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Original Article

Effect of a pre-operative web-based dietary self-management intervention on patient satisfaction, body weight and quality of life of esophageal cancer patients: A prospective, observational study

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SUMMARY

Purpose: The purpose of this study was to investigate the adoption and actual use of a digital dietary monitoring system (DDMS) and its impact on patient satisfaction with the provided hospital care, body weight changes and health-related quality of life (HRQoL) in patients with potentially curable esophageal cancer planned for surgery. The DDMS enables patients and dietitians to monitor patients' nutritional intake and body weight during the preoperative period.

Methods: In this prospective observational study, the first 47 included patients received usual nutritional care, and were followed

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from diagnosis until surgery. After implementation of the DDMS 37 patients were followed, again from diagnosis until surgery. Main outcomes were actual use of the DDMS, by means of adoption and usage measures, overall patient satisfaction (EORTC-INPATSAT32), weight change and HRQoL (EORTC QLQ-C30 and EORTC-OG25). Outcomes were assessed immediately after diagnosis, and 6 and 12 weeks later.

Results: The system had an adoption rate of 64% and a usage rate of 78%. No significant effects on patient satisfaction were found at 12 weeks after diagnosis between the intervention and the usual care group. The implementation of the DDMS also had no significant effect on body weight and HRQoL over time.

Conclusions: Patients with potentially curable esophageal cancer planned for surgery were able to use the DDMS. However, no significant effects on patient satisfaction, body weight changes and HRQoL were observed. Further research should focus on the specific needs of patients regarding information and support to preoperatively optimize nutritional intake and nutritional status.

Introduction

The incidence of esophageal cancer (EC) is increasing, particularly due to the growing number of adenocarcinomas diagnosed in the Western world [1]. Esophagectomy with or without neoadjuvant chemoradiotherapy (CRT) is the cornerstone of curative treatment for EC, achieving a 5-year survival rate of 40–50% [2,3]. Patients with EC often present with progressive dysphagia resulting in inadequate oral intake, involuntary weight loss, and a decreased muscle mass. The deterioration in nutritional status may affect the functional capacity to undergo intensive treatment [4]. Weight loss has been associated with decreased patient tolerance for chemotherapy, an increased rate of chemotherapy-associated toxicity, and an increase in postoperative complications [4–6]. In contrast, intensive nutritional support, with stabilization of patients' weight and nutritional status, has been shown to decrease morbidity during chemotherapy and after surgery [7].

Accordingly, preoperative optimization of nutritional status is of utmost importance and patient counseling by a dietitian is recommended [7,8]. Also, patients' motivation and thus self-management support is considered to be an additional stimulus to increase nutritional intake. Self-management support is defined as the systematic provision of education and supportive interventions by healthcare professionals to increase patients' skills and confidence in managing their health problems, including regular assessment of progress and problems, goal setting, and problem-solving support [9]. Presently, self-management support is offered through face-to-face contact and/or by digital tools.

Digital self-management support tools (DSMST) can be any kind of electronic platform (e.g., website, app) and have been shown to increase knowledge, the experience of social support, some clinical outcomes (i.e. physical outcome, functional status) among users, to stimulate patient empowerment [9–11] and quality of life [12–14]. To stimulate and support patients in nutritional self-management, we implemented a digital dietary monitoring system (DDMS) that enabled patients and dietitians to monitor patients' nutritional intake and body weight during the preoperative period and to stimulate patient-dietitian interaction. If patients and dieticians both monitor patients' nutritional intake and body weight, interventions might be made more timely, optimizing nutritional status, and probably improving patient satisfaction and health-related quality of life (HRQoL) [15].

The purpose of this study was to investigate the adoption and actual use of a digital dietary monitoring system (DDMS) and its impact on patient satisfaction with the provided hospital care, body weight changes and health-related quality of life (HRQoL) in patients with potentially curable esophageal cancer planned for surgery.

Methods

Study design

This study was conducted at the Catharina Hospital Eindhoven, a referral center for EC surgery in the Netherlands. For three consecutive years, potentially curable EC patients planned for neoadjuvant CRT and subsequent surgery were asked to participate in our prospective observational study by a nurse specialist. The study started with the prospective follow-up of patients who received usual care, from the moment of diagnosis until just before surgery. Consecutively, the DDMS was implemented after which again patients were prospectively evaluated from the moment of diagnosis until just before surgery.

Patients

Consecutive patients with EC, who were referred to the Catharina Hospital Eindhoven for surgery preceded by neoadjuvant CRT, were invited to participate in this study. Patients who were not able to speak, read, and write Dutch or had no access to the internet were not deemed eligible. The study protocol was approved and in accordance with the regulations of the Ethics Committee of Catharina Hospital Eindhoven (non-WMO 2013-37). All participants signed informed consent.

Usual care group

Usual care consisted of a weekly face-to-face contact between dietician and patient and evaluation of body weight and nutritional intake during the past week. In case of inadequate nutritional intake or weight loss, patients were informed about how to achieve protein and energy intake goals. The patient started with protein and energy enriched food, with adapted consistency and oral nutritional supplements when needed. When the patient was still not able to meet the nutritional goals, (additional) tube feeding was provided.

Intervention group

After inclusion, patients were given access to the web-based DDMS designed to support EC patients in self-management of their nutritional intake and body weight, independent of location and time. Patients had 24/7 access to this system until one year after surgery. All patients received a short face-to-face instruction by a dietician.

The main objective of this system was to increase patients' insight into their nutritional patterns to improve intake resulting in stabilization of body weight, improvement of HRQoL, and tolerance to intensive treatment, and ultimately, enhance self-efficacy. The DDMS contained four components:

1. *An informative component* in which patients had access to information on the recommended nutritional schedule, i.e., the recommended number of calories and amount of protein.
2. *A self-management component*, consisting of a weight and nutritional diary, to monitor their weight, calorie, and protein intake.
3. *An email component*, for direct communication with the dietician.
4. *A follow-up component.* Before every consultation, the dietician was able to review the weight and nutritional diary and use the information in subsequent contact with the patient.

Data collection

After obtaining written informed consent, all participants received three questionnaires. HRQoL was assessed with the European Organization for Research and Treatment for Cancer Quality of Life Questionnaire (EORTC-QLQ)-C30 [16], and the EORTC Oesophago-Gastric Module (EORTC-OG25) [17]. Furthermore, additional questions about age, sex, body weight changes, smoking status, alcohol use, and use of oral nutritional supplements and tube feeding were assessed. The questionnaire was sent at baseline (at diagnosis), at 6 weeks and 12 weeks after diagnosis, using the PROFILES (Patient Reported Outcomes Following Initial treatment and Long-term Evaluation of Survivorship) registry, which is a registry for studies on the physical and psychosocial impact of cancer and its treatment [18]. At 12 weeks, the questionnaire also incorporated the first eleven items of the EORTC In-Patient Satisfaction with Care (EORTC IN-PATSAT32) [19,20] score list.

The EORTC-QLQ-C30 includes five functional scales (physical, role, emotional, cognitive, and social), one global QoL scale, three general symptom scales (fatigue, nausea and vomiting, and pain), and six single-item general symptom measures (dyspnea, insomnia, appetite, constipation, diarrhea, and financial difficulties). The EORTC-OG25 [17] is a disease-specific quality of life questionnaire and is complementary to the general EORTC QLQ-C30. It evaluates HRQoL among patients with cancer of the esophagus, the esophagogastric junction, and/or the stomach varying in disease stage and treatment modality (i.e. surgery, chemotherapy, radiotherapy, palliation). The EORTC-OG25 has six symptom scales (dysphagia, eating restrictions, reflux, odynophagia, pain and discomfort, and anxiety) and 10 single items (eating with others, dry mouth, sense of taste, body image, saliva, choking, cough, speech, weight loss, and hair loss). In both the EORTC QLQ-C30 and EORTC-OG25, each item has four response alternatives: (1) "not at all," (2) "a little," (3) "quite a bit," and (4) "very much," except for the global QoL scale of the EORTC QLQ-C30 which ranges from (1) "very poor" to (7) "excellent." All scales and item scores from both questionnaires were linearly transformed to a 0–100 score according to the EORTC QLQ-C30 and EORTC-OG25 scoring manual [21]. High scores in the multi-item function scales indicate better levels of functioning and QoL, whereas high scores in the symptom scales and single items represent more symptoms. Accordingly, the EORTC QLQ-C30 Summary Score was calculated from the mean of 13 of the 15 QLQ-C30 scales (the Global Quality of Life scale and the Financial Impact scale were not included) [21]. For this study, we chose to only assess the symptom scales of the EORTC QLQ-OG25, because this study focused on aspects of quality of life, related to the effects of the use of the DDMS, e.g. changes in nutritional intake and anxiety.

Satisfaction with care was assessed with the EORTC IN-PATSAT32 [19,20]. The EORTC IN-PATSAT32 is composed of 32 items assessing cancer patients' perceptions of the quality of hospital doctors and nurses, as well as selected aspects of the care organization and hospital environment that are relevant across national settings. The questionnaire is organized into eleven multi-item scales, including doctors' and nurses' technical skills (knowledge, experience, assessment of physical symptoms), interpersonal skills (interest, willingness to listen), information provision (about the disease, medical tests, and treatment), and availability (time devoted to patients); other hospital staff members' interpersonal skills; waiting time; hospital access; and three single items consisting of information exchange, hospital comfort, and overall satisfaction. A "poor", "fair", "good", "very good", or "excellent" response scale is used to rate each aspect of care [20]. For this study, we chose to only assess patients' appraisal of the care team's supervision during treatment, because this study focused on preoperative multidisciplinary care for EC patients. Scores of the EORTC INPATSAT-32 for items within a scale were summed and divided by the number of items in the scale. Multi-item, as well as single-item scale scores, were then linearly transformed to scores ranging from 0 to 100, with a higher score representing a higher level of satisfaction [19].

According to the study of Duman-Lubberding *et al.* [22], adoption was calculated as the percentage of patients that agreed to participate in the study and completed the T0 survey and usage was defined as the percentage of patients that used the DDMS as intended, based on logging data of the application and actual use of the nutritional diary.

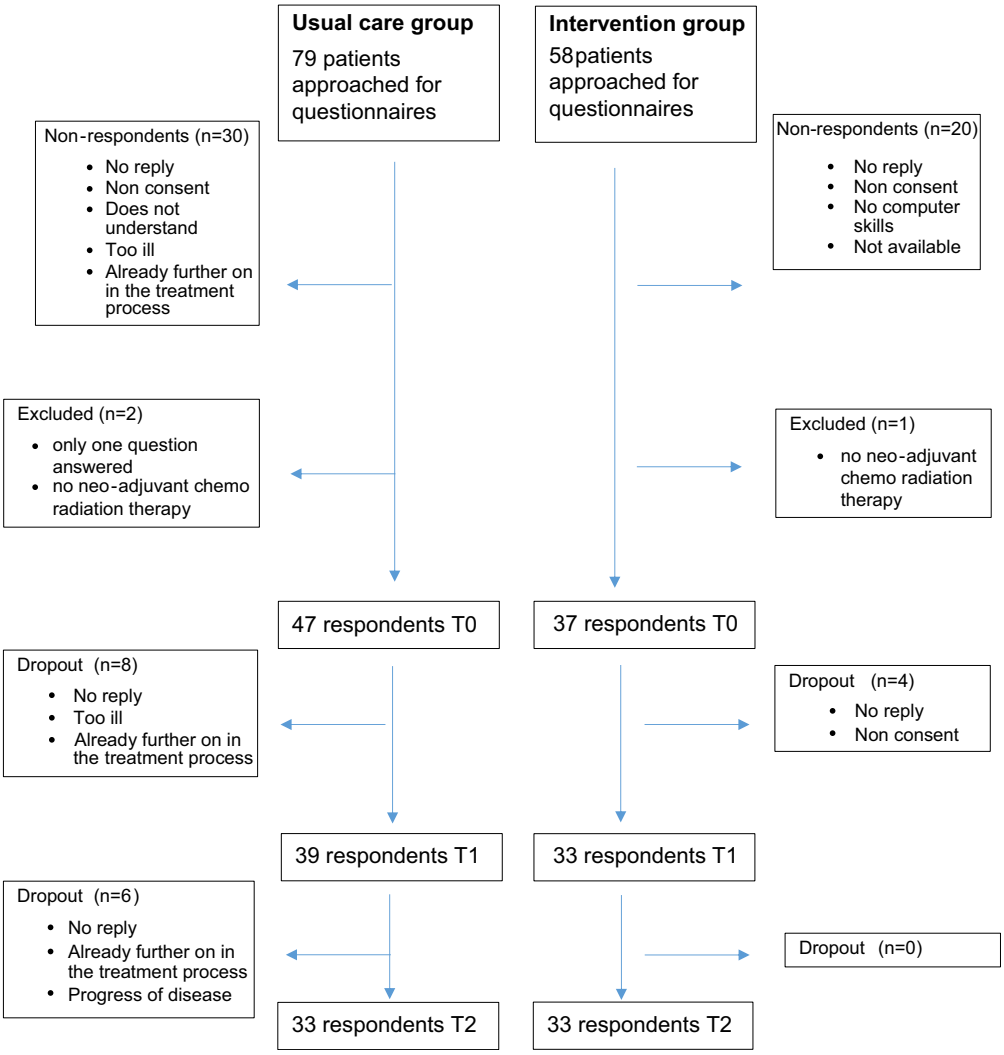

Fig. 1. Flow diagram of study participants in usual care and intervention group. T0: Baseline (at diagnosis); T1: 6 weeks after baseline (at the end of neoadjuvant CRT); T2: 12 weeks after baseline (just before surgery).

Statistical analysis

Baseline characteristics were presented as means and standard deviations for normally distributed continuous variables, median and interquartile range for not normally distributed continuous variables, and as numbers and percentages for categorical data. Baseline characteristics of the usual care group vs. the intervention group were compared using student t-test for normally distributed continuous variables, Mann–Whitney *U*-test for non-normally distributed continuous variables, and the chi-square test or the Fisher's exact test when appropriate for categorical variables.

For analysis of between-group differences, linear mixed models (LMM) for repeated measures were fitted to test differences in body weight changes and HRQoL over time (preoperative period) between the usual care and intervention group. A diagonal covariance structure was used to model dependencies among measurements on the same individual at different time points. Models for each

outcome consisted of three effects: measurement occasion (time), intervention (web-based augmented vs usual care), and the interaction of time and intervention. Mann-Whitney *U*-test was used to test between-group differences in patient satisfaction at 12 weeks.

All statistical analyses were performed using SPSS Statistics 23 (IBM SPSS Statistics, Chicago, IL) and *P* values < 0.05 were considered statistically significant.

Results

Patient characteristics

A total of 137 patients were asked to participate in our study. Finally, 84 (61%) patients participated and completed the baseline assessment (Fig. 1). Forty-seven patients participated in the usual care group (UC) and 37 patients after implementation of the DDMS (intervention group (I)). No differences between participants and non-participants regarding gender and age were observed. The main reasons for non-participation included: no reply (n = 29) and non-consent (n= 16; Fig. 1). During the study, 18 patients dropped out between the T0 and T2 measurement. (4 of 37 participants (11%) in the intervention group; 14 of 47 participants (30%) in the usual care group). Information on the reasons for withdrawal between the T0 and T2 measurement was not available. Most patients were male (I:89.2%; UC:89.4%) and the mean age was 63.2 ± 9.2 in the intervention group versus 65.9 ± 8.8 in the usual care group. At baseline, no statistically significant differences in demographic and clinical characteristics were observed between the intervention and usual care group (Table 1).

Adoption and usage of the intervention

The adoption rate of the DDMS was 64%: 37 out of 58 patients had the intention to use the system and completed the T0 measurement. Fig. 2 shows the frequencies of logins of the patients. The use of the intervention varied considerably. Twenty-nine of the 37 patients (78%) used the intervention. The frequency of logins ranged from 1 to 787 times. Most patients used the intervention between 101 and 150 times. Two patients used the intervention only once and eight patients did not use the intervention at all. Information on reasons for non-use was not available.

Patient satisfaction with hospital care

In both groups, most patients were satisfied with hospital care at 12 weeks after baseline. Patients' level of satisfaction with interpersonal skills was similar in both groups (I: 80.0 ±15.1; UC: 80.0±30.0). Patients' level of satisfaction with technical skills, information provision, and availability was higher in the intervention group, albeit not statistically significant (Table 2).

Quality of life

In both the intervention and usual care group, scores on the functioning scales, overall QoL, and the summary score decreased from baseline until 6 weeks after baseline (at the end of neoadjuvant CRT) representing deterioration in HRQoL. From 6 until 12 weeks after baseline (just before surgery) an increase in scores on the functioning scales, overall QoL, and the summary score was seen in both groups, indicating an improvement in HRQoL (Table 3). The scores on the symptom scales increased from baseline until 6 weeks after baseline in both the intervention and usual care group (representing a deterioration in symptoms) and decreased from 6 until 12 weeks after baseline (representing an improvement in symptoms). However, no statistically significant or clinically relevant differences were observed in the course of functioning and symptom scales, single items, overall QoL, and the summary score over time (from baseline until 12 weeks after baseline) between the intervention and usual care group (Table 3).

Table 1
Demographic and clinical characteristics at baseline

Characteristics	Intervention group (n=37)	Usual care group (n=47)	*P*-value
Age (years) (mean (SD))	63.2(9.2)	65.9(8.8)	0.171
Sex (number (%))			0.980
Male	33(89.2)	42(89.4)	
Female	4(10.8)	5(10.6)	
Stage (number (%))			0.326
1	8(21.6)	4(8.9)	
2	13(35.1)	15(33.3)	
3	15(40.5)	25(55.6)	
4	1(2.7)	1(2.2)	
Histology (number (%))			0.789
Adenocarcinoma	30(81.1)	37(78.7)	
Squamous carcinoma	7(18.9)	10(21.3)	
BMI at diagnosis (kg/m^2) (mean (SD))	26.5(4.7)	25.0(3.4)	0.174
%Weight loss in the last six months (kg)(mean (SD))	-5.9(3.7)	-6.8(7.5)	0.595
Smoking behavior (number (%))			0.391
Never smoked	6(16.2)	4(8.5)	
Quitted smoking	25(67.6)	31(66,0)	
Smoking	6(16.2)	12(25.5)	
Alcohol behavior (number (%))			0.792
Never used	4(10.8)	4(8.5)	
Quitted use	5(13.5)	5(10.6)	
Occasional use	28(75.7)	38(80.9)	
Artificial feeding (number (%))			
Oral nutritional support	9(24.3)	21(44.7)	0.053
Enteral artificial feeding	1(2.7)	4(8.5)	0.378
EORTC QLQ-C30 (mean (SD))			
Global health status	73.4(15.6)	74.5(16.0)	0.666
Physical functioning	93.9(9.6)	92.6(11.4)	0.866
Role functioning	86.5(23.2)	89.4 19.5)	0.792
Social functioning	86.5(22.2)	88.7(16.7)	0.798
Emotional functioning	76.6(18.0)	73.2(17.6)	0.314
Cognitive functioning	92.3(13.4)	89.4 17.5)	0.387
Fatigue	17.7(19.3)	23.2(23.5)	0.264
Pain	8.1(14.5)	9.6(14.6)	0.432
Nausea_vomiting	5.9(11.9)	11.7(19.9)	0.117
Dyspnoea	9.9(20.6)	7.1(13.8)	0.820
Sleeping disturbances	13.5(25.4)	22.7(27.9)	0.076
Appetite loss	12.6(19.8)	17.7(25.9)	0.456
Constipation	11.7(19.6)	7.1(16.9)	0.184
Diarrhea	9.0(15.0)	9.9(21.9)	0.671
Financial problems	4.5(14.0)	5.0(17.0)	0.980
Summary Score	88.3(8.8)	86.5(11.5)	0.623
EORTC OG-25 (mean (SD)) at diagnosis			
Dysphagia	23.1(20.7)	25.3(24.3)	0.852
Eating restrictions	27.9(22.7)	30.4(24.5)	0.750
Reflux	4.5(10.9)	5.8(11.8)	0.454
Odynophagia	21.6(21.1)	21.4(21.6)	0.908
Pain and discomfort	14.4(18.1)	12.7(17.3)	0.652
Anxiety	58.1(25.0)	63.0(26.5)	0.415

P values were calculated: χ^2 tests for categorical variables and a two-tailed Students t-test (independent samples) or Mann-Whitney U-test for continues variables.

Weight changes

In both the intervention and usual care group, absolute weight decreased from baseline (I: 82.3 kg; UC: 75.6 kg) until 6 weeks after baseline (at the end of neoadjuvant CRT) (I: 81.4 kg; UC: 74.5kg). From 6 weeks after baseline until 12 weeks after baseline (just before surgery) a decrease in absolute weight was observed for the intervention group, while an increase in absolute weight was seen for the usual

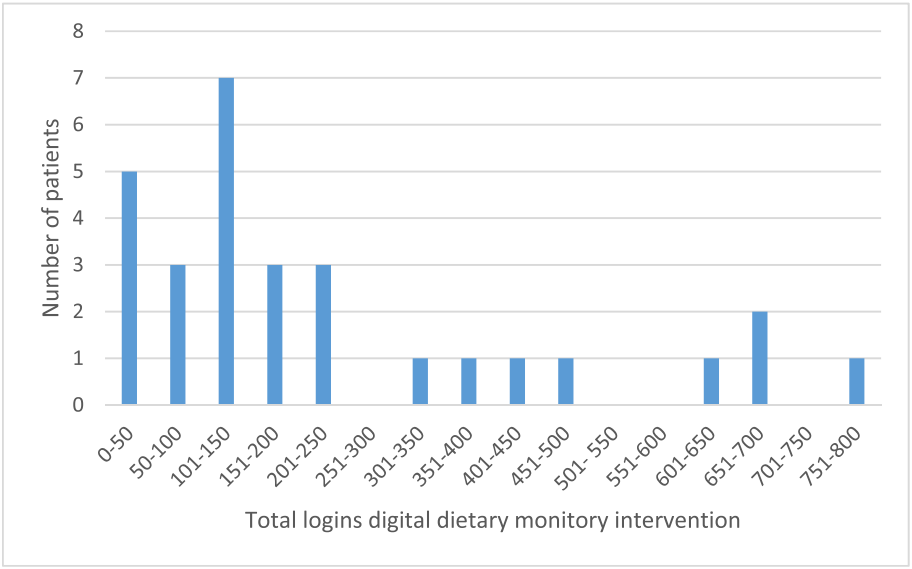

Fig. 1. Total logins digital dietary monitory intervention.

Table 2
Mean scores of patient satisfaction with hospital care between intervention (n = 33) and usual care (n = 33) group at 12 weeks after baseline

Satisfaction with hospital care	12 weeks after baseline Mean ± SD	*P*-value
Technical skills		0.335
Intervention group	80.4 ± 15.1	
Usual care group	76.0 ± 18.6	
Interpersonal skills		0.470
Intervention group	80.0 ± 15.1	
Usual care group	80.0 ± 30.0	
Information provision		0.748
Intervention group	81.0 ± 16.3	
Usual care group	78.6 ± 18.4	
Availability		0.385
Intervention group	78.5 ± 18.7	
Usual care group	74.2 ± 19.4	

care group (I: 80.2kg; UC: 76.4kg). However, no significant difference was seen in the course of absolute weight over time (from baseline until 12 weeks after baseline) between the intervention group and usual care group (P=0.085).

Artificial feeding

At baseline, the number of patients receiving oral nutritional supplements was lower in the intervention group versus the usual care group (I: 24.3%; UC: 44.7%; P=0.053). In both the intervention and usual care group, the number of patients receiving oral nutritional supplements increased from baseline until 6 weeks after baseline (I: 30.3%; UC: 53.8%) and decreased from 6 until 12 weeks after baseline (I: 21.2; UC: 18.2). However, no significant difference was seen in the course of receiving oral nutritional supplements over time (from baseline until 12 weeks after baseline) between the intervention and usual care group (P=0.228).

Table 3
Mean scores of EORTC-QLQC30 functioning and symptom scales and single items and EORTC-OG25 symptom scales between intervention and usual care group over time

Quality of life	Baseline[a] Mean ± SD	6 weeks after baseline[b] Mean ± SD	12 weeks after baseline[c] Mean ± SD	*P*-value[d]
Functioning scales				
Global health status				0.782
Intervention group	73.4 ± 15.6	63.1±17.1	73.0±17.7	
Usual care group	74.5 ± 16.0	61.1±16.6	77.0±16.7	
Physical functioning				0.474
Intervention group	93.9 ± 9.6	82.6±19.7	86.9±13.7	
Usual care group	92.6 ± 11.4	79.3±14.4	86.3±17.1	
Role functioning				0.529
Intervention group	86.5 ± 23.2	57.6±31.2	69.7±28.4	
Usual care group	89.4 ± 19.5	65.0±23.8	70.7±28.9	
Social functioning				0.429
Intervention group	86.5 ± 22.2	73.7±27.3	81.3±20.3	
Usual care group	88.7 ± 16.7	74.4±19.8	86.9±21.6	
Emotional functioning				0.775
Intervention group	76.6 ± 18.0	77.8±20.8	81.1±18.5	
Usual care group	73.2 ± 17.6	84.3±14.1		
Cognitive functioning				0.678
Intervention group	92.3 ± 13.4	83.8±20.6	92.9±11.0	
Usual care group	89.4 ± 17.5	86.3±18.7	89.9±14.4	
Symptom scales				
Fatigue				0.499
Intervention group	17.7 ± 19.3	42.1±26.5	31.3±23.8	
Usual care group	23.2 ± 23.5	44.4±21.2	28.3±23.4	
Pain				0.976
Intervention group	8. 1 ± 14.5	21.2±17.3	12.1±22.9	
Usual care group	9.6 ± 14.6	23.5±23.8	11.1±21.9	
Nausea_vomiting				0.952
Intervention group	5.9 ± 11.9	24.2±34.1	6.6±13.1	
Usual care group	11.7 ± 19.9	15.4±19.6	7.6±13.2	
Dysphagia				0.856
Intervention group	23.1±20.7	33.7±31.2	10.1±16.5	
Usual care group	25.3±24.3	33.6±24.4	12.1±16.0	
Eating restrictions				0.398
Intervention group	27.9±22.7	43.4±31.9	22.5±25.3	
Usual care group	30.4±24.5	49.8±27.4	20.7±25.3	
Reflux				0.854
Intervention group	4.5±10.9	8.6±17.7	3.5±10.8	
Usual care group	5.8±11.8	7.3±16.1	3.5±8.1	
Odynophagia				0.528
Intervention group	21.6±21.1	29.8±22.7	10.6±21.2	
Usual care group	21.4±21.6	32.9±28.0	14.1±21.7	
Pain and discomfort				0.719
Intervention group	14.4±18.1	19.2±22.1	8.6±19.1	
Usual care group	12.7±17.3	22.6±24.6	10.6±19.0	
Anxiety				0.837
Intervention group	58.1±25.0	48.5±23.3	47.0±24.8	
Usual care group	63.0±26.5	48.3±24.1	50.0±19.5	
Single item symptom scales				
Dyspnea				0.599
Intervention group	9.9±20.6	22.2±29.7	14.1±25.0	
Usual care group	7.1±13.8	22.2±25.7	15.2±26.5	
Sleeping disturbances				0.232
Intervention group	13.5±25.4	21.2±27.4	14.1±26.4	
Usual care group	22.7±27.9	22.7±27.9	19.2±27.7	
Appetite loss				0.676
Intervention group	12.6±19.8	41.4±39.1	21.2±31.0	
Usual care group	17.7±25.9	37.6±30.8	20.2±30.0	
Constipation				0.853

Table 3 (*continued*)

Quality of life	Baseline[a] Mean ± SD	6 weeks after baseline[b] Mean ± SD	12 weeks after baseline[c] Mean ± SD	*P*-value[d]
Intervention group	11.7±19.6	21.2±26.1	12.1±21.8	
Usual care group	7.1±16.9	23.1±28.8	12.1±23.3	
Diarrhea				1.000
Intervention group	9.0±15.0	16.2±23.7	12.1±21.8	
Usual care group	9.9±21.9	11.1±25.7	11.1±16.0	
Financial problems				0.312
Intervention group	4.5±14.0	8.1±20.5	4.0±11.0	
Usual care group	5.0±17.0	12.0±23.6	14.1±25.0	
Summary Score				0.825
Intervention group	88.3 ± 8.8	74.3±15.7	83.7±13.4	
Usual care group	86.5 ± 11.5	74.9±10.5	84.1±12.9	

[a]Intervention group n = 37, control group n = 47.
[b]Intervention group n = 33, control group n = 39.
[c]Intervention group n = 33, control group n = 33.
[d]*P*-value: differences in the course of functioning and symptom scales, single items, overall QoL and summary score over time (from baseline until 12 weeks after baseline) between the intervention and usual care group.

The number of patients receiving tube feeding increased from baseline (I: 2.7%; UC: 8.5%) until 6 weeks after baseline (I: 18.2%; UC: 12.8%) in both the intervention and usual care group. From 6 weeks until 12 weeks after baseline, the number of patients receiving tube feeding decreased for the intervention group, while the number of patients increased for the usual care group (I: 15.2%; UC: 15.2%). However, no significant difference was seen in the course of receiving tube feeding over time (from baseline until 12 weeks after baseline) between the intervention and usual care group (P=0.882).

Post-hoc analysis

In the intervention group, 78% of patients used the DDMS. Among these patients, the frequency of logins was highly variable (from 1 to 787 times). Two patients used the intervention only once and 8 patients did not use the intervention. After exclusion of these 10 patients a post-hoc analysis showed no significant difference over time between the intervention and usual care group for patient satisfaction or quality of life. However with regard to absolute weight changes, a significant difference over time between the intervention and usual care group was found, in favor of the intervention group (P=0.048; I: baseline 82.6 kg, 6 weeks after baseline 81.8 kg, 12 weeks after baseline 82.6 kg; UC: baseline 77.2 kg, 6 weeks after baseline 75.9 kg, 12 weeks after baseline 76.5 kg).

Discussion

In this study, we investigated the adoption and actual use of a digital dietary monitoring system (DDMS) and its impact on patient satisfaction with the provided hospital care, body weight changes and health-related quality of life (HRQoL) in patients with potentially curable esophageal cancer planned for surgery. The adoption rate of the intervention was 64% and the usage rate was 78%. No significant influence of the implementation of the DDMS was observed on patient satisfaction or on the secondary outcome measures body weight changes, and quality of life over time. A post-hoc analysis excluding the participants not using or only once using the DDMS showed a significant difference over time for weight change between the intervention and control group in favor of the intervention group.

Our adoption and usage rates are in line with previous studies in EC patients [23] and cancer patients in general [22,24–27], showing that these e-health interventions are acceptable to many cancer patients. Our results show that patients were able to use the digital dietary monitoring system, even though they underwent neoadjuvant CRT, which is associated with reduced condition, physical function, and treatment-related fatigue [28]. This is remarkable, as a better health status is related to better acceptance of Internet applications [22].

Nevertheless, not all patients used the digital dietary monitoring system, possibly due to different needs, internet skills, preferences, and coping styles compared to patients who used the system [22]. The variable uptake and use of technology in health care which influences outcomes can be explained by several general models such as the Unified Theory of Acceptance and Use of Technology (UTAUT) [29] and the Normalization Process Theory (NPT) [30]. The UTAUT includes explanatory factors which influence use behavior. These factors are the degree of ease associated with the use of the technology, the degree to which using a technology will be helpful for doing a job, and social influence. The strongest predictor for the use of the technology is the degree to which the user expects technology to be helpful for doing a job [31]. In future research, it is recommended to include these influencing factors, to understand the effects of using technology.

Patient satisfaction results of our study sharply contrast the only previous study focusing on digital interventions in EC patients [23]. That study showed consistently higher patient satisfaction rates in the intervention group. However, that study aimed at improving functional status, using a 12-week supervised physiotherapy with telerehabilitation intervention for patients with EC who underwent esophagectomy. In our study, most patients of both groups were satisfied with hospital care at 12 weeks after baseline and no significant difference was found between groups at 12 weeks after baseline. A possible explanation for our findings might be that during data collection time, the patients had many possibilities to increase their knowledge from different sources. In addition, all of our patients received the standard oral and written patient education and were guided by the dietician. Perhaps the current standard systems used to educate and inform patients already function quite well and there is little room for improvement.

The non-significant results on HRQoL over time in our study are also in contrast with previous studies. Two studies have shown a positive effect on HRQoL by using eHealth interventions for cancer patients in general [12,13]. The study of van der Hout *et al.* [13] investigated a web-based eHealth application that supports cancer survivors in self-management by monitoring HRQoL and cancer-generic and tumor-specific symptoms and provided tailored feedback with a personalized overview of supportive care options. The study of Urech *et al.* [12] investigated a Web-based stress management program for newly diagnosed patients with cancer. The different outcomes might be explained by the fact that these studies focused on a different kind of digital intervention (e.g. web-based stress management system). Moreover, our study focused on a specific group of patients with EC in the preoperative setting. At the time of diagnosis, EC patients are often affected by symptoms such as dysphagia, inadequate nutritional intake, involuntary weight loss, fatigue, and loss of skeletal muscle mass, resulting in a suboptimal state for treatment [4]. This might result in different needs for information and support in contrast to other patients with a different kind of cancer. Future research should focus on specific needs in different stages of the clinical pathway of patients regarding self-management support. Further studies designed to better understand for whom, why, under which circumstances, and how digital interventions work, could provide important insights into how to improve and specifically tailor such interventions to meet the needs of individual (esophageal) cancer patients in different phases of their illness.

Differences in weight change over time between the intervention group and usual care group in favor of the use of the DDMS were only seen in the post-hoc analysis in which the participants not using or only once using the DDMS were excluded. Although differences were small, this might suggest that using the DDMS more frequently might have benefits.

A strength of this study is that it covers two relevant topics in modern health care: self-management and eHealth. However, there are some limitations regarding the generalizability of the results of this study. The sample size was too small to account for the variation in the data, which might also explain the non-significant results. Furthermore, this digital intervention required respondents to have access to the internet at home, computer skills, and health literacy, such as competence at accessing, understanding, appraising, and applying digital interventions. However, since digital literacy was not assessed in this study, it is not possible to estimate the extent to which this might have influenced initial recruitment and the adoption and usage of the digital dietary monitoring

intervention. Another limitation is the difference of dropout between the groups (I: 11%; UC: 30%), however the dropout rate in the control group was higher than in the intervention group, which argues that the intervention was not a reason for the dropout. A fourth limitation is that the digital dietary intervention was not developed according to a participatory design approach. Involving end-users and stakeholders in the creation of requirements has been shown to be a fruitful approach. It improves usability, prevents the inclusion of superfluous features, and can prevent the spending of money on bad design [32]. Therefore, a next step should be to design a qualitative study to obtain insight into the barriers and facilitators of the use of the digital dietary intervention for EC patients in the preoperative phase. Also, it might be of interest to investigate whether the implementation of the digital intervention has a positive effect on the patient-dietician interaction and saves time in the face-to-face contacts with the dietician.

Conclusion

In conclusion, this study showed that a digital dietary monitoring intervention is feasible for many potentially curable esophageal cancer patients even during neoadjuvant CRT before surgery. However, no significant effect was shown of the implementation of the digital dietary monitoring system on patient satisfaction with the provided hospital care at 12 weeks after diagnosis and the use of artificial feeding, body weight changes and HRQoL over time in patients with potentially curable esophageal cancer planned for surgery.

Declarations

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Availability of data and material

Data is available on request from the authors.

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Daniëlle JM Adriaans, Nicole Horevoorts, Fanny Heesakkers, Lisette de Craen-Kat, Sandra Beijer, Lonneke van de Poll-Franse and Grard AP Nieuwenhuijzen. The first draft of the manuscript was written by Daniëlle Adriaans and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Ethical approval

The study protocol was approved and in accordance with the regulations of the Ethics Committee of Catharina Hospital Eindhoven.

Consent to participate

All participants signed informed consent.

Consent to publish

All participants signed informed consent.

Conflict of interest

The authors declare no other conflicts of interests.

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