

## ORIGINAL RESEARCH ARTICLE

# Dietary intake of esophageal cancer survivors in Ireland: Adherence to recommendations and comparison to general population

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## Abstract

The curative treatment for esophageal cancer (EC) is esophagectomy, a procedure which modifies the capacity to normally metabolize food. Post-esophagectomy, individuals may struggle with food intake, malabsorption, weight loss, and gastrointestinal issues, negatively impacting their quality of life (QOL). Despite the increasing survival rate of EC patients, little is still known about their dietary intake pattern over the course of long-term survivorship. This study aims to explore the nutritional intake of EC survivors, comparing it to the general Irish population and recommended standards. Male EC survivors were recruited from St James’s Hospital and completed a detailed food diary over 7 days. Diaries were analyzed using nutritics and nutrient intakes were compared to the National Adult Nutrition Survey cohort. A modified World Cancer Research Fund (WCRF) score was created to assess adherence to the WCRF recommendations for cancer prevention. QOL scores were calculated using the European Organization for Research and Treatment of Cancer guidelines. Twenty-eight participants completed food diaries. EC survivors had significantly lower intakes of energy, protein, fat, carbohydrate, fiber, sugar, Vitamin E, and alcohol compared to the general population. Participants scored 2.99/6 on the WCRF score, with particularly poor adherence to fruit/vegetable, fiber, and red/processed meat guidelines. While 10.7% of the cohort were obese, 57.1% experienced >10% weight loss in >6 months. QOL results indicated deficits in physical and functional capacity among EC survivors compared to population norms. EC survivors have numerous nutritional deficits, alongside reduced physical and functional status. It is evident that continued dietary advice is needed long-term in EC survivorship to optimize diet quality, thus reducing the risk of cancer recurrence and all-cause mortality and improving QOL.

**Keywords:** Esophageal cancer; Survivorship; Malnutrition; Dietary quality

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**Citation:** Quigley E, O’Kelly R, Byrne K, *et al.* Dietary intake of esophageal cancer survivors in Ireland: Adherence to recommendations and comparison to general population. *Cancer Plus*. 2024;6(4):4814.  
doi: 10.36922/cp.4814

**Received:** September 10, 2024

**Accepted:** December 13, 2024

**Published Online:** January 8, 2025

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## 1. Introduction

Esophageal cancer (EC) is the eighth most prevalent cancer diagnosis received worldwide. Frequency of cases and death rates are both 2 – 3 times higher in males than females.<sup>1</sup> In men, EC was the fifth most prevalent cause of cancer deaths in Ireland from 2018 to 2020, accounting for 6% of overall mortalities from invasive malignancies.<sup>2</sup> Although life expectancy for EC has doubled in recent years, it persists as a public health concern given its overall poor prognosis.<sup>3,4</sup>

Curative treatment for EC involves esophagectomy ± chemoradiotherapy<sup>5-9</sup> and EC survivors can continue to struggle with consequences of their cancer treatment for many years.<sup>10,11</sup> An esophagectomy is a life-changing procedure that alters the architecture of the digestive tract, in turn modifying capacity to normally metabolize food.<sup>12</sup> As a result, survivors may experience symptoms such as delayed gastric emptying, gastroesophageal reflux, dumping syndrome (DS), nausea, decreased appetite, unintentional weight loss, inability to regain weight, malabsorption, and malnutrition.<sup>12-14</sup> Further issues include early satiety and ongoing dysphagia from anastomotic strictures or recurring tumors. EC survivors may experience anxiety around eating due to difficulty consuming food before surgery.<sup>14</sup> Previous studies of EC survivors indicate that rates of malabsorption increase with time after esophagectomy, standing at 7.6% and 14.3% at 6 months and 12 months, respectively. Furthermore, occurrence of DS was reported at 67.7% and 74.3% at 6 and 12 months, respectively.<sup>15</sup> Collectively, these issues can be described as nutrition impact symptoms (NIS), *that is*, long-term symptoms which hinder oral intake and have a negative impact on prognosis.<sup>15,16</sup>

The high prevalence of malabsorption and NIS invariably negatively impacts body composition in EC survivors. Weight loss has been reported to be most severe in the first 6 months postoperatively, with up to 62% of patients experiencing “severe” weight loss.<sup>15</sup> Sarcopenia and sarcopenic obesity are further issues which EC survivors face.<sup>17-20</sup> Sarcopenia is defined as a “loss of skeletal muscle mass and function.”<sup>21</sup> At diagnosis, incidence rates of sarcopenia have been reported to be as high as 75% among EC patients<sup>22</sup> and the prevalence rises throughout the process of neoadjuvant therapy and into survivorship.<sup>18,23,24</sup> Its presence is strongly linked with poor health-related quality of life (HRQOL), particularly impacting physical and functional capacities.<sup>25</sup>

Existing evidence shows that EC survivors have reduced HRQOL versus their disease-free counterparts, patients with other forms of cancer, and those yet to undergo treatment.<sup>9,15</sup> Poor nutritional status and ongoing

NIS, as described above, can significantly impact QOL. Bennett *et al.*<sup>15</sup> used measures such as hand grip strength, malabsorption, DS, and gastrointestinal issues to assess HRQOL in EC survivors. NIS was widespread among the survivors. Over 40% of survivors reported two or more symptoms associated with their surgery 6 months postoperatively, with over one-third still experiencing symptoms after 1 year. Further, the study showed that an increased burden of gastrointestinal symptoms was predictive of reduced HRQOL.<sup>15</sup> Such compromised social function can leave survivors feeling tied to the term “cancer patient” instead of “cancer survivor.”<sup>26</sup> The Lasting Symptoms after Esophageal Resection study cohort ( $n = 876$ ) reported similar findings, with 66% reporting long-standing symptoms as a consequence of their esophagectomy, including dysphagia, early satiety, abdominal pain, and gastroesophageal reflux.<sup>27</sup>

Prompt identification of malignancies and advancements in treatment options has resulted in increased numbers of cancer survivors in recent years.<sup>28</sup> According to the National Cancer Registry of Ireland, there are 1 and ½ times more cancer survivors in Ireland versus 10 years ago.<sup>2</sup> In the case of EC, some studies report that survival rates may be as high as 50%.<sup>15,29</sup> At present, there is a lack of research exploring the specific dietary needs of EC survivors. The modified digestive processes and malabsorption that EC survivors experience may lead to shortfalls in meeting nutritional requirements. In a previous study of EC survivors 18 – 24 months postoperatively, 89.7% experienced a fat-soluble vitamin deficiency. The greatest decrease was evident in Vitamins A and E, with 81.5% of the cohort presenting with Vitamin A deficiency in survivorship. Furthermore, almost half of this patient group were deficient in iron 2 years postoperatively.<sup>30</sup> Similar results were reported in other Irish and European studies.<sup>15,31,32</sup>

Research is ongoing to define the optimal diet for cancer survivors, and the role of diet, exercise, and weight control in cancer recovery and recurrence. The World Cancer Research Fund (WCRF) has completed extensive meta-analyses in this area and has produced detailed population guidelines for cancer prevention. Further, they have conducted reviews for survivors of specific cancer types, including EC.<sup>33</sup> They concluded that the literature was lacking in evidence to make specific recommendations for the prevention of recurrence of EC. In absence of clear-cut guidelines, survivors are advised to follow the Cancer Prevention Recommendations.<sup>28,33,34</sup> The WCRF score was created to generate a standardized approach to assess compliance with these recommendations and evaluate its impact on reducing cancer risk.<sup>35</sup> In the

European Prospective Investigation into Cancer and Nutrition cohort, those with the highest WCRF scores had a 34% reduced risk of death in comparison to those with the lowest scores.<sup>36</sup> The literature shows varying levels of conformity to the cancer prevention goals among survivors of breast, prostate, and colorectal cancers. In general, good adherence was observed to the red meat, alcohol, and smoking recommendations, with poor adherence to the fruit and vegetable, processed meat, fat, fiber and exercise guidelines.<sup>37,38</sup> To the best of our knowledge, no previous studies have explored adherence to the WCRF guidelines specifically among EC survivors.

Many adverse nutritional consequences occurring during EC survivorship negatively impact QOL. There are dietary guidelines designed for cancer survivors, but little is known about the specific dietary intake of EC survivors and their ability to adhere to recommendations. By identifying the specific deficits in their diet, targeted interventions could be designed to support them in living better with and beyond cancer. This study aims to explore the Irish population further by assessing the current dietary intake of a cohort of EC survivors and comparing it with population norms and the WCRF recommendations.

## 2. Data and methods

### 2.1. Participant recruitment and study design

Data were collected in St James's Hospital, Dublin between October 2021 and March 2022. The study received ethical approval from the Research Ethics Committee for Tallaght University Hospital and St James's Hospital (2020 – 10 Chairman's Action [49]).

This study sought to recruit post-esophagectomy participants after more than 12 months of treatment. To be eligible for this study, participants must have undergone a curative esophagectomy procedure for EC. They must have completed all adjuvant treatment and be considered disease-free at time of recruitment. Experience of a post-operative complication in acute recovery did not preclude participants from this study, which provided that they were resolved. Those who underwent previous gastrectomy procedure, were undergoing adjuvant treatment, or had evidence of recurrent malignancies were excluded from this study.

Participants were identified through the St James's Hospital database and invited to attend an in-person clinic and provided informed consent for data collection.

### 2.2. Clinical and anthropometric measures

Clinicopathological details were collected from the medical records. Anthropometric measurements including height

(cm), weight (kg), and waist circumference (cm) were recorded following standard protocols. Body mass index (BMI) ( $\text{kg/m}^2$ ) was calculated as per the World Health Organization guidelines.<sup>39</sup>

### 2.3. QOL and functional measures

Participants completed a series of questionnaires including the European Organization for Research and Treatment of Cancer (EORTC) QOL questionnaires, which was scored according to the EORTC protocol.<sup>40,41</sup> The Fatigue, Resistance, Ambulation, Illnesses, and Loss of weight scale was used to identify frailty,<sup>42,43</sup> and compared to reference standards.<sup>44</sup> Maximum hand-grip strength was measured using digital or manual grip dynamometer. Measurements were combined with gender to provide a functional parameter for sarcopenia.<sup>45</sup>

### 2.4. Dietary intake

Participants completed a 7-day food diary and were given detailed instructions on how to record intake. Nutritics software (education version 5.93, Nutritics, Dublin, Ireland) was used to analyze food diary data. Average intake of macronutrients and micronutrients were quantified and compared to the European Food Safety Authority (EFSA) guidelines.<sup>46</sup> Percentage intake obtained from supplementation, including single- and multi-vitamin and mineral supplements as well as contribution from oral nutritional supplements were calculated. Furthermore, nutritional intake in this cohort was compared to nutritional intake of the general disease-free population using data from the National Adult Nutrition Survey (NANS) 2011.<sup>47</sup>

To determine adherence to cancer prevention recommendations, each food diary was scored using the WCRF score.<sup>48</sup> Participants were classified as “meeting,” “partially meeting,” or “not meeting” the recommendations.<sup>35</sup> In the absence of physical activity data, a modified score of 0 – 6 was generated for each participant.

The NOVA classification was used to assess consumption of “ultra-processed” foods. This method accurately assessed and quantified the volume of fast foods and highly processed foods consumed by participants. Highest to lowest consumers of ultra-processed foods were ranked in their respective tertiles.<sup>49</sup>

### 2.5. Statistical analysis

Data were analyzed using IBM Statistical Package for the Social Sciences (SPSS) Statistics software (version 29.0.1.0 for Windows, SPSS Inc, Chicago, IL) and Nutritics (education version 5.93, Ireland). In this paper, categorical

data are presented as number of participants (*n*) and percentage (%), whereas continuous data are expressed as mean  $\pm$  standard deviation or median (interquartile range). One sample Z-tests and one sample *t*-tests were used to compare data to published reference values. In all cases,  $P < 0.05$  was considered statistically significant.

### 3. Results

#### 3.1. Participant characteristics

Participant characteristics are displayed in Table 1. Twenty-eight male post-esophagectomy patients, with a mean age of 67.4 years, were analyzed. All participants underwent an open esophagectomy with a pyloroplasty. No participant underwent re-intervention. Participants had undergone surgery at a mean time of 23 months before enrolment. More than half of the cohort reported  $>10\%$  weight loss in  $>6$  months, which is considered moderate malnutrition<sup>50</sup> and almost a third were sarcopenic (29.6%). In the case of tumor morphology and reported weight loss, some data were missing in the hospital database, in the case of handgrip, one participant was unable to perform the activity.

#### 3.2. Dietary intake of EC survivors compared to population norms and European recommendations

Table 2 demonstrates that this group of EC survivors consume significantly lower total amounts of energy in comparison to the general population (1794 kcal versus 2347 kcal,  $P < 0.01$ ), as well as lower amounts of protein, fat, carbohydrate, sugar, fiber, and calcium. When analyzed as a percentage of energy, the macronutrient intake of the EC survivors was similar to the general population. This group of survivors also had decreased alcohol consumption compared to the general population.

When comparing data to the EFSA Dietary Reference Values, optimal intake is achieved in four micronutrients: Vitamin A, folate, B<sub>12</sub>, and iron. Suboptimal intake is evident for fiber, calcium, Vitamin E, Vitamin K, Vitamin C, and copper. With respect to Vitamin D, the EC cohort had a significantly higher intake than adult males in NANS (10.4  $\mu\text{g}$  vs. 4.7  $\mu\text{g}$ ,  $P \leq 0.01$ ), but levels did not reach the EFSA Population Reference Intake.

Our patient cohort was divided into those  $<2$  years post-surgery and those  $>2$  years post-surgery, and data analysis showed no difference in macronutrient intake. The participants that were 2 years post-surgery had significantly lower intakes of Vitamin C (49.5 mg vs. 121.5 mg,  $P = 0.01$ ), Vitamin D (4.1  $\mu\text{g}$  vs. 13.7  $\mu\text{g}$ ,  $P = 0.02$ ), Vitamin E (4.9 mg vs. 14.8 mg,  $P = 0.01$ ), and Vitamin K (19.5  $\mu\text{g}$  vs. 51.3  $\mu\text{g}$ ,  $P = 0.03$ ), with a trend toward lower iron intakes (8.9 mg vs. 13.8 mg,  $P = 0.06$ ).

**Table 1. Participant demographic, clinicopathological, and anthropometric details**

| Variable  | Participants ( <i>n</i> =28) (%) |
|---|----------------------------------|
| Gender, <i>n</i> (%)  |                                  |
| Male  | 28 (100)                         |
| Female  | 0 (0)                            |
| Participant age on recruitment (years)  | 67.4 $\pm$ 9.5                   |
| Employment status, <i>n</i> (%)   |                                  |
| Working   | 16 (57.1)                        |
| Retired   | 11 (39.2)                        |
| Out of work   | 1 (3.6)                          |
| Current medications, <i>n</i> (%)   |                                  |
| Proton-pump inhibitors  | 20 (71.4)                        |
| Pancrelipase  | 2 (7.1)                          |
| Domperidone   | 6 (21.4)                         |
| Colesevelam   | 0 (0)                            |
| Multivitamin and mineral  | 19 (67.9)                        |
| Oral nutrition supplements  | 4 (14.3)                         |
| Type of surgery <sup>i</sup> , <i>n</i> (%)                                       |                                  |
| Transhiatal esophagectomy   | 7 (31.8)                         |
| 2-stage esophagectomy   | 15 (68.2)                        |
| Time since surgery (months)   | 23.1 $\pm$ 10.2                  |
| Tumor morphology <sup>i</sup> , <i>n</i> (%)                                      |                                  |
| Adenocarcinoma  | 21 (95.5)                        |
| Squamous cell carcinoma   | 1 (4.5)                          |
| Current body mass index (kg/m <sup>2</sup> ), mean $\pm$ SD                       | 25.5 $\pm$ 3.5                   |
| Classification of current body mass index, <i>n</i> (%)                           |                                  |
| Underweight   | 1 (3.6)                          |
| Normal weight   | 11 (39.3)                        |
| Overweight  | 13 (46.4)                        |
| Obese   | 3 (10.7)                         |
| Preoperative body mass index (kg/m <sup>2</sup> ), mean $\pm$ SD                  | 28.6 $\pm$ 4.1                   |
| Reported weight loss $\geq 10\%$ in past $>6$ months <sup>ii</sup> , <i>n</i> (%) |                                  |
| Yes   | 12 (57.1)                        |
| No  | 9 (42.9)                         |
| Waist circumference (cm), mean $\pm$ SD   | 96.0 $\pm$ 11.3                  |
| Frailty score, <i>n</i> (%)   | 0.9 $\pm$ 1.2                    |
| Robust health status (non-frail)  | 13 (46.4)                        |
| Pre-frail health status   | 13 (46.4)                        |
| Frail health status   | 2 (7.2)                          |
| Hand grip <sup>iii</sup> , mean $\pm$ SD  |                                  |
| Maximum hand grip strength, right hand (kg)                                       | 41.0 $\pm$ 17.7                  |
| Maximum hand grip strength, left hand (kg)  | 38.8 $\pm$ 18.6                  |
| Sarcopenia (maximum hand grip strength 27 kg), <i>n</i> (%)                       | 8 (29.6)                         |

Notes: Categorical data are presented as number of participants and percentage (*n* [%]). Continuous data are expressed as mean $\pm$ standard deviation (SD). <sup>i</sup>Data available from hospital database for 22 participants.

<sup>ii</sup>Data available from hospital database for 21 participants. <sup>iii</sup>Data available for 27 participants who were able to complete hand grip dynamometry.



**Table 2. Average nutritional intake of the current cohort compared to EFSA's dietary reference values and intakes of Irish males from the NANS**

| Nutrient                         | Population reference intake (EFSA) <sup>46</sup> | Average intakes of this cohort (n=28) | Average intakes of Irish males (NANS) (n=740) <sup>47</sup> | P-value |
|----------------------------------|--|---------------------------------------|---|---------|
|                                  |  | Mean±SD                               | Mean±SD   |         |
| Energy (kcal/day)                |  | 1794±510                              | 2350±659  | <0.01   |
| Protein (g/day)                  | 0.8 g/kg   | 81.1±40.5                             | 98.1±28.3   | <0.01   |
| Protein (% of energy)            |  | 18.1%                                 | 16.7%   |         |
| Fat (g/day)                      |  | 73.0±28.5                             | 89.9±32.3   | 0.01    |
| Fat (% of energy)                | 20.0 – 35.0%                                     | 36.6%                                 | 34.4%   |         |
| Carbohydrate (g/day)             |  | 187.7±48.3                            | 260.2±84.6  | <0.01   |
| Carbohydrate (% of energy)       | 45.0 – 60.0%                                     | 41.9%                                 | 44.3%   |         |
| Alcohol (g/day)                  |  | 9.5±14.3                              | 21.5±30.1   | 0.04    |
| Sugars (g/day)                   |  | 70.8±24.1                             | 100.3±48.7  | <0.01   |
| Fiber (g/day)                    | 25.0 g   | 14.4±5.4                              | 20.9±8.6  | <0.01   |
| Calcium (mg/day)                 | 950.0 mg/day                                     | 835.1±413.6                           | 1038.2±4  | 0.01    |
| Iron (mg/day)                    | 11.0 mg/day                                      | 15.3±11.8                             | 15.4±13.4   | 0.95    |
| Zinc (mg/day)                    | 12.9 mg  | 11.3±5.6                              | 11.6±5.5  | 0.5     |
| Copper (mg/day)                  | 1.6 mg*  | 1.3±1.1                               | 1.4±1.0   | 0.54    |
| Vitamin C (mg/day)               | 110.0 mg   | 88.2±63.4                             | 112.3±151.1   | 0.4     |
| Vitamin B <sub>12</sub> (µg/day) | 4.0 µg*  | 6.3±3.5                               | 7.2±6.6   | 0.47    |
| Folate (µg/day)                  | 330.0 µg DFE/day                                 | 500.7±924.1                           | 409.9±279.0   | 0.09    |
| Vitamin A (µg/day)               | 750.0 µg RE/day                                  | 1106.4±625.3                          | 1176.9±974.6  | 0.73    |
| Vitamin D (µg/day)               | 15.0 µg  | 10.4±10.3                             | 4.7±6.8   | <0.01   |
| Vitamin E (mg/day)               | 13.0 mg*   | 11.1±8.6                              | 11.3±22   | 0.97    |
| Vitamin K (µg/day)               | 70.0 µg*   | 40.5±35.9                             |   |         |

\*Denotes average intake measures.

Abbreviations: DFE: Dietary folate equivalents; EFSA: European Food Safety Authority; NANS: National Adult Nutrition Survey; RE: Retinol equivalent.

Table 3 shows that 19 participants supplemented their diet with a single- or multi-vitamin/mineral supplement, and/or oral nutritional supplements. Supplement consumption contributed to a notable proportions of Vitamin A (41.6%), Vitamin D (65.6%), Vitamin K (46.3%), and folic acid (42.1%) intake.

### 3.3. Dietary quality in EC survivors

As seen in Table 4, this cohort of EC survivors achieved an average WCRF score of 2.99 (range 1.75 – 5.00) out of a possible 6. Less than half of participants (46.4%) achieved the “waist circumference” goal, and 11 of the 28 participants were compliant with the “BMI” recommendation.

Participants of this study consumed on average, 270 g of processed meat, 376 g of red meat, 1932 g of ultra-processed food each week, and 118 g of fruit and vegetables each day. The “fruit and vegetable” recommendation was the dietary recommendation most poorly adhered to, with

**Table 3. Contribution of supplements to micronutrient intakes**

| Micronutrient           | Total intake, mean±SD |
|-------------------------|-----------------------|
| Folic acid              | 42.1±22.8             |
| Calcium                 | 16.0±12.3             |
| Iron                    | 37.1±23.9             |
| Zinc                    | 35.5±18.0             |
| Vitamin B <sub>12</sub> | 32.1±21.5             |
| Vitamin A               | 41.6±23.7             |
| Vitamin D               | 65.6±27.2             |
| Vitamin E               | 32.1±30.5             |
| Vitamin K               | 46.3±32.3             |
| Copper                  | 17.0±18.3             |
| Vitamin C               | 28.1±24.6             |

Notes: Supplement users (n=19).

only one participant (3.57%) meeting the recommendation of 400 g/day. Poor compliance with the “meat and

Table 4. Scoring of the EC survivors' adherence to the WCRF recommendations using the WCRF scoring system

| Participant                   | BMI         | Waist circumference | Fruit and vegetables | Fiber       | Alcohol    | Ultra-processed food | Sugar-sweetened beverages | Red and processed meat | Total score |
|-------------------------------|-------------|---------------------|----------------------|-------------|------------|----------------------|---------------------------|------------------------|-------------|
| 1001                          | 0.25        | 0.25                | 0                    | 0           | 0.5        | 1                    | 1                         | 0                      | 3.00        |
| 1002                          | 0.5         | 0.5                 | 0                    | 0           | 0          | 1                    | 0.5                       | 0                      | 2.50        |
| 1003                          | 0.5         | 0.5                 | 0                    | 0           | 1          | 0.5                  | 1                         | 1                      | 4.50        |
| 1006                          | 0.5         | 0.5                 | 0                    | 0.25        | 0.5        | 0.5                  | 1                         | 0                      | 3.25        |
| 1010                          | 0.5         | 0.5                 | 0.25                 | 0.25        | 0.5        | 1                    | 1                         | 0                      | 4.00        |
| 1013                          | 0.5         | 0.25                | 0                    | 0           | 1          | 0.5                  | 0                         | 0                      | 2.25        |
| 1014                          | 0.25        | 0.25                | 0                    | 0           | 0.5        | 1                    | 1                         | 0                      | 3.00        |
| 1016                          | 0.25        | 0.5                 | 0.25                 | 0.25        | 0.5        | 1                    | 0.5                       | 0                      | 3.25        |
| 1017                          | 0.5         | 0.5                 | 0                    | 0.25        | 0.5        | 1                    | 1                         | 0                      | 3.75        |
| 1019                          | 0.5         | 0.5                 | 0                    | 0           | 0.5        | 0                    | 0.5                       | 0                      | 2.00        |
| 1020                          | 0.25        | 0                   | 0                    | 0           | 0.5        | 1                    | 1                         | 0                      | 2.75        |
| 1021                          | 0.25        | 0.5                 | 1                    | 0.25        | 0.5        | 1                    | 1                         | 0                      | 4.50        |
| 1022                          | 0.25        | 0.25                | 0                    | 0           | 0.5        | 1                    | 1                         | 0                      | 3.00        |
| 1023                          | 0           | 0                   | 0                    | 0           | 0.5        | 1                    | 1                         | 0                      | 2.50        |
| 1024                          | 0.25        | 0                   | 0                    | 0           | 1          | 1                    | 0                         | 0                      | 2.25        |
| 1025                          | 0.5         | 0.5                 | 0                    | 0           | 1          | 1                    | 1                         | 1                      | 5.00        |
| 1029                          | 0.25        | 0                   | 0                    | 0           | 1          | 1                    | 0.5                       | 0                      | 2.75        |
| 1030                          | 0           | 0                   | 0                    | 0.25        | 0.5        | 1                    | 1                         | 0                      | 2.75        |
| 1032                          | 0           | 0.5                 | 0                    | 0           | 1          | 0.5                  | 1                         | 0.5                    | 3.50        |
| 1033                          | 0           | 0                   | 0                    | 0           | 1          | 0.5                  | 1                         | 0                      | 2.50        |
| 1040                          | 0.25        | 0                   | 0                    | 0           | 0.5        | 1                    | 1                         | 0                      | 2.75        |
| 1041                          | 0.25        | 0.25                | 0                    | 0           | 1          | 1                    | 0.5                       | 0                      | 3.00        |
| 145a                          | 0.5         | 0.5                 | 0                    | 0           | 1          | 0.5                  | 1                         | 0                      | 3.50        |
| 150a                          | 0.25        | 0.25                | 0                    | 0.25        | 0.5        | 0                    | 0.5                       | 0                      | 1.75        |
| 152a                          | 0.25        | 0                   | 0                    | 0.25        | 0.5        | 0.5                  | 1                         | 0                      | 2.50        |
| 154b                          | 0.25        | 0.5                 | 0                    | 0.25        | 0.5        | 0.5                  | 1                         | 0                      | 3.00        |
| 156b                          | 0.5         | 0.25                | 0                    | 0.25        | 0.5        | 1                    | 1                         | 0                      | 3.50        |
| 158b                          | 0.5         | 0.5                 | 0                    | 0.25        | 0          | 0                    | 0                         | 0                      | 1.25        |
| Total score, mean±SD          | 0.31±0.18   | 0.29±0.22           | 0.05±0.2             | 0.1±0.12    | 0.63±0.29  | 0.75±0.35            | 0.79±0.35                 | 0.1±0.27               | 2.99±0.81   |
| Meeting recommendation, n (%) | 11 (39.29%) | 13 (46.4%)          | 1 (3.57%)            | 11 (39.29%) | 9 (32.14%) | 17 (60.71%)          | 19 (67.86%)               | 2 (7.14%)              | 0 (100%)    |

Notes: Green indicates meeting recommendations; Orange indicates partially meeting recommendations; Red indicates not meeting recommendations. Abbreviations: EC: Esophageal cancer; WCRF: World Cancer Research Fund.

processed meat” was also evident, with only 2 participants (7.14%) meeting recommendations. Good compliance was observed to the recommendation for limiting sugar sweetened beverages, with 67.86% of study participants observing this recommendation. Less than 40% of study participants met fiber recommendations. A little over 60% of study participants were classified in the lower tertile regarding ultra-processed food consumption.

### 3.4. QOL in EC survivors

Table 5 demonstrates QOL scores in this cohort of survivors in comparison to the general population, cancer patients in general, and male EC patients. Of note, global QOL scores within this cohort were comparable to the general population, with this group scoring higher than male EC patients, and cancer patients in general. Their physical function was lower than the general population,

**Table 5. Quality of life scores in the current cohort compared to general population, all cancer patients, and male EC patients**

| Quality of life variable <sup>i</sup> | Current cohort's score ( <i>n</i> =27) | Population reference score <sup>ii</sup> |                     |                    |
|---------------------------------------|--|--|---------------------|--------------------|
|                                       |  | General population                       | All cancer patients | Male EC patients   |
| Global quality of life scores         | 75.9 (33.3–100.0)                      | 75.0 (58.3–83.3)                         | 66.7 (50.0–83.3)    | 58.3 (41.7–75.0)   |
| Physical function score               | 85.4 (33.3–100.0)                      | 100.0 (86.7–100.0)                       | 80.0 (66.7–93.3)    | 86.7 (66.7–100.0)  |
| Role function score                   | 78.4 (0.0–100.0)                       | 100.0 (70.8–100.0)                       | 83.3 (50.0–100.0)   | 83.3 (50.0–100.0)  |
| Emotional function score              | 85.2 (16.7–100.0)                      | 76.3±22.8                                | 71.4±24.2           | 72.3±23.2          |
| Cognitive function score              | 74.7 (0.0–100.0)                       | 100.0 (83.3–100.0)                       | 83.3 (66.7–100.0)   | 100.0 (66.7–100.0) |
| Social function score                 | 80.2 (16.7–100.0)                      | 87.5±22.9                                | 75.0±29.1           | 76.8±27.5          |
| Fatigue score                         | 38.7 (0.0–88.9)                        | 22.2 (0.0–33.3)                          | 33.3 (11.1–55.6)    | 33.3 (11.1–55.6)   |
| Nausea and vomiting score             | 13.6 (0.0–50.0)                        | 0.0 (0.0–0.0)                            | 0.0 (0.0–16.7)      | 0.0 (0.0–33.3)     |
| Pain score                            | 21.0 (0.0–100.0)                       | 0.0 (0.0–33.3)                           | 16.7 (0.0–50.0)     | 16.7 (0.0–33.3)    |
| Dyspnea score                         | 25.9 (0.0–100.0)                       | 11.8±22.8                                | 21.0±28.4           | 18.5±26.6          |
| Insomnia score                        | 26.9 (0.0–100.0)*                      | 21.8±29.7                                | 28.9±31.9           | 28.9±32.8          |
| Appetite loss score                   | 22.2 (0.0–100.0)                       | 0.0 (0.0–0.0)                            | 0.0 (0.0–33.3)      | 33.3 (0.0–66.7)    |
| Constipation score                    | 6.2 (0.0–33.3)                         | 0.0 (0.0–0.0)                            | 0.0 (0.0–33.3)      | 0.0 (0.0–33.3)     |
| Diarrhea score                        | 28.4 (0.0–100.0)                       | 7.0±18.0                                 | 9.0±20.3            | 7.0±18.2           |
| Financial difficulty score            | 14.8 (0.0–100.0)                       | 0.0 (0.0–58.33)                          | 0.0 (0.0–33.3)      | 0.0 (0.0–33.3)     |

Notes: \**n*=26. <sup>i</sup> Data are displayed as number of participants and percentage (*n* [%]), mean±standard deviation, or median (interquartile range).

Variables are scored on a scale of 0 – 100, where 100 represents greater quality of life/function, or higher severity/interference of symptoms. <sup>ii</sup>Population reference values taken from the EORTC C30 reference manual. 44 Complete QOL data available on *n*=27 participants.

Abbreviations: EC: Esophageal cancer; QOL: Quality of life.

but comparable to cancer patients in general. Some symptom scores were higher in this sample than the general population, including nausea and vomiting, constipation, diarrhea, dyspnea, fatigue, pain, and appetite loss scores. In the case of nausea and vomiting, dyspnea, and diarrhea, these scored below the EORTC Thresholds for Clinical Importance,<sup>51</sup> indicating a clinically relevant issue.

## 4. Discussion

Despite the growing population of EC survivors in recent years,<sup>52</sup> little is known about the quality of their diet.<sup>9,53,54</sup> To the best of our knowledge, this study is the first to explore dietary intake among EC survivors in Ireland and compare it against the same parameter of the general population and the WCRF cancer prevention recommendations.

### 4.1. Dietary quality in EC survivors

When considering their diet as a whole, the EC survivors appeared to have a lower intake of energy and macronutrients compared to the general population; however, the dietary composition is similar to the Irish population when examining percentage intake of each macronutrient. This lower reported energy intake does not reflect the fact that over half of the cohort was overweight or obese, underscoring the possibility of under-reporting. Persistent weight loss is common in EC survivors,<sup>30,55</sup> and

in the present study, >57% reported losing >10% weight in 6 months. Thus, it is possible that the intakes reported are accurate and they are in negative energy balance.

With respect to micronutrient status, this cohort had similar intakes of iron, zinc, copper, Vitamins A, B<sub>12</sub>, and E intake when compared to the general population, with significantly higher intakes of folate and Vitamin D. This higher intake is likely driven by supplement use as evidenced by 19 of 28 participants consuming one or more supplement. Micronutrient deficiency is common in EC survivors;<sup>30,32</sup> thus, the observation of higher intakes among this cohort is encouraging, although Vitamin D intake still did not meet the requirement of EFSA Population Reference Intake. It must also be noted that with increasing time, levels of Vitamins C, D, E, and K, and iron reduced, likely driven by reduced supplement use, given that only three individuals >2 years post-surgery were still taking a multivitamin/mineral complex. This confirms the need for longer-term support for EC survivors to ensure continuity of nutrition education and dietary adequacy.

In terms of food intake and dietary quality as per the WCRF recommendations, this cohort scored particularly poorly in the fiber, fruit, and vegetable and red and processed meat categories. This cohort consumed significantly less fiber daily than the general population

(14.41 g vs. 20.9 g), and this is likely influenced by the lack of compliance with fruit and vegetable recommendations. The average daily intake of fruit and vegetables in this cohort was 118 g, 38.5% less than the average intake of the Irish adult population reported by NANS (192 g).<sup>47</sup> Poor adherence to the red and processed meat recommendation was largely influenced by overconsumption of processed meat, with an average consumption of 270 g/week. Specific information regarding the intake of processed meat among the general population is lacking, but considering the average daily gram intake of ham, bacon, and sausages alone among the males in NANS data (60.12 g), it may be inferred that the adult Irish population are similarly over consuming processed meat.<sup>47</sup>

On a positive note, the findings of this study indicate that EC survivors consume less alcohol than the general Irish population (9.53 g vs. 21.50 g). This may be a result of postoperative advice to avoid alcohol as it may trigger hypoglycemic events or perhaps a reduced tolerance of alcohol postoperatively.<sup>56</sup>

#### 4.2. What influences ongoing dietary patterns in EC survivors?

Within the literature, there is a lack of specific evidence concerning food choices of EC survivors and the reasoning behind them; however, reasonable hypotheses can be made based on clinical observations.

After surgery, patients are advised to follow a high-protein and high-calorie (HPHC) diet to curb weight loss and help them through recovery.<sup>14</sup> Habits learned from post-operative recommendations may continue into survivorship, leading to continued consumption of HPHC foods, such as red meat, processed meat, and ultra-processed foods, as well as avoidance of lower-calorie foods such as fruit and vegetables. While some EC survivors experience persistent weight loss and malabsorption as they progress through the cancer care continuum,<sup>30,55</sup> others have a normal or high BMI, as was evident among participants in this study and other EC survivors reported in literature.<sup>57</sup> Inappropriate continuation of a HPHC diet in survivorship could lead to excessive weight gain or maintenance of a high BMI, which is unfavorable for preventing cancer recurrence and all-cause mortality.<sup>58</sup>

In addition, patients may have aversions to specific foods due to fear around recalled difficulties experienced preoperatively.<sup>14</sup> Dysphagia may be a common source of fear. Many fruits and vegetables are considered “high-risk” foods for dysphagic patients, due to their stringy, crunchy, or fibrous texture, which may promote dysphagia or choking episodes,<sup>59</sup> giving further reasoning to the low fruit and vegetable consumption in this cohort. In addition,

gastro-esophageal reflux, wind, and belching often remain problematic in EC survivorship.<sup>15,60,61</sup> This may influence the intake of foods considered to be “gas-producing,” such as cruciferous vegetables and legumes,<sup>62,63</sup> and also carbonated drinks,<sup>64</sup> which may be why positive adherence to reduced consumption of sugar-sweetened beverage was observed in this cohort.

Varying levels of conformance with the guidelines have been reported in other studies of cancer survivors. In a study from the Netherlands, colorectal cancer survivors scored an average of 3 out of 7 points, with low levels of adherence to the red and processed meat and fiber recommendations, comparable to the findings of this present study.<sup>65</sup> A Spanish study of 420 breast cancer survivors similarly showed poor compliance with the WCRF guidelines, scoring an average 3.9/7 points. Of interest, while this Spanish study showed comparable poor adherence to the red and processed meat and fiber recommendations, there was good adherence to the fruit and vegetable recommendation with an average compliance of 73%.<sup>66</sup> It is believed that impact of population norms may be at play here, as Spaniards typically follow a Mediterranean-styled diet and on average consume more fruit and vegetables than the general Irish population (336 g vs. 192 g).<sup>47,67</sup> Studies have also demonstrated that a lack of education, low household income, old age, and presence of chronic disease are barriers to meeting the guidelines,<sup>68-70</sup> whereas social support and positive self-reported health enhance adherence to guidelines.<sup>71</sup>

It must be considered that in order for the diet of EC survivors, and cancer survivors in general, to improve, the habitual diet of the population must align with healthy eating principles. In Ireland, adherence to the WCRF dietary guidelines among the general population is unknown; however, a recent study of healthy older adults (aged >50 years) indicated that there was poor adherence to the Mediterranean diet, which resembles the dietary style recommended by the WCRF. Of note, the recommendations for intakes of monounsaturated fats, fruit, nuts, legumes, and fish were not achieved, and adherence was poorer among males.<sup>72</sup> Reviewing current population-based dietary guidelines and ensuring they align with WCRF dietary principles, while addressing the established barriers, could support cancer survivors in transitioning toward diets more aligned with the goals of cancer prevention and all-cause mortality reduction.

#### 4.3. Consequences of poor dietary intake

The WCRF recommendations are designed to optimize health with the aim of preventing cancer and other chronic diseases. Furthermore, population nutrition guidance is aimed at preventing nutritional deficiencies and excesses.



Not meeting these recommendations may indicate the presence of poor health status and increased disease risk. The observations in this current cohort of low levels of fiber, calcium, Vitamins C, D, E, and K may be negatively impacting their nutritional function and status.

Malnutrition may manifest as over- or under-nutrition and the literature indicates high levels of weight loss and undernutrition in EC survivors.<sup>30,73-75</sup> In this cohort, both significant weight loss and high BMI were present, along with evidence of sarcopenia in almost 30% of participants. This underscores the need for detailed anthropometric assessments in this cohort to detect malnutrition and sarcopenic obesity.<sup>19,20</sup> Further, notable functional deficits were evident. This cohort were still struggling with pain, fatigue, constipation, diarrhea, nausea, and vomiting, after an average of 23 months post-surgery. In addition, they reported reduced physical function scores in comparison to the disease-free population, and most QOL scores fell below thresholds of clinical importance, indicating a clinically relevant issue.

Providing ongoing dietary education to EC survivors throughout recovery may help to improve their nutritional status, and in turn physical function and QOL. Further, supporting survivors to achieve the WCRF dietary recommendations will not only reduce the risk of cancer recurrence, but also decreases the risk of other chronic illnesses.<sup>34,58,76-81</sup>

#### 4.4. Dietary education for EC survivors

Participants of this study did not explicitly receive education about dietary recommendations in long-term survivorship. This is standard within the Irish healthcare system, with post-esophagectomy patients typically attending 1 – 2 dietetic appointments in the 1 – 6-month periods postoperatively. Within these consultations, advice is mainly centered around managing acute symptoms. Emphasis is not placed on discussing the optimal diet beyond the immediate post-operative recovery due to time constraints.

While the National Clinical Guideline for the Diagnosis, Staging and Treatment of Patients with Esophageal or Esophagogastric Junction Cancer recommends “early referral to a specialist dietitian,”<sup>82</sup> it fails to elaborate regarding aims, objectives, frequency, or time allocation for these consultations. Further, there is no national dietetic care plan in place to educate and support EC survivors long-term in their recovery.

St James’s Hospital is the National Esophageal and Gastric Cancer Center. In 2018, a nutrition survivorship clinic was established at this center with aim to enhance recovery and QOL for post-esophagectomy patients.

A clinical specialist dietitian was appointed to assess patients at 6 and 12 months postoperatively and if severe malabsorption or reactive hypoglycemia was observed, patients were provided specific, specialized dietetic support.<sup>83</sup> While this service is welcome and targets troublesome symptomatic issues, it would not address optimal dietary intake in survivorship. As the sample in this present study consists mainly of individuals who are seemingly “healthy” and “recovered,” with a normal, overweight, or obese BMI and minimal acute issues, they would not qualify for this additional nutrition counseling despite experiencing dietary inadequacies as demonstrated in the study results.

Dietary education for EC survivors can be executed in tandem with other programs. Multidisciplinary rehabilitation programs such as the Rehabilitation Strategies Following Esophagogastric Cancer (ReStOre) trial can encourage adherence to the cancer prevention guidelines for nutrition and exercise, using peer support and encouraging self-management. The results of this clinical trial have demonstrated significant improvements in QOL and physical performance.<sup>84</sup>

#### 4.5. Strengths and limitations

Strengths of this study include the volume of dietary data collected and analyzed. Detailed 7-day food diaries were collected, which are the gold standard for assessing habitual dietary intake. Further, comparisons were made to multiple standards, *that is*, EFSA, NANS, and the WCRF cancer prevention guidelines.

Small sample size and an entirely male cohort are two of the limitations of this study. The demographic makeup of this sample was not representative of the EC survivor population; therefore, findings should be interpreted carefully. Furthermore, food diaries were self-recorded by the participants, posing a concern regarding the reporting accuracy.

#### 5. Conclusion

This study has identified several dietary deficits among EC survivors, namely, fiber, calcium, and Vitamins C, D, E, and K. Furthermore, this cohort demonstrated poor compliance with the WCRF cancer prevention guidelines, particularly fruit and vegetable intake and red and processed meat intake. Of note, this lack of adherence to healthy eating advice is reflected in the general Irish diet, possibly demonstrating the influence of societal norms on eating patterns of EC survivors. In addition, in this cohort, functional and physical deficits were reported, which may be in part a consequence of their less-than-optimal dietary intake.

It is evident that EC survivors have a distinct set of dietary needs. Dietary advice to patients should continue throughout the continuum of cancer care and demonstrate a clear shift from managing immediate post-operative symptoms and issues such as nausea, bloating, and pain to optimizing dietary intake for achieving cancer prevention and chronic disease prevention.<sup>85</sup> Further, our findings underscore the need for a national care plan with a focus on nutrition education and rehabilitation for EC survivors in Ireland.

## Acknowledgments

The authors wish to acknowledge the participants for their time and willingness to complete this study.

## Funding

None.

## Conflict of interest

The authors declare that they have no competing interests.

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## Ethics approval and consent to participate

The study received ethical approval from the Research Ethics Committee for Tallaght University Hospital and St James's Hospital (2020 – 10 Chairman's Action [49]).

## Consent for publication

All participants were provided with a detailed participant information leaflet that outlined how data would be handled, anonymized, stored, and destroyed. Participants were advised that the results of this study will be published in medical journals and presented at research conferences and in all cases, their identity will remain confidential. All participants signed the consent form before proceeding with the study.

## Availability of data

Supporting data can be requested from the corresponding author on reasonable request.

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