ORIGINAL ARTICLE

Usability Testing of a Database Management System for Nutritional Care Delivery

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ABSTRACT

Introduction: Effective healthcare systems must integrate smoothly with clinical workflow by minimizing unnecessary steps and ensuring quick access to patient data. Poor integration can create difficulties for healthcare professionals, affecting their long-term use. Therefore, a well-designed system must prioritize usability and workflow integration to support high-quality care. As such, this paper evaluates the usability of a database management system for nutritional care in a diet clinic. **Methodology:** The evaluation involved four steps: (1) filling out a demographic form, (2) performing task-oriented scenarios using the think-aloud method to assess effectiveness and efficiency, (3) completing a survey using the System Usability Scale (SUS) to measure satisfaction, and (4) participating in an interview to provide suggestions for improvement. **Results:** The DietCARE system demonstrated an efficiency rate of 80.48%, with 100% effectiveness. Although all assigned tasks were completed, some had minor challenges, with Task 3 being the most difficult, as 80% of respondents struggled with scheduling appointments. The SUS score had a median (IQR) of 77.50 (76.25–91.25), indicating good user satisfaction. Four themes related to suggestions for improvement were identified: improving data interpretation, enhancing flexibility in data entry, tracking and monitoring patient progress, and expanding data scope for comprehensive patient profiling. **Conclusion:** Overall, the DietCARE system demonstrated good efficiency, effectiveness, and user satisfaction. While some improvements are needed based on user feedback, incorporating their suggestions could enhance the system's usability, efficiency, and overall user experience. Addressing these usability issues will help create a more user-friendly system that meets the needs of its users.
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INTRODUCTION

Healthcare systems should be designed with the provider-focused approach as it plays a crucial role in ensuring they can focus on patient care rather than navigating complex interfaces. Effective healthcare systems must integrate smoothly with existing clinical workflow by minimizing unnecessary steps in processes, allowing quick access to patient data, and having the information readily available when needed (1,2). Without this integration, healthcare providers will resist the adoption and implementation of the technology (2,3). Besides, it is important to design interfaces that are easy to navigate, regardless of the user's technical proficiency (4). As technology continues to evolve, new challenges emerge, affecting not only the accuracy of healthcare systems but also the way users interact with them. While it is crucial to involve users in the design and implementation of any electronic system, it is equally important to ensure the system is well-designed and caters to the diverse needs of the users to optimize workflow efficiency and improve patient care. One effective method to achieve this is usability testing.

Usability testing, commonly known as user testing, is a method used to identify problems within a product by asking the user to perform specific tasks related to the product while the researcher observes and listens to their feedback (5). It is recommended to combine both usability testing and heuristic evaluation to identify a wider range of usability issues, particularly for health information systems, as each method can identify different usability issues (6). Usability testing is capable of finding more severe usability problems and has been proven as an effective and efficient method for finding usability problems in a system (7). A previous study demonstrated that clinician testing of an electronic health record proved to be significantly more useful and user-friendly for clinicians (8).

Healthcare professionals often face challenges when using digital healthcare systems that are not well integrated into their workflows, which may affect the sustainability of these systems (9). Many existing systems are overly complex and require excessive navigation, which can divert their attention from patient care (10,11). Healthcare technology with poor usability is one of the main contributors to stress and burnout among healthcare providers (12,13). Moreover, poorly designed systems that do not fit with the existing workflows can frustrate the users, decrease the efficiency of the healthcare providers, disrupt access to information, and subsequently lead to potential medical errors (14,15). Without a healthcare provider-focused approach, the digital healthcare system may become a burden rather than a tool that enhances decision-making and patient management. Therefore, it is crucial to develop a healthcare system that prioritizes usability, workflow integration, and accessibility to support health practitioners in delivering high-quality care.

Given these challenges, assessing the usability of digital healthcare systems is essential to ensure they effectively support healthcare professionals rather than hinder their workflows. Usability testing provides valuable insights into system design, helping to identify areas for improvement and enhancing user experience. As such, this paper aims to evaluate the usability of a database management system for nutritional care delivery at a diet clinic.

METHODS

Usability testing was conducted to evaluate the usability of a nutritional care database management system called DietCARE. This is the second part of evaluation and testing for DietCARE, following the earlier heuristic evaluation, which identified the usability issues based on the expert's evaluation. Three usability features were measured during usability testing: effectiveness, efficiency, and satisfaction. Additionally, interviews were conducted to gather suggestions and recommendations for enhancing the system. Ethical approval was obtained from the UMT Human Research Ethics Committee before conducting the research (UMT/JKEPM/2021/62).

System Description

The system that was evaluated in this study was a nutritional care database management system known as DietCARE. It was designed and developed following a comprehensive needs analysis conducted by the researcher to identify the system's specific requirements (16). It is a web-based system tailored specifically for the nutritional care delivery for the Diet Clinic of Universiti Malaysia Terengganu (UMT). DietCARE incorporates the Nutrition Care Process and Model (NCPM), focusing on non-communicable diseases (NCDs) such as overweight/obesity, diabetes mellitus, hypertension, hypotension, and hypercholesterolemia (16). It consists of two main modules: the Patient Management Module and the Dietitian Module, each designed to handle specific tasks assigned to staff nurses and dietitians, respectively. At the time of the study, the system was still in the prototype stage and had not yet been implemented at the Diet Clinic.

Respondents

A total of five respondents participated in the usability testing of the system. This sample size was selected as it represented the entire population of the system's intended end-users, with all relevant staff members expected to use the system included in the study. Given that the study was conducted at Technology Readiness Level 4 (lab testing), the aim was to evaluate the usability of the DIETCARE prototype and identify core usability issues to guide further system refinement. Moreover, a sample of five participants aligns with established usability testing guidelines, which suggest that this number is generally sufficient to identify the majority of common usability problems (5). All respondents were staff members of the Diet Clinic at Universiti Malaysia Terengganu (UMT) and were considered end-users of the system. Two were dietitians, while the remaining three included staff nurses and a physiologist. They were contacted by phone, and appointments were scheduled accordingly.

Procedures

Each usability testing session involved one respondent and one researcher/investigator. Informed consent was obtained from all respondents before the study. They were informed that the purpose of the test was to evaluate the system, not to assess their skills in using it. respondents completed four steps during the testing process: 1) filling out a demographic form, 2) performing task-oriented scenarios using the think-aloud method to assess system effectiveness and efficiency, 3) completing a survey to evaluate satisfaction, and 4) participating in an interview to provide suggestions or recommendations for improving the system.

The effectiveness and efficiency of the system were evaluated using the think-aloud method by completing five tasks that were given to the respondent (Table 1). Each task evaluates different sections of the system. They were also provided with a user manual to guide them in navigating the system. During the think-aloud method, they were instructed to use the system and complete all the tasks given using hypothetical data. As they navigated the system, a screen recording software, ScreenRec version 3.37, was used to record both video and audio of their interactions with the system. This approach allowed the researcher to record the respondents' on-screen interactions with the system while they simultaneously expressed their immediate thoughts and comments about the system's interface and functionality. Respondents were encouraged to express their thoughts verbally, such as what bothered them and the difficulties they faced while completing each task. If respondents were unable to proceed to the next step, it was considered a failure to complete the task.

Table I: Task for usability testing

Task	Instructions
Task 1	Log in to the system as staff and register a new patient by filling in their socio-demographic data
Task 2	Complete the patient's profile including history, anthropometric, biochemical, and clinical data
Task 3	Schedule an appointment and log out of the system
Task 4	Log in to the system as a dietitian and fill in the nutrition assessment
Task 5	Complete the nutrition diagnosis, nutrition intervention, and nutrition monitoring & evaluation data, then log out of the system.

Upon completing the think-aloud method, respondents' satisfaction with the system was assessed using the System Usability Scale (SUS) (17). The SUS is widely recognized as one of the most frequently used questionnaires for evaluating the usability of healthcare systems (18,19). It has previously been evaluated for its validity, reliability, and sensitivity (17,20,21). It consists of 10 questions, each rated using a 5-point Likert scale. The scale ranges from "strongly disagree" to "strongly agree", and the score ranges from 0 to 4 (17). The respondents completed the questionnaire, which was collected immediately after they finished.

Finally, the respondents took part in an interview conducted using semi-structured interview guidelines adapted from a previous study by Walsh et al., 2022, specifically incorporating questions related to suggestions for systems improvement (22). Only questions relevant to this aspect were selected and modified to align with the objectives of this study. The interview session was recorded using an audio recorder.

ANALYSIS

Descriptive statistics such as frequency (n), percentage (%), median, and interquartile range (IQR) were calculated using IBM SPSS Statistics version 26. The analysis for effectiveness, efficiency, and satisfaction were described as below.

Effectiveness

The International Organization for Standardization (ISO) defines effectiveness as the accuracy and completeness with which users achieve specified goals (23). Effectiveness was calculated using the following equation (24):

$$effectiveness = \frac{(number\ of\ tasks\ completed\ successfully)}{(total\ number\ of\ tasks\ performed)} \times 100$$

An effectiveness range of 0–50% will be considered awful, 50–75% as bad, 75–90% as normal, and 90–100% as good. Meanwhile, task completion was coded into three categories: 1) completed with ease, when the respondents completed the task without any difficulties; 2) completed with difficulty, when the respondent was able to complete the task, but with difficulties or with some hints from the researcher, and 3) failed to complete when the respondents unable to complete the task.

Efficiency

Efficiency is the mean or average time taken by the respondents to complete each task, calculated using the following equation (24):

$$Efficiency = \frac{\left(\ (total\ of\ full\ completion\ (1)\ OR\ non-completion\ (0)\ \right)}{time\ spent\ on\ task} \Big/ (total\ number\ of\ tasks \times number\ of\ respondent) \times 100$$

Efficiency is calculated by dividing the total number of completed or non-completed tasks (represented as 1 and 0, respectively) by the time spent on the task. The result is then divided by the multiplication of the total number of tasks and the total number of respondents and finally multiplied by 100 to express it as a percentage.

Satisfaction

The score for the SUS questionnaire will be calculated based on Brooke's scoring guideline (17). For items number 1, 3, 5, 7, and 9, the score would be positive scoring with a 0 score for "strongly disagree" and a 4 score for "strongly agree". Meanwhile, reverse scoring was applied for items number 2, 4, 6, 8, and 10 with a 0 score for "strongly agree" and a 4 score for "strongly disagree". Lastly, the total score was multiplied by 2.5 to obtain the overall SUS score (17). The score can range from 0 to 100. A mean score of less than 50 is considered poor satisfaction (significant usability issues), scores above 70 are considered as acceptable or good (usability meets usability needs and generally satisfies the user), while scores above 85 are considered as excellent (high user satisfaction with minimal changes) (21,25,26).

Interview

Meanwhile, the interview recordings were transcribed verbatim, with Malay transcripts translated into English. The qualitative data from interviews was then analysed using the qualitative package ATLAS.ti (version 9.1.3.0) through thematic analysis, which involved open coding to systematically analyse, compare, and categorize the data. This approach focused on identifying themes from the content rather than merely counting frequently occurring words or phrases.

RESULTS

Respondent's characteristics

The five respondents are the users of the system; all of them are females with ages ranging from 25 to 51 years old. In terms of occupation, an equal distribution was observed between dietitians and staff nurses, each comprising 40% (n=2) of the respondents. The remaining 20% (n=1) was a physiotherapist. At the Diet Clinic, nurses are responsible for patient registration, blood sampling, anthropometric measurements, appointments, and maintaining record files. Meanwhile, dietitians are responsible for delivering personalized nutrition counselling and providing interventions. Lastly, the physiologist is responsible for assessing physiological health and planning exercise routines for patients

Table II: Characteristics of the respondents (n=5).

Respondents' ID	Gender	Age (Years)	Occupation	Job Description
R1	Female	25	Physiologist	Assessing physiological health and planning exercise routines
R2	Female	37	Nurse	Registration, blood sampling, measuring anthropometric, managing appointments and record-keeping.
R3	Female	31	Nurse	
R4	Female	51	Dietitian	Delivering personalized nutrition counselling and providing interventions
R5	Female	38	Dietitian	

Effectiveness

The task effectiveness results are presented in Figure 1. Out of 25 tasks performed by the five respondents (five tasks per respondent), all 25 (100%) were completed. Since all respondents completed every task, the overall effectiveness of the system was 100%, which is considered good. Task 3 (scheduling an appointment and logging out of the system) was the most difficult to complete, with 80% of users experiencing difficulties in completing the task related to scheduling an appointment. The respondents also had trouble completing Task 4 (logging in as a dietitian and filling in the nutrition assessment) and Task 5 (completing nutrition diagnosis, nutrition intervention, and nutrition monitoring & evaluation data, then logging out of the system) with 60% and 40% of them completing the tasks with difficulties, respectively. Meanwhile, Task 1 (logging into the system as staff and registering a new patient) and Task 2 (completing the patient's profile, including history, anthropometric, biochemical, and clinical data) were completed with ease by all.

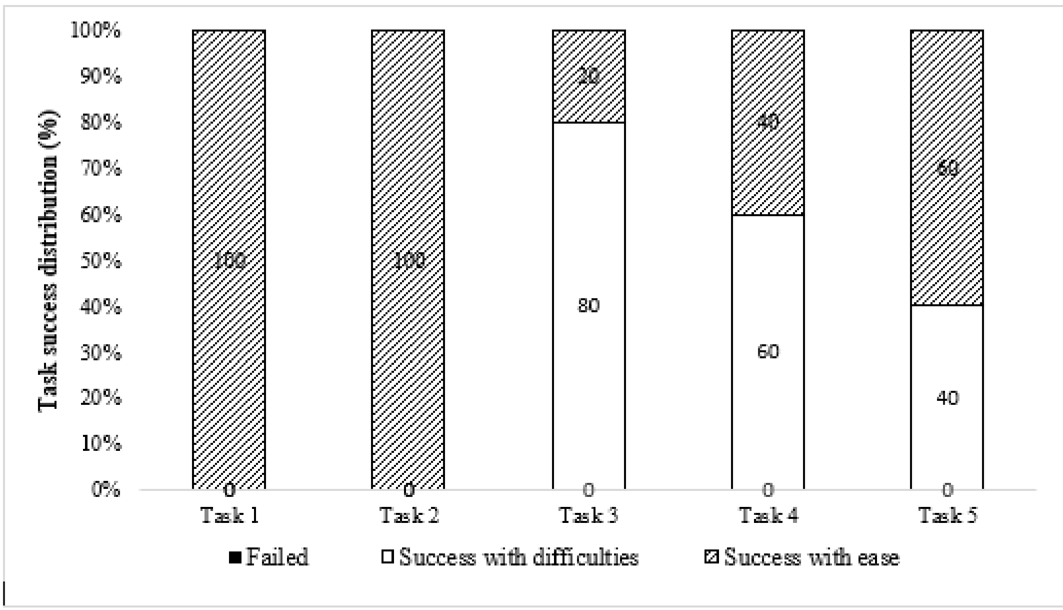

Figure 1: Task success distribution

Efficiency

The mean overall time for all tasks was 20.12 (3.73) minutes. As shown in Table 3, Task 2 and Task 4 took the longest completion time compared to the other tasks, as might be expected given that these two tasks involved the most steps and required users to enter the most variables. Specifically, users had to input most of the information in these tasks, making the process more time-consuming than the others. According to the equation, the overall efficiency of the DietCARE system was 80.48%.

Table III: Mean time to perform each task.

Task		Task 1	Task 2	Task 3	Task 4	Task 5
Time per task (minutes)	Mean (SD)	2.68 (0.49)	5.54 (1.05)	1.63 (0.35)	5.65 (0.76)	4.62 (2.86)
	Range	2.27 - 3.50	4.62 - 7.23	1.20 - 1.98	4.35 - 6.30	2.23 - 9.42

Table 4 shows usability issues expressed by the users along with their related tasks. Initially, a total of 34 issues were identified in this evaluation, however, only 10 remain after eliminating duplicates by grouping similar concerns reported by different users. All the users expressed that the system lacks visual indicators for clickable items, that scheduling an appointment is complicated and not user-friendly, and that choosing more than two options required using the "Ctrl" key instead of simply clicking on the options. Meanwhile, three users complained that the system does not provide any warning if the data is incomplete for all tasks. Although the system appears to save the information, no data is saved upon checking, requiring the users to re-enter everything from the beginning.

Table IV: The issues identified by the users in the usability testing.

No.	Problems	Number of users addressing the issue	Task number
1	There are no clear warnings if the data are not complete	3	All tasks
2	The system lacks a clear visual indicator, making it difficult to recognize which features or items are clickable	5	1,2,4,5
3	The appointment schedule is complicated and not user-friendly.	5	3
4	Appointments are only available in fixed time slots	4	3
5	Choosing more than two options is required using the "Ctrl" key with no clear instructions.	5	4,5
6	The system requires the user to fill in all information, even when the data does not apply to the patient, without the option to indicate that the data does not apply	3	1,2,4,5
7	The system does not automatically calculate certain variables, requiring users to enter data manually	2	2,4
8	No blank space to add additional information related to the patient	3	4,5
9	The available options for certain variables are primarily focused on weight management and NCDs, with no selectable option for other cases if mentioned	2	4,5
10	Options for time at the dietary evaluation are not flexible	2	4

Satisfaction

The median (IQR) score for SUS was 77.50 (76.25–91.25), showing that the satisfaction with the DietCARE systems was good, as seen in Table 5. Based on their responses, all the respondents strongly agree that they would like to use the system frequently (Q1) and that most people would learn to use the system very quickly (Q7).

Table V: System Usability Scale (SUS) data

No	Question (Q)	n (%)					Median (IQR)
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
1	I think that I would like to use this system frequently	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (100.0)	4.00 (4.00–4.00)
2	I found the system unnecessarily complex	3 (60.0)	1 (20.0)	1 (20.0)	0 (0.0)	0 (0.0)	4.00 (2.50–4.00)
3	I thought the system was easy to use	0 (0.0)	0 (0.0)	1 (20.0)	1 (20.0)	3 (60.0)	4.00 (2.50–4.00)
4	I think that I would need the support of a technical person to be able to use this system	1 (20.0)	2 (40.0)	1 (20.0)	0 (0.0)	1 (20.0)	3.00 (1.00–3.50)
5	I found the various functions in this system were well-integrated	0 (0.0)	0 (0.0)	1 (20.0)	1 (20.0)	3 (60.0)	4.00 (2.50–4.00)
6	I thought there was too much inconsistency in this system	3 (60.0)	2 (40.0)	0 (0.0)	0 (0.0)	0 (0.0)	4.00 (3.00–4.00)
7	I would imagine that most people would learn to use this system very quickly	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (100.0)	4.00 (4.00–4.00)
8	I found the system very cumbersome to use	3 (60.0)	0 (0.0)	1 (20.0)	0 (0.0)	1 (20.0)	4.00 (1.00–4.00)
9	I felt very confident using the system	0 (0.0)	0 (0.0)	1 (20.0)	1 (20.0)	3 (60.0)	4.00 (2.50–4.00)
10	I needed to learn a lot of things before I could get going with this system	3 (60.0)	0 (0.0)	0 (0.0)	1 (20.0)	1 (20.0)	4.00 (0.50–4.00)
	TOTAL SCORE						77.50 (76.25–91.25)

*Scores: <50=poor; >70=acceptable or good; >85=excellent

Interview

Based on interviews, a total of four themes for improving the DietCARE system have been identified (Table 6). First, improving data interpretation by incorporating reference ranges for anthropometric and biochemical data, displaying staff and patient names on their home page for better identification and references, as well as adding auto-calculate feature for some variables such as ideal body weight and total/HDL ratio based on the information provided by the user to reduce the need for manual input and improve efficiency. Second, enhancing flexibility in data entry by adding blank spaces and a "not applicable" option for variables that do not apply to certain patients. Third, tracking and monitoring patient progress through visual presentation of the patient's progress over time, and incorporating patients' statistics into the dashboard. Lastly, expanding data scope for comprehensive patient profiling by including additional variables, such as CAM, type, and intensity of exercise.

Table VI: Themes for suggestions to improve the system (interview)

Themes	Quotes
Improving data interpretation	"It would be helpful to include reference ranges for normal, under, or over levels for anthropometric and biochemical data" (R3)
	"If a user logs in but their identity is unknown, therefore, the system should display who is logged in. The same applies to patients, their names should be displayed for better identification and reference" (R5)
	"Total/HDL cholesterol should be auto-calculated based on the information provided by the user" (R4)
	"Ideal body weight should be auto-calculated" (R1)
Enhancing flexibility in data entry	"It is necessary to add a blank space in the nutrition intervention and monitoring to allow for cases beyond weight management and NCDs" (R4)
	"There is no additional space to write about specific details regarding the patients, I would appreciate if there is a blank space to include additional information related to the patient (R4)
	"It would be helpful to include a "not applicable" option for variables that may not be relevant to certain patients, especially for patients who visit the clinic for the first time" (R4)
Tracking and monitoring patient progress	"Include a feature on the dashboard to provide a visual representation of the trend or progress of the patient's data over time" (R5)
	"To know how many patients visit the clinic per months or per year, I suggest to incorporate patient statistics into the dashboard by linking them with the available data" (R5)
Expanding data scope for comprehensive patient profiling	"Consider adding additional variables, such as complementary alternative medicine (CAM), type of exercise, and intensity of exercise, to enhance the comprehensiveness of the data" (R4)

*Respondents ID: R1=physiologist; R2-R3= nurses; R4-R5= dietitians

DISCUSSION

The advantage of involving users in testing the usability of an electronic healthcare system is that it allows the system to be tailored to the specific needs of the field and ensures that the systems align with their workflows and preferences (27). For example, the clinical workflow of Diet Clinic is unique to this healthcare setting. This approach ensures that the DietCARE system aligns with the specific needs of different job roles, making navigation easier and more efficient. The involvement of nurses, dietitians, and physiotherapists in this testing brings diverse perspectives to patient care, with nurses specializing in managing workflows, dietitians in nutrition guidelines, and physiotherapists focused on the physical aspects of health (28,29). Besides, usability testing or user testing led to significant improvements in usability outcomes, including task completion time and error rates, highlighting the effectiveness of user testing in enhancing electronic healthcare systems (27). Consequently, the present study was conducted with the participation of potential users using actual clinical scenarios to ensure an accurate evaluation of the system's usability and functionality.

Although the system had 100% effectiveness, it does not necessarily mean that the system is perfect. It simply indicates that, within the context of the tasks and with the respondents involved, the system enabled all the tasks to be completed successfully. The majority of the respondents struggled to complete Task 3, reporting that the feature was not user-friendly and that they had trouble selecting the dietitian and appointment time after choosing the date because the options were not easily accessible or were unclear, leading to confusion and delays in completing the task. The usability issues arises when the users choose the appointment date, but subsequent options to choose dietitian name and time slot did not appear immediately. Instead, users must click at any part of the screen for these options to appear. The system failed to provide immediate feedback confirming that the date had been selected, which violated the user interface heuristic of "visibility of system status" (30). Although Task 3 is relatively simple and involves fewer steps than the other tasks, it is evident that the feature related to appointment scheduling needs to be redesigned or modified. The current design makes it hard for respondents to navigate and complete the task efficiently. To address this issue, all scheduling details, including the appointment date, dietitian name, and time slot, should be presented simultaneously using dropdown menus. Each menu should be clearly labelled, such as "select a dietitian" or "choose a time slot" to help users navigate the system more easily. This layout design enables users to view and select all the scheduling options on a single screen. Since the options are not dependent on one another, this approach streamlines the scheduling process while maintaining the simplicity of the system.

Meanwhile, during Task 4, 60% of them struggled with the dietary evaluation section of the nutrition assessment.

They were required to enter all food and beverages consumed for each meal (breakfast, snacks, lunch, and dinner), along with the corresponding calorie intake. This was challenging because even if the patient had skipped a meal or did not eat at a particular time, the system still required them to provide information about that meal. If they failed to provide any of the required information, the data could not be saved, leading to confusion, frustration, and delays in completing the task. Considering the current trend of artificial intelligence (AI) applications, integrating AI technology to allow users to take pictures of their meals for automatic calorie estimation, rather than manually entering each food item, would be advantageous. Implementing this feature is the next planned upgrade, depending on further budget approval. Of note, they also expressed their frustration because the system provided no warning about the missing information, and upon checking, the data was lost, forcing them to repeat the steps.

During Task 5, they struggled with selecting multiple options in the nutrition monitoring & evaluation section. They were required to hold down the "Ctrl" key to choose multiple options, which they found difficult and not very user-friendly. This step, which relies on the use of the "Ctrl" key as keyboard modifiers, was perceived as impractical and added unnecessary complexity to the system. The need for extra keystrokes during nutrition counseling can distract the dietitian from engaging with the patients, as it shifts their focus toward the computer screen (31). Replacing this selection method with a checkbox selection that allows multiple options to be chosen would simplify the process and reduce the cognitive burden on users. Besides, the section also should be labelled with instructions such as "select all that apply" to guide users accordingly.

Another usability issue discovered through the evaluation is that the system lacks a clear visual indicator, which makes it difficult for users to distinguish interactive or clickable elements, such as buttons or menu items, from non-clickable elements. As such, the system had violated basic user interface heuristics, specifically "visibility of system status" and "recognition rather than recall" (30). Without clear visual indicators such as colour changes or distinct button styling, users were more likely to overlook actionable buttons, resulting in longer search times and difficulties navigating the interface efficiently. This can lead to frustration, increased task completion time, and potential errors, as users might not immediately recognize where to click or how to proceed. Improving the system's visual indicators and ensuring that all clickable elements are easily identifiable would improve usability and create a more user-friendly experience.

The overall satisfaction indicated good usability of the system. However, 20% (n=1) of the respondents found the system to be quite cumbersome. This issue may be related to Task 3 (scheduling appointments), which required users to repeat the steps multiple times before completing the task. This led to frustration, contributing to their perception of the system as difficult to use. Addressing the inefficiencies in this task could help reduce users' frustration and improve the overall experience. Similarly, 20% of the respondents also felt that they needed to learn a lot of things before they could get started with the system. This might be because they were new users who had never used the system before. A previous study had demonstrated that users with more experience with a product tend to give higher SUS scores than those with little or no experience, with scores increasing by 15-16% as experience levels rise (32). This suggests that the frequent use of a product improves users' satisfaction and perceptions of its usability.

In regards to suggestions for improving the system, four themes emerge from the interviews, including improving data interpretation, enhancing flexibility in data entry, tracking and monitoring patient progress, and expanding data scope for comprehensive patient profiling. One of the suggestions for improving data interpretation is the inclusion of reference ranges, which are essential for accurately interpreting data. Automated warning systems integrated into the system can further improve data interpretation by flagging values outside the normal range (33). Moreover, automatic calculations for variables such as ideal body weight or total/HDL cholesterol ratio can significantly reduce manual errors. Previous studies had demonstrated that automated calculations reduced manual efforts required by healthcare professionals, improved accuracy and consistency of the data, and minimized potential errors associated with manual entry and calculation (34,35). Besides, digital health systems can leverage the efficiency and comprehensiveness of automated data extraction to lay a strong foundation for incorporating more automated calculations into digital health, ultimately promoting more effective and efficient healthcare delivery (36) .

Meanwhile, enhancing flexibility in data entry for digital health systems is crucial for improving the efficiency and effectiveness of healthcare services. By incorporating features such as blank space or "not applicable" options, healthcare professionals can tailor the data entry process to their specific needs and clinical requirements, ensuring only relevant information is collected and subsequently minimizing errors. This flexibility is particularly important in diverse healthcare settings where patient conditions, medical requirements, and data availability can vary significantly. Adding this feature ensures that healthcare professionals can document patient information more accurately and efficiently. Customizable interfaces further support this adaptability by allowing users to tailor data entry fields based on their workflow requirements, improving data management and decision-making in healthcare settings (37,38).

This study, however, has several limitations. First, the small sample size may limit the generalizability of the findings to broader user populations. While the sample represented the entire population of intended end-users within the clinical setting and was appropriate for early-phase usability testing, future evaluations with a larger and more diverse group are needed to validate the system's usability across different user types and settings.

Second, the usability evaluation was conducted among respondents who had no prior experience using the system. Although they were provided with a user manual, written instructions are not equivalent to practical experience. As a result, their feedback may have been influenced by a lack of familiarity rather than the system's actual usability. If the respondents had the opportunity for in-depth use of the system beforehand, their perception of its usability might have improved. Additionally, difficulties related to the navigation of the system could have been minimized or avoided.

Despite this limitation, this study provided valuable insights into the system's learnability and first-time user experience. The use of the think-aloud protocol helped mitigate or lessen its impact by distinguishing whether user confusion is due to user interface design flaws or due to the inexperience with the system. Therefore, it is strongly recommended that a follow-up usability testing session be conducted after the system has been implemented at the clinic and the end-users have gained significant experience and become familiar with it. Conducting usability testing at this later stage will provide more accurate feedback, as the users will have interacted with the system in the actual clinical workflow. This is because continuous usability assessment is necessary to improve the system's usability, user satisfaction, and overall effectiveness (39).

To the best of our knowledge, this is the first study to use usability testing to assess the effectiveness, efficiency, and satisfaction of a nutritional care database management system in Malaysia by using validated measures. The authors hope that this study will serve as a milestone in the development of the nutritional care database management system in Malaysia and guide future research and development efforts in this field.

CONCLUSION

Overall, the DietCARE system demonstrated an efficiency rate of 80.48%, indicating that the users were able to complete tasks with minimal time and effort. It achieved 100% effectiveness, meaning all assigned tasks were completed, though some of them encountered minor challenges while performing the tasks. Additionally, the system received a 77.50% satisfaction score, reflecting users' overall positive experience. Although the system needs some improvements based on user feedback, incorporating their suggestions could improve its usability, efficiency, and overall user experience. Addressing these usability issues will help create a more user-friendly system that meets the needs of its users.

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