

# User Centered Design Practices in Healthcare: A Systematic Review

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**Abstract**—Effectiveness in modern healthcare and services and the optimization of processes and operational sequences must be designed from the perspective of the end user. This paper aims to identify and analyse the common practices of User Centered Design (UCD) that had been implemented in previous studies in the context of analysis, design and evaluation phases and provide an overview from the research findings as a reference for other researchers. Studies were manually searched via online databases and further analysed based on the predefined research questions. This study reviews 60 papers published in the field of healthcare services on adopted UCD approaches between 1992 and 2014 (May). The results show that although UCD approach has a history of 22 years, it is not yet a normalcy in Asia countries. Interview, prototyping and usability testing are the most common activities adopted in respect to the UCD phases.

**Keywords** - user-centered design; healthcare; systematic literature review; UCD

## I. INTRODUCTION

User Centered Design (UCD) is a design philosophy that stressed on the importance of end user's requirement in developing a product or services and it largely relies on end user feedback together with intuitive design to ensure the quality of design [1]. Donald Norman contributed to the new transformation of user development in design, which he has given a new impetus to participatory design and redefines into User Centered Design [2]. This design approaches emphasizes the needs and interests of end users rather than focusing on user testing. There are three common phases in UCD and users are involved from the earliest phases of the development of the concept: analysis, design and implementation [1], [3]. In UCD context, the implementation phase is considered as a phase where evaluation of the proposed design(s) is performed [3].

This work focuses on reviewing the adoption of the UCD approaches into healthcare services, where the UCD approaches are believed to be able in improving healthcare services that leads into more effective, efficient, and safe [4]. Furthermore, failure of a healthcare system is considered from deficiency consideration of human issues in current healthcare technology [5]. To improve the intended health outcomes, user involvement in healthcare system development and testing is very important, as well as to ensure that the system meets the required functionality and usability [6]. The significance of

involving or streamlining the efforts to re-design the current healthcare and services with UCD have been acknowledged by many medical practitioners. The most recent is highlighted by Moore [7] in the Healthcare IT News, who pointed out the Electronic Medical Records at hospitals are lack of user-centred designed and encouraging vendors to embrace human factors and user-centred design principles. In addition to this, it was also found that even when an integrated system is in place, it was still not a success, as it did not properly consider the involvement of users in the implementation process [8].

## II. REVIEW PROCESS

This study has undertaken a few guidelines to derive to a systematic literature review (SLR) [9]. The next sub-section defines the review planning phase. This phase involves defining research questions, search strategy and selection criteria, and finally undertaking qualitative analysis.

### A. Research Questions

There are five research questions that guide these review findings.

- RQ1: How long has the UCD been implemented in the healthcare services?
- RQ2: What domains of healthcare have applied the UCD approaches?
- RQ3: What are the common activities used in the analysis phase of UCD in healthcare
- RQ4: What are the common activities used in the design phase of UCD in healthcare
- RQ5: What are the common activities used in the evaluation phase of UCD in healthcare

In order to address RQ1, the papers are collected from journals and conferences that were published ever since the UCD was first introduced. RQ2 aims to identify the area or domain of healthcare that has adopted and implemented the UCD. RQ3, RQ4 and RQ5 focus on finding the common practices for each phase, i.e. the analysis, design and evaluation respectively.

### B. Search Strategy

Preliminary search strings in major indexing databases was first performed. Any strings that match with the term "user",

“user centered design”, “human centered design”, “user centered healthcare design” and any medical term for disease or healthcare services/system were selected. The SLR process recommends searching from several selected electronic sources. The major indexing databases that had been used were the Web of Science (ISI) and Scopus, besides the IEEEExplore and ACM. All materials that have been found were recorded as search results. Types of publications were then categorized according to conference proceedings, book chapters, books, and technical reports.

C. Selection Criteria

The inclusion and exclusion criteria are defined based on the following statement (in order to prevent from unrelated articles to be reviewed). This paper examines works/studies which have implemented UCD approach into healthcare practices. There are five main parameters that were considered when including a paper for further review; a paper which falls under the domain of Cognitive Ergonomics [10], must have been available online, must have been written in English, must offer full text, and, must have declared implemented UCD approach into healthcare areas. All papers that obviously did not match these inclusion criteria were not accounted for, i.e. excluded. While, any papers that discuss UCD approaches in healthcare are kept as the review sources for this work.

D. Quality Assessment

Quality assessment was performed after the data collection was undertaken from the selected studies. The objective of this phase was to evaluate how relevant the source studies are for our study. After performing the search strategy process, there are 87 papers that were deemed suitable for further review. The number of papers after the inclusion and exclusion criteria decreases to 60 papers. Appendix A presents the list of studies included in the review.

III. RESULTS

This section of the paper presents the results of the analysis on the dataset of primary studies. In Fig. 1, the publication count per year is being presented. Fig. 2 depicts the most active countries in user centred design healthcare research. Table I and II present the research publication outlets for user centred design healthcare studies. The data in Figs. 1-2 and Tables I-II will be the basis of the discussion in RQ1.

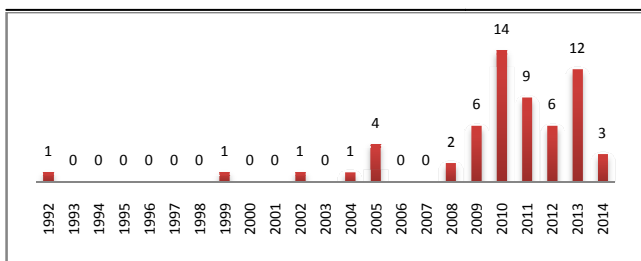


Fig. 1. The number of papers published by year

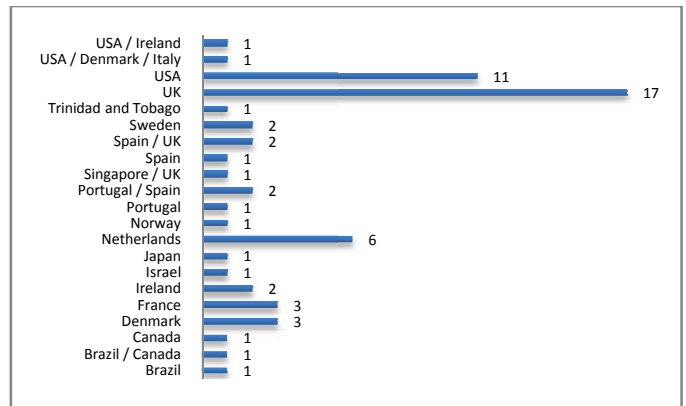


Fig. 2. Countries contributing to UCD in healthcare literature

TABLE I. DISTRIBUTION OF THE SELECTED ARTICLES BY JOURNAL

Journal	No. Of paper
Applied Ergonomics	1
Artificial Intelligence in Medicine	1
Australasian Medical Journal	1
Computer Methods and Programs in Biomedicine	1
Computers, Informatics, Nursing	1
Health Informatics Journal	3
IEEE Transactions on Information Technology in Biomedicine	1
Information Technologies and International Development	1
International Human Computer Studies	1
Intensive and Critical Care Nursing	1
International Journal of Medical Informatics	5
Journal of Biomedical Informatics	8
Radiotherapy and Oncology	1

TABLE II. DISTRIBUTION OF THE SELECTED ARTICLE BY CONFERENCE/PROCEEDING VENUE

Conference/Proceeding	Year (no of paper)
27 <sup>th</sup> International BCS Human Computer Interaction Conference	2013 (2)
4 <sup>th</sup> International Conference on Software Development for Enhancing Accessibility and Fighting Info-exclusion (DSAI 2012)	2012 (1)
ACM CHI Conference on Human Factors in Computing Systems	1992 (1) 2008 (1) 2013 (1) 2014 (3)
ACM Conference on Creativity and Cognition	2013 (1)
AMIA Annual Symposium Proceedings/AMIA Symposium	2009 (1)
Conference on Enterprise Information Systems	2011 (2)
International ACM SIGGROUP Conference on Supporting Groupwork	2005 (1)

TABLE II. CONTINUED

International Conference on Active Media Technology	2012 (1)
International Conference on eHealth, Telemedicine and Social Media	2009 (1)
International Conference on Information Visualisation	2011 (1)
International Conference on Interaction Design and Children	2013 (2)
International Conference on Mobile and Ubiquitous Multimedia	2013 (1)
International ICST Conference on Pervasive Computing Technologies for Healthcare	2010 (5) 2011 (2) 2012 (1) 2013 (1)
International Conference on Pervasive Technologies Related to Assistive Environment	2009 (1)
International Conference on Smart Homes and Health Telematics (ICOST)	2009 (1)
International Symposium on IT in Medicine and Education (ITME)	2011 (1)
Participatory Design Conference	2010 (2)

#### IV. DISCUSSION

This section will be discussing the answers to the research questions posed in the earlier section.

##### A. RQ1: How long has the UCD been implemented in the healthcare services?

Fig. 1 shows the results of the paper published by year, starting with the year 1992 until May 2014. Throughout the 22 years, there was only one publication appeared in 1992, 1999, 2002 and 2004. Despite the slow numbers in the first ten years, the topic was becoming popular in 2005, and started to increase in 2008, with the highest number in 2010.

The UCD approaches had been adopted in the healthcare areas as early as 1992 [S43], six years after the UCD approaches were introduced by Donald Norman [1]. But there are also some research studies used some other to describe their approach that are adopting the same characteristic as UCD approaches, which are Patient-Centered Design (PCD) [S23];, and Human Centered Design (HCD) [S45].

Whilst, Fig. 2 shows the number of countries of author's institution contributed to the publication of UCD approaches in healthcare. There were 16 countries with United Kingdom recorded as the highest number of publication in this field with 17 papers. There were 8 papers which were co-written between countries. Most of the work appeared to be written by European countries and very small contributions from Asian countries.

Table I shows the distribution of the published papers by journals. Most work of UCD in healthcare was published in the Journal of Biomedical and Informatics. Meanwhile, Table II shows the distribution of the published papers by proceedings. It appears that most work tend to contribute to the International Conference on Pervasive Computing Technologies for Healthcare with 5 papers were published in the 2010 proceedings alone, 2 in 2011, and 1 in 2012 and 2013. Another popular platform is ACM CHI Conference on

Human Factors in Computing Systems, in which the oldest work found was published in the 1992 proceeding of ACM CHI.

##### B. RQ2: What domains of healthcare have applied the UCD approaches?

Diabetes shows the highest number of healthcare domain implemented the UCD approach in their study, followed by research studies that are focus on elderly (see Table III). Most of the research conducted emphasis the use of UCD approach into general healthcare system and not specific to any healthcare domain In addition to this, there are 5 systems that are found most often used as major research studies as well as outlined in Table IV.

##### C. RQ3: What are the common activities used in the analysis phase of UCD in healthcare?

Based on Table V, interview, observation, focus group, and scenario are the four most common techniques used in the analysis phase of UCD approaches in the healthcare areas. This is based on the analysis that has been conducted, where

TABLE III. DOMAINS OF HEALTHCARE INVOLVED IN PREVIOUS STUDIES

Domain	Frequency
HIV / AIDS	1
Dermatologists	1
Dementia	1
Diabetes	4
Ophthalmologist	1
Physiotherapist	1
Hypertension	1
Osteoarthritis	1
Chronic disease	1
Lung transplant	1
Elderly	2
Stroke, chronic pain and heart failure	1
Infection control of methicillin-resistant staphylococcus aureus	1
Nephrology and immunology	1
Not defined	16

TABLE IV. COMMON TYPE OF SYSTEM INVOLVED IN PREVIOUS STUDIES

Type of System	Frequency
Mobile device applications	5 [8], [15-18]
Web based	4 [19-22]
Ward services	2 [14], [23]
Self-management system	3 [18], [19], [24]
Decision support system	3 [25-27]

TABLE V. UCD ANALYSIS ACTIVITIES IN HEALTHCARE

Activity s	Frequency
Interview	39 [S1, S3, S4, S6, S9, S10, S12, S16, S17, S18, S19, S20, S21, S22, S23, S24, S26, S27, S31, S32, S35, S36, S37, S38, S39, S40, S41, S43, S44, S45, S46, S48, S49, S50, S51, S54, S56, S57, S59, ]
Observation	15 [S10, S11, S12, S18, S22, S24, S26, S31, S38, S39, S41, S43, S48, S51, S59,]
Questionnaire	6 [ S11, S24, S39, S43, S51, S52 ]
Workshop	10 [S2, S3, S13, S17, S20, S27, S30, S32, S35, S43, ]
Focus group	15 [S4, S7, S19, S21, S25, S26, S27, S31, S44, S46, S49, S50, S53, S54, S59 ]
Personas	6 [S13, S16, S31, S42, S53, S54]
Scenario	11 [S1, S10, S12, S13, S19, S27, S42, S44, S53, S54, S55 ]
Card Sort Task	1[S20]
Storyboarding	1[S1]
Work Shadowing	1[S54]

TABLE VI. UCD DESIGN ACTIVITIES IN HEALTHCARE

Activity	Frequency
Prototyping	33 [S1, S2, S3, S4, S10, S12, S13, S17, S21, S22, S24, S25, S26, S27, S28, S29, S30, S31, S34, S35, S37, S38, S41, S43, S44, S45, S48, S49, S50, S52, S55, S56, S60 ]
Hierarchical Task Analysis (HTA)	1 [S19]
Card Sort Study	1 [S20]
Sequence Diagram	1 [S25]
Not defined or other methods	6 [S3, S34, S39, S47, S53, S58]

*E. RQ5: What are the common activities used in the evaluation phase of UCD in healthcare?*

Table VII shows tht usability testing, study or inspection is the most common method used, followed by heuristic evaluation. The terms testing, study and inspection are used interchangeably but most of the time refers to the same meaning. Parameters such as efficiency and effectiveness are the two most common criteria being evaluated. Heuristic meanwhile, requires the experts to perform the evaluation.

## V. CONCLUSION

UCD is seen as an integrative approach system development process, which can help the developers to identify and fulfil users' needs and requirements. In the context of healthcare, indirectly, it can help to provide intended health outcomes that can please the end users whether the patients or the medical practitioner. The limitation of this study is, as we only sought papers written in English and indexed in ISI and Scopus databases, we may miss out those which were written in one's own mother tongue. This could be the contribution to the low number of papers from Asia countries. Having said so, by scoping the papers only in the indexed databases, which had been written in English and in high quality, we firmly believe the findings provide a general yet sufficient overview of UCD practice in healthcare.

TABLE VII. UCD EVALUATION ACTIVITIES IN HEALTHCARE

Activity	Frequency
Heuristic evaluation	5 [S8, S28, S41, S44, S52]
Subjective methods – pre and post survey / test	1 [S55]
Usability testing/study/inspection	6 [S4, S8, S10, S11, S13, S29, S38]
Direct observation	1 [S45]
End user evaluation	1 [S52]
Cognitive walkthrough	1 [S52]
Content-based testing	1 [S52]
Expert-based testing	1 [S52]
Not defined or other methods	6 [S3, S34, S39, S47, S53, S58]

interview technique is used in 39 previous studies. Examples of these interview techniques used in data analysis phases are semi-structured interview, unstructured interview, structured interview, open-ended interview, group interview and informal telephone interview. The different types of observation technique that have been used in the reviewed literatures include live, direct and video recorded observations.

In terms of the analysis tools, the most common type of tool used by the reviewed researches is scenario technique. A total of 11 literatures were found to have used this approach. Other than that there is also new techniques of analysis tools which were based on experience-based stories of the end user and virtual personas.

*D. RQ4: What are the common activities used in the design phase of UCD in healthcare?*

Table VI shows the most common method that has been used during the design phase is prototyping (a total of 33 research works). This high rating is due to the cost and ease of creating a prototype. The type of prototype developed varies from hi-fidelity to low-fidelity prototypes. The selection is influenced by various factors such as cost, time, and at which point the prototype will be used in the design phase. Another factor is whether the prototype developed is for formative or summative evaluation purposes.

Using a tangible prototype will make it easier for users to give comments on the proposed systems. It will also be easier for developers to gauge users' reactions and get appropriate input. Most importantly, it will increase the chances of prospective users' "buy-in" towards the proposed system. During this phase, users will be involved in giving comments or suggestions based on the prototype tested. Furthermore, prototypes are also easily corrected after end users' evaluations and comments.

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