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# An AI-Assisted Conceptual Framework for Personalized Nutrition Recommendation Based on Oral Mucositis Severity in Head and Neck Cancer Patients

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***Abstract*— Oral mucositis often occurs in head and neck cancer (HNC) patients during treatment and can make eating difficult because of pain and swallowing problems. A recent meta-analysis reported oral mucositis in approximately 94% of HNC patients receiving radiotherapy, with 37% experiencing severe mucositis. In Sri Lanka, cancers of the lip, tongue and mouth accounted for 18.8% of reported cancers among males and 4.1% among females in 2022. Nutritional needs may change according to mucositis severity, treatment related symptoms, dietary restrictions and individual preferences. This paper proposes an AI assisted conceptual framework for personalized nutritional recommendation for HNC patients with oral mucositis. The framework integrates clinical information, nutritional requirements, patient reported symptoms, dietary preferences and mucositis severity to support individualized meal recommendations. Its main components include patient data collection, mucositis assessment, nutritional requirement estimation, meal recommendation, patient feedback and healthcare professional supervision. The proposed framework was developed using findings from the literature and initial interviews with 16 patients, 4 doctors, and 5 nurses. This study mainly focuses on identifying system requirements and developing the conceptual framework. System implementation, AI model training and clinical validation are considered future work. Future evaluation will focus on accuracy, safety, usability and clinical relevance.**

***Keywords*— *Head and Neck Cancer, Personalized Nutrition, Artificial Intelligence, Oral mucositis***

## I. Introduction

Patients with Head and Neck Cancer (HNC) often face nutritional difficulties before and throughout treatment. Tumour location, radiotherapy, chemotherapy and combined treatment can affect oral intake through pain, dysphagia, taste changes, xerostomia and other treatment related symptoms [1], [2]. Oral mucositis can cause painful mouth inflammation and ulcers, making it harder for patients to eat and increasing the risk of malnutrition [3], [4]. Nutritional care is therefore a central component of supportive care for HNC patients [5]. Head and neck cancers represent an important cancer burden, particularly cancers of the oral cavity in Sri Lanka. National cancer statistics indicate a substantial proportion of cancer cases among Sri Lankan males are related to the lip, tongue and mouth [6]. In addition, oral mucositis is a common complication among head and neck cancer patients receiving radiotherapy, highlighting the need for appropriate nutritional support during treatment. However, nutritional needs are not static during treatment. A patient may tolerate ordinary food at one stage, require soft food during moderate mucositis and require liquid or modified texture meals when symptoms become severe. Meal recommendation should also take into account energy and protein requirements, weight changes, dietary restrictions, allergies, personal preferences and safety considerations [2], [5].

Existing nutritional interventions such as, counseling, oral nutritional supplements and enteral nutrition, are essential when needed [7]. As well as, there is a need for structured decision support approaches that can integrate changing clinical and patient-reported information and translate it into individualized meal recommendations under professional supervision. Artificial Intelligence (AI) techniques may support such integration through image-based assessment, Natural Language Processing (NLP), predictive modelling and recommendation methods [8], [9], [10]. Although nutritional support, oral mucositis management and AI-based meal recommendation have each been investigated, they are often addressed separately. A gap remains for an integrated approach combining mucositis severity, nutritional requirements, treatment-related symptoms, dietary restrictions, patient preferences, feedback and healthcare professional oversight. This study therefore proposes an AI-assisted conceptual framework for mucositis-aware personalized nutrition recommendations. Its novelty lies in explicitly linking mucositis related eating difficulties with safety constrained meal recommendations and professional review. Accordingly, the objectives of this study are:

- To identify the key factors required for personalized nutrition recommendation for mucositis patients.

- To design an AI assisted framework integrating mucositis, nutrition and patient factors.
- To provide a structured framework to guide the future implementation of an AI assisted personalized nutrition recommendation system.
- To define an evaluation strategy for assessing the technical performance, nutritional adequacy, usability, safety and clinical relevance of the proposed framework.

The contribution of the paper is not an implemented software system, but a structured framework that identifies the required data inputs, analytical modules, recommendation process, feedback loop, professional supervision mechanism and evaluation strategy. System implementation, model training and clinical validation are outside the scope of the present study and are identified as future work.

## II. Literature Review

### *A. Head and Neck Cancer and Oral Mucositis*

Head and neck cancers usually include several types of cancer that start in the squamous cells lining the mouth, throat or larynx[11]. In some cases, head and neck cancer also forms in the sinuses and salivary glands. Globally, approximately 947,000 new head and neck cancer cases were estimated in 2022, accounting for about 4.7% of all newly diagnosed cancers worldwide [12]. In Sri Lanka, cancers of the lip, tongue and mouth represent a particularly important burden. According to the National Cancer Control Program, 3,805 new cases of lip, tongue and mouth cancer were reported in 2022, including 3,013 males and 792 females [6]. These cancers accounted for 18.8% of all reported cancers among males and 4.1% among females [6]. Treatment methods such as surgery, radiation therapy and drug therapy are commonly used for head and neck cancer [5].

Oral mucositis is a major clinical problem associated with cancer treatment, especially radiation therapy and chemotherapy. A recent meta-analysis reported that radiation-induced oral mucositis occurs in approximately 94% of head and neck cancer patients receiving radiotherapy, while severe oral mucositis occurs in approximately 37% [13]. It is an inflammatory response of the mucosa that causes soreness and pain and can severely affect the patient's ability to obtain and maintain adequate nutrition [4]. Oral mucositis can also lead to mouth pain, bleeding, loss of appetite and difficulty eating, which may negatively affect nutritional status and quality of life [3].

### *B. Nutritional Challenges and Existing Interventions*

Nutrition is an important factor for head and neck cancer patients because treatment related complications can directly affect food intake. Mucositis, salivary gland dysfunction, altered taste, oral pain and mucosal sensitivity can make eating difficult and may contribute to weight loss and malnutrition [1], [2]. So, nutritional management aims to maximize nutritional intake, prevent excessive weight loss, maintain nutritional status and reduce the risk of treatment delays [14].

Traditional nutritional interventions include oral nutritional supplementation, tube feeding and nutritional counselling [7]. Food texture and taste may also need to be modified according to the patient's oral function and symptoms [2]. Personalized nutrition is important because patients may experience different treatment-related symptoms, dietary restrictions and food preferences. By examining the condition of each patient separately, nutritional support can be better adapted to individual needs [15].

### *C. Artificial Intelligence in Nutritional recommendation*

Artificial intelligence includes techniques such as machine learning, deep learning, natural language processing and machine vision [8]. These methods have been increasingly used in healthcare to support diagnosis, prediction and personalized decision-making [9]. In cancer-related applications, AI has also been explored for personalized treatment recommendation and improved diagnostic support [16]. AI can support nutritional recommendation by analyzing patient and dietary information and generating personalized dietary recommendations. By combining advanced analytical techniques with metabolic or patient-related data, AI can support individualized meal recommendation [10]. AI algorithms can also analyze large datasets, manage recipes, monitor food intake, provide feedback and support healthier food choices [17]. These capabilities indicate the potential of AI assisted approaches for personalized nutritional recommendation in patients with complex and changing nutritional needs.

### *D. Mucositis-Aware Personalized Meal recommendation*

Mucositis can cause soreness, swelling, pain and difficulty eating and may negatively affect oral care and quality of life [18]. When mucositis becomes more severe, food texture and tolerability become particularly important. Rough-textured foods may be difficult to consume, while softer or liquid foods may be more suitable, although adequate nutritional content must still be maintained [19]. Monitoring mucositis severity may therefore support the adaptation of nutritional recommendations according to changes in the patient's condition. Patient reported symptoms, clinical information and oral images could be used as possible inputs for assessing mucositis severity. Integrating this information with nutritional requirements, treatment-related symptoms, dietary restrictions and patient preferences may support more individualized meal recommendations.

### *E. Real-Time Data Integration and Existing AI-Based Meal recommendation*

Real-time data integration may further support personalized nutritional recommendation by allowing recommendations to be updated when patient conditions change. Information may come from clinical records, patient self-reports, mobile applications and wearable devices. Dynamic data such as nutritional status and other patient related information can potentially be used to adapt dietary recommendations over time.

Existing AI-driven meal recommendation applications and research systems demonstrate the potential of computational approaches for personalized meal recommendations. Systems such as Meal Mate, Meal Planner, Nutri Admin, Cook Assist and the MARY food management approach have explored meal recommendation based on preferences, restrictions or nutritional requirements [10], [20]. Important features for such systems include real time data integration, dynamic meal recommendation, nutritional adequacy, symptom management, user feedback, customization, ease of use and access to healthcare support.

### *F. Research Gap*

The reviewed literature shows that oral mucositis can significantly affect nutritional intake among head and neck cancer patients, while personalized nutritional interventions and AI based meal recommendation have both received increasing attention. However, these areas are often considered separately. There remains a need for a structured framework that combines mucositis severity, nutritional requirements, treatment related symptoms, clinical information, dietary restrictions, patient preferences, patient feedback and healthcare professional supervision within a single personalized nutritional recommendation process. Therefore, this study proposes an AI assisted conceptual framework to integrate these components and support individualized meal recommendations for head and neck cancer patients experiencing oral mucositis.

## III. METHODOLOGY

This study followed a review informed and stakeholder informed framework design methodology. First, relevant literature on head and neck cancer nutrition, oral mucositis, artificial intelligence in healthcare and personalized meal recommendation was reviewed to identify the clinical problem, existing approaches and potential AI techniques. In addition to the literature review, preliminary stakeholder interviews were conducted with 25 participants, including 16 patients, four doctors and five nurses. The interviews were used to understand practical challenges related to oral mucositis, food intake, nutritional difficulties, treatment related symptoms, current nutritional support and requirements for a personalized nutritional recommendation system. The necessary permission was obtained before data collection and informed consent was obtained from all participants prior to the interviews.

The interviews were structured and were conducted individually. Responses were recorded using written notes and google form. The collected responses were reviewed and grouped into recurring themes related to mucositis symptoms, nutritional requirements, dietary restrictions, patient preferences, healthcare professional supervision and patient feedback. The findings from the literature review and stakeholder interviews were then mapped to the functional components of the proposed framework. These components include patient data collection, mucositis assessment, nutritional requirement estimation, meal recommendation, healthcare professional review and patient feedback.

The collected stakeholder information was used only for requirement identification and conceptual framework design. It was not used for AI model training, clinical prediction or clinical effectiveness evaluation. AI model development, technical validation, usability testing and clinical validation are considered future stages of this research.

## IV. RESULTS AND DISCUSSION

### *A. Participant Characteristics*

A total of 25 participants contributed to the requirement identification process, including 16 patients, 4 doctors and 5 nurses. The interviews focused on oral mucositis related eating difficulties, treatment related symptoms, nutritional problems, current dietary support, food preferences and expectations for a personalized nutritional recommendation system. The collected information was used only for requirement identification and conceptual framework development and was not used for AI model training, prediction or clinical validation.

### *B. Main Findings from Stakeholder Interviews*

The stakeholder interviews identified several recurring factors that should be considered when developing personalized nutritional support for head and neck cancer patients experiencing oral mucositis.

First, oral mucositis related symptoms were identified as important factors affecting food intake. Participants reported oral pain, swallowing difficulty, mouth sensitivity, reduced appetite and difficulty consuming solid foods. These findings support the inclusion of mucositis related symptoms when generating individualized meal recommendations.

Second, nutritional needs were found to differ between patients according to their condition and treatment-related difficulties. Weight change, ability to eat, food tolerance, treatment stage and nutritional condition were identified as relevant factors for nutritional recommendation.

Third, individual patient characteristics including food preferences, allergies, dietary restrictions and tolerance of different food textures were identified as important factors for meal selection.

Healthcare professionals emphasized that nutritional recommendations should consider the patient's clinical condition and should remain subject to professional review. Therefore, healthcare professional supervision was included as a core requirement of the proposed framework.

Then, the interviews supported the inclusion of a patient feedback mechanism because symptoms, food tolerance and meal acceptability may change during treatment. Patient feedback can therefore be used to support future adaptation of meal recommendations.

### *C. Framework Requirements Derived from the Findings*

Based on the literature review and stakeholder interviews, the key requirements, their purposes and

corresponding framework components are summarized in Table I.

Table I: Framework Requirements and Corresponding Components

| Requirement | Framework Component |
|---|---|
| Patient and clinical data collection | Personalization input |
| Mucositis severity assessment | Mucositis assessment and texture/safety constraints |
| Nutritional requirement estimation | Nutrition Estimation Module |
| Symptom-aware meal recommendation | Safety/Rule Engine |
| Allergy checking | Safety Filtering |
| Food preferences and texture tolerance | Personalized Recommendation Module |
| Healthcare professional review | Clinical safety and supervision |
| Patient feedback | Adaptation of future recommendations |
| Privacy and data security | Protection of patient information |

### *D. Relationship Between Findings and Framework Design*

The identified requirements were mapped directly to the framework architecture. Mucositis related symptoms and oral image information are connected to the mucositis assessment module, while weight, nutritional condition, treatment related information and other relevant factors are used by the nutritional requirement module. Allergies, dietary restrictions, food preferences and texture tolerance are passed to the meal-recommendation component. A safety and constraint layer is used to prevent recommendations that conflict with known allergies, dietary restrictions, nutritional requirements or mucositis related food limitations. The resulting meal options are then made available for healthcare professional review. Patient feedback is returned to the framework to support subsequent personalization. This mapping ensures that the proposed framework is based not only on the reviewed literature but also on practical requirements identified from patients and healthcare professionals.

## V. PROPOSED AI-ASSISTED FRAMEWORK

### *A. Framework architecture*

Figure 1. illustrates the conceptual architecture of the proposed framework. The process begins with the collection of clinical information, nutritional indicators, patient reported symptoms, dietary preferences, allergies and mucositis related information. These inputs are processed by the mucositis assessment and nutritional assessment modules. The resulting patient profile is then passed through clinical safety and dietary constraints before the recommendation module generates suitable meal options. Recommendations are reviewed by an appropriate healthcare professional before being presented to the patient. Patient feedback is subsequently returned to the system to support future personalization.

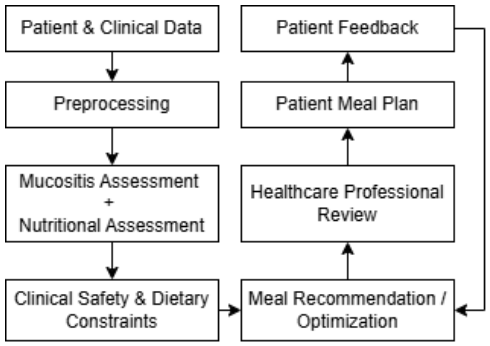



Figure 1. Conceptual design of the AI-assisted nutritional recommendation framework.

### *B. Patient data collection module*

The data collection module is designed to capture information needed for nutrition personalization. Core inputs include age, weight, height, recent weight change, treatment stage, nutrition-related symptoms, swallowing difficulty, oral pain, mucositis grade, allergies, food restrictions and patient preferences. In a future implementation, these data could be entered by patients or healthcare professionals and supplemented with electronic health record data where ethically and legally permitted.

### *C. Mucositis assessment module*

The mucositis assessment module represents the severity of oral mucositis using symptom reports and, where available, oral images. Image analysis may support visual assessment of oral lesions, while NLP may support interpretation of symptom descriptions. Because automated assessment errors could lead to unsafe recommendations, this module should include uncertainty handling and professional review. A validated clinical oral mucositis grading scale should be selected during system implementation and automated image-based estimates should be treated as decision support information rather than as replacements for clinical assessment.

### *D. Nutritional requirement estimation module*

The nutritional requirement module represents individual nutritional needs using patient characteristics and clinical context. Relevant factors may include body weight, recent weight change, treatment related eating difficulties, hydration needs and nutritional risk indicators. Nutritional targets should primarily be based on accepted clinical nutrition guidance and healthcare professional judgement. In future implementation, predictive models may be evaluated for supportive tasks

such as nutritional risk estimation or identification of patients who may require closer professional review.

*E. Meal recommendation module*

The recommendation module generates meal options by combining nutrition targets with patient-specific constraints. For example, severe oral pain or swallowing difficulty may trigger soft, moist or liquid meal options, while allergies and dietary restrictions remove unsuitable foods. Recommendation methods may include rule-based reasoning, constraint-based optimization or machine learning-based recommendation. A rule-based safety layer is required to prevent inappropriate suggestions.

*F. Feedback and adaptation module*

After a meal recommendation is used, the patient can provide feedback on taste, tolerance, pain during eating, portion completion and acceptability. This feedback can be used to adjust future recommendations. In the conceptual framework, the feedback loop supports personalization over time, but it does not replace dietitian or clinician judgement

*G.Framework workflow*

The proposed framework follows a structured process beginning with the collection of patient, clinical, nutritional and mucositis related information. These data are processed through the mucositis assessment and nutritional requirement modules. Clinical safety constraints, dietary restrictions and patient preferences are then applied before suitable meal recommendations are generated. The recommendations are reviewed by a healthcare professional before being provided to the patient. Patient feedback is subsequently used to support future personalization of meal recommendations.

## VI. PROPOSED IMPLEMENTATION TECHNOLOGIES

The proposed framework has not yet been implemented. Python is considered for AI and data processing tasks. PyTorch, OpenCV and Albumentations may support future oral image analysis, while scikit-learn and XGBoost may be evaluated for structured clinical data modelling. BioClinicalBERT through Hugging Face Transformers may be investigated if textual symptom analysis is included. Google OR-Tools is proposed for constraint-based meal optimization, while SHAP may support model explainability. FastAPI and MySQL are proposed for backend services and structured data storage, with Flutter for the patient mobile application and React for the clinician dashboard. Docker and GitHub may support deployment and version control. These technologies are proposed candidates and have not yet been experimentally evaluated within the framework.

## VII. PROPOSED EVALUATION STRATEGY

Future work should evaluate the framework at multiple levels. Technical evaluation should measure the performance of any mucositis image analysis model, symptom processing method and recommendation algorithm using appropriate datasets and expert labelled references. Nutritional evaluation should examine whether recommended meals satisfy energy, protein, texture and safety requirements. Usability evaluation should include patients, caregivers and healthcare professionals. Clinical evaluation, if pursued, should be conducted only after ethical approval and should assess feasibility, acceptability and potential effects on nutritional outcomes.

Future evaluation measures will depend on the implemented component. Oral image classification may be evaluated using accuracy, precision, recall, F1-score, sensitivity and specificity. Structured data models may be evaluated using classification or regression metrics appropriate to the selected prediction task. NLP components may be evaluated using precision, recall and F1-score. Meal optimization should be evaluated according to nutritional target satisfaction, constraint violations and computational performance. System level evaluation should consider usability, recommendation safety, clinician agreement, patient satisfaction, missing data handling and explainability. These measures represent future validation criteria and are not reported results of the present study.

## VIII.LIMITATIONS AND FUTURE WORK

The main limitation of this study is that it presents a conceptual framework only. No software prototype has been implemented, no AI model has been trained, no dataset has been used for AI model training or predictive evaluation and no clinical validation has been performed. Therefore, the study cannot make claims about model accuracy, recommendation effectiveness, patient outcomes or quality of life improvement. Future work will involve developing a prototype, defining a clinically appropriate dataset, selecting validated mucositis assessment criteria, training and testing candidate AI models, implementing recommendation logic and conducting usability testing with healthcare professionals and patients. Subsequent clinical evaluation should investigate whether the framework can safely support personalized nutrition recommendation in real world HNC care.

## IX. CONCLUSION

This paper proposed an AI assisted conceptual framework for personalized nutritional recommendation in HNC patients with oral mucositis. The study identified key clinical, nutritional, symptom related and patient specific factors required for personalization and incorporated them into the framework. The proposed framework integrates mucositis assessment, nutritional requirement estimation, safety constraints, personalized meal recommendation, healthcare professional review and patient feedback. The framework was designed by the literature review and preliminary stakeholder interviews involving patients, doctors and nurses. It provides a structured approach for generating safer and more individualized meal recommendations under professional supervision. As the system has not yet been implemented or clinically validated, future work will

focus on prototype development, AI model training, usability testing, safety evaluation and clinical validation.


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