

ORIGINAL ARTICLE

USABILITY GUIDELINES FOR DESIGNING M-HEALTH CLINICAL CODING AND GROUPING APPLICATION

Shariffah Syazwana Aljunid*, Nurhizam Safie Bin Mohd Satar and Rozailawati Razali

*The Center for Software Technology and Management, Faculty of Information Science and Technology, Block H, Faculty of Information Science & Technology, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi Selangor, Malaysia****Corresponding author: Shariffah Syazwana Aljunid**Email: syazwanaaljunid1996@gmail.com

ABSTRACT

The rapid progression of technology has led to web-based e-Health systems migrating to mobile device systems known as m-Health apps. Past researchers gave guidelines on the general e-Health, but the usability guidelines for m-Health apps were lacking. General guidelines are challenging to refer to when developing mobile apps with specific domains and complex functionalities. However, the absence of specific m-Health guidelines has made it challenging to design a quality and suitable app if it follows the general guidelines. Hence, specific usability guidelines for specific domains and complex functionalities apps with quality and sound research were developed to ensure the users get the best usable app. This study aims to produce a m-Health usability guideline for the clinical-based app of clinical coding and grouping for healthcare users. A total of ten participants participated in this study, which were fell into three categories; namely four industrial practitioners in the field of UI/UX, four experts with more than 20 years of experience in UI/UX and usability expertise, and two end-users, which consist of doctors and lecturers in public health and clinical coding. The data were collected through semi-structured interviews, allowing the participants to share feedbacks and comments to improve the usability guidelines and prototype for clinical coding and grouping of the m-Health app. The four participants from the expert categories had undergone usability evaluations, namely heuristic evaluations, while the two end-users' groups had engaged in cognitive walkthroughs to improve the usability guidelines and the app's prototype. The transcript of the interviews and usability evaluations were transcribed for thematic analysis using Nvivo software. The emerging themes were categorised into legibility and readability consisting of sub-themes font, icon, label and logo, buttons, and visual design that includes the sub-theme, theme and style, illustration and animation and colour. The emerging themes were a few vital usability components that were taken into consideration during the development of the m-Health app. The study highlights some of the usability components that were the foundation of the usability guidelines and the prototypes developed may be used by researchers and developers to develop the clinical-based m-Health app in the future. The usability guidelines and the clinical coding and grouping m-Health app prototype can be further tested towards other m-Health apps with similar features and between more experts and other wider audiences, such as older age groups and colour-blind people to produce a more robust and holistic app that is universally suited for all people. Moreover, the expansion from a medium-fidelity prototype to a high-fidelity app was also encouraged for future researchers and developers.

Keywords: m-Health; guidelines; usability; design; clinical coding; clinical grouping; app; apps; application

INTRODUCTION

Technology advancements have brought about a paradigm shift from a web-based information system that relies on desktop computers and laptops to an information system based on mobile devices¹. The health sector is keeping pace with this modernisation by adopting technological advancements in mobile devices, such as tablets and smartphones, and developing m-Health apps². m-Health apps are part of e-Health, which has many positive aspects regarding information access, efficient and effective service delivery³. With m-Health technology, the health sector would further complement it with the e-Health system by providing users with more efficient and convenient health information service and delivery⁴. The m-Health apps complement the web-based e-Health system⁵. It also demonstrated increased in quality and care coverage, access improvement, and more effective, prompt, and timely medical information sharing. Additionally, using these apps on mobile devices allows them to

be accessed just about anywhere. Three issues prompt the need for guidelines for the m-Health app, with the theme of a clinical-based app in the study. The first issue was that usability could contribute to failure in an m-Health app if the researchers, designer, and developers do not thoroughly emphasize its importance. Plus, the involvement of usability researchers in design was, however, not widely practiced and not given in-depth emphasis, hence the need for further research in theoretical and empirical studies⁶⁻⁹. Furthermore, usability should be systematically considered in every study phase, not just at the beginning or end of phases in research^{8,10}.

The shift to focus on the clinical-based app, specifically for clinical coding and grouping features was more prominent as it has more target users, which the app can be developed for healthcare professionals and patients¹¹. Moreover, no clinical-based m-Health app has yet been developed by researchers, interface designers, developers and experts. The absence of

specific usability guidelines focusing on the clinical-based m-Health app also caused the developer to be unable to develop high-quality clinical coding and grouping app. Usability in the guidelines was also considered in developing the clinical-based m-Health app, as it is a quality feature that enables users to use the app with ease and better performance¹². An appropriate and precise interface design is essential for m-Health app to deliver health information and services efficiently and effectively while simultaneously improving the healthcare professionals' quality of patient care¹³. The m-Health app for clinical coding and grouping has the potential to be an additional support and solution to the existing clinical coding software, complement its shortcomings, and support the clinical coding professionals^{14,15}.

The ICD-10 and ICD-9-CM were classification systems published by the World Health Organisation (WHO), and were specifically used as a reference to develop the prototype app for clinical coding and grouping in the study¹⁶. The ICD-10 and ICD-9-CM classify all diagnoses, symptoms, and procedures into coded structures recorded by healthcare professionals specialising in clinical coding. These classification systems were well-known and familiar references among healthcare professionals. Figure 1 illustrates that clinical coding and grouping apps were among the least frequently used apps by healthcare professionals during clinical practice. The lowest rate of four percent was indicated as a research gap to further explore the study^{17,18}.

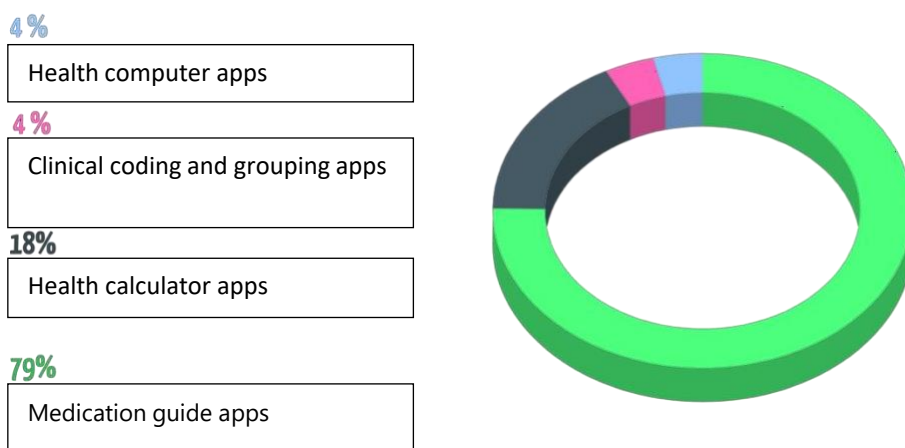


Figure 1: Apps Frequently Used By Healthcare Professionals

METHODOLOGY

Study Design and Participant Recruitment

A qualitative study was conducted among participants in user interface (UI) design and development, m-Health design, development and UI/UX. and doctors in the clinical coding field. This study has four phases, namely theoretical analyses, empirical studies, guidelines development, and usability evaluation. The study was conducted by analysing the results of the theoretical data based on literature reviews from past researchers, empirical data, and usability data. Interviews were carried out with a total of ten participants, who were separated into three categories, namely industrial practitioners, experts, and end-users. Four were industrial practitioners, including UI designer, mobile app developer, UI/UX designer, and automation tester engineer. The other four participants were categorised as experts as they had 10 or more years of experience, which consists of UI/UX expert, system domain expert, health system expert, hybrid mobile app developer. The end-users were practicing doctors and lecturers in public health and clinical coding. Table 1 below shows the participants' information regarding the field of expertise, position, and years of service.

Participants in the three categories were assigned the code 'P' for industrial practitioners, 'E' for experts, and 'U' for end-users.

A prototype was then developed based on the themes found during the thematic analysis of the theoretical and empirical phases. The guidelines development phase continued with continuous improvements implemented on the guidelines and the prototype. The final phase of this research was the evaluation of the guidelines through usability evaluation and prototype testing by four experts and two end-users. Usability evaluation and prototype testing between four experts that included the UI/UX expert, system domain expert, health system expert, hybrid mobile app developer was conducted through heuristic evaluation, whereby specific tasks on the prototype of clinical coding and grouping m-Health app were tested and given feedback side-by-side with the developed usability guidelines. As for the end-users, which were doctors and lecturers in public health and clinical coding, a cognitive walkthrough was carried out. A set of tasks and instructions were given to the two doctors to navigate and test the prototype and comment on the guidelines, and their feedback and suggestions were recorded. The usability

guidelines and the prototype were further improved and enhanced. Thematic analysis was used to analyse the theoretical, empirical, and usability data. The Nvivo software was utilised to digitally process the analysis of contents from the interviews with four industrial practitioners, heuristic evaluation and interviews with four experts, and cognitive walkthrough and

interviews with two doctors. The interviews between the participants were conducted in Malay and translated into English during the transcription process. Thematic analyses were performed by skimming through the transcripts and finding meaningful themes across the data, forming the foundation of the usability guidelines.

Table 1: Participants' Information

Code	Categories	Field of Expertise	Position	Years of Service
P1	Industrial practitioner	<ul style="list-style-type: none"> ▪ UI Designer- Mobile ▪ Usability of Mobile Application 	UI Designer	Five years
P2	Industrial practitioner	<ul style="list-style-type: none"> ▪ Android Mobile App Development 	Mobile App Developer	Four years
P3	Industrial practitioner	<ul style="list-style-type: none"> ▪ (UI/UX Design) ▪ (Usability of Web and Application Systems) 	User interface/User experience (UI/UX) (UI/UX Designer)	Four years
P4	Industrial practitioner	<ul style="list-style-type: none"> ▪ Software Testing ▪ Software Development Process 	Automation Tester Engineer	Five years
E1	Expert	<ul style="list-style-type: none"> ▪ User Interface/User Experience (UI/UX) 	UI/UX Expert	22 years
E2	Expert	<ul style="list-style-type: none"> ▪ System domain expert (clinical coding and grouping system) 	Chief Group Executive Officer	25 years
E3	Expert	<ul style="list-style-type: none"> ▪ Health system expert - Web dan mobile apps 	Senior SAP Consultant	17 years
E4	Expert	<ul style="list-style-type: none"> ▪ m-Health developer expert 	Hybrid Mobile App Developer	10 years
U1	End-user	<ul style="list-style-type: none"> ▪ Doctor (Public health and clinical coding) 	Doctor and Senior Lecturer in Public Health Medicine at University Malaya Medical Centre (UMMC) and USIM Health Centre	10 years
U2	End-user	<ul style="list-style-type: none"> ▪ Doctor (Public health and clinical coding) 	Doctor and Senior Lecturer in Public Health Medicine at University Malaya Medical Centre (UMMC) and USIM Health Centre	10 years

RESULTS

Thematic analysis

The thematic analysis of the transcriptions of the interviews and usability evaluations produced important emerging themes: legibility and readability that included the sub-theme font, icon, label and logo, buttons and visual design consisting of the sub-theme, theme and style, illustration and colour as shown in Figure 2. These

themes were a few of the important usability components in developing the guidelines that are important for mobile app developers and designers to use as guidance when developing the clinical-based m-Health app in the future. The medium-fidelity prototype for the clinical coding and grouping m-Health app was developed in the study to act as supplementary to the guidelines, as displayed in Figure 3.

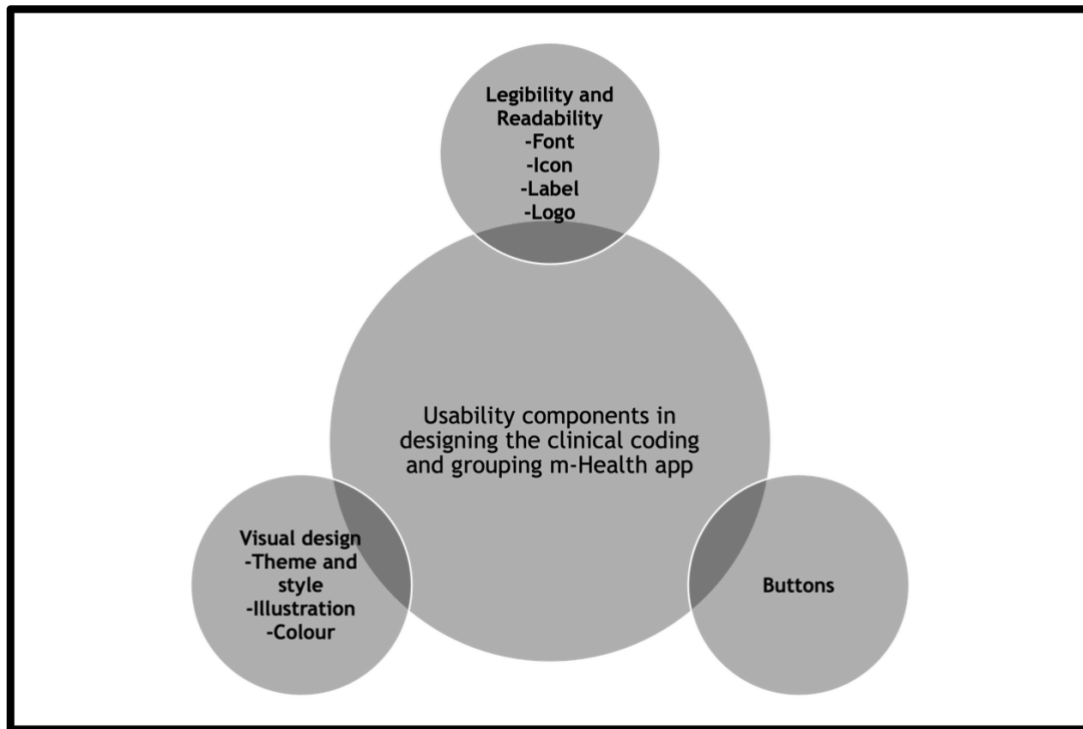


Figure 2: Themes Obtained from Thematic Analysis

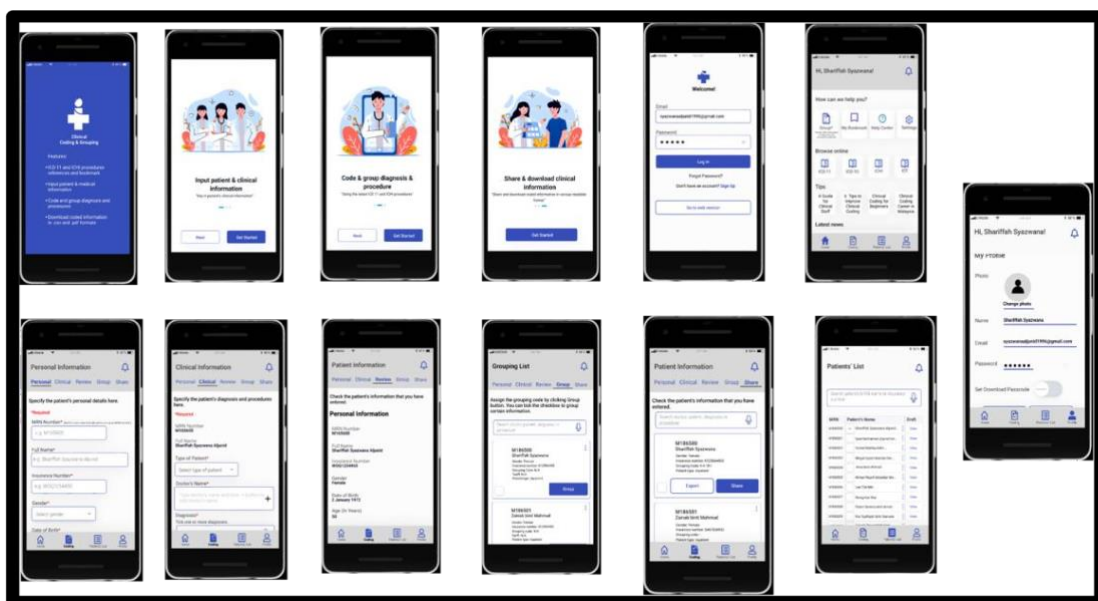


Figure 3: Prototype for The Clinical Coding and Grouping M-Health App

Legibility and Readability: Font, Icon, Label and Logo

Font

The majority of industry practitioners agreed with the type of font selected in the early stages of the prototype for the m-Health app of clinical coding and grouping, which was the Nunito font with a sans serif typeface. The sans serif typeface is a typeface that has no serif. A serif is a small decorative part perpendicular to (or angled at) the end of the stem of the letter¹⁹. Based on past studies, the sans serif typeface-type fonts were faster and easier to read than serif typefaces when shown on a digital screen²⁰⁻²². Three out of four industrial practitioners suggested the prototype to be tested with the guidelines among senior healthcare professionals aged 45 years and above so that the inclusivity feature can be tested as well.

"Yes, the types, sizes and fonts which are Nunito in the app are suitable for all ages as their size and text contrast are already large enough but need to be tested with the elderly healthcare users in the future. The type, size and color of the fonts used are also easy to read and clear." - Industry Practitioner (P1) - UI Designer

However, there was a difference of opinion between industry practitioners and experts where the experts disagreed with the type and size of the font chosen, which was the Nunito font because of its wide width, whimsical theme and the possibility of taking a large amount of space on the app. The wide font size was incompatible as the app's content had to display extensive information. The UI/UX expert and the system domain expert suggested a more robust and thinner font, which was the Roboto or Inter font that belongs to the sans serif typeface as an improvement to the previous Nunito font. The end users had suggested that the font in certain areas be increased to be easily readable.

"Inter and Roboto have a variety of font weights and are versatile and professional, compared to Nunito, which is a whimsical and playful font. So, using Roboto or Inter fonts suits the app's serious theme more than Nunito. For example, for important text, you can choose a solid or bold font; for less important information, you can choose a medium or regular font". - Expert (E1)- UI/UX Expert

Icon

Accurate, clear and easily identifiable icons that match the overall theme of this m-Health were required to maintain the overall consistency of the design. All four industry practitioners agreed with the choice of icons in this app except for the Group icon and the use of various icon families,

which needed improvement to avoid confusion. In addition, these four industry practitioners have also provided several constructive recommendations to improve the quality of font sub-components, thus improving the legibility and readability of the m-Health app. The experts all agreed with the icons and emphasized the importance of visual hierarchy, whereby the most essential information was displayed with a much bigger size and colourful icons such as the 'How can we help you?' section on the Home page, which was the main page, and other colourful icons were avoided in sections below that. The UI/UX expert and the mobile app developer industrial practitioner emphasized using consistent icon families across the app, such as solid and regular. Solid icons should be implemented when healthcare users click the icon, while regular icons are set when users do not click the icon. Other industrial practitioners and end-users had suggested the icon size in certain areas was too small and needed to be enlarged, and icons like Group and Coding required to be simplified to increase their understandability.

"The design of the icon needs to be simplified because it is a bit confusing. For example, the icon for Group is complicated but saved by the label underneath. These family icons are somewhat inconsistent and need to be standardized further." - Industry Practitioner (P2) - Mobile App Developer

Label

The label component was a complement to the icon component in the app. Industry practitioners, experts and end-users had agreed that the labels on icons were clear and much needed to improve the understanding and usability of the app. One of the industrial practitioners, the test engineer and the UI/UX expert suggested adding a line or divider to separate the 'Patient Information' and 'Clinical Information' on the app's Review page. A short description below the label 'Group' button was added to enhance the understandability of the feature as suggested by the UI/UX expert.

"Yes, with the label on the icon will increase the legibility and readability because not everyone can understand the meaning of the icon. It is a good precaution to add labels to meet the understanding of all healthcare professionals." - Expert (E3) - Health System Expert

Logo

The logo is part of the branding theme of any app. Therefore, the theme, font, and all details on the logo should be the same and suitable for the m-Health for clinical coding and grouping to maintain overall uniformity. The experts mentioned that the logo component also impacted users' first impressions because it is the

first component they encounter when they open the app. The app's logo was placed on the splash screen which was the first page of the app when the healthcare users open them.

"The logo is clear and appropriate. Please add the letter "i" to the medical cross sign to symbolize health information system."
- Expert (E2) - System Domain Expert

Buttons

All the industry practitioners agreed that the buttons used in the m-Health app were clear, readable, and had a suitable touch target area. All the buttons did not cause users trouble like the 'fat fingers' issue when clicking the buttons. The buttons of the app were divided into primary, secondary, and tertiary. The primary button, or the main button was designed to be the main colour of the app, which was blue, while the secondary button was set up to a white colour with a blue border and the tertiary button was represented as a blue text. The buttons were arranged in stacks because the design saved much more space than a horizontal arrangement.

"The size of the button in the is all okay. Please remove the 'Save' button and add the 'Group' button with the 'Save' and 'Cancel' so that users continue to store the patient's clinical information after performing the Group function" - Industry Practitioner (P4) - Automation test engineer

Visual design: Theme and style, Illustration and Colour

Theme and style

The themes and styles implemented in this m-Health app were consistent, minimal and professional across all pages. All the industrial practitioners, experts and end-users agreed that the app's themes and styles were designed to be user-friendly and neat to avoid distractions and improve the focus of the healthcare users when navigating the app.

"The theme and style of this app is consistent overall and looks neat and professional. I'm calm looking at this app. The app is *smooth*." - End User (U1) - Doctor

"I like the theme and style of this app. In my opinion, the App is user-friendly, easy to use and self-explanatory." - End User (U2) - Doctor

Illustration

The illustrations implemented in the app were in the onboarding and the pop-up messages. The usage of illustrations was balanced, appropriate and relevant so that it does not distract the users from the main content of the m-Health app. The addition of illustrations added an attractive value

and cheerfulness to the app. The use of copyrighted illustrations was also avoided in this app to steer clear of copyright infringements and issues with third-party lawsuits.

"I can see that the the illustrations in this app are available in onboarding and pop-up messages, it is beautiful and adds a cheerful element to the m-Health app." - Expert (E4) - Hybrid Mobile App Developer

Colour

The main colour used in the m-Health was blue. The colour chosen was a primary colour and the blue colour instilled a sense of trust among end-users in the study. It was also appropriate and neutral which suits all users including colour-blind and older users. Grey and white colour that was also used to complement the primary blue colour of the app. All the industrial practitioners, experts and end-users were in unison on the use of colors for this app because of its suitability for all types of users but suggested that further testing should be carried out in the future to improve the app's accessibility and inclusivity.

"The overall use of colour is in accordance with my profession as a doctor. It is professional and serious, making me trust to use this app while doing my task." - End User (U2) - Doctor

DISCUSSION

Legibility and Readability: Font, Icon, Label and Logo

Font

The m-Health app had used fonts with appropriate size, professional typeface, and a professional font type that fits the user's target audience: healthcare users, which had been emphasized by past researchers^{23,24}. The font's minimum size on this m-Health app design was 16 pixels, reaching a maximum of 24 pixels. The 16-18 pixels size was appropriate and smaller for pages or sub-pages with extensive information, such as the top tab bar navigation sub-pages, i.e., Personal, Clinical, Review, Group, Export, and Home page. The Register, Login, and Profile pages did not have as much content, so they should have bigger font sizes of at least 18-24 pixels.

Icon

Past researchers supported that the icon element needed to be well designed as it affects the motivation of users to download a certain app^{25,26}. The pixel recommendation for icon design on this m-Health app was 16 pixels. The goal was for healthcare users to use the zoom-in feature on their mobile devices without the icon becoming distorted, allowing them to understand it easily. The pixel size on all icons on the m-Health app had a width of 16.85 pixels and a length of 19.49 pixels.

Label

Labels were also required on each icon as this m-Health app had complex functionality to ease healthcare users who were new to the field and just starting to get used to the app. Therefore, a label on each icon was required to increase the legibility and readability of the app. Accurate, simple, descriptive field labels were also placed on pages with forms for healthcare users to fill.

Logo

The logo of any app was supposed to be simple, straightforward, and minimal, as agreed by past researchers and it was applied to the prototype m-Health for clinical coding and grouping²⁷. The m-health logo utilised the generic and widely recognised cross-medical logo combined with the letter 'i' to symbolize health information. The app's name was 'Clinical', followed by 'Coding & Grouping' on the next line.

Buttons

Past researchers were in tandem that the button element affects the usability and user experience of an m-Health app²⁸. Buttons in the app were appropriately sized to avoid frustration with users with larger fingers, hence having an impact on user experience if the buttons were designed poorly. Additionally, the button components should be designed effectively because users of the m-Health app frequently use the buttons to communicate with the app²⁹.

Visual design: Themes and styles, Illustration and Colour**Themes and styles**

Based on prior studies, the theme and style of an m-Health app strongly influenced the perception of acceptance of that app in either a positive or negative way³⁰. Among the details for the theme and style sub-component was to use a consistent, minimal, simple theme. The aim of a uniform and simple theme was that it can promote clarity of content and foster the engagement of healthcare users while avoiding unnecessary distractions as agreed by past researchers^{31,32}.

Illustration

The appropriate illustration was vital for the m-Health app and past researchers also mentioned that the implementation patterned backgrounds or fast-moving objects, such as animation were excluded as it did not match the app's formal and professional theme^{31,33}.

Colour

The use of a consistent colour pallet was implemented across the app's theme and it was chosen to cater to colour-blind and elderly healthcare users which was also supported by prior studies^{31,33,34}. According to past findings, using consistent colours garnered optimistic and excited feelings among users when operating the app³⁵.

CONCLUSION

The current study highlights the few usability components that made up the guidelines for designing the m-Health app for clinical coding and grouping. The prototype for the m-Health app that covered the features of clinical coding and grouping was also developed. The usability guidelines and prototype can guide researchers and developers to develop the clinical-based m-Health app in the future. It is suggested that the guidelines and prototype be tested on other m-Health apps with similar functionalities among more experts and audiences such as older and colour-blind healthcare users to strengthen the validity of the guidelines and produce a robust, inclusive and accessible app. The current prototype was also in its medium-fidelity stage and can be expanded to a high-functioning prototype and tested in a hospital setting so that the testing process can be conducted comprehensively and accurately.

ACKNOWLEDGEMENTS

The authors would like to thank the four industrial practitioners in UI design, mobile app development, UI/UX design and tester engineering. The authors would also like to thank the four experts: the UI/UX principal, an expert in UI/UX, the Chief Group Executive Officer of Universiti Malaysia Pahang (UMP), who was a system domain expert in clinical coding and grouping legacy system, the senior SAP Consultant of Malaysia that specializes in health web and mobile apps development and the hybrid mobile app developer that trained as m-Health app developer.

The authors would like to show appreciation to the two doctors and senior lecturers in Health Medicine and clinical coding at the University Malaysia Medical Centre (UMMC) and the Faculty of Health Sciences and Programmes at Universiti Sains Islam Malaysia (USIM). The mentioned industrial practitioners, experts and doctors provided substantial support in publishing this article.

REFERENCES

1. Cajas V, Urbieta M, Rossi G, Dominguez Mayo F. Challenges of Migrating Legacies Web to Mobile: A Systematic Literature Review. *IEEE Latin America Transactions* 2020; 18(5):861-873.
2. Materia FT, Faasse K, Smyth JM. Understanding and preventing health concerns about emerging mobile health technologies. *JMIR Mhealth and Uhealth* 2020; 8(5), e14375. <https://doi.org/10.2196/14375>

3. Villarreal V, Berbey-Alvarez A. Evaluation of mHealth applications related to cardiovascular diseases: A systematic review. *Acta Informatica Medica* 2020; **28**(2):130-137.
4. da Fonseca, M. H., Kovaleski, F., Picinin, C. T., Pedroso, B., & Rubbo, P. E-Health Practices and Technologies: A Systematic Review from 2014 to 2019. *Healthcare (Basel, Switzerland)*; **9**(9), 1192.
5. Kariuki EG, Okanda P. Adoption of m-health and usability challenges in m-health applications in Kenya: Case of Uzazi Poa m-health prototype application. In: 2017 IEEE AFRICON: Science, Technology and Innovation for Africa, AFRICON 2017;530-535.
6. Granić A, Ćukušić M. Usability testing and expert inspections complemented by educational evaluation: A case study of an e-learning platform. *Educational Technology and Society* 2011; **14**(2):107-23.
7. Mtebe JS, Kissaka MM. Heuristics for evaluating usability of Learning Management Systems in Africa. *IST-Africa* 2015:1-13.
8. Nakamura WT, De Oliveira EHT, Conte T. Usability and user experience evaluation of learning management systems a systematic mapping study. *ICEIS 2017 - Proceedings of the 19th International Conference on Enterprise Information Systems* 2017;**3**:97-108.
9. Zahra F, Hussain A, Mohd H. Usability factors of mobile health application for chronic diseases. In: Applied Science and Technology 2016 (ICAST'16) 2016;1761.
10. Kaipio J, Lääveri T, Hyppönen H, Vainiomäki S, Reponen J, Kushniruk A, et al. Usability problems do not heal by themselves: National survey on physicians' experiences with EHRs in Finland. *International Journal Medical Information* 2017; **97**: 266-281. <http://dx.doi.org/10.1016/j.ijmedinf.2016.10.010>
11. Fadzillah FM, Arshad NI. Evaluating the impact of non-medical m-health application: Towards development of a framework. *2016 3rd International Conference on Computer and Information Sciences, ICCOINS 2016 - Proceedings*; **14**(1): 137-142.
12. Dahri AS, Al-Athwari A, Hussain A. Usability evaluation of mobile health application from AI perspective in rural areas of Pakistan. *International Journal of Interactive Mobile Technologies* 2019; **13**(11): 213-225.
13. Bhuyan SS, Lu N, Chandak A, Kim H, Wyant D, Bhatt J, et al. Use of Mobile Health Applications for Health-Seeking Behavior Among US Adults. *Journal of Medical Systems* 2016; **40**(6), 153. <https://doi.org/10.1007/s10916-016-0492-7>
14. Campbell S, Giadresco K. Computer-assisted clinical coding: A narrative review of the literature on its benefits, limitations, implementation and impact on clinical coding professionals. *Health Information Management* 2019; **49**(1): 5-18. <https://doi.org/10.1177/1833358319851305>
15. Shephard J. Clinical coding and the quality and integrity of health data. *Health Information Management Journal* 2019; **49**(1): 3-4. <https://doi.org/10.1177/1833358319874008>
16. Centers for Disease Control and Prevention. International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) <https://www.cdc.gov/nchs/icd/icd9cm.htm> (accessed 20 August 2022).
17. Franko OI, Tirrell TF. Smartphone app use among medical providers in ACGME training programs. *Journal of Medical Systems* 2012; **36**(5): 3135-3139.
18. Ramos D, Grad R, Saroyan A, Nugus P. Seeking coherence between 'mobile learning' applications and the everyday lives of medical residents. *Perspectives on Medical Education* 2019; **8**(3): 152-159.
19. Bigelow C. Typeface features and legibility research. *Vision Research* 2019;**165**: 162-72.
20. Dogusoy B, Cicek F, Cagiltay K. How serif and sans serif typefaces influence reading on screen: An eye tracking study. In: Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) 2016; 578-586.
21. Helgerson A, Walton J, Loya C, Kawell C, Atwell K, Monaghan Q, et al. Developing an optimized UI for traffic incident managers. *Proceedings of the Human Factors and Ergonomics Society Annual*

- Meeting* 2018;**62**: 292-296.
22. Kascak L, Sanford J. Universal Design Mobile Interface Guidelines (UDMIG) for an Aging Population. In: Marston, H., Freeman, S., Musselwhite, C. (eds) *Mobile e-Health. Human-Computer Interaction Series*. Springer, Cham 2017:17-37.
 23. Humphrey G, Chu JT, Ruwhiu-Collins R, Erick-Peleti S, Dowling N, Merkouris S, et al. Adapting an Evidence-Based e-Learning Cognitive Behavioral Therapy Program Into a Mobile App for People Experiencing Gambling-Related Problems: Formative Study. *JMIR Informative Research* 2022; **6**(3) e32940. <https://doi.org/10.2196/32940>
 24. Moulaei K, Sheikhtaheri A, Ghafaripour Z, Bahaadinbeigy K. The Development and Usability Assessment of an mHealth Application to Encourage Self-Care in Pregnant Women against COVID-19. *Journal of Healthcare Engineering* 2021;**2021**(9968451). <https://doi.org/10.1155/2021/9968451>
 25. Tajudeen FP, Bahar N, Maw Pin T, Saedon NI. Mobile Technologies and Healthy Ageing: A Bibliometric Analysis on Publication Trends and Knowledge Structure of mHealth Research for Older Adults. *International Journal of Human-Computer Interaction* 2022; **38**(2):118-30. <https://doi.org/10.1080/10447318.2021.1926115>
 26. Yang J, Kanthawala S, Joo E, Kononova A. Can Brand Sponsorship Increase Download Intention for mHealth Apps? The Role of Issue Relevance, Brand Involvement, and Perceived App Quality. *Journal of Promotion Management* 2022; **28**(6):869-892. <https://doi.org/10.1080/10496491.2021.2015513>
 27. Cho H, Yen PY, Dowding D, Merrill JA, Schnall R. A multi-level usability evaluation of mobile health applications: A case study. *Journal of Biomedical Informatics* 2018; **86**(2018):79-89. <https://doi.org/10.1016/j.jbi.2018.08.012>
 28. Moeini S, Watzlaf V, Zhou L, Abernathy RevP. Development of a Weighted Well-Being Assessment Mobile App for Trauma Affected Communities: A Usability Study. *Perspectives In Health Information Management* 2022; **18**(Winter):10
 29. Alwakeel L, Lano K. Functional and Technical Aspects of Self-management mHealth Apps: Systematic App Search and Literature Review. *JMIR Human Factors* 2022; **9**(2):e29767. <https://doi.org/10.2196/29767>
 30. Matera FT, Smyth JM. Acceptability of intervention design factors in mHealth intervention research: Experimental factorial study. *JMIR Mhealth and Uhealth* 2021; **9**(7):e23303. <https://doi.org/10.2196/23303>
 31. Ahmad N, Rextin A, Kulsoom UE. Perspectives on usability guidelines for smartphone applications: An empirical investigation and systematic literature review. *Information and Software Technology* 2018;**94**:130-149. <http://dx.doi.org/10.1016/j.infsof.2017.10.005>
 32. Roy B, Call M, Abts N. Development of Usability Guidelines for Mobile Health Applications. In: *HCI International 2019-Communications in Computer and Information Science* 2019;500-506.
 33. Development And Evaluation Of Culture-Based Mhealth User Interface Guidelines For Elderly Arab Users. <http://eprints.usm.my/48664/1/AH%20MED%20HOUSNI%20AHMED%20AL%20SSWEY%2024.pdf> (accessed 28 August 2023)
 34. Farao J, Bessie M, Nailah C, Mutsvangwa T, Rangaka MX, Douglas TS. A user-centered design framework for mHealth. *PLOS ONE*; **15**(8);1-18. <http://dx.doi.org/10.1371/journal.pone.0237910>
 35. Kascak L, Harrington C, Sanford J. Universal Design Mobile Interface Guidelines for Mobile Health and Wellness Apps for an Aging Population Including People Aging with Disabilities. *International Journal on Advances in Software* 2018; **10**:372-3