Original Article

Identifying errors in meals provided to and sourced by patients on therapeutic diets in hospital

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Background and Objectives: Patients requiring therapeutic diets in hospital are at risk of exposer to dietary errors that may pose an acute threat to their safety. This study aimed to determine the prevalence of meal-related errors among hospitalised patients prescribed therapeutic diets, following the implementation of an electronic foodservice system (EFS). **Methods and Study Design:** This observational study involved six wards in a tertiary metropolitan hospital that used an EFS for meal ordering and plating. Participants were adult medical inpatients receiving a therapeutic diet for medical or nutritional reasons. Meal accuracy was assessed for up to 48-hours per patient by comparing the dietary items placed on patients' meal trays or personal meals consumed by patients to their therapeutic diet prescription. Inaccuracies were categorised as *critical* or *non-critical errors* and were identified as having occurred at one of four steps in the EFS: *menu planning* (main-meals), *meal assembly* (main-meals), *meal delivery* (mid- and main-meals) and *meal consumption* (personal-meals). **Results:** A total of 167 inpatients were included in the study. Of the 906 meals assessed, 69 errors (8%) were observed; with 97% classified as critical. Error rates differed according to the foodservice system step assessed: 17% for *menu planning*, <1% for *meal assembly*, 53% for *meal delivery*: main-meals, 9% for *meal delivery*: mid-meals and 33% *meal consumption*. **Conclusion:** An EFS almost completely eliminated errors associated with *meal assembly*. However, when foodservice staff and patients selected dietary items at ward level (without a guiding system) a substantial number of potentially *critical errors* occurred.

Key Words: meal accuracy, food safety, patient safety, meal delivery, specialised diets specialised

INTRODUCTION

Health care organisations aim to provide safe and quality care to their patients.[1] Despite an international focus on patient safety, approximately 10% of patients experience a preventable adverse event during their admission[2] Medication errors,[3] falls[4] and communicable/ post-operative infections[5] are the main preventable risks reported to threaten patient safety. Consequently, strategies and polices to improve patient safety often target these high-risk areas.[6,7] In addition, meal-related errors among patients prescribed therapeutic (specialised) diets may pose chronic and acute threats to patient safety.

Over extended periods, exposure to restrictive therapeutic diets may contribute to the high prevalence of protein energy malnutrition (PEM) in hospital.[8,9] While liberalising dietary restrictions and avoiding the unnecessary prescription of therapeutic diets may help reduce PEM prevalence,[10] patients are often reliant on theses diets to manage and/or improve their health.[11,12] As such, the provision of accurate therapeutic meals remains an important aspect of a patient's immediate safety.

The provision and consumption of inaccurate food or fluids by patients requiring a therapeutic diet could interfere with their medical treatment and under certain circumstances, pose a risk to their immediate health.[11-13] For example, choking or aspiration (i.e. from incorrect food texture or fluid thickness),[11] imprecise examination of the bowel (i.e. from errors in bowel preparation diets),[14] exacerbation of inflammatory bowel disease/gastrointestinal discomfort (i.e. from excessive fibre intake on a low-fibre diet)[15] or allergic reactions[16] may occur if incorrect food or fluid items are consumed. Despite this extensive list of potential consequences, a limited number of studies have investigated the accuracy of therapeutic dietary provision in medical facilities.[17,18]

A study conducted in our hospital prior to the implementation of an Electronic Foodservice System (EFS) found an error rate of 20% among meals provided to patients on therapeutic diets;[19] a finding in agreement with previous studies.[17,18] While these studies illustrate the provision of accurate meals to patients on therapeutic diets is problematic, the majority have exclusively assessed the accuracy of meal tray assembly; only one step in the foodservice system. Food assembled and delivered

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by staff at ward level or sourced by patients from outside the hospital's catering system may also contain errors that pose a risk to patient safety. Further research is therefore warranted to investigate the actual prevalence of meal errors when all steps in the foodservice system are assessed (i.e. meal planning, meal assembly, meal delivery, and personal meal consumption). Additionally, no study to date has investigated the accuracy of meals delivered to patients using an EFS. Previous work suggests EFS streamline workflow and improve patient satisfaction,[20] however it is unknown if they are also effective in decreasing meal errors.

Therefore, the present study aimed to assess the accuracy of meals provided to patients prescribed a therapeutic diet, following the implementation of an EFS. In addition, the investigation aimed to identify errors by foodservice step and diet type. Understanding the source and type of therapeutic diet errors will facilitate targeted interventions designed to improve patient safety.

MATERIALS AND METHODS

Study overview

A prospective observational study was undertaken to assess the accuracy of meals delivered to patients requiring a therapeutic diet following the implementation of an EFS. The study was approved by the relevant hospital and university Human Research Ethics Committees (reference numbers: HREC/13/QGC/162 and AHS/24/14/HREC).

Setting

The accuracy of meals delivered to patients was evaluated across six medical and surgical wards in a Queensland (Australia) tertiary metropolitan teaching hospital. The following wards were selected to maximise the potential of recruiting eligible patients: (1) gastrointestinal, (2) short stay surgical, (3) surgical, (4) neurological, (5) neurovascular, and (6) rehabilitation. A schedule was developed to ensure each day of the hospitals 14-day cyclic menu was observed, in a randomised order, on two separate occasions (i.e. totalling 28 days of data collection) over a 6 week period (February – March 2015). An EFS (Delegate Software, Australia) was in operation, whereby patients ordered meals via their personal entertainment screen at their bedside. This system ensured patients could only order foods appropriate to their prescribed therapeutic diet, eliminating the potential of errors occurring from patients ordering inaccurate dietary items. Approximately 2 hours before main-meals (i.e. breakfast, lunch and dinner) were delivered on wards, foodservice staff printed the electronic orders as 'meal tickets' (i.e. paper slips indicating the meal items ordered by individual patients) and these were used to inform the assembly of meals plated in the kitchen. Meals were plated cold and heated or kept cool in temperature-controlled delivery trolleys (Burlodge, Australia) before distribution to patients on wards. The EFS was not in operation for mid-meals, instead patients choose their mid-meals at bedside point-of-service.

Participant eligibility

Patients were eligible to participate in the study if they were: (a) able to provide informed consent (i.e. aged ≥18 years, cognitively intact, and able to speak, read and write English); (b) an inpatient for ≥24 hours prior to the commencement of data collection, to allow sufficient time for staff to enter patients' diet prescriptions into the EFS; and (c) prescribed one of 12 therapeutic diets selected for observation in the present study (refer to *Therapeutic diets* below). Patients were excluded if they were: (a) palliative or dying; (b) unable to provide informed consent and (c) previously enrolled in the study. Informed consent was obtained from all participants prior to data collection. Given the exploratory nature of this study, a sample size was not predetermined.

Therapeutic diets

The accuracy of meals delivered to patients on one or more of the following therapeutic diets was investigated: (1) clear fluids (2), free fluids, (3) low fibre, (4) low lactose, (5) low gluten, (6) low allergen, (7) soft, (8) minced and moist, (9) smooth pureed, (10) mildly thick, (11) moderately thick, and (12) extremely thick. These diets were selected for investigation as they are commonly prescribed in the acute care setting and dietary error could result in adverse patient-related outcomes (e.g. choking, aspiration and elicit an auto-immune response).[9, 11-13]

Meal accuracy

Meal accuracy was assessed using a standardised data collection form for a minimum of one main meal and a maximum of six main meals (i.e. up to 48 hours) per patient. All meals were categorised into one of four steps in the foodservice system following post hoc analysis: (1) *meal planning*, (2) *meal assembly*, (3) *meal delivery* and (4) *meal consumption*. With the exception of *menu planning*, inaccurate meals were defined as meals containing one or more incorrect therapeutic dietary items. A complete description of each foodservice step is indicated below and the protocol used to assess accuracy is displayed in Figure 1.

All inaccurate meals were further classified as *critical* or *non-critical errors*. *Critical errors* included the provision of dietary items that could pose an immediate risk to patients' health. For example, choking or aspiration (e.g. from the provision of more advanced food/fluid textures than the patient could tolerate), delay of surgery/procedure (e.g. from food or full fluids given on a clear fluid diet), exacerbation of bowel disease/gastrointestinal discomfort (e.g. from too much fibre provided on a low-fibre diet or lactose containing food given on a low lactose diet) or cause an immune response (e.g. from gluten-containing foods given on a gluten-free diet). *Non-critical errors* were defined as those that could negatively impact on a patients' nutritional intake (e.g. providing lactose free milk instead of regular milk or a pureed diet instead of soft diet).

The accuracy of hospital main-meals (breakfast, lunch and dinner) were assessed via direct observation, while the accuracy of hospital mid-meals (morning tea, afternoon tea and supper) and personal-meals (i.e. food/s purchased at cafeterias or vending machines, or brought in by family or friends) were assessed retrospectively via patient recall. To prevent inter-rater variability, one investigator independently assessed the accuracy of all meals.

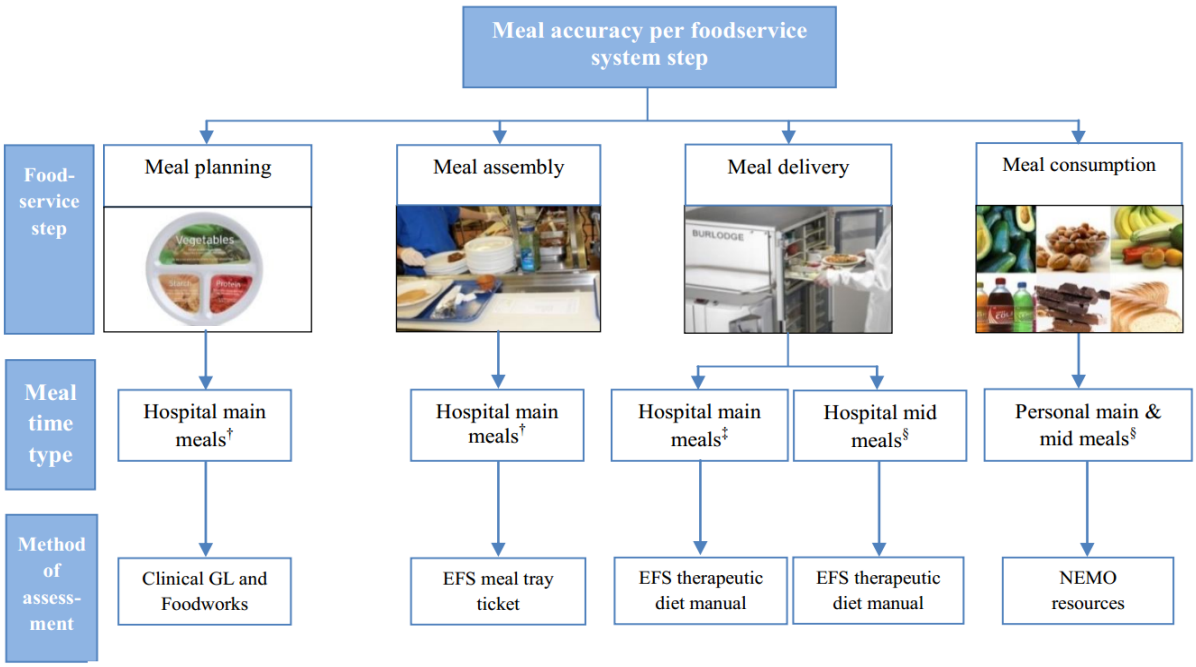

Figure 1. Data collection protocol illustrating the steps and methods utilised to assess meal accuracy in an Electronic Foodservice System. EFS: Electronic Foodservice System; GL: Guidelines (Nutrition Education Materials Online). Accuracy assessed via observation at ward level †prior to or ‡upon delivery to patients. §Accuracy assessed retrospectively at bedside via patient recall.

Meal planning

'Low fibre' was the only therapeutic diet assessed for accuracy at the time of meal planning. Current clinical guidelines stipulate a low fibre diet should contain ≤15 g of fibre per day,[21] therefore a main-meal was considered inaccurate if it contained ≥5 g fibre (i.e. 5 g per main meal ≈ 15 g fibre per day). While it is important to acknowledge that excess consumption of fibre at mid-meals could contribute to excess fibre intake across the day, hospital mid-meals provided to patients on low fibre diets contained minimal fibre (<1 g) and were therefore unlikely to considerably influence total daily fibre intake. To evaluate accuracy, the fibre content of low fibre main-meals were computed using a FoodWorks 7 database (Xyris Software, Australia) and subsequently compared against the threshold limit of 5 g.

Meal assembly

All main-meals were assessed for accuracy at the time of *meal assembly*, where foodservice staff used individually printed meal tray tickets to assemble each patient's tray. The foods placed on each tray were compared against the order indicated on the meal tray ticket. If one or more items were inappropriate for the patient's therapeutic diet, the meal was considered inaccurate. (Note: where food items were missing, added or substituted, but appropriate for a given diet code, these changes were *not* recorded as inaccuracies). To blind kitchen staff to the study's' aim and thus observe 'true' practice, the accuracy of these meals were assessed on the ward, before delivery to patients. This could be achieved as trollies transporting patient meals were held in holding rooms, on each ward, before delivery.

Meal delivery

Main-meals that were altered or assembled by staff at patients' bedsides (a result of pre-assembled trays not reflecting patients' immediate diet prescription) and all mid-meals (considering these were selected at bedside point-of-service) were assessed for accuracy at the time of *meal delivery*. (Note: if a main-meal was not altered or assembled on delivery, it was not included in this assessment, having already been evaluated for accuracy at the time of *meal assembly*). No guidance system (e.g. individualised meal tray tickets) was present at this stage of the foodservice system. The therapeutic accuracy of these main- and mid-meals were evaluated as per *meal assembly*, whereby the inclusion of one or more food items deemed inappropriate for the patient's therapeutic diet was considered to be inaccurate.

Meal consumption

Personal-meals (including mid-meals and main-meals) were assessed for accuracy at the time of *meal consumption*, where food/s sourced by patients from outside the hospitals foodservice (e.g. supplied by patients or their family/friends and/or purchased in hospital cafeterias/vending machines) were assessed for accuracy. In this instance, an inaccuracy was defined as the inclusion of one or more foods deemed inappropriate for a given therapeutic diet prescription according to Nutrition Education Materials Online (NEMO) recommendations.[22] The NEMO recommendations were selected to assess accuracy because they are commonly used by dietitians to provide patients in Queensland hospitals with food and nutrition information.

Data analysis

All data was entered into SPSS version 22.0 for Windows (IBM Corp. 2012, Armonk, N.Y., USA). Following data entry, a random data check comparing entered data against original documentation was completed on 10% of

the data, which yielded <1% of errors. Diet types were grouped into five categories for data analysis: 1) soft diet; 2) other texture modified diets (TMD): smooth pureed, minced and moist, and all thickened fluid diets; 3) oral fluid diets: clear fluid and free fluid diets; 4) food allergy/intolerance diets: low lactose, low gluten and low allergen diets; and 5) low fibre diet. Categorical variables were described by frequency and percentage. Continuous variables were presented as mean ± standard deviation. The number of inaccurate meals was calculated as a percentage of the total number of meals assessed overall, for each step in the foodservice system and by diet type.

RESULTS

Participants

One-hundred and eighty-six patients were approached and informed of the study's protocol and asked to participate; of these, 11 (6%) declined. A further eight patients were excluded after gaining informed consent due to being discharged (n=4) or changed to a diet code that did not meet the inclusion criteria (n=4), resulting in a final study population of 167 patients. The majority of patients were female (n=95, 57%) and the mean age and BMI of patients were 55.4±17.5 years and 27.6±6.3 kg/m², respectively.

Total number of meals and inaccuracies

Of the 906 therapeutic meals assessed, 69 were inaccurate (8%), with the majority classified as *critical errors* (n=67, 97%).

Inaccuracies according to foodservice system step

The proportion of errors differed according to the step assessed in the foodservice system (Figure 2). The highest proportion of meal inaccuracies occurred at *meal delivery*: main-meals where 53% of meals were inaccurate. A high proportion (33%) of personal-meals (*meal consumption*) were also inaccurate, with food delivered to patients by their family and friends contributing to the largest source of inaccuracy (n=17, 55%), followed by patients themselves either purchasing food at cafeterias/vending machines (n=9, 29%) or brining in food on admission (n=5, 16%). Lower error rates were observed among *meal planning*: main-meals (17%) and *meal delivery*: mid-meals (9%), whilst the lowest proportion of inaccuracies was observed at *meal assembly*: main-meals (<1%).

Inaccuracies according to diet type

The proportion of total inaccuracies differed between the therapeutic diet types assessed. Overall, food allergy and intolerance diets had the highest inaccuracy rate (17%, 12 from 69 meals), followed by low fibre diets (11%, 20 from 187 meals), soft diets (8%, 24 from 289 meals), other TMD (7%, 6 from 83 meals) and oral fluid diets (3%, 7 from 278 meals). However, errors by diet type differed according to the step assessed in the foodservice system, with the exception of *meal planning* (all errors specifically related to low fibre diets).

The majority of inaccuracies for *meal delivery:* mid-meals (n=10 total errors) occurred on the soft diet (n=8), followed by other TMD (n=1) and food allergy/intolerance diets (n=1). The majority of inaccuracies observed at *meal delivery:* main-meals (n=16 total errors) occurred on the low lactose diet (n=8), however inaccuracies were also observed on the soft (n=3), low fibre (n=3), other TMD (n=1), and oral fluid (n=1) diets. For inaccuracies of *meal consumption:* personal-meals (n=31 total errors from 94 meals), the majority occurred on soft diets (n=13 from 23 meals), followed by low fibre (n=7 from 19 meals), other TMD (n=4 from 8 meals), oral fluid (n=4 from 14 meals) and food allergy/intolerance (n=3 from 17 meals) diets.

Inaccuracies according to meal time

For *meal planning:* main-meals, the highest proportion of inaccuracies occurred at dinner (n=7 from 18 meals), followed by lunch (n=3 from 19 meals) and breakfast (n=0 from 21 meals). For *meal delivery:* main-meals the highest proportion of errors were observed at breakfast (n=6 from 10 meals) and dinner (n=7 from 12 meals), while errors at *meal delivery:* mid-meals were distributed evenly across meal times: morning tea (n=4 from 46 meals), afternoon tea (n=5 from 50 meals) and supper (n=1 from 16 meals).

DISCUSSION

The present study investigated the accuracy of meals delivered to and consumed by hospitalised patients pre-

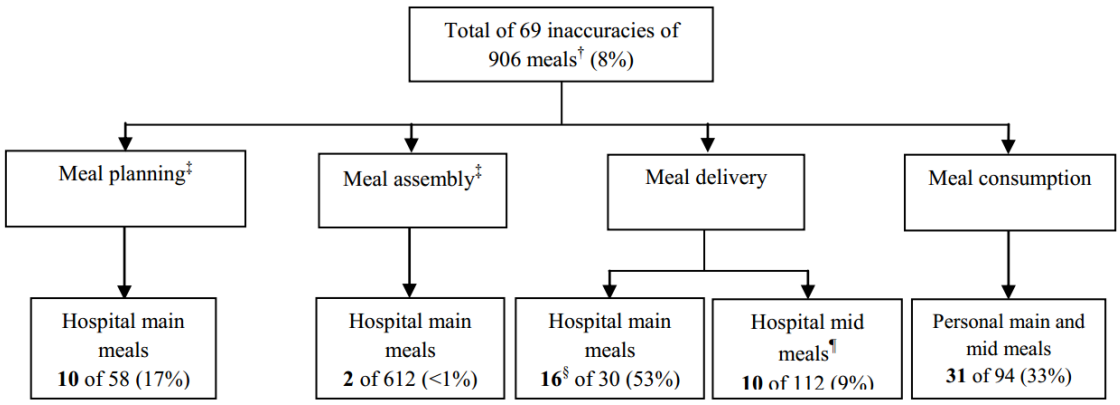

Figure 2. Number and source of meal inaccuracies in an Electronic Foodservice System. Unless specified otherwise all inaccuracies were *critical errors*. †Each meal was categorised into one of four steps in the foodservice system. ‡The Electronic Foodservice System was directly involved in influencing the accuracy of these meals. §2 meal inaccuracies were *non-critical errors*. ¶Mid meals for which patients received food or a fluid (excluding water) were included in analysis.

scribed a therapeutic diet for medical and/or nutritional purposes. A total error rate of 8% was observed from all meals, which was substantially lower than the inaccuracy rate reported at the same hospital prior to implementation of an EFS (19.6%).[19] The majority of observed inaccuracies were classified as *critical errors*; posing a risk to the patients' health. The frequency of inaccuracies varied considerably depending on the step assessed in the foodservice system.

Meal assembly: main-meals had the lowest proportion of inaccuracies (<1%) observed and was the only step directly influenced by the EFS. This finding is much lower than previously reported by studies exclusively assessing the accuracy of therapeutic tray assembly (3-16%).[17,18] In the current study, the EFS generated a patient specific meal tray ticket for each main meal, outlining the dietary items ordered by the patient in accordance with their therapeutic diet. This ticket was then used as a guide by foodservice staff to assemble each patient's meal tray. The results of the current study support previous research highlighting the benefits of individualised meal tray tickets to produce fewer errors in comparison to the use of a diet manual or no guidance system at all.[23] It appears that automated tray assembly processes almost completely remove meal assembly errors in the kitchen by eliminating the need for human judgements on the appropriateness of food items.

The highest proportion of errors was observed at *meal delivery:* main-meals, where meals were re-assembled at the patient's bedside. High error rates at this step in the foodservice system are likely the result of both system limitations (e.g. plating meals too far in advance of delivery) and human error (e.g. greater decision making required by foodservice staff). Having an extended period of time between meal plating and delivery increases the potential for diet codes to change prior to meal delivery. In the current setting, meals were plated ~2 hours in advance of delivery. In the event of a diet code change, ward level staff could order a 'new' meal from the kitchen (a rare occurrence) or opt to re-assemble the patient's tray to reflect their updated dietary prescription. Re-ordering meals due to diet changes has been shown to impact significantly on costs (from food wastage and labour) and patient dissatisfaction (from additional waiting time).[18] Such reasons may, in part, explain why foodservice staff chose to alter patient meal trays upon delivery. Given that tray re-assembly is a task involving decision-making in the absence of the EFS to guide permissible/restricted foods, there appeared more opportunity for human error. Thus, understanding staff behaviour at ward level regarding the provision of food to patients receiving therapeutic meals may provide an opportunity to substantially reduce error rates.

Behaviour change frameworks such as The Theoretical Domains Framework[24] have been used in attempt to understand human behaviour in complex clinical environments. Therefore, the Theoretical Domains Framework which identifies a number of domains, including lack of knowledge or skills; memory, attention and decision processes; environmental context and resources; and social influences, may be used to help explain the high error rate observed at *meal delivery*. For example, staffs' lack of knowledge or skills around appropriate foods for different therapeutic diets may have contributed to the provision of inaccurate items.[24] Memory, attention and decision processes may have also played a role (e.g. prioritising the delivery of food over ensuring its accuracy in the busy clinical environment).[24] Previous research conducted among nursing staff highlights how this can impact on patient safety, with tiredness, stress and a busy clinical work environment all resulting in high error rates.[25] Further, the environmental context and resources available at the hospital, such as the processes, technology and terminology used for foodservice tasks, may have influenced the capacity of staff to provide accurate meals.[24] Finally, social influences (i.e. social norms, pressures and modelling of behaviours by colleagues) have been demonstrated to affect staff behaviour.[24] For example, in the current study, it was anecdotally observed some patients pressured foodservice staff into providing them with dietary items that were not permitted on their diet code. Therefore, further research is needed to understand factors underpinning staff and patients' behaviour around meal provision, in order to develop interventions to improve accuracy of meals delivered in hospital.

More than one third of patients consumed (*meal consumption*) inaccurate personal-meals sourced from outside the hospital's foodservice, with over half these brought to patients by their family/friends. Reasons patients may consume inaccurate personal food items could relate to their poor knowledge regarding permitted dietary items and/or experience with, or perceived consequences of non-compliance. In support of this, the lowest proportion of errors for this step occurred among patients prescribed food allergy and intolerance diets, as opposed to patients on TMD, low fibre and oral fluids; diets commonly prescribed for short periods of time in the acute care setting.[22] Given that food allergy and intolerance diets often require life-long adherence,[26,27] patients may be more familiar with their dietary restrictions and the consequences of acute non-compliance (e.g. allergic reaction, diarrhoea, abdominal pain and/or nausea).[12,13,26,27] Further, these patients may have had previous experiences with the consequences of non-compliance, resulting in greater intrinsic motivation to avoid non-permitted foods. However, as reasons for patient and family non-compliance were not assessed in the current study, this is just speculation. This study's findings do highlight that vigilance is required not only from hospital staff, but patients and their families and friends, to ensure safe food delivery and consumption practices among patients prescribed therapeutic diets.

Due to the observational nature of this study, an unavoidable limitation is that foodservice staff may have changed their behaviour due to the presence of a researcher (i.e. the Hawthorne effect).[28] In this instance, an observer effect would most likely be predicted to result in an underestimation of error rates as staff attempt to demonstrate "best practice" whilst undertaking tasks. Despite this, high error rates were still found, particularly for *meal delivery:* main-meals and *meal delivery:* mid-meals, suggesting that high error rates at these stages of the foodservice system are likely to occur, with the precise magnitude of these errors being difficult to quantify. Sec-

ondly, error rates found at *meal planning* and *meal assembly* may only be applicable to institutions using an EFS. Conversely, inaccuracies found at *meal delivery* and *meal consumption* can be generalised across different institutions, given these steps are involved in most foodservice systems and were not influenced by the EFS. This study did not explore reasons why foodservice staff, patients and/or their families provided or consumed inaccurate dietary items, as it was beyond the scope of the study's aims. Thus, future research is required to understand factors influencing behaviours of staff, patients and families; and barriers and facilitators to providing accurate dietary items to patients receiving therapeutic diets; in order to inform targeted intervention strategies to improve this aspect of clinical care.

Conclusion

This study demonstrated a considerable reduction in meal errors provided to patients on therapeutic diets following the implementation of an EFS. The EFS almost completely eliminated errors associated with meal assembly. In contrast, a substantial number of errors occurred when foodservice staff and patients selected foods at ward level (without a guiding system). Further research is required to understand the factors influencing why staff, patients and their families provide or consume inaccurate dietary items when patients are on therapeutic diets in hospital.

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AUTHOR DISCLOSURES

The authors declare no conflicts of interests. This study received internal institutional support only.

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