposed an approach to design successful monitoring systems in team based, critical-settings, regarding this recent HCI studies investigated to design of CDSS to assist medical teams in monitoring systems. An approach (Tadas & Coyle, 2020) of innovation design engineering organization to HCD, involving three stages. To prepare various components of CDSS, both in house and filed testing were conducting.

A mixed method approach containing site observations, meeting with stakeholders and laboratory simulations, development team and quality testing to meet research objectives of each step. Another review (Taneva et al., 2014) highlighted scope, potential applications and limitation of Artificial Intelligence in Cardiology through Decision Support System to support diagnose of cardiovascular diseases. Another study(Yang et al., 2016) ratify the effectiveness of remote patient monitoring system to improve healthcare delivery. The study divides the development and design phase into three layers and challenges faced by researchers while designing were highlighted. The study's design however has certain limitations.

Some HCI researchers evaluated monitoring systems that had been used in clinical settings and determined that the absence of HCI was the most likely cause of their failure. Instead of poor technical performance, the primary reason of these failures may have been a lack of HCI consideration in the design of these systems (Liberati et al., 2017).

Some of the HCI related issues highlighted by researchers are given below:

- Lack of workflow integration: Doctors reported monitoring systems cause disruption, take a lot of time, and contradict how hectic clinical work is (Duran et al., 2023)
- Poor social integration: Researchers investigated these system's social integration. According to a lab study, doctors are worried that if they used a tool to make medical decisions, their patients would have a lower regard for them and their abilities.
- Less concern for clinicians need: Clinicians do not often feel inspired to utilize system (Liberati et al., 2017). Clinicians are concerned about how informative these systems' outputs are for the patients they treat (Tariq et al., n.d.)

While making important advances in healthcare field, the prior work offer insight into how to integrate intelligent systems into human cantered design environment as well as describe several challenges still present and contain usability issues, there is research gap as in previous most of work done on remote or wearable patient monitoring systems, a few researchers worked on hospital based monitoring systems(Andrade et al., 2019). However, there is a lack of knowledge regarding the usability of medical devices, particularly for nurses and in particular for the management of clinical alarms (Sowan et al., 2021). The design problem is complex as there are number of factors to be considered including the needs of individual or group and how to best utilize the screen space. In order to enhance the ease of learning, effectiveness the aim is to design Cardiac Patient Monitoring System that helps the physician to interact more easily. Adverse outcomes and poor design of system can cause many issues including information retrieval of patients.

3. METHODS

Cardiac patient monitoring systems are used to monitor patient's vital signs. In a wide range of patient care settings, including intensive care units, monitoring systems are used to monitor patients' vital signs. The visual layout of existing systems used in hospitals of Sialkot, Pakistan is shown in following Fig 1. An intriguing observation is that over the past 20 years, the design of monitoring systems has not significantly changed, with the layout and structure of these monitoring systems largely remaining the same and incremental design changes rather than

transformational ones (Andrade et al., 2020). Due to lack of research and weak user interactions it is time to review the design of these monitoring systems. Based on existing design enhancement deductive research approach is used in this study. For this purpose, these systems were examined and techniques for interface design are described in detail.

3.1 Methods and Tools

Different prototype tools were tested, some of them were not found usable due to limited and paid features. Figma is a design tool for groups of people or individuals who collaborate to create UX. For the prototype design of Cardiac patient monitoring systems Figma proved very useful.

For the evaluation process, heuristics, a task list, and a questionnaire were created.

3.1.1 Heuristics: A document on heuristics was created that contained a list of heuristics along with a brief description of each one. The phase focuses on the user interface, which includes screen controls, navigational elements, user controls, and accessibility features.

3.1.2 Task List: A task list with comprehensive guidance on how to initiate, carry out, and conclude the evaluation process was created. Additionally, a rating for heuristics evaluation was also included in the questionnaire. The tasks were included on the basis of actions or events to be performed by the cardiologists and medical staff. The tasks include adding new patients, recording, Limits & Basic parameters, alarm, interval and setup. Tasks and corresponding task activities are provided in table.

Task	Task item	Task activity
1.	Adding new patient	Delete old patient record and adding new patient
2.	Limits & Basic parameters	Set the value of basic parameters and applying limits
3.	Alarms	Apply new alarm limits
4.	Intervals	Set the interval which can be later use in records
5.	Setup	Setup activities include date and time setup
6.	Large numeric	Large numeric values setting
7.	Time & date	Set date and time values

TABLE 1: Task Activities for Usability Testing.

3.1.3 Questionnaire: Following the heuristic evaluation, the evaluators would use a questionnaire to compile all of the findings and write down the issues after using the designed prototype in order to provide further details for a redesign.

3.2 Evaluation Method

One of the most well-known techniques for evaluating a system's user interface's usability without involving people is the ***heuristic evaluation*** method(Jaspers, 2009) In this type of evaluation, the evaluator examines a system and rates its user interface using a set of accepted usability guidelines, or heuristics. These heuristics typically refer to rules that describe common characteristics of functioning systems. Heuristic evaluation includes following set of principles (Langevin et al., 2021):

1. Make use of easy, simple dialogue

2. Try to communicate in user's language
3. Reduce the memory load
4. Be reliable
5. Provide comments
6. Offer shortened forms
7. Send out effective error messages
8. Avoid errors
9. Provide guidance and information
10. Consistency

In heuristic evaluation, the evaluator steps through the interface twice; 1). To obtain a general understanding of the system in depth and navigational structure. 2). To narrow in on the screen layout and interaction structure in greater detail and assess how well they were designed and implemented in comparison to the pre-established heuristics. Each heuristic evaluation generates a list of usability issues with a note on the heuristic that failed. Once the issues are identified, it is preferable for each evaluator to independently determine the extent of each issue. The result identifies usability issues in the context of heuristic violations and aids system designers in changing the design to adhere to the heuristics' requirements.

3.2.1 List of Heuristic and Severity Scale

In evaluation, ten heuristics were applied. Identified usability issues were rated according to their severity. To scale the severity of problem Neilson proposed severity scale (Cho et al., 2022) given below:

0 = not a usability issue
1 = cosmetic issue, shouldn't be addressed unless more time is provided for the project.
2 = minor problem: fixing this should be given low priority
3 = major problem: important to fix, should be given high priority
4 = usability catastrophe: need to fix this before the product can be released

Heuristic	**Description**
Visibility of system status	Users should always be aware of what is going on, which should provide through feedback in a timely manner.
Match between the system and world	System must be design in user's language, using words, phrases familiar to user.
Users control and freedom	Users shouldn't feel as though the device determines how they behave. Actions should be started by users.
Consistency and standards	Words and terminologies used must be related to the tasks or events.
Error prevention	System must be able to prevent errors before it occurs.
Minimize memory load	Reduce the amount of information the user needs to remember in order to operate the device.
Flexibility and efficiency of use	Shortcuts should be provided to increase flexibility and efficiency of work.
Aesthetic and minimalist design	Interfaces shouldn't include information that is unnecessary or hardly used. No messy pages or screen should be added.

Help user, recognize from action	User should be able to identify and find solution to any kind of problem.
Help and documentation	Help always in form of documentation

TABLE 2: Heuristic applied in Evaluation.

Following diagram shows the three-phase methodology:

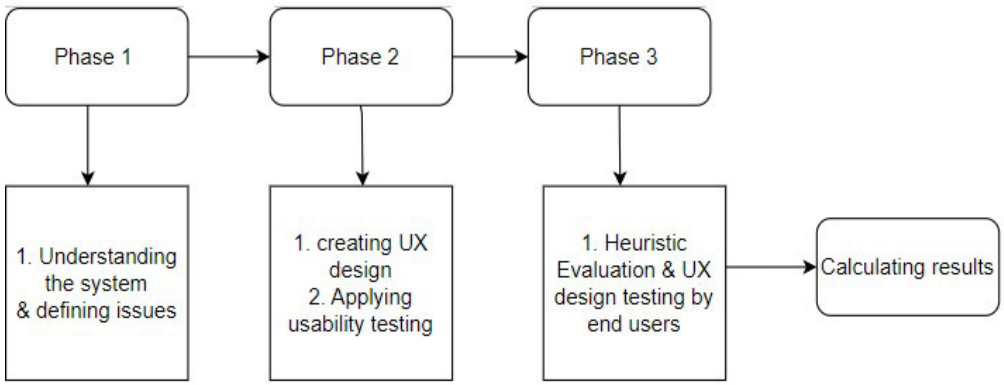

FIGURE 2: Three Phase Methodology.

This study includes following phases:

Phase 1. *Investigating the system under study:* The first phase is to understand the system, its user interface to become familiar with the system. The goal of this step is to determine all the design functionalities including all navigations, interfaces, of existing cardiac patient monitoring system all the design issues relating to user interface of the system are taken into consideration. *Issues faced by cardiologist are listed:* Cardiologists and medical staff working on cardiac patient monitoring systems in from three describe issues they face during interaction with these systems. These issues are stated; too much information placed on main page creating confusion and made the screen crowded. It does not meet characteristics of usability that is ease of use. Users feel discomfort while accomplishing their tasks. Icons on the home page were scattered and not aligned at same place or screen. Navigations that create confusion somehow to complete certain tasks for cardiologist and medical staff. Menu button on existing systems causes confusion while interaction as they design at different places on main screen.

Phase 2. *UX Design Based on User Requirements*: A UX design is designed based on the surveys conducted and evaluation is performed on design and after the evaluation, the UX design/prototype is redesigned to meet the requirements of the clinician and medical staff. According to justin mifsud UX design is defined as "User Experience Design (UX or UED) is a design process whose sole objective is to design a system that offers a great experience to its users. Thus, UX design embraces the theories of a number of disciplines such as user interface design, usability, accessibility, information architecture, and Human Computer Interaction."

UX Design for Cardiac Patient Monitoring System: The UX is designed on prototyping tool Figma. UX design having features that fulfil requirements of the participants. The UX design contains pages include:

Home page contains basic parameters, patient information, time and date, buttons including large numeric, time and date, trend table, interval silence alarm and freeze. *Home page* includes vital signs like heart rate, ECG lines and saturation rate along with their numerical values.

Menu page contain setting limits for basic parameters shown on home screen and setup settings like date and time settings. Screen values can be recorded by recorded button. Menu button further extend to *sub-menu* buttons like review, basic parameters, patients and setup.

Large numeric show all numeric reading in large font. Interval button contain different interval values. Silence alarm button will provide feature to silent alarm in different condition.

Freeze button provide feature to freeze screen for limited time that can resume function over click.

FIGURE 3: Main interface of proposed design.

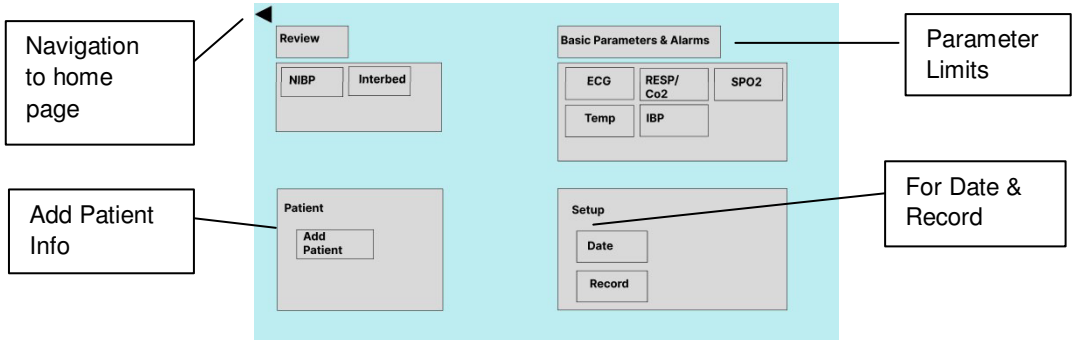

FIGURE 4: Menu Buttons.

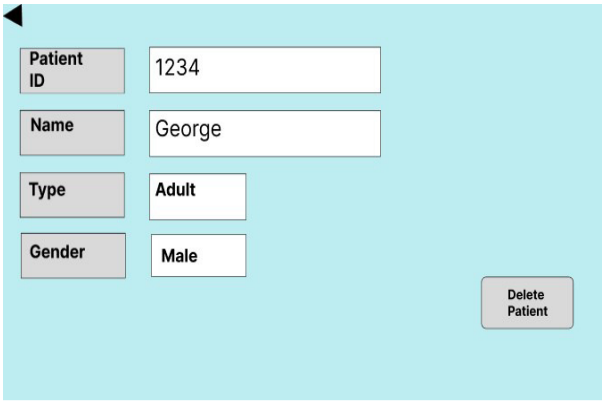

FIGURE 5: To Add New Patient.

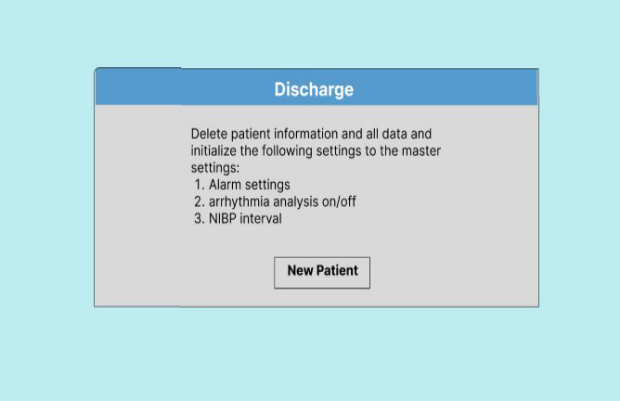

FIGURE 6: Pop-up to Delete Information.

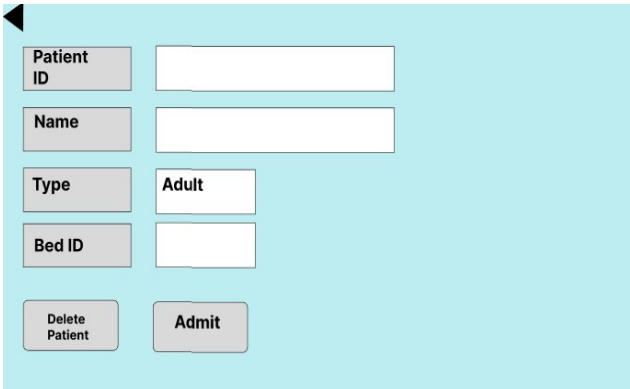

FIGURE 7: Add Data for New Patient.

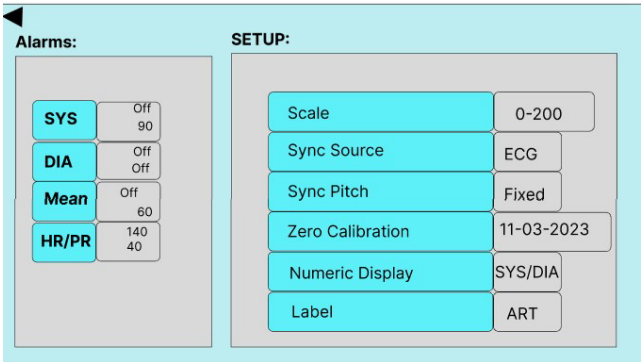

FIGURE 8: Parameter Value Settings.

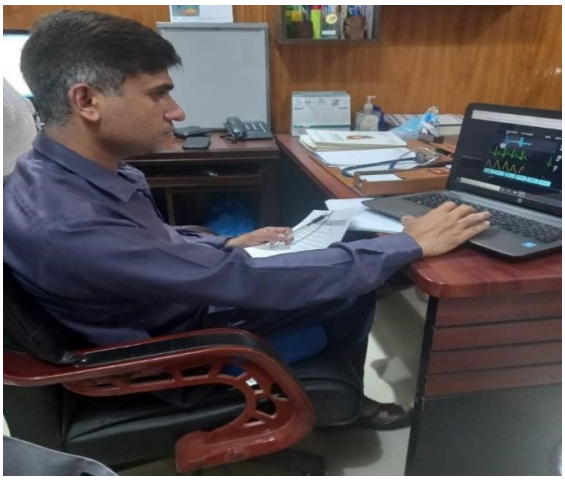

FIGURE 10: User Evaluating UX Design.

FIGURE 11: User Evaluating UX Design.

Phase 3. *Questionnaire:* A questionnaire can be defined as a document with questions and other things intended to collect data suitable for analysis. Type of questionnaires used in this research is *Descriptive Questionnaire.* In order to meet the needs of users, questionnaire with Cardiologists and other medical staff was conducted and issue they face while interacting with monitoring systems are included. A detailed user research was conducted. A questionnaire was created comprised of 17 questions. The questions are based on the designed prototype of cardiac patient monitoring system.

Data Analysis: The data gathered from questionnaire was analyse using data analysis tool SPSS (Statistical Package for the Social Sciences). SPSS is helpful for data analysis, provide analysis for descriptive and multivariate statistics, estimates numerical outcome, and predictions for group identification. Additionally, the program offers data transformation by showing results in bar charts or pie charts. Total participants were 85 among those 85 there were 25 cardiologists and 60 participants were medical staff.

4. RESULTS

4.1 Findings from Usability Questionnaire

The data gathered from questionnaire was analyse using data analysis tool SPSS. Results collected from questionnaire are shown in bar chart. Each question is analysed using tool.

Answers gathered from users are categorized and analysed by SPSS. Effectiveness is important factor while designing prototype of a system, it is measured as completeness of achieved goals.

Question 1 is about effectiveness of system that is how to use UX design of system, among 85 participants 11 respond no to this question while 74 respond yes to the question.

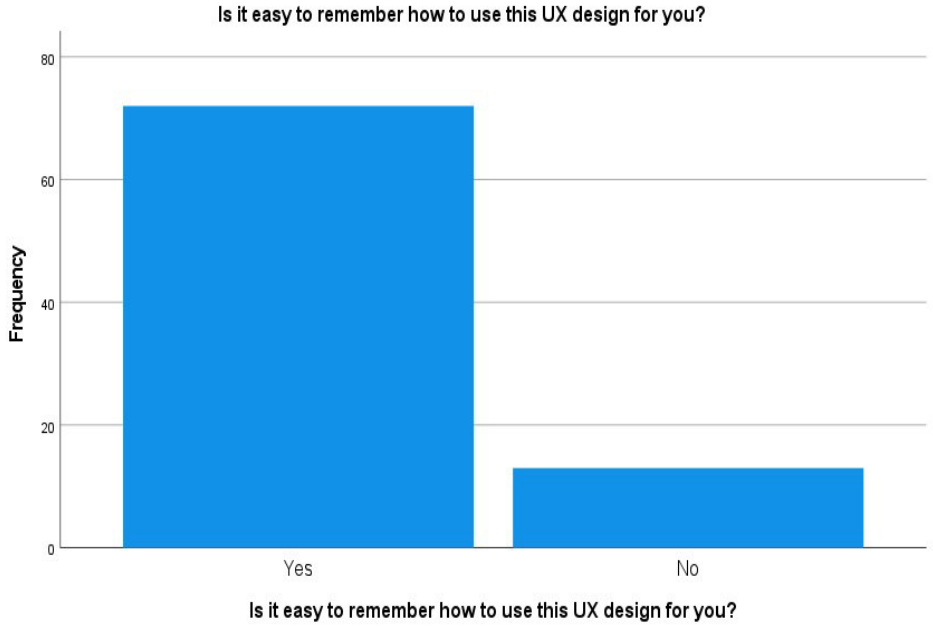

FIGURE 11: Results from Question 1.

Question 2 is about content of UX design that should be clear and relevant end user, among 85 participants 10 respond no to this question while 75 respond yes to the question.

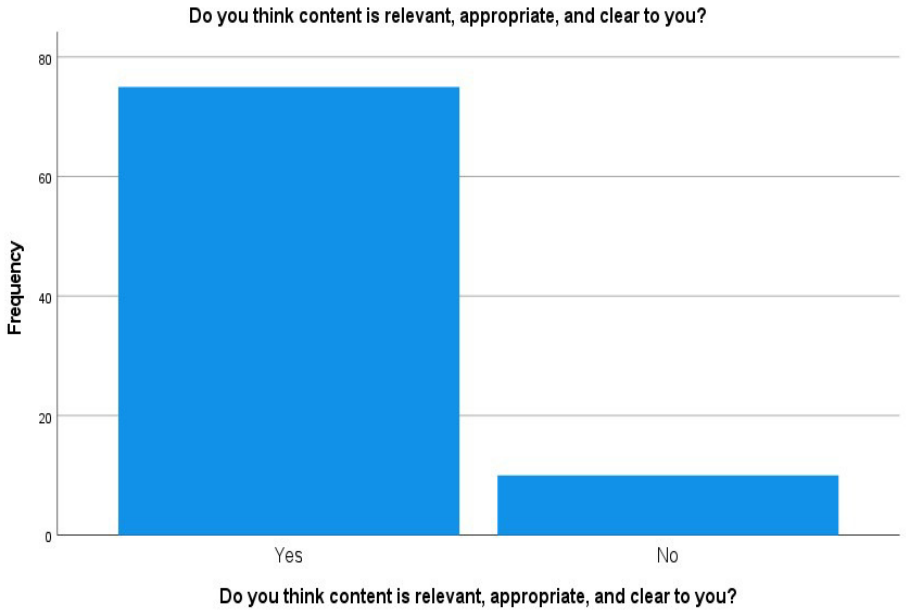

FIGURE 12: Results from Question 2.

Question 3 is about UX design should free from irrelevant which is not helpful for end users, among 85 participants 10 respond no to this question while 75 respond yes to the question.

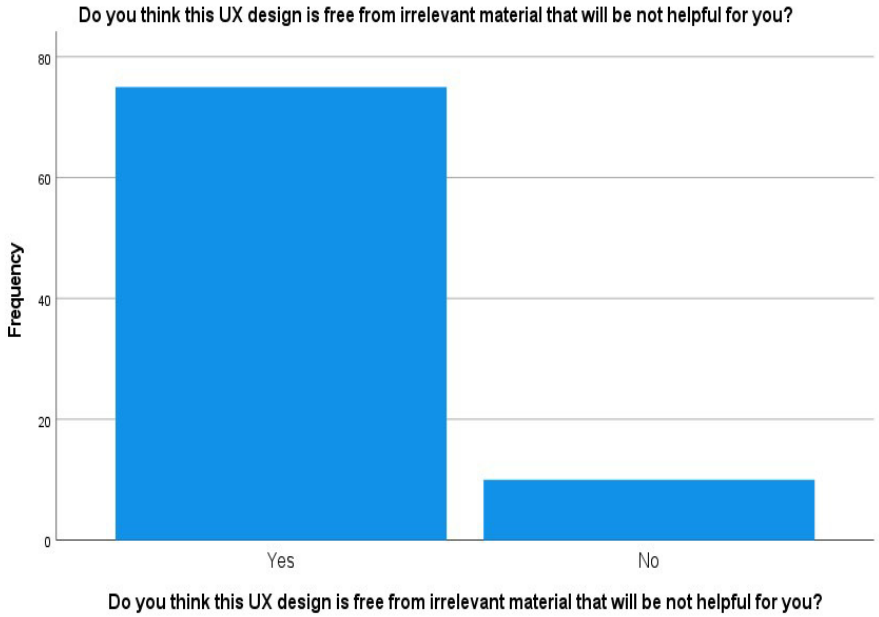

FIGURE 13: Results from Question 3.

The terminologies used in design must be related to tasks because irrelevant terms could cause confusion so, question 4 is about terminologies used in UX design which are helpful for end users, among 85 participants 4 respond no to this question while 81 respond yes to the question.

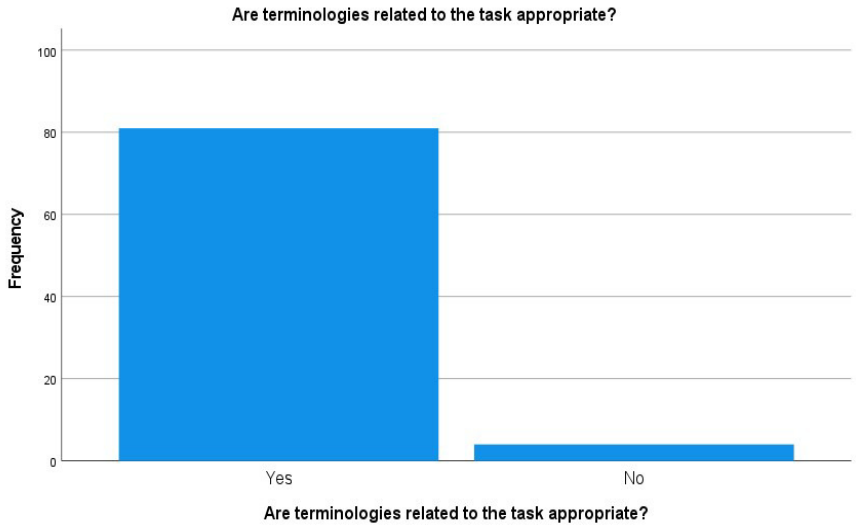

FIGURE 14: Results from Question 4.

To improve design question was asked if end users have any suggestion, their answers were divided in three categories. Question 5 is about suggestions asked from end users for UX design, among 85 participants 63 responded to nothing 15 respond to add more information while 7 respond to need more work on design this question.

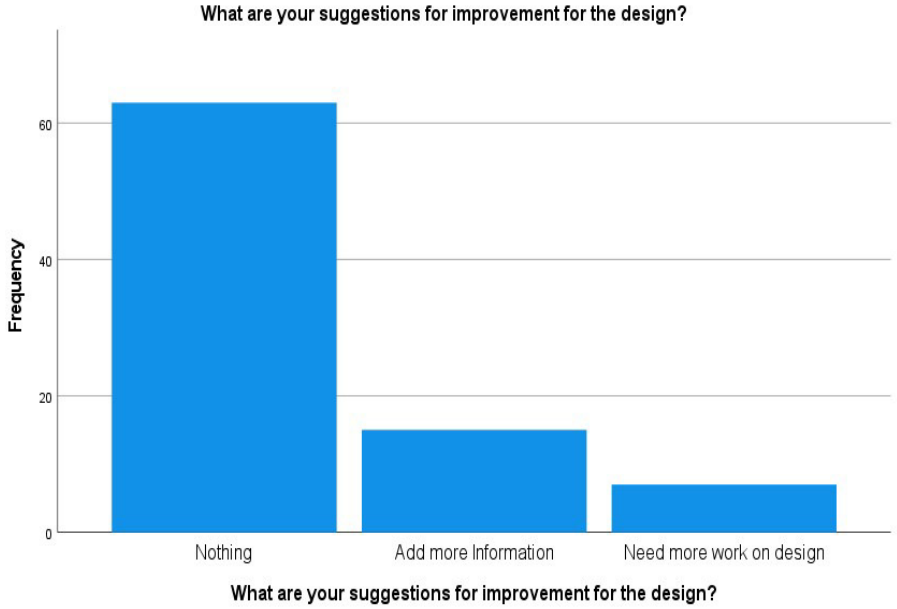

FIGURE 15: Results from Question 5.

UX design should easy and understandable for end user that it must support learning. Question 6 is about degree to which design support overall learning of end user, among 85 participants 74 respond that it helps a lot, for 3 participants it was not helpful and 8 respond to design is just fine.

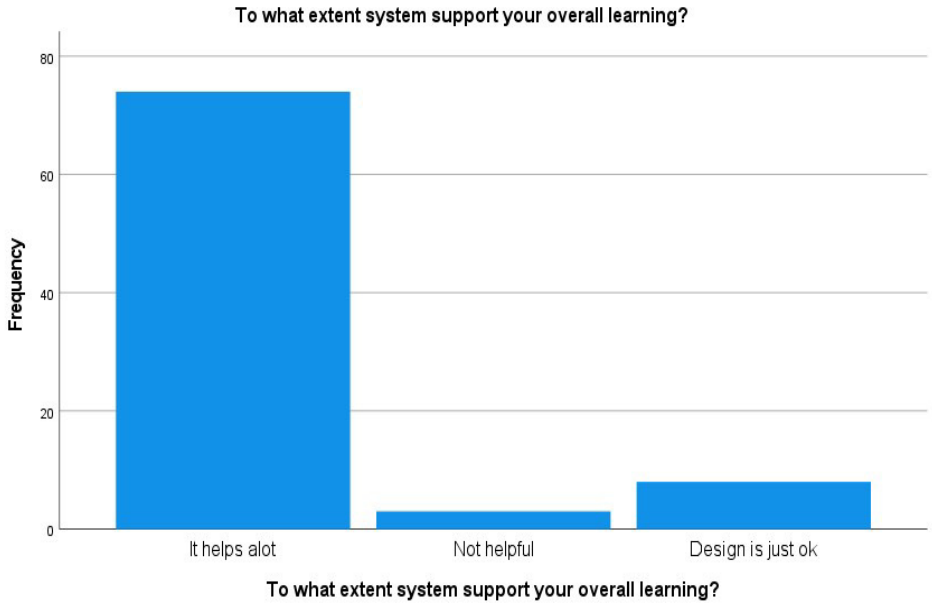

FIGURE 16: Results from Question 6.

After completing task list provided to end users, question 7 is about UX design whether it help users to accomplish their goal or not. 6 participants responded no while 79 respond yes.

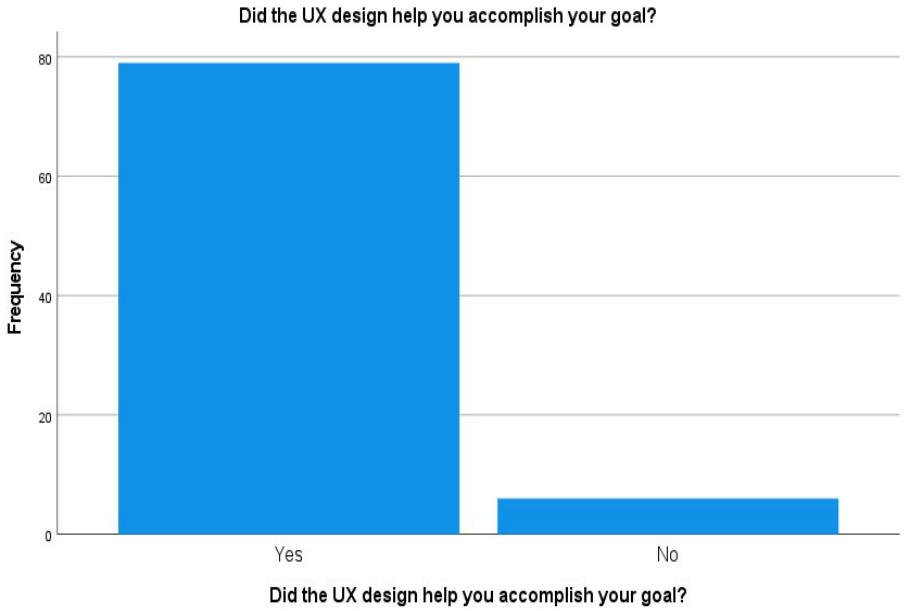

FIGURE 17: Results from Question 7.

Navigation of system basically connect one page of same or relevant content to another based on hierarchy of the design, navigation must be easy. Question 8 is about navigation of system design, among 85 participants 2 respond navigation is bad, 74 respond good while 9 respond navigation to normal.

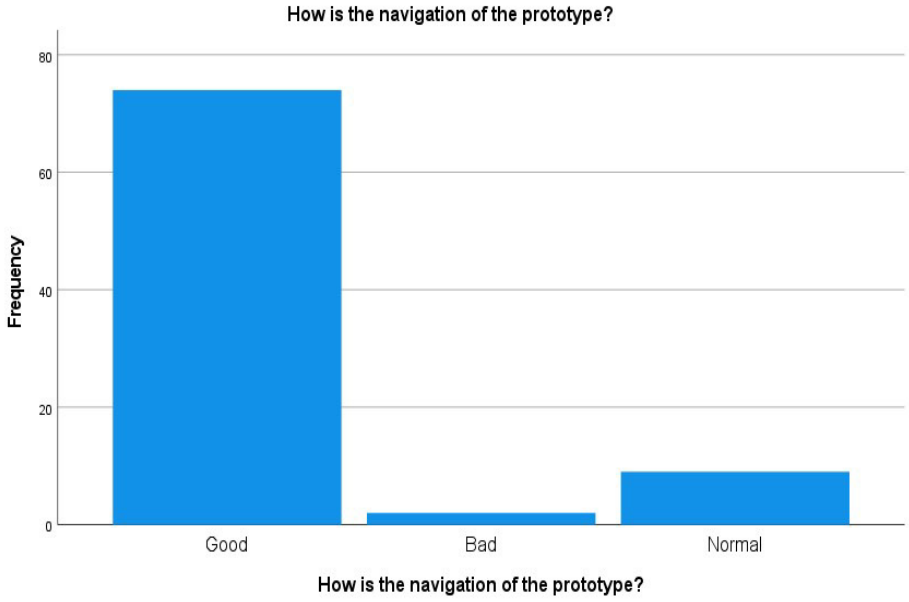

FIGURE 18: Results from Question 8.

Good UX design must have features that are helpful for end user, design must have clear terminologies, easy to use and interface should eye catching. Question 9 is about to ask end

user, what did he/she like most about prototype/UX design. Among 85 participants 39 like design of UX, 16 respond to features, 26 respond design is easy to use, and 4 participants respond interface of design.

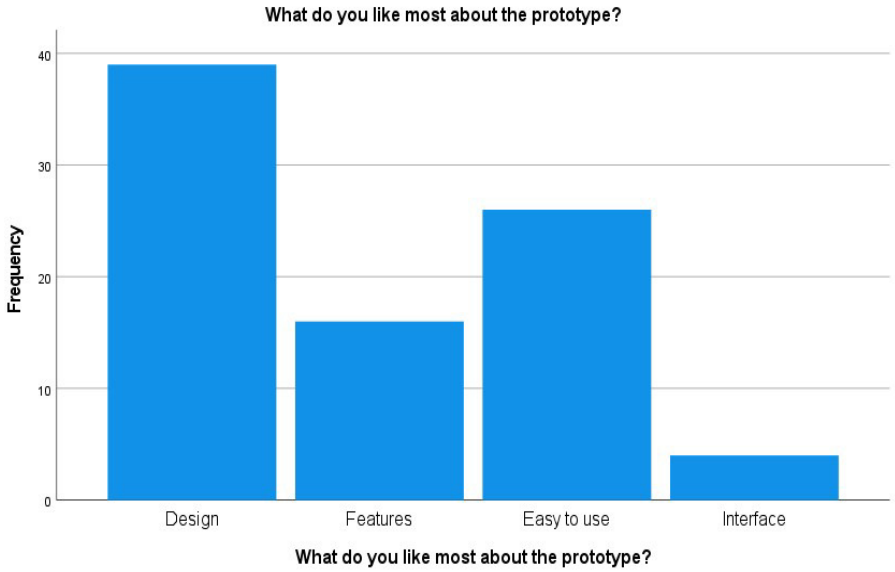

FIGURE 19: Results from Question 9.

Question 10 is about to ask end user, what did he/she like least about prototype/UX design. Among 85 participants 8 respond to less information, 5 respond to poor design, 75 respond to nothing.

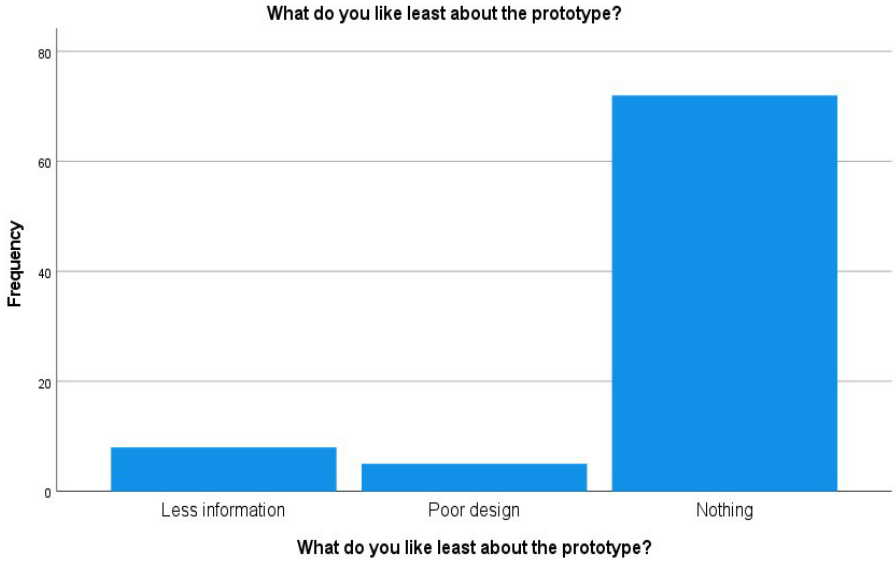

FIGURE 20: Results from Question 10.

UX design include some features that were not on home page. Question 11 is about features of UX design, among 85 participants 37 responds to depend on need option while 48 respond to all are useful.

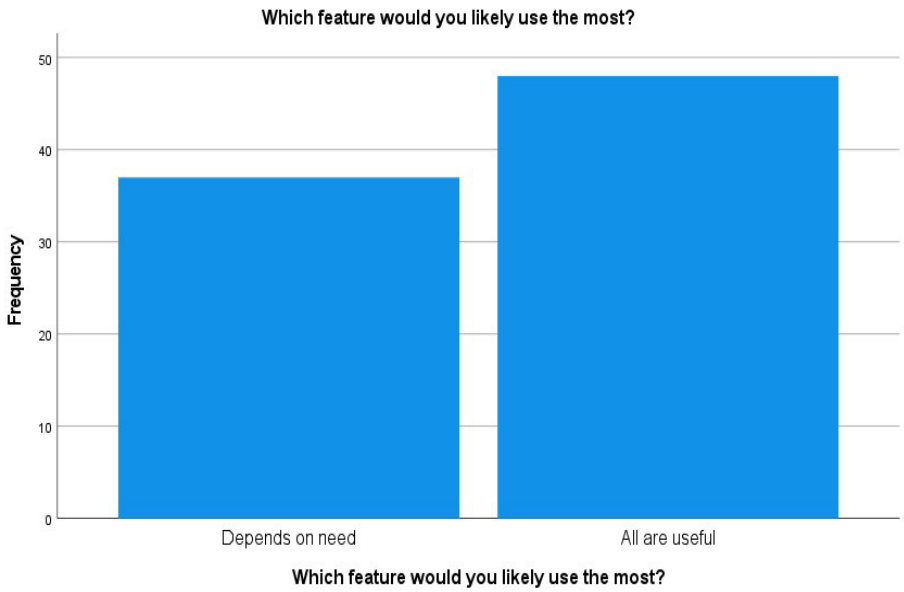

FIGURE 21: Results from Question 11.

After evaluation from end users, users were asked to give suggestion if there is any feature missing in UX design. Question 12 is about to ask end user, are there any features that he/she think are missing in prototype/UX design. Among 85 participants 15 respond to yes, while 70 respond to no.

FIGURE 22: Results from Question 12.

Rating questions are helpful to improve design, helping designer to get better understanding of end users and what they are looking for in UX design. Question 13 is rating question about end user experience with design out of 5. 6 users give rating 3 out of 5, 31 users give rating 4 and 48 give rating 5.

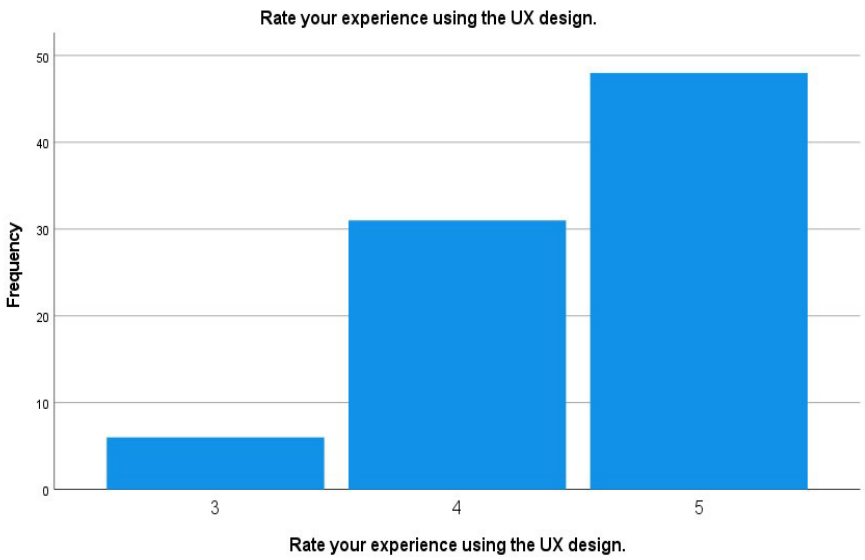

FIGURE 23: Results from Question 13.

Rating questions are helpful to improve design, helping designer to get better understanding of end users and what they are looking for in UX design. Question 14 is rating question about interface of design out of 5. 1 user give rating 3 out of 5, 26 users give rating 4 and 58 give rating 5.

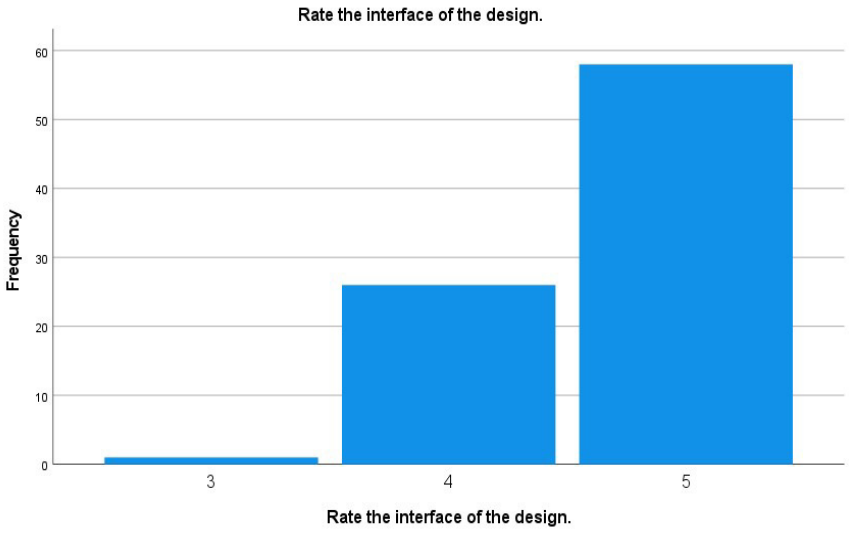

FIGURE 24: Results from Question 14.

Rating questions are helpful to improve design, helping designer to get better understanding of end users and what they are looking for in UX design. Question 15 is rating question about icons of UX design out of 5. 1 user give rating 3 out of 5, 29 users give rating 4 and 55 give rating 5.

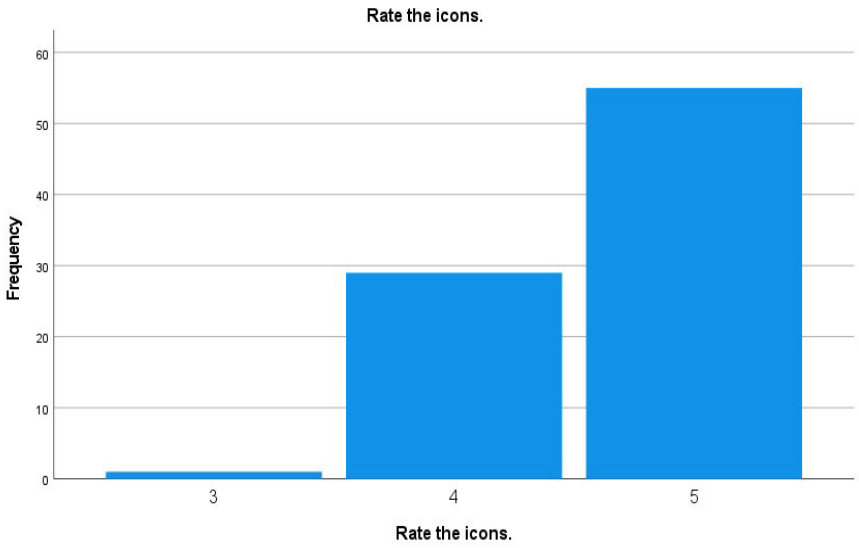

FIGURE 25: Results from Question 15.

After evaluation from end users, users were asked to provide ideas if they think UX design should improve on. Question 16 is about to ask end user if he/she the UX design should improve on. Among 85 participants 16 respond to yes, while 69 respond to no.

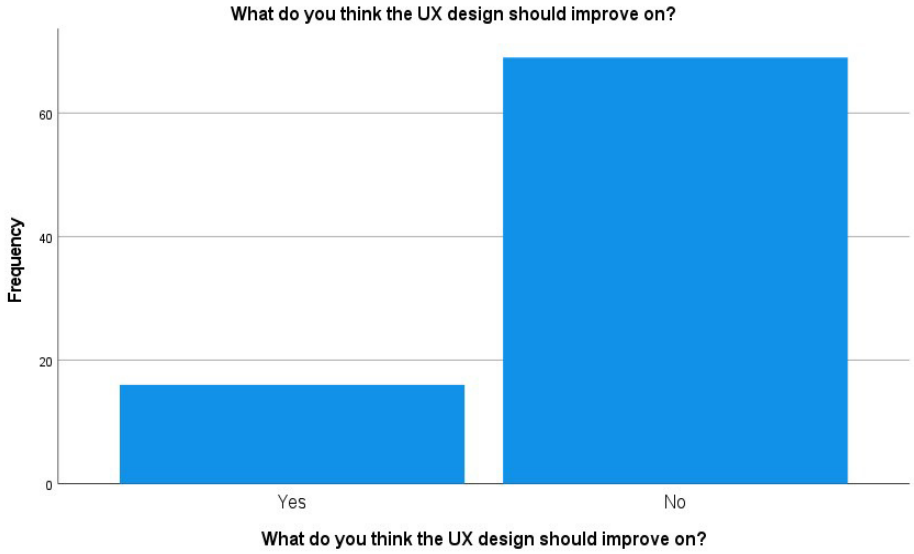

FIGURE 26: Results from Question 16.

Overall results show positive response from end users. Aim of this research was to study usability of UX design of cardiac patient monitoring system and to obtain participants opinions on those aspects. Additionally, software developers might gain significant knowledge from the data regarding requirements that should be made when designing software. Participants expressed their ideas for the tested program and participants' qualitative feedback was gathered. There were no significant problems during the testing, and no dropouts. Usability was tested with four different components involving usefulness, ease of use and learnability, interface quality, interaction quality and satisfaction and future use. These components had average and positive results.

4.2 Findings from Heuristic Evaluations

Heuristic	Description	Heuristic Violated	Severity
Visibility system status	Users should always be aware of what is going on, which should provide through feedback in a timely manner.	Actions and tasks are user familiar; user is aware of what is going on.	1
Match between the system and world	System must be design in user's language, using words, phrases familiar to user.	The symbols and language are relevant and comprehensible	0
Users control and freedom	Users shouldn't feel as though the device determines how they behave. Actions should be started by users.	It is possible to set limits, record screen added to home page made it easy to initiate actions.	1
Consistency and standards	Words and terminologies used must be related to the tasks or events.	Words and terminologies are clear and related to particular event or task. Tasks are accomplished in same way.	0
Error prevention	System must be able to prevent errors before it occurs.	Does not turn itself off in case of error. Returns to home page.	3
Minimize memory load	Reduce the amount of information the user needs to remember in order to operate the device.	Added this feature and make it easy to remember functions in order to operate.	1
Flexibility and efficiency of use	Shortcuts should be provided to increase flexibility and efficiency of work.	In some settings shortcuts are not provided to reduce complexities.	2
Aesthetic ar minimalist design	Interfaces shouldn't include information that is unnecessary or hardly used. No messy pages or screen should be added.	Unnecessary information is removed from home page that may cause confusion.	0
Help user, recognize from action	User should be able to identify and find solution to any kind of problem.	Users are able to remember past actions.	1
Help and documentation	Help always in form of documentation	It is possible to add help if needed for some function.	2

TABLE 3: Detected Usability Issues.

4.3 Response Time Calculation

Performance can be measured in response time and users' interactions. Comparison between Existing design and proposed UX design is given below:

Task Item	Existing Design (ms)	Proposed Design (ms)
Adding new patient	17000	15150
Limits & Basic parameters	12500	11620
Alarms	18530	14700
Intervals	5600	4860
Setup	20310	16820
Large numeric	4500	3360
Time & date	14230	9620

TABLE 4: Response Time Comparison.

The response time is given in millisecond's, a user performs a task and mean value is calculated comparing results of both. The mean value is calculated by using mean formula by dividing sum of terms to number of terms. Calculated Mean value is given below:

	Existing Design (ms)	Proposed Design (ms)
Mean	13289	10876

TABLE 5: Mean Value Results.

Response time for proposed design can be seen in above table calculated mean value is smaller than the value calculated for existing design. Considering the work (Brunner et al., 2017)which have worked on user-centred design approach to improve and about 62% conducted provided satisfaction assessment. Usability and user experience are still frequently ignored in the medical industry in favour of therapeutic effectiveness. Another study (Schlöglhofer et al., 2023) worked on icon improvement design for monitoring system using HCI techniques, showed user satisfaction with results of 84.5%. Medical device user errors are frequent and can have catastrophic effects, another application was created (Dehghani Champiri, 2021) on application that was created on cardiovascular disease monitoring with results of 67% usability, and app was easy to use. This research provides an enhanced user layout of cardiac patient monitoring system and usability of prototype was evaluated through usability testing and heuristic evaluation and achieved user satisfaction and improves user interaction up to 88%.

5. DISCUSSION

Overall results show positive response from end users. Aim of this research was to study usability of UX design of cardiac patient monitoring system and to obtain participants opinions on those aspects. Additionally, software developers might gain significant knowledge from the data regarding requirements that should be made when designing software. Participants expressed their ideas for the tested program and participants' qualitative feedback was gathered. There were no significant problems during the testing, and no dropouts. Usability was tested with four different components involving usefulness, ease of use and learnability,

interface quality, interaction quality and satisfaction and future use. These components had average and positive results.

Implementing the best clinical practice in cardiovascular disease is a growing challenge for healthcare professionals. In cardiology ward, Patient Monitoring systems helps a clinician to understand overall heart health by considering certain aspects of heart function. This study provides an enhanced user layout of cardiac patient monitoring system and usability of prototype was evaluated through usability testing and heuristic evaluation. Usability testing was conducted involving medical staff and cardiologist through questionnaire and task activities, and heuristic evaluation was conducted in which no major problem was detected. Heuristic analysis's well-known limitation is that many issues discovered by this method are only trivial or minor in scope. The majority of the usability violates in this investigation were rather minor issues. To uncover more possible serious issues, more evaluation techniques are required which were done through a usability questionnaire.

Minor issues shouldn't be ignored, though, as resolving them can increase user pleasure and the absence of minor annoyances may be what distinguishes a medical device from those of its competitors. However, participants brought up issues with the high frequency of false alerts and difficulties browsing the menu under difficult circumstances. Participants also mentioned that they would want to see more information on the screen. In the medical industry, it is common for end users to have limited capabilities. Devices are frequently utilized by a variety of persons in the field, including clinical professionals and medical staff. On the other hand, there are numerous different types of medical equipment, and the groups of people who use them are diverse and may have particular demands. It is therefore unlikely to compile a list of heuristics that are applicable to all medical devices.

6. CONCLUSIONS

The objectives set by proposed work achieved by designing an enhanced UX design for cardiac patient monitoring systems used in cardiology ward. This study provides challenges and issues related to interface and design. The cardiologists face these issues while interacting these systems, in literature review challenges and issue faced by medical staff and cardiologists are highlighted. Considering question one, study was conducted on user interaction design of cardiac patient monitoring system with the help of HCI techniques, results indicate that design is easy and simple for cardiologist and staff using the system in cardiology ward, based on results, it can be verified that the proposed work meets its set question and played a significant role in the research with the help of HCI techniques. There is a challenge instead of focusing on just one new system, there is the difficulty of comprehending how new healthcare technologies are connected with other existing technologies and what are the impacts of interacting with these technological devices. The proposed work will helpful to contribute in research and for clinicians and medical staff as well it has highlighted interaction issue and provide an enhanced user interaction design for cardiac monitoring systems, that was accepted by cardiologists.

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