Smartphone Application for Self-monitoring Dietary Intake (iDSA) among Cancer Patients

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Abstract

Objective: Evidence accumulates that optimal nutrition status positively influences cancer treatment outcomes. A "smartphone application" (intelligent dietitian support apps [iDSA]) was developed to act as a tool to assist patients in terms of dietary monitoring. This study aimed to examine the feasibility of iDSA for self-monitoring dietary intake among cancer patients. **Materials and Methods:** This was a pilot study. Eligible patients were approached and recruited. Dietitian entered individual estimated energy-protein requirement into iDSA after installation. Participants recorded and monitored own daily dietary intake. Dietitian arranged for a 2-week follow-up to monitor nutritional status (weight and dietary intake). **Results**: This study enrolled 14 participants, six males and eight females, with a mean age of 36.4 ± 10.1 years. iDSA improved participants' nutritional outcomes significantly; weight gained 1.2 ± 0.2 kg, increased energy intake 215 ± 100 kcal/day, and protein intake 8 ± 5.1 g/day. There were 92.9% of participants agreed or totally agreed that they were able to monitor and increase dietary intake during using iDSA. However, about 57.1% reported that it was burdensome to record their diet daily and sometimes they forgot to record their food intake. **Conclusion:** Self-monitoring dietary intake through iDSA was feasible among cancer patients. The compliance of iDSA in self-monitoring dietary intake increased the dietary intake and body weight after 2-week. iDSA usability was rated good and can be used to study dietary intake among cancer patients.

Keywords: smartphone application, intelligent dietitian support apps, self-monitoring dietary intake, cancer

Introduction

Cancer cells alter energy metabolism which increases resting energy expenditure and increases the metabolism of sugar, protein, and lipid. Cancer patients are at high risk of being malnourished even before starting on any treatment.[1] Nutrition requirement for the cancer patient is higher if compared with the normal requirement to optimize nutritional status and promote recovery.[2] Dietitians' consultation for cancer patients has long been implemented in most of the hospital. The effectiveness of different dietary assessment methods was studied and Table 1 shows the advantages and disadvantages of different dietary assessment methods.[3]

However, these conventional methods aim to trace patients' dietary patterns. It is difficult for patients to monitor and assess their dietary intake. One of the main problems with nutritional assessment is recalling food intake over a certain period time. It is unlikely that a person would be able to precisely recall how much of a certain food s/he has consumed during the past week, month, or year.[4] A study on food intake measurement in scientists found that "very few subjects were able to accurately remember the types and amounts of food they had

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Table 1: Dietary assessment methods

Type of assessment	Measure	Advantage	Disadvantage
Food frequency questionnaire	Frequency and size of food intake	Easy and cheap to manage Particularly useful in the epidemiological study	Average frequency and size of food intake during a long period time Recalling errors and other measurement errors Difficult to use in the clinical setting (cognitive effort required)
Diet history	Frequency of food intake and food preparation	Meal pattern and food intake are investigated extensively	Representativeness bias (subjects often recall and report habits more than actual behavior)
Healthy eating index	Measure the nutrient adequacy of the diet	Highly contextualized Standardized scores	Overall diet information Qualitative data
Food diaries	Quantities of food consumed per day	Providing quantitative information about food consumed during a sensible period	Motivation biases Reactivity effects
24 h diet recall	Food intake last 24 h	Low reactivity effect	Subjects may not report their food intake accurately
Short dietary assessment method	Evaluating a specific range of food intake	Contribute to help individuals to change diet habits	Failed to detect information on all food intake

consumed in the previous 24 h."[5] In other words, the patients will record their diet intake but they have limited knowledge to interpret the data and assess their diet correctness. As such, they cannot make the necessary corrective diet changes as required. Furthermore, cancer patients and their family members tend to listen to the "advice" for their diet from different inappropriate sources such as direct selling agents of food products. The patients might end up with malnutrition as a result of the misleading "advice." Besides, each patient has their specific diet intake that is calculated based on professional knowledge by a dietitian. The patients should not blindly follow the general information available in different sources such as websites and mobile apps.

For most medical conditions, correct diagnosis and effective medical treatment are essential to a patient's survival and quality of life. A significant barrier to effective medical treatment, however, is the patient's failure to follow the recommendations of his or her physician or other health-care providers. Non-adherence to medical advice might due to misunderstanding, forgotten, or even ignored on the advice given to patients by their health-care professionals to cure or control disease.[6] Furthermore, most of the time, patients were having difficulty in estimating their nutrient intake in the diet. It is almost impractical for the caretaker of cancer patients to calculate the nutrient intake for each meal for the patient. There is a lack of an effective approach to improving dietary adherence among cancer patients.

Smartphones have been widely used by almost everyone in this new world. There are many mobile apps in health-care available. There are many healthcare-related studies in terms of mobile apps available; comparison of traditional versus mobile app self-monitoring dietary in weight loss program,[7] self-monitoring of calcium intake in young women,[8] and self-monitoring of early stages of adolescent depression.[9] However, the studies on the effectiveness of using mobile apps in the aspect of dietary monitoring for cancer patients remain limited.

Smartphone application becomes trendy nowadays. According to Google consumer Barometer (2017), the ubiquitous use of smartphone is 81% in Malaysia. Advantageous features in the mobile application were shown in a promising result in other chronic conditions.[10] Theory-based health apps increased the likelihood or long-term dietary

change in behavior.[11] With self-monitoring on own nutrient intake, cancer patients can adjust food intake as per requirement according to the dietitian recommendation to optimize energy and protein intake and reduce the risk of having malnutrition. The use of mobile apps is a relatively new method in providing a method for cancer patients to self-monitor their nutrient intake. There is limited validated mobile application focusing on dietary monitoring among Malaysian cancer patient in the current market. Hence, a "smartphone application" (intelligent dietitian support apps [iDSA]) was developed to act as a tool to assist patients in terms of dietary monitoring. This feasibility study aimed to examine the feasibility of iDSA for self-monitoring dietary intake over traditional pen-and-paper method among cancer patients.

Materials and Methods

Development of the mobile application

We innovated and developed a dietary intake self-monitoring mobile application for cancer patients, called iDSA. Due to Malaysia's multiculturalism, we designed iDSA with three languages, which are Malay, Mandarin, and English. Translations were verified by language experts. The further translations verifications were completed in two rounds, whereby the back translations were done by three dietitians and five medical staffs who are fluent in respective languages. The final version of translation was further corroborated by 12 cancer patients.

The menu of iDSA was composed of five parts: Records of daily dietary intake, nutritional symptoms, food myths, additional supplementation, and dietary achievement monitoring. The structure of iDSA consisted of dietary intake summary (food type, portion, and time), macronutrient calculation, food intake monitoring, and comparison with the individual requirement as well as menu modification. The smartphone application, iDSA, was integrated with energy and macronutrients (carbohydrate, protein, and fat) contents for each food category from the food composition.[12] Energy and macronutrient intake achievements were compared to requirements and presented in percentage. Hence, participants able to counter check on the intake progress (under, average, or overeat). Micronutrients intake were not specified in the application as the current recommendation for the cancer population is the same for the general healthy population and it would be too burdensome for patients to keep track of every micronutrient.

After the patient logged into iDSA, dietitian in-charged entered the patient's name, individualized energy, and macronutrients requirement as a target or mission for subjects to be achieved daily. The energy and macronutrients requirements were calculated based on participant's age, gender, current nutritional status (weight, biochemical profile, and dietary intake), primary diagnosis, and comorbidities. To record food or beverage intake, the patient could click on food or beverage items and the portion size of intake (in household measurement, e.g., 1 rice scoop) on the screen. The diet record was daily, according to time the food to be recorded, where the subject was allowed to recall and record his/her diet intake on the same day but not the following day. If subjects missed recording his/her diet on the exact day, the data would be skipped.

Daily energy and macronutrient intake were calculated from the sum of energy and macronutrient contents based on every food and beverage consumed. Energy and macronutrient calculations were based on the Malaysian Food Atlas database.[12] iDSA was designed to act as an "artificial dietitian" support to monitor patients' daily food intake at home. The energy and macronutrients of every food items that were keyed in would be auto-calculated and compared against set requirements determined by the dietitian in-charged in the clinic. The calculation would then be translated into achievement percentage indicators that were divided into five stages with every 25% of requirement as the cutoff point, and the final stage as the warning of any excessive intake of >100%. These would be displayed in the application that can be assessed by patients at any time to know their intake status and further motivate them to make necessary diet changes to optimize energy-protein intake. Menu modification screen provided information and recommendation on tips to increase energy or certain macronutrients content in the menu to ease patients or patients' caregivers in food preparation. During follow-up session with the dietitian at the outpatient clinic, the daily food intake summaries (food type, portion size, energy, and macronutrients calculation) were able to be traced from the iDSA. The meal that was missed or skipped also can be traced and identified from the summaries. With this feature, clinical nutrition

verification and nutritional intervention could be implemented accordingly.

Study design

This study was a study reanalyzing patient who enrolled in the previous innovation project. This innovation project was registered in National Medical Research Registry, Malaysia, with reference number NMRR-19-1256-48645.

Participants

During the innovative project study, we recruited cancer patients in dietitian outpatient clinic, National Cancer Institute, Putrajaya, Malaysia. Convenient sampling was conducted. Inclusion criteria for the current pilot study were cancer patients who used a smartphone operating on android and willing to join. Since this was a pilot study on the feasibility of smartphone application, the sample size that was suggested by Julious (2005) in the medical field was 12.[13] Another sample size in applied statistics by Van Belle (2011) also suggested that 12 as a minimum sample size for a pilot study.[14] Fourteen cancer patients participated in this study. Among 14 participants who met inclusion criteria, male and female used iDSA and reported on feasibility. All participants completed pre- and post-intervention 24 diet recall.

Questionnaires

In the first session, dietitian explained the framework of study to participants after dietitian consultation. Nutritional status data (weight, height, diagnosis, daily energy, and protein intake) were recorded in the questionnaire as pre-intervention data after participants agreed to join. Dietitian described the functions and ways to use iDSA, participants download and installed iDSA into their smartphone. Individual estimated energy and protein requirement was entered into iDSA. Participants were instructed to record all food and beverage intake on that day through iDSA for 2 weeks.

In the second session (follow-up), participants completed the questionnaire about the feasibility and usability of iDSA. The items on the feasibility questionnaire are adopted from a local study (Umar *et al*., 2015). It was conducted in two versions (English and Malay) to facilitate the completion process. Using a 5-point Likert scale from 1 (totally disagree) to 5 (totally agree), 12 items were designed to measure the degree of satisfaction, convenience, and efficacy. Anthropometric data (weight) were assessed by body composition scale (TANITA) while dietary intake post-intervention was assessed using 24 h recalls by trained dietitians.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences version 23.0. All sociodemographic data were analyzed descriptively and presented as frequency and percentages. Nutritional status data (continuous data) were analyzed by paired t-test and evaluated using a two-tailed test of significance level at $P < 0.05$. Each item in the feasibility questionnaire was analyzed descriptively by determining frequencies who answered in each Likert scale (*n*) and corresponding percentage. For the final outcome, those chose for strongly agree or agree are considered as agree and satisfied with it whereas strongly disagree and disagree as the opposite.

Results

Sociodemographic and clinical characteristics of participants iDSA

Sociodemographic and clinical characteristics of all participants are shown in Table 2. There were six male and eight female participants recruited in this pilot study. Mean age was 36.4 ± 10.1 years old while male and female subjects were 33.8 ± 11.7 years old and 38.4 ± 9.0 years old, respectively. Majority of participants were Malay (57.1%), diagnosed with head-and-neck cancer and Stage IV (50%).

Comparison of pre- and post-intervention nutritional status of participants iDSA

Comparison of pre- and post-intervention nutritional status of participants iDSA is shown in Table 3. Mean value of the weight, daily energy, and protein intake pre-intervention was compared with post-intervention (with iDSA), the difference between pre-intervention and post-intervention was statistically significant. Weight, daily energy, and protein intake showed improvement significantly with $P < 0.05$.

Feasibility and acceptance of iDSA

Feasibility and acceptability of iDSA are presented in Table 4. All participants responded their satisfaction on iDSA. There were 92.1% of participants agreed that iDSA easy to operate, 71.4% agreed language

Table 2: Sociodemographic and clinical characteristics of participants iDSA

Characteristics	Male (*n*=6)	Female (*n*=8)	Total (*n*=14)
Ethnic			
Malay	4	4	8
Chinese	2	2	4
India	0	1	1
Sabah and Sarawak Bumiputera	0	1	1
Diagnosis			
Colon cancer	1	1	2
Ovarian cancer	0	2	2
Endometrial cancer	0	1	1
Breast cancer	0	3	3
Head-and-neck cancer	4	1	5
Testicular cancer	1	0	1
Stage			
I	0	5	5
II	1	0	1
III	0	1	1
IV	5	2	7

Table 3: Comparison of pre- and post-intervention nutritional status

Characteristics	Pre-intervention	Post-intervention	*P*-value
Weight (kg)	63.7±18.6	64.9±18.8	0.024*
Energy (kcal/day)	1647±463	1862±363	0.004**
Protein (g/day)	62.9±18.2	70.9±13.1	0.013*

Paired *t*-test; *P<0.05; **P<0.01

used in iDSA is simple and easy to understand, and 92.1% agreed iDSA helps to increase their nutritional knowledge and improve nutritional status. However, 57.1% of participants admitted that it was burdensome to record diet intake and did not remember to record diet intake daily.

Discussion

The precision of diet history reported by patients is essential to ensure the accuracy of diet intervention prescribed by a dietitian. The conventional way of dietary monitoring using 24 h diet recall or paper food diary methods is subjected to memory and motivation biases.[3] Moreover, the adherence to paper food diary method has been shown to decrease overtime because this method is not only time consuming but also void of immediate feedback.[15] Mobile devices are global tools in everyday life and are increasingly becoming part of the armaments for patients in chronic disease management.[16] In light of the limitations in the conventional methods and the increasing potential of technology integration to advance healthcare, the idea of using mobile apps to record dietary intake for self-monitoring by interpretation of real-time data for immediate feedback was generated. To the best of our knowledge, iDSA would be the first dietary self-monitoring mobile apps designed specifically for cancer patient in Malaysia that incorporates individualized energy and macronutrients requirements with automated calculation of dietary intake progress using real-time data interpretation feature.

Majority patients (>85%) have positive feedback (agreed or strongly agreed) on iDSA feasibility in terms of ease of operation, easy to understand language, attractive color scheme, and features. This may be credited to the option of three

Table 4: Feasibility (item 1–4) and acceptability (item 5–12) of iDSA (*n*=14)

Statement	Responses, *n* (%)				
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
iDSA is easy to operate	5 (36)	8 (57)	1 (7)	0	0
The language used in iDSA is simple and easy to understand	5 (36)	7 (50)	2 (14)	0	0
The color scheme of iDSA is good and attractive	6 (43)	7 (50)	1 (7)	0	0
The features in iDSA are catchy	7 (50)	5 (36)	2 (14)	0	0
iDSA will help to increase nutritional knowledge	5 (36)	8 (57)	1 (7)	0	0
iDSA will help to improve my nutritional status	8 (57)	5 (36)	1 (7)	0	0
iDSA will beneficial to me	9 (64)	5 (36)	0	0	0
iDSA attract my attention	5 (36)	9 (64)	0	0	0
Overall, I think iDSA is a good application	7 (50)	6 (43)	1 (7)	0	0
I would recommend iDSA to other patient/people	9 (64)	5 (36)	0	0	0
It is burdensome to record diet intake	0	8 (57)	0	5 (36)	1 (7)
I did not remember to record diet intake daily	1 (7)	7 (50)	0	3 (21)	3 (21)

languages (Malay, English, and Mandarin) in the app to eliminate language barrier instead of using English as sole language medium, taking into consideration that patients may be more comfortable to operate the app in their mother tongue language. In terms of usability, iDSA also presented with excellent usability with >90% of patients agreed or strongly agreed that iDSA will help to increase nutritional knowledge and improve nutritional status, with 100% would recommend iDSA to others. It is believed that the immediate feedback feature that compares dietary intake progress versus individualized requirements entered in the app played a big role in enhancing acceptance on the usability of this application.

Instead of waiting for a follow-up appointment with dietitian which might be taken for months, the automated real-time data interpretation feature in iDSA empowers patients to self-monitor and adjust their daily dietary intake according to targeted energy and macronutrients requirement and recommendation on the menu modification. Thus, there was a significant improvement for energy intake ($P < 0.01$) and protein intake ($P < 0.05$), leading to significant weight gain ($P < 0.05$) in this study. Provision of real-time data allows early detection and resolution of adherence issues, whereas real-time communication can be used to provide individualized dietary advice in intervention studies.[17] During follow-up session, dietitian could trace the daily food intake summaries (food type, portion size, energy, and macronutrients) from the iDSA. Further clarification and investigation could be done if there was any unclear or daily food intake not tally with nutritional progression (weight changes) during follow-up. Hence, clinical nutrition verification and nutritional intervention could be implemented accordingly to facilitate patients in self-monitoring daily food intake and complying nutritional intervention at home.

In terms of long-term commitment, patients' compliance in the daily use of iDSA remains as a major challenge. Majority respondents reported that it is burdensome or they forgot to record food intake. This concurs to the barriers identified in other mobile health apps study, including forgetting to make a record entry in smartphone,[18] time consuming,[19] or feeling too sick to make entries.[20] Similar to conventional pen and paper method, iDSA may not overcome errors such as participants' portion size estimations or omission of foods.[19] There is a need to improvise iDSA with more user-friendly features in the future to enhance compliance. Some features suggested by Chen *et al*. (2017) include food images captured through camera or barcode scanning function instead of text entry alone for food records, customizable reminders, in-app tutorial, and entertainment component besides improvising overall appearance.[21]

Strengths and limitations

This study served as a first study demonstrated that the self-monitoring dietary intake through intelligent dietitians supports mobile application which integrated artificial intelligent features, multilingual, and Malaysia local food. This feasibility studies might be used as a novel study to inform planning decisions related to a definitive randomized controlled trial in the future. Moreover, this study could provide initial parameter estimates for a sample size calculation, such as a standard deviation or the "success" rate for a binary outcome for future study.

There were few limitations in this study. As this is a pilot study, the sample size is relatively small to be generalized to all cancer patients' groups. For example, this mobile application might not be suitable for elderly or patients with lower education level due to limited understanding or lack of experience with touchscreen display. There is a need to be considered that different phases of cancer illness may cause patients to experience side effects of cancer treatment or disease-related symptoms such as pain or lethargy that impede the ability to use this app. Further study, with a longer intervention period and more heterogeneous cancer patient groups, is suggested to further investigate the accuracy of self-monitoring dietary intake smartphone application in the near future.

Conclusion

Self-monitoring dietary intake through iDSA was feasible among cancer patients. The compliance of iDSA in self-monitoring dietary intake increased the dietary intake and body weight after 2-week. The iDSA usability was rated good and can be used to study dietary intake among cancer patients.

Authors' Contributions

Conceptualization, methodology, formal analysis, investigation, resources, data curation, visualization, and writing original draft preparation, HCY; validation, HCY and BZH; writing – review and editing, HCY, NWH, and NMK; supervision, ZAR and NJ; and project administration, HCY, NWH, and NMK. All authors read and approved the final manuscript.

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