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Original article

Engaging patients and families in nutritional monitoring: A validation study of food record charts to quantify food intake

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SUMMARY

Background & aims: Malnutrition is common in hospitalised patients and contributes to poor clinical outcomes. To support adequate nutritional intake in patients, accurate assessment of dietary food intake is critical, but it remains challenging and time-consuming. The present study aims to assess how accurate patients and family members estimate food intake using food record charts (FRCs) compared with weighed food records (WFRs).

Methods: In a cross-sectional study, 30 patients (≥18 y, Dutch-speaking, no delirium and no isolation restrictions) and 30 family members (≥18 y, Dutch-speaking, non-healthcare professionals) estimated simulated food consumption of nine different hospital meals (three breakfasts, three lunches, and three dinners) consisting of 79 different food items with FRCs, and these estimates were compared to WFRs. Subgroup analyses were performed for food consumption estimations by food item, including energy and protein content, food consistency, consumed amount, and food groups. Bland–Altman plots and inter-rater agreement were used to identify the accuracy of food intake estimation. Values are presented as mean ± SD.

Results: Food consumption estimated by patients using FRCs was comparable to food consumption measured by WFRs with a mean overestimation of 1.2 ± 8.1 % ($p = 0.178$), whereas family members overestimated intake by 2.2 ± 7.5 % with FRCs compared to WFRs ($p = 0.012$). Protein-dense products (>10 g/100 g) were underestimated by ~2 %, while products with lower consumption (<25 % consumption) were overestimated by ~8 % by patients and family members. The inter-rater agreement was $W = 0.71$ for patient FRCs ($p < 0.001$) and $W = 0.74$ for family members' FRCs ($p < 0.001$).

Conclusions: FRCs provide comparable estimates to WFRs for patients. Although family members slightly overestimated food intake (~2 %), the deviation remained within acceptable limits. Therefore, FRCs present an accurate assessment tool to quantify food consumption of hospital meals by both patients and family members. The engagement of patients and families in assessing food consumption forms an important opportunity to monitor nutritional intake during hospitalisation, rehabilitation, and at home.

1. Introduction

Malnutrition is a significant problem in hospitalised patients, with prevalence rates of up to 50 % during hospitalisation and more than 35 % at predischarge [1,2]. The risk of malnutrition is largely driven by increased breakdown of protein stores together with elevated metabolic demands, as a result of illness, as well as decreased or suboptimal food intake [3,4]. This insufficient intake is often caused by patient- and clinical-related factors, including reduced appetite, increased satiety, medication side effects (e.g.,

Abbreviations: BMI, Body Mass Index; FRCs, Food Record Charts; IQR, Interquartile range; WFRs, Weighed Food Records.

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nausea), mood disturbances (e.g., anxiety or depression), and fatigue [5,6]. In addition to patient-related and clinical factors, food intake during hospital stay is negatively impacted by hospital system and organisational factors, including meal assistance challenges (e.g. needing help eating or opening packaging), inappropriate meal times or missed meals, fasting procedures, lack of nutritional advise, or staff shortages [7–9]. As malnutrition is associated with poor outcomes, including, increased length of hospital stay and, mortality [10–13]. Therefore, adequate nutritional management is crucial to reduce the risk of malnutrition and improve patient recovery, a key component of patient treatment.

The accurate monitoring of patients' nutritional intake is essential to identify and address potential deficits during recovery from disease, during, and after hospitalisation [14–16]. Currently, the responsibility for monitoring patients' nutritional intake is most often assigned to nursing staff. Given their substantial workload, it is relevant to consider whether this task could be delegated to patients themselves or their family members. However, it is essential to first establish whether patients and their families are able to accurately estimate food intake. Previous studies indicate a poor correspondence between meals ordered or prescribed and patients' actual food intake [17–19]. Therefore, the difficulty of accurately estimating patients' nutritional requirements further complicates adequate nutritional assessment, potentially leading to misestimation of intake or needs. The challenging hospital environment and fluctuations in food consumption necessitate the need for accurate food intake monitoring. Several methods of monitoring food intake are currently available, and weighed food records (WFRs) are considered the gold standard for accuracy to measure food intake in a hospital setting [20]. However, WFRs are labour-intensive, resulting in low compliance rates and, therefore, often unsuitable for daily practice [15,20]. There is a need to explore the accuracy and feasibility of different, easy-to-use methods to quantify food consumption in hospitalised patients [21]. We have recently demonstrated that food record charts (FRCs) and digital photography are accurate methods for healthcare professionals to quantify patients' consumption of hospital meals with an overestimation of less than 5 % compared to WFRs [22].

Involving patients and their families in nutritional assessment is an emerging focus of nutrition management, thereby shifting towards more self-directed and family-centred care [23]. Patient and family involvement are especially valuable during ward transitions, such as from the ICU to the general ward or from hospital to rehabilitation centres or home. During these transitions, family members can help to prevent loss of food intake recall, as they are often involved in the preparation of meals, and, as such, support continuity of care [23,24]. Handovers during the transition of care after leaving the hospital have often been identified as lacking; leading to inadequate nutritional intake [25,26]. Self-reported FRCs could provide valuable data on dietary intake, compliance with therapy, and patient's food preferences for dietitians and healthcare providers, enabling them to offer more tailored and practical dietary advice during follow-up consultations. However, the reliability of food consumption estimation by patients and their family members remains to be investigated. The present study aims to assess the accuracy of FRCs completed by patients and family members compared to WFRs as a valid tool for monitoring daily nutritional intake.

2. Materials and methods

2.1. Study participants

This single-centre, cross-sectional study was conducted at Gelderse Vallei Hospital, a university-affiliated hospital in Ede, the Netherlands, in November 2024. Thirty in-hospital patients were recruited from the general medical and surgical hospital wards. Patients could participate in the study if they were 18 y or older, Dutch-speaking, and not delirious (as indicated by the responsible nurse) and not subject to any restrictions of isolation. In parallel, thirty family members were recruited, including direct family members of inpatients or other hospital visitors (e.g., those visiting admitted patients or attending outpatient appointments). Family members could participate if they were ≥18 y, Dutch-speaking, and did not have a healthcare professional background. Family members and visitors were recruited from the central hall of the hospital and in the general wards during patient visits. Both patients and family members were informed about the purpose of the study and provided written consent prior to its commencement.

The local medical ethics review board approved the study on 4 October 2024, and the hospital board granted its agreement to conduct the study within the proposed time frame. As the study involved a single occasion of completing a questionnaire that included non-burdensome questions, it did not fall under the scope of the Dutch Medical Research Involving Human Subjects Act (WMO). Participants' data were collected in accordance with the Personal Data Protection Act and were used anonymously for all data analysis. The participants were requested to provide information regarding their sex, age, height, and body weight. However, it was also possible for them to take part in the study without disclosing these details. In addition, data was collected on ward admission location (e.g. general medical or surgical ward). All participants received a voucher to be redeemed for a free coffee or tea at the hospital restaurant upon completion of study participation.

2.2. Study design

The study was conducted over three consecutive days, during which both patients and family members were enrolled in random order. None of the participants had prior experience completing the FRCs themselves. Participants were presented with two trays simultaneously, each containing composite meals, single food items, and drinks. Participants were then asked to quantify the amount remaining from nine hospital meals (three breakfast meals, three lunch meals, and three dinners) that were part of the actual hospital meal menu and included a variety of most ordered food items. Each meal was presented twice on separate serving trays; one contained the whole meal, and the other contained the same meal with a portion removed to simulate meal consumption. The meals were prepared and delivered by the hospital kitchen in accordance with the standard procedures used for preparing meals for inpatient consumption and the hospital's meal service system. The portion sizes that were removed (0, $^{1}/_{8}$, ¼, ½, ¾, $^{7}/_{8}$, and 1) were randomly determined using a random number generator (www.random.org). We intentionally opted to simulate patient meal consumption instead of using actual food leftovers, as this approach provides better standardisation of the simulated amounts of food consumption and eliminates the variability caused by individual preferences, appetite and satiety, and dietary restrictions, thereby enhancing the consistency and reproducibility of the study outcomes. Food items on the post-consumption trays were mixed, stirred, and cut to closely resemble how a patient's meal would appear after consumption. The portion that was removed was an estimate of the randomised portion size to simulate real food consumption, which was done by one researcher only (MCP). All meals and separate food items were weighed in duplicate by a single researcher (RF) before presentation to the study participants, using an industrial weighing scale

(*Mettler Toledo, Tiel, the Netherlands*), and documented as part of the WFR. Nutritional content, e.g. macronutrient composition, was accessible for all individual food items and composite meals via the hospital's nutrition information system, as provided by the food suppliers and the Dutch Food Consumption Database 2016 (NEVO; RIVM, Bilthoven, the Netherlands) [27]. All participants were instructed to indicate the quantity of each food item remaining from the meal by observation of the serving tray. In total, each participant scored nine meals containing a total of 79 food items (see the full description of all items in the Online Supplementary Material). No further instructions were provided, and participants were not assisted during the study to ascertain the viability of utilising FRCs in routine practice.

2.3. Food consumption estimations

To estimate the remaining quantity of each food item per meal, participants were allowed to visually and physically examine the meals and individual food items. The two serving trays, one containing the complete meal ('before consumption') and one with a portion of each food item removed ('simulated food consumption'), were presented to participants in consecutive order. Participants were asked to report the amount that was 'consumed' of each food item using an FRC form. Instructions on the use of the FRC were given orally and provided in writing on top of the form. For family members, the meal trays were presented on a table in a linear arrangement. For patients and family members on the ward, the researchers (MCP and SWvB) retrieved the trays from a food trolley in a sequential manner and presented them to the participants. The same FRC form was used for both patients and family members and comprised a seven-point scale for each food item 0, $^{1}/_{8}$, ¼, ½, ¾, $^{7}/_{8}$, and 1 equivalent to 0, 12.5, 25, 50, 75, 87.5, and 100 % (see Online Supplementary Material). A food item was scored as 'missing' if no score or multiple scores were selected from the seven-point scale. The estimates based on the seven-point scale were converted to percentages of food consumption, thereby allowing for comparison with the weighed percentages derived from the WFRs.

2.4. Statistical analyses

Data are presented as means with standard deviations (SD) when normally distributed; otherwise, data are presented as medians with interquartile ranges (IQRs). Characteristics of the participants are presented as means with SD, medians with IQRs, and frequencies with proportions (%). The accuracy of estimating food consumption was calculated using the following formula: accuracy estimated food consumption (%) = estimated food consumption with FRCs (%) - actual food consumption with WFRs (%) [28]. Beforehand, it was decided by consensus that a difference of <5 % between the two methods would be regarded as good accuracy, a difference below 10 % as acceptable, and a difference greater than 10 % as unacceptable, based upon previous work [28,29]. A Bland–Altman analysis was used to assess the level of agreement between FRCs and WFRs for all food items among both patients and family members. Additionally, inter-rater reliability was determined using the Kendall Coefficient of Concordance W, with inter-rater agreement ranging from 0 (indicating perfect disagreement) to 1 (indicating perfect agreement) [30]. A value below 0.20 was considered a poor agreement; between 0.21 and 0.40, a fair agreement; between 0.41 and 0.60, a moderate agreement; between 0.61 and 0.8, a substantial agreement; and a value above 0.81, an almost perfect agreement [31]. In cases of missing values, these were imputed using the mode for the representative food item category unless a food item had more than 10 % missing values. Pre-planned subgroup analyses were conducted based on the energy and protein content of food items, the consistency of food items, and food groups according to the Dutch Wheel of Five [32]. All calculations were performed using the statistical software SPSS (version 29.0, IBM Corp., Armonk, USA) and GraphPad Prism (version 5.04, GraphPad Software, La Jolla, California, USA). Statistical significance was set at $p < 0.05$.

3. Results

Baseline characteristics of the participants are presented in Table 1. Thirty patients (60.0 % male; 68 [55–78] y) and thirty family members (37.9 % male; 66 [54–71] y) assessed nine meals with FRCs. The body mass index (BMI) differed significantly between the groups ($p = 0.004$). In total, 4669 entries were scored for consumption estimations, with 47 missing entries in FRCs completed by patients (2.0 %), of which 22 could be attributed to a single patient who discontinued the form due to medical reasons, and 24 missing entries in FRCs completed by family members (1.0 %).

3.1. Accuracy of food record charts by patients and families

Food consumption estimated by patients using FRCs did not differ to food consumption measured by WFRs with a mean overestimation of 1.2 ± 8.1 % (95 % CI: −0.58–3.09, $p = 0.178$), whereas family members slightly overestimated intake by 2.2 ± 7.5 % (95 % CI: 0.51–3.91, $p = 0.012$). Bland–Altman plots of the two methods are presented in Fig. 1. The 95 % limits of agreement ranged from −14.8 % to 17.3 % and −12.6 %–17.1 % for the patient and family member groups, respectively. However, when assessing for proportional bias by fitting a regression line to the plot, significant slopes were observed ($B = -0.136$, $p < 0.001$) for patients and ($B = -0.098$, $p < 0.001$) for family members, respectively. This finding suggests that discrepancies between the two methods vary according to the average amount consumed. In total, 7.4 % of the food items fell outside the limits of agreement for the estimations conducted by patients and 4.6 % for the family member group.

The inter-rater agreement (Kendall's coefficient of concordance) between participants for all food item estimations taken together was $W = 0.706$ for patient FRCs ($p < 0.001$) and $W = 0.740$ for family member FRCs ($p < 0.001$).

3.2. Estimation of food consumption based on energy and protein content of food items

Food consumption estimations based on energy and protein content are presented in Table 2. For all food items, the difference in energy consumption averaged −4.6 ± 131.5 kJ for patients and +15.5 ± 78.3 kJ for family members when food consumption was estimated with FRCs compared to WFRs. For the protein content of the food item, food consumption estimations using FRCs compared to WFRs resulted in a difference of −0.01 ± 0.80 g and −0.01 0.77 g for patients and family members, respectively. In the lowest protein group (<1 g protein/100 g product), food consumption was overestimated the least, by only 0.6 ± 8.4 % by patients and 3.2 ± 6.7 % by family members using the FRCs. In more protein-dense food items (>10.1 g protein/100 g product), underestimations of 2.5 ± 5.4 % by patients and 2.3 ± 6.0 % by family members were observed using FRCs compared to WFRs.

Table 1
Characteristics of patients and family members who quantified simulated food consumption by completing food record charts (FRCs) of nine different hospital meals.

Characteristics	Patients ($n = 30$)	Family members ($n = 30$)[a]	p-value
Sex, *n* (%)			0.090
Male	18 (60.0 %)	11 (37.9 %)	
Female	12 (40.0 %)	18 (62.1 %)	
Age (y), median [IQR]	68 [55–78]	66 [54–71]	0.891
Body weight (kg), mean (SD)	79.0 (16.2)	85.7 (12.2)	0.084
BMI (kg/m^2), median [IQR]	24.7 [24.1–27.6]	28.5 [26.6–32.3]	0.004
Admitted to hospital ward, *n* (%)			
Medical	15 (50.0 %)		
Surgical	15 (50.0 %)		

[a] Baseline characteristics were available for $n = 30$ patients and $n = 29$ family members. Weight was only reported for $n = 28$ family members. BMI: body mass index, IQR: interquartile range, SD: standard deviation.

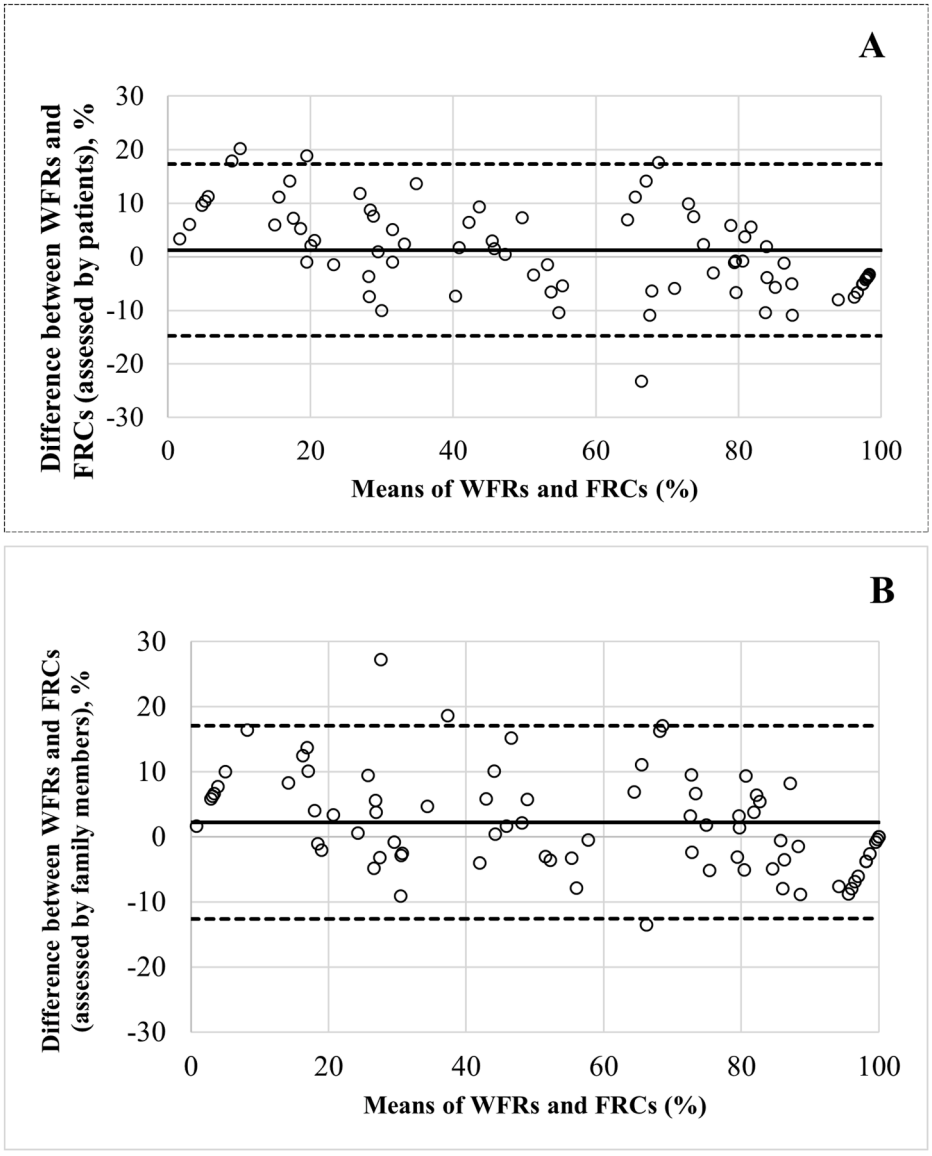

Fig. 1. Bland-Altman plot of Weighed Food Records (WFRs) and Food Record Charts (FRCs) of 79 food items, of which simulated food consumption was estimated by patients (A) and family members (B) to assess the accuracy of FRCs completed by patients and family members. Legend: black line = mean difference, dashed lines = limits of agreement = bias ± (1.96xSD) = precision. Patients (A): mean = 1.17 ± 8.05 % (ULA = 17.3 %; LLA = −14.8 %). Family members (B): mean = 2.21 ± 7.53 % (ULA = 17.1 %; LLA = −12.6 %). Each dot in the figure represents the mean estimated amount of simulated food consumption of a single food item. WFRs: Weighed Food Records; FRCs: Food Record Charts.

Table 2
Food consumption estimations of 79 food items using Food Record Charts compared to Weighed Food Records conducted by patients ($n = 30$) and family members ($n = 30$) based on protein and energy content per food item.

	Energy content of food item (kJ/100 g)				Protein content of food item (g/100 g)			
	0.0–200.0 ($n = 16$)	200.1–500.0 ($n = 22$)	500.1–1000.0 ($n = 17$)	>1000.0 ($n = 24$)	<1.0 ($n = 26$)	1.0–5.0 ($n = 17$)	5.1–10.0 ($n = 17$)	>10.0 ($n = 19$)
Difference in estimated food consumption by patients, % (SD)	+1.5 (10.4)	+3.9 (8.2)	−1.6 (6.4)	+0.5 (7.1)	+0.6 (8.4)	+4.0 (8.4)	+3.4 (9.0)	−2.5 (5.4)
Difference in estimated food consumption by family members, % (SD)	+3.2 (6.9)	+3.8 (7.4)	+0.0 (7.0)	+1.6 (8.5)	+3.2 (6.7)	+4.7 (8.8)	+3.3 (7.7)	−2.3 (6.0)

The values (% difference in food consumption) are presented as means and standard deviations (SD). Positive values refer to an overestimation of the food item, and negative values refer to an underestimation compared to Weighed Food Records. In total, 79 food items were quantified, and *n* refers to the number of food items per category. FRCs: Food Record Charts.

3.3. Estimation of food consumption based on the consumed amount of the food items

In Table 3, the estimation of simulated food consumption is presented, showing the consumed amount of food items. Of food items consumed <25 % were overestimated by 8.6 ± 6.1 % and 7.5 ± 6.6 % by patients and family members, respectively. In contrast, food items with >75 % consumption were underestimated by 4.0 ± 5.5 % and 1.8 ± 5.2 % by patients and family members, respectively.

3.4. Estimation of food consumption based on food group

In Fig. 2, the 79 food items were categorised by food groups based on the Dutch Wheel of Five developed by The Netherlands Nutrition Centre [32]. The food group 'animal products and nuts' showed the smallest difference in consumption estimations for FRCs compared to WFRs (+0.6 ± 9.6 % by patients and −0.1 ± 8.2 % by family members). The greatest difference was observed in the food group classified as 'others'; patients and family members overestimated this food group by 4.2 % ± 9.4 % and 5.5 % ± 8.3 %, respectively. Types of food items in this category were strawberry jam, applesauce, tuna salad sandwich, soup, chocolate sprinkles, gravy, salad dressing, and sugar.

3.5. Estimation of food consumption based on the consistency of food items

Food consumption estimations based on the consistency of food items are presented in Fig. 3. Liquid foods and drinks were more frequently overestimated (+4.6 ± 7.5 % by patients and +4.7 ± 6.7 % by family members) than semi-solid (+0.4 ± 8.1 % by patients and +1.3 ± 6.4 %) and solid foods (−0.02 ± 8.2 % by patients and +1.5 ± 8.3 % by family members).

4. Discussion

In the present study, we included patients and family members to quantify simulated food consumption estimations of hospital meals using FRCs. In total, nine hospital meals were analysed with FRCs and compared with simulated consumption using WFRs. Food consumption estimated by patients using FRCs did not differ to food consumption measured by WFRs, whereas family members slightly, but significantly, overestimated intake by approximately 2 %. Since both estimations remained below the predefined 5 % threshold for good accuracy, FRCs can be considered a reliable method of assessing food intake by both patients and family members.

To date, several studies have evaluated the validity of tools for monitoring food intake in hospitalised patients [15,20,22,28,29,33–35]. However, different monitoring tools have been employed in these studies, including pictures of food items and plate diagrams using various scoring scales, such as six- or 11-point scales. In most of these studies, researchers, nurses, or other clinical staff were asked to use these tools for food intake assessment [15,20,22,29,33,35]. These studies showed highly significant correlations between estimates of food intake assessed with specific monitoring tools (e.g., Pictorial Dietary Assessment Tool, plate diagram sheet, and visual estimation with an 11-point percentage scale) and WFRs employed by dietitians, nurses, and nursing and serving assistants [15,33,35]. We have previously shown that FRCs conducted by bedside nurses result in an overestimation rate of approximately 3 % [22]. In our present study, we build upon this finding by demonstrating that individuals without prior experience, such as patients and family members, can also apply FRCs to estimate food consumption, resulting in in food intake estimations deviations <5 %. Food consumption estimated by patients using FRCs did not differ to food consumption measured by WFRs, whereas family members slightly overestimated intake. These differences are only minor compared to estimates using WFRs, and while the overestimation observed by family members (~2 %) was significant, this is likely not clinically relevant. It could be that

Table 3
Food consumption estimations of 79 food items using Food Record Charts compared to Weighed Food Records by patients ($n = 30$) and family members ($n = 30$) based on the amount consumed (%) of total portion.

	0.0–25.0 % consumed ($n = 20$)	25.1 %–50.0 % consumed ($n = 16$)	50.1 %–75.0 % consumed ($n = 15$)	75.1 %–100.0 % consumed ($n = 28$)
Difference in estimated food consumption by patients, % (SD)	+8.6 (6.1)	+1.0 (6.1)	+1.2 (9.3)	−4.0 (5.5)
Difference in estimated food consumption by family members, % (SD)	+7.5 (6.6)	+2.3 (7.5)	+2.5 (8.7)	−1.8 (5.2)

The values (% difference in food consumption) are presented as means and standard deviations (SD). Positive values refer to an overestimation of simulated food item consumption, while negative values indicate an underestimation compared to Weighed Food Records. In total, 79 food items were quantified, and *n* refers to the number of food items per category. FRCs: Food Record Charts.

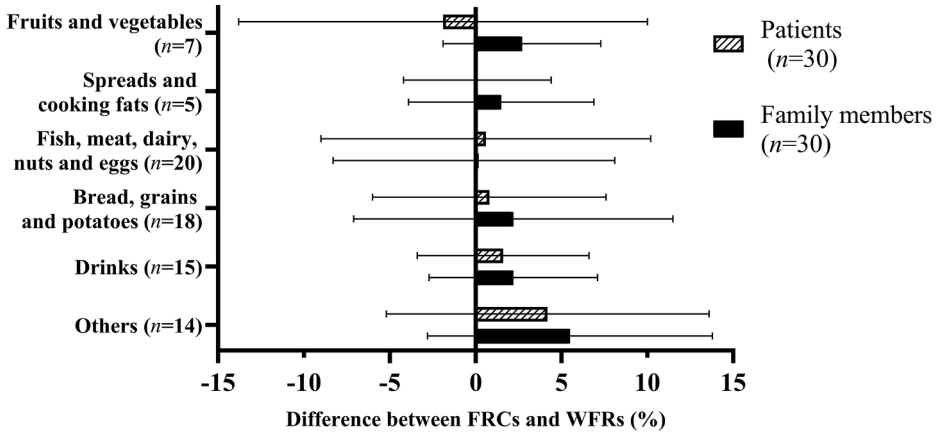

Fig. 2. Comparison of food consumption estimations for 79 food items by patients (n = 30) and family members (n = 30) using Food Record Charts (FRCs) compared to Weighed Food Records (WFRs) based on the food group. Food group categories were based on the Wheel of Five [32], developed by The Netherlands Nutrition Centre. Values (% difference of food consumption) are represented as boxplots with whiskers. Positive values refer to an overestimation of food consumption, and negative values refer to an underestimation of food consumption compared to Weighed Food Records. In total, 79 food items were quantified, and n refers to the number of food items per category. Types of food items in the 'others' category included strawberry jam, applesauce, tuna salad sandwich, soup, chocolate sprinkles, gravy, dressing, and sugar. FRCs: Food Record Charts; WFRs: Weighed Food Records.

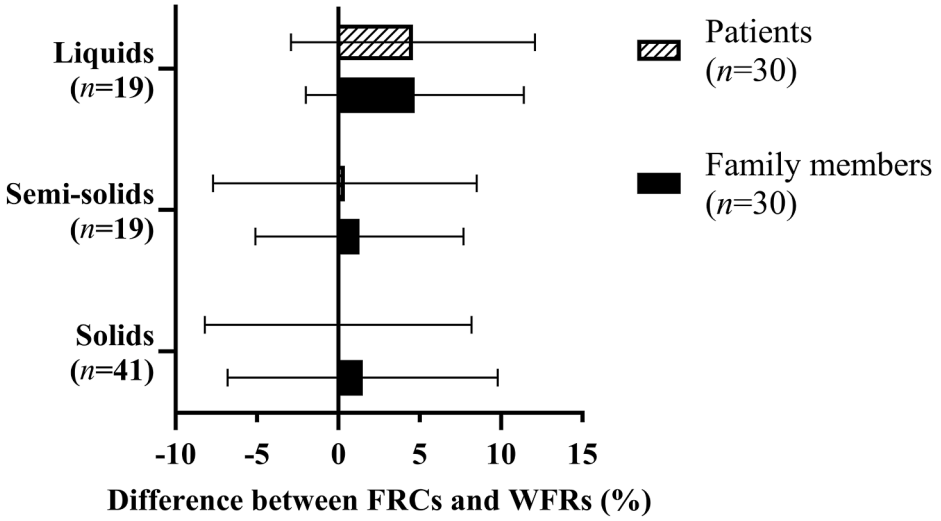

Fig. 3. Comparison of food consumption estimations for 79 food items by patients (n = 30) and family members (n = 30) using Food Record Charts (FRCs) and Weighed Food Records (WFRs) based on the consistency of food items. Values (% difference of food consumption) are represented as boxplots with whiskers. Positive values refer to an overestimation of food consumption, and negative values refer to an underestimation of food consumption compared to Weighed Food Records. n = number of food items per food consistency category (liquid, semi-solid, or solid). FRCs: Food Record Charts; WFRs: Weighed Food Records.

patients were more familiar with the displayed hospital foods compared to family members. However, the differences in food consumption estimations remain well-below the pre-established threshold of 5 % and thus can be considered indicative of good accuracy for FRCs.

In our study, there were few missing values, as each participant scored 79 items, with only 71 entries (~1.5 %) missing or invalid across all participants. This low rate of missing data further supports the feasibility and reliability of using FRCs by patients and family members in the process of conducting nutritional assessments. Our study represents an important development, as self-directed care, such as patient and family involvement, is particularly valuable during transitions of care, such as from the acute ward or ICU to a general medical ward or from a hospital to a rehabilitation centre or home, during which they can assist in providing information on food intake and therapy compliance, support continuity of care, and contribute to adequate nutrition management in the post-discharge phase [23,24]. By including patients and their families in monitoring patients' food intake, nutritional monitoring tools can be improved, as current existing tools still show low accuracy due to low compliance with dietary record completion, time pressure, and other competing priorities for healthcare staff, who are primarily responsible for monitoring patients' food intake [21]. To our knowledge, only one study has compared FRCs with WFRs completed by patients, using a visual tool with fraction circles to estimate intake [28]. This study reported a mean overestimation of 1.4 ± 15.7 % but wider limits of agreement (ULA 32.8; LLA -29.9) than observed in our study [28]. However, we also found a substantial degree of inter-rater variability among the 30 patients and 30 family members in our study. Notably, family members demonstrated a slightly higher level of agreement than patients. This discrepancy may be attributed to a more heterogeneous patient population in our cohort, with probable factors such as age and disease-related symptoms, e.g.

fatigue or impaired cognitive status potentially affecting food estimation.

Subgroup analyses were conducted to investigate whether food items with differing energy or protein densities were systematically under- or overestimated, as such misestimations may lead to biased assessments of total intake and failure to detect malnutrition. We observed no relevant differences in food consumption estimates for items with different energy densities. However, for protein content, products with a lower protein amount (<10 g protein/100 g) were typically overestimated, while products with a higher protein amount (>10 g protein/100 g) were underestimated. This aligns with our previous work, in which nurses were more likely to overestimate low-protein products than high-protein products [22]. Clinically, this is of less concern as this would result in an underestimation of total protein intake. Analyses based on the amount consumed were performed, as previous studies observed that highly consumed food items are more often overestimated, while products with low consumption are underestimated [36–38]. In contrast, we observed that food items with consumption rates <75 % were more likely to be overestimated, whereas those with higher simulated consumption (>75 %) were more often underestimated. A reason for this discrepancy may be that previous studies used digital photographs to estimate food intake rather than visual observations of food trays. In our previous work with healthcare professionals, we observed similar results, where products that were consumed in lower amounts were overestimated. Lastly, we performed analyses based on food consistency; as liquid food items have been shown to be more difficult to estimate compared to solids and semi-solids [22,39,40]. We observed that liquids were overestimated to a greater extent compared to semi-solids and solids. This observation is clinically relevant for patients on liquid or texture-modified diets, which often include oral nutritional supplements and high-protein products, and are prone to intake overestimation. Older adults in healthcare facilities, particularly those requiring texture-modified diets, are at increased risk of malnutrition due to inadequate intake, indicating that this population might require meticulous monitoring of dietary intake [41,42].

4.1. Strengths and limitations

This study has several strengths. Comparing FRCs completed by patients and family members to the gold standard of WRFs allows direct validation assessment. The use of data collected in a clinical setting enhances the practical relevance of the findings. However, several limitations must also be acknowledged. The selected composite meals and food items were not actually consumed by patients, but included pre- and post-consumption food trays to simulate food consumption in a controlled setting. Real-world clinical environments can present challenges such as interruptions and distractions during meals, and extended mealtimes, thereby affecting recall of the untouched meal prior to consumption, particularly when foods are mixed and cut during consumption. This highlights the need to develop more advanced methods for food intake estimation, such as digital food tracking or real-time monitoring, to improve accuracy and applicability in clinical settings. Additionally, in our sample, we included only patients who were able to fill out the FRCs, which might have introduced a particular aspect of selection bias (e.g. patients who were not able to fill in FRCs might be the patients who need more nutritional care, because of their illness severity or their dependency on other people for food intake). Additionally, the sample size was not based on a power calculation, but rather on a previous study conducted by our research group.

4.2. Feasibility in clinical practice

The involvement of patients and family members in using FRCs during hospitalisation requires little to no training, as participants in this study who received no prior training yet were able to complete the FRCs and accurately estimate their food intake. Findings from our work can contribute towards improving the involvement of patients and family members in nutritional assessment [23]. In this context, the use of FRCs in rehabilitation centres or care facilities has the potential to facilitate continuous patient monitoring, as it can enable daily nutritional intake monitoring even after hospital discharge. However, quantifying nutritional intake in a home setting is more challenging due to difficulties in assessing the nutritional content of prepared meals and underreporting of the number of foods [34,43]. While digital tools may improve compliance and accuracy, issues such as missing data and the challenges of translating home-prepared meals into accurate values highlight the need for improved nutritional analysis methods in both clinical and home settings [44,45]. Successful implementation of these tools also depends on engaging patients and families in nutrition care, including education on the therapeutic role of nutrition and the importance of accurate intake recording. While the present study offers opportunities for more self-directed patient care and nutritional management, further research is needed to validate the use of FRCs over multiple days for home-based meals and to assess their impact on clinical outcomes.

Technological advancements in health care offer promising opportunities to enhance the accuracy and efficiency of dietary intake monitoring in hospitalised patients and during remote assessment after hospital discharge. Related work on patient-led, technology-assisted nutrition care has shown that engaging patients through digital tools is feasible, acceptable, and cost-effective, therefore, using such approaches including real-time feedback to patients might be effective to support nutrition intake monitoring and improved achievement of nutritional goals [46]. An emerging approach involves photography before and after consumption of meals to estimate food intake. With further development, such image-based assessment methods could be integrated into nutritional management. Artificial intelligence (AI)-driven image recognition tools have the potential to automatically identify food items, estimate portion sizes, and calculate nutrient intake with minimal user input. A food intake estimation system utilising an AI–based model to estimate leftovers of liquid foods in a hospital setting was developed and validated in a clinical environment [47]. While these technologies are still in development and require validation in diverse patient populations, they may ultimately offer a scalable, low-burden alternative to traditional intake assessment methods. Future research focusing on evaluating the accuracy and feasibility of such methods in hospital and out-of-hospital environments, particularly among patients who are unable to monitor their intake themselves, is needed to explore the validity of this technology further.

4.3. Conclusions

In the present study, we demonstrated that FRCs completed by patients provided comparable estimates to WFRs and family members only slightly overestimated intake (~2 %) compared to WFRs, both remaining well below the clinically acceptable difference of <5 %. Therefore, FRCs present an accurate assessment tool to quantify simulated food consumption for both patients and family members. Food items that are poorly consumed result in larger overestimation, which can have implications for the overall estimation of food intake in patients with inadequate food intake.

The use of FRCs by patients and family members can creates new advances in nutritional food monitoring tools and strengthen patient and family engagement in nutrition support management.

Author contributions

Conceptualisation: MCP, SWvB, ARHvZ, IWKK.
Recruitment of participants: MCP, SWvB.
Data curation: MCP, SWvB.
Formal analysis: MCP, SWvB, IWKK.
Writing – Original draft: MCP, SWvB, IWKK.
Writing: Review and editing: MCP, SWvB, ARHvZ, IWKK.
Funding acquisition: ARHvZ
All authors approved the final version of the manuscript.

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Conflict of interest

ARHvZ reported receiving honoraria for advisory board meetings, lectures, research, and travel expenses from Abbott, AOP Pharma, Baxter, Cardinal Health, Danone Research and Innovation, Dutch Medical Food, Fresenius Kabi, GE Healthcare, Nestle Healthcare, PAION, and Rousselot. IWKK holds an NWO/ZonMW Veni Fellowship (2023) for a research program focused on improving nutrition support in (post)-ICU patients. All other authors have no declarations to make.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnesp.2026.102952.

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