

Title: NutriOrion: A Safety-Constrained Multi-Agent AI Framework for Scalable Personalized Nutrition Consultation

Authors: Junwei Wu, Hanqi Luo, Darren Liu, Minxiao Wang, Kimberly L. Townsend, Lydia S. Hartwig, Derek Miketinas, Xiao Hu, Carl Yang, Runze Yan

Objectives: Personalized nutrition care for stroke patients is challenged by multiple comorbidities, medication-related constraints, and complex dietary guidelines. We developed NutriOrion, a hierarchical multi-agent large language model (LLM) framework designed to provide clinically grounded, drug–nutrient interaction (DNI)-safe dietary recommendations.

Methods: NutriOrion integrates three specialized analytical modules (disease-specific, medication-aware, and nutrient optimization). We evaluated NutriOrion using data from stroke patients ($n = 330$) from NHANES 2019–2021, constructing each participant's profile from: (1) Day-1 24-hour dietary recall; (2) medical diagnoses; and (3) prescription medications. NutriOrion's recommendations were evaluated across four domains: 1) recommendation quality via NCP-QUEST (0–8; AHA/ADA guideline adherence, clinical appropriateness, personalization, feasibility), assessed by two dietitians blinded to source (Cohen's κ); 2) actionability and 3) DNI safety — both compared against general-purpose GPT and Claude; and 4) nutritional impact via 1:1 meal substitution, with macro- and micronutrients recalculated.

Results: NutriOrion performed well across all four evaluation domains. 1) Clinician-facing quality: NutriOrion's recommendations achieved a mean NCP-QUEST score of 7.5/8 (inter-rater agreement $\kappa = 0.82$). 2) Actionability: NutriOrion's recommendations achieved 97.8% actionability, compared with 91.2% for both GPT and Claude. 3) DNI safety: NutriOrion's recommendations had a DNI violation rate of 12.1%, compared with 16.6% (GPT) and 11.5% (Claude). 4) Nutritional impact: substitution analysis demonstrated favorable dietary improvements — +167% fiber, +27% potassium, –9% sodium, and –12% added sugars following NutriOrion — compared with baseline intake.

Conclusions: NutriOrion generated personalized, medication-aware dietary recommendations that dietitians rated as actionable and guideline-adherent, with fewer harmful food-drug combinations than general-purpose AI tools. These findings support its potential to scale up to provide individualized nutrition care.

AI Disclosures:

Generative AI tools were used to assist with editing for clarity and concision. The authors reviewed and take responsibility for the accuracy and integrity of the content.