Clinical Decision Support for Collaborative Diet Goal Setting in Primary Care

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Structured Abstract
Purpose: Our goal was to develop a useable and feasible clinical decision support system (CDSS) that captures patient diet data and aids PCPs in adopting brief, data-driven collaborative goal setting, an evidence-based technique for promoting health behavior change.
Scope: Despite evidence and guidelines, few patients report receiving diet counseling from their PCP, even when they have a diet-related chronic disease diagnosis. This missed opportunity is attributed to three barriers, namely PCPs' lack of 1) time to address diet, 2) data to assess patient diet, and 3) training in effective strategies to support patient dietary behavior change.
Methods: In three studies, we 1) Developed a user-centered and clinical workflow-compatible CDSS by engaging key stakeholders in iterative feedback and testing; 2) Tested the CDSS with practicing PCPs in a controlled "lab" setting and refined it based on results, and 3) Deployed the CDSS in a clinic-based pilot cluster randomized trial to evaluate trial and intervention feasibility.
Results: 25 PCPs and patients contributed to Nutri's initial design, which was tested in simulated primary care appointments. All PCPs selected one high impact diet goal using Nutri with the patient actor and agreed/strongly agreed that *Nutri* would be useful in patient-provider collaborative diet goal setting and improve chronic disease management. 16 PCPs and 30 patients initiated into our pilot trial; all participants completed. PCPs used *Nutri* in 100% of appointments and Nutri PCPs significantly improved in diet counseling competence compared to control PCPs. Nutri was feasible in a real clinic setting.

Key Words: clinical decision support, nutrition education, dietary behavior change, chronic disease management

Purpose

Despite broad acknowledgement of its role in chronic disease, diet is addressed inconsistently and ineffectively in primary care, the setting in which most patients' chronic disease risk is managed. While primary care providers (PCPs) are ideally positioned to promote adoption of a healthful diet to reduce chronic disease risk, doing so effectively is challenging because PCPs have limited training in nutrition.
Our goal in this exploratory research project was to develop a useable and feasible clinical decision support system (CDSS) that captures patient diet data and aids PCPs in adopting brief, data-driven collaborative goal setting, an evidence-based technique for promoting health behavior change. As current electronic health records (EHRs) do not have standards for diet data, this requires a specially designed system. Therefore, our interdisciplinary team set out to solve the issues that limit PCPs from engaging with patients in collaborative diet goal setting by:

1. Developing a user-centered and clinical workflow-compatible CDSS by engaging key stakeholders in iterative feedback and testing,
2. Testing the CDSS with practicing PCPs in a controlled "lab" setting and refining it based on results, and
3. Deploying the CDSS in a clinic-based pilot cluster randomized trial to evaluate trial and intervention feasibility.

Scope

Despite the necessity of dietary management for chronic disease prevention and management, most patients are left to navigate diet changes and seek out education and support on their own. This is especially true for patients from low-income and historically minoritized communities who bear a disproportionate burden of diet-related chronic disease and have less access to dietetics and specialist care. While self-management can yield patient success, it is difficult to maintain changes through self-management alone. The Chronic Care Model emphasizes synergy between self-management and the healthcare system for chronic care[1] that improves patient's chronic disease outcomes[2,3] and ultimately reduces health inequity.[4] Thus, there is a critical need for multi-level interventions that improve diet via the healthcare system.

When primary care providers (PCPs) address diet, patients improve their diet and health outcomes. Patients who receive diet advice from providers more frequently report dietary behavior change attempts, reducing their calorie intake, and successfully losing weight.[5–7] Some research has suggested a dose-response effect with more diet counseling strategies used by PCPs linked to additional weight loss.[7] Furthermore, both patients and physicians recognize the value of addressing diet in primary care. For example, in our prior research, patients with diabetes reported confusion and disappointment that PCPs did not address their diet and blood glucose logs during a visit.[8] Thus, PCPs have an important role to play in supporting patients to adopt a healthful diet.

Despite evidence and guidelines, few patients report receiving diet counseling from their PCP, even when they have a diet-related chronic disease diagnosis.[9–11] This missed opportunity is attributed to three barriers, namely PCPs' lack of 1) time to address diet, 2) data to assess patient diet, and 3) training in effective strategies to support patient dietary behavior change. PCPs are notoriously short of time to accomplish necessary clinical tasks with each patient[12,13] and this is a key reason for the infrequency with which PCPs address diet in primary care.[14] This time pressure makes collecting useful diet data during a regular appointment, already a challenging task, seem futile. Thus, any discussion of diet by PCPs is typically comprised of non-specific advice.[15,16] On the rare occasions when PCPs assess patient diet, it often consists of unsystematic questioning about common nutrition habits, a time-consuming process subject to social desirability and anchoring biases.[17,18] This state of affairs leaves patients feeling judged and providers feeling that patients are unlikely to follow their advice, ultimately reducing the likelihood that clinical guideline-based diet counseling occurs at all.

PCPs' lack of diet counseling competence and self-efficacy stems from a historic lack of nutrition training in undergraduate, graduate, and continuing medical education.[19,20] The majority of PCPs never learn key principles of dietary behavior change. This translates to less effective diet advice in practice. For example, despite strong evidence that collaborative diet goal setting promotes weight loss, in a study of family medicine residents, only 14% reported setting a diet goal with patients.[16] Without goal-setting, PCPs struggle to provide

relevant resources or follow-up, despite patients' strong desire for their support in these areas.[21] With the right strategies, PCPs could close the current gap in supporting patients with dietary management of diabetes. When PCPs discuss diet with patients, they are more likely to change their diet and lose weight. Collaborative goal setting, in which patients and providers participate in a shared decision-making process about a health behavior change and select a single goal that the patient is activated to pursue, is linked to patient self-efficacy and behavior change[22–24] and is a key element of self-management education guidelines.[25,26] Prior research suggests that guiding collaborative goal setting with patient-generated data is efficacious, but no methods were available to do so for diet goal setting.[27] Therefore, our interdisciplinary team of nutrition scientists, technologists, and practicing clinicians developed *Nutri©*, a useful and usable clinical decision support software to solve barriers to personalized collaborative diet goal setting in primary care and demonstrated its feasibility in a clinic-cluster randomized trial (cRCT) in our partnering federally qualified health center (FQHC; i.e., safety net clinic) network.

Methods

We developed and evaluated Nutri in a series of three studies.

1. Nutri User-centered Design

Study Design: We conducted 30–60-minute user interviews with PCP and patient participants in an iterative process depicted in Figure 1. We began with an initial design prototype consisting of:

- diet data collection via the automated self-administered 24-hour recall tool (ASA24) a widely used online tool;
- a set of rules based on the USDA Dietary Guidelines to transform patient diet data into prioritized patient-specific goals;
- display screens that summarize the patient's diet data, present personalized and guideline-based recommendations, and guide PCPs through collaborative goal setting; and
- a personalized patient education handout and EHR visit note to record the goal selected during the visit and tips to support the patient in achieving it.

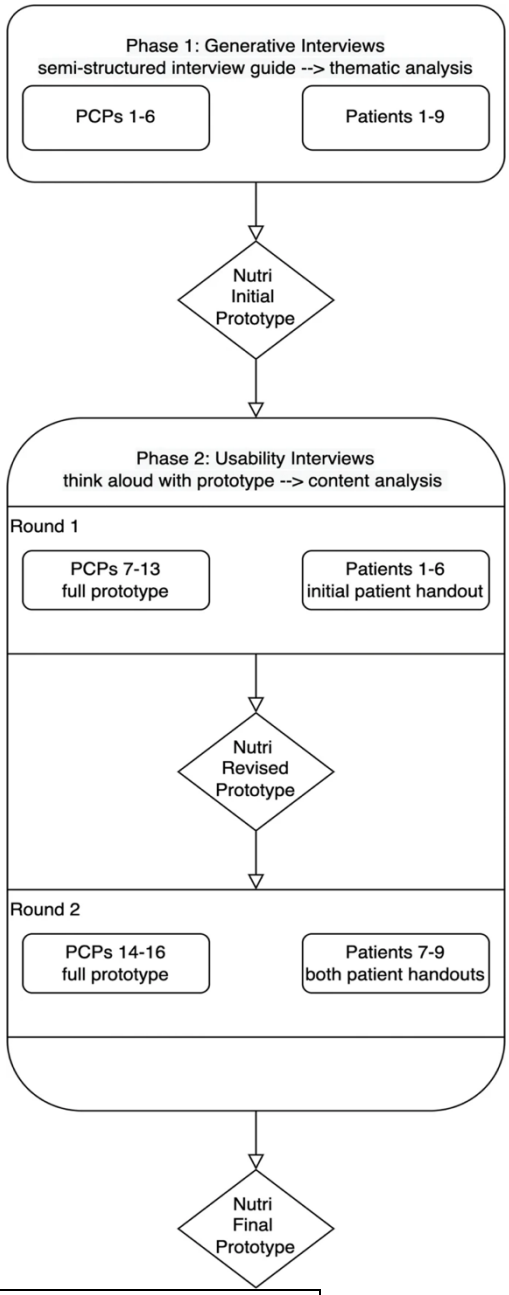
Participants: We recruited PCPs from our partnering FQHC network and from clinics serving un- and under-insured patients affiliated with Dell Medical School/University of Texas at Austin School of Nursing via email. We recruited adult patients from our partnering FQHC who met inclusion criteria (Table 1) via flyers distributed by clinicians on the study team. This project was approved by the University of Texas at Austin's Institutional Review Board (Protocol 2019-11-0038).

Table 1. Inclusion and Exclusion Criteria

	Inclusion Criteria	Exclusion Criteria
Patients	• Adult patients aged 18-65 • BMI ≥ 25kg/m^2 with a diet-related co-morbidity (e.g., hypertension, hypercholesterolemia, pre-diabetes) • Had ≥ 1 PCP visit in past 24 months • Fluent in either English or Spanish	• No diagnosis of cognitive deficit that would render the patient unable to provide informed consent
Clinical Staff	• Member of the clinic team who interacts with patients during a visit (i.e., PCPs, RNs, MAs, CHWs, front desk) • Employed at LSCC for ≥ 6 months	• Resident physicians or nurse trainees

Data Collection and Analysis: In Phase 1, we conducted semi-structured interviews with PCPs and patients with the goal of identifying supports and barriers to diet goal setting in primary care appointments. We used thematic analysis to code, synthesize, and generate themes. In Phase 2, we conducted two rounds of iterative prototype design and usability interviews using a "think-aloud" interview strategy. In these interviews, a research assistant walked PCPs through the prototypes of the entire tool or patients through prototypes of the patient education handout. Participants thoughts and reactions were recorded while they experienced the mockup and suggestions for improvement were captured in an interview. These interviews were coded using a content analysis approach with a set codebook of a priori codes related to content, usability, usefulness, and workflow integration that reflected common usability metrics and the themes identified in Phase 1.

Figure 1. Study Flow



2. Nutri Usability Testing

Study Design: We conducted lab-based testing of a HiFi prototype of the *Nutri* user interface prior to developing the software.
Participants: We recruited participants via email and word of mouth as in study 1 and included physicians, physician assistants, or nurse practitioners who were currently seeing adult patients for primary care. This study was designated exempt by the University of Texas Institutional Review Board.
Intervention: PCPs were asked to use the Nutri prototype in a simulated telehealth appointment with a standard patient actor who presented with diabetes, a diet-related chronic disease. Via Zoom, each consented PCPs viewed a 7-minute Nutri training video, practiced using the Nutri prototype with a study team member, and completed a simulated virtual diabetes follow-up appointment with a patient actor.

Data Collection: The session was video recorded and transcribed. Following the simulation, PCPs completed the System Usability Scale (SUS)[28] and Health Information Technology Usability Evaluation Scale (Health ITUES)[29] usability measures. Finally, PCPs completed a debriefing interview with a study team member according to the interview guide in Table 2.

Table 2. Nutri Lab Testing Interview Guide.

Domain	Question
Nutri Value	1. What about Nutri makes you want to use it with your patients? 2. Imagine one of your own patients that you could envision using Nutri with. How would you describe this patient? 3. Can you describe how using Nutri would change your patient encounters? 4. Are there ways that Nutri could improve your patient encounter? 5. In what situations would Nutri not work for you/your patient?
Nutri Usability	6. What would you change about Nutri? a. Are there any features that you would want to add, get rid of, or change? b. Where would you like to see these features in the Nutri workflow? 7. Were there any times when you were using Nutri that you felt stuck?

Data Analysis: Two study team members time coded each screen and feature used during a simulation. We calculated means, standard deviations, means and ranges for Health ITUES and SUS. We summarized interview responses using Rapid Qualitative Analysis [30] based on domains listed in Table 2 that represent key

information we wanted to glean from PCPs' immediate reactions. Within each domain, three coders inductively identified key value and usability themes, discussing themes to establish a consensus.[31]

3. Nutri Pilot cRCT

Study Design: 3-month Pilot cluster randomized controlled trial in 10 high-volume primary care clinics of a non-academic federally qualified health center network. PCPs were randomized to receive Nutri or control (usual care), stratified by training (MD/DO vs NP/PA) and self-reported need for interpreter for Spanish-speaking patients. Our prespecified hypotheses were: 1) patients whose providers received Nutri would have better a) diet goal setting, b) diet goal self-efficacy, and c) diet quality than patients whose providers did not receive Nutri; and 2) PCPs who received Nutri would have better diet counseling a) attitudes, b) competence, and c) self-efficacy than those who did not receive Nutri.

Participants: PCPs at our partnering clinic network who treat adult patients with or at risk for diabetes were recruited via clinic list servers, meetings, and messaging. Patients with upcoming appointments were recruited via text message; English- or Spanish-speaking patients ages 18-65 on the clinic's diabetes registry were included.

Interventions: PCPs randomized to Nutri were trained and received Nutri reminders prior to and at the time of each appointment. Nutri PCPs received a 10-minute training video on theory-based diet counseling, a live Nutri demo, and Q&A; Control PCPs received training on a health record alerting tool.
Data Collection: Among PCPs in the treatment group, PCP software usage data was collected via software logs, PCP satisfaction with Nutri was collected via an in-app pop up item, and SUS was collected at posttest. All PCPs completed common survey measures to assess diet counseling competence, attitudes, and self-efficacy at baseline and post-test. Patient diet quality was calculated using standard methods for calculating Healthy Eating Index from 24-hour diet recalls collected via ASA24 at baseline and 1-week post study visit. Patient self-reported behavioral intention and diet behavior change self-efficacy were assessed 1 day post study visit.

Analysis: We described measure and trial completion among patients and PCPs. Among those PCPs in the Nutri condition, we described Nutri usability and satisfaction. We used an intent-to-treat approach for our patient and PCP trial outcomes analyses. To assess Nutri's impact on patient outcomes, we compared patient behavioral intention, self-efficacy, and diet quality using mixed effects logistic and linear regression models that accounted for clustering of patients within PCPs. To measure the effect of Nutri on patient outcomes, we applied a Bayesian approach, partly due to the potential for unstable frequentist estimates for parameters of interest given the small sample size and small numbers per cluster. For binary outcomes, we fit a random effects probit regression model with a fixed effect at the cluster (PCP) level for treatment arm (Nutri vs. control) and a random cluster-level intercept. For continuous outcomes we used linear mixed effects models. Using Bayesian posterior parameter inferences and, for binary data, established analytic formulae for averaging over random effects in probit models[32], we calculated the response prevalence for treatment and control, the average between the two groups, the average (across groups) within-group within-PCP covariance, variance, and ICC (the ratio of covariance to variance). Bayesian computations were performed using the 'bayes' suite of functions in Stata v.18 (StataCorp. 2023. Stata Statistical Software: Release 18. College Station, TX: StataCorp LLC). For the Healthy Eating Index (HEI), we included the pre-intervention HEI value as a covariate; the estimated mean HEI value in each arm is adjusted to the overall mean pre-intervention HEI value.

Results (Principal Findings, Outcomes, Discussion, Conclusions, Significance, Implications).

Principal Findings

Nutri was developed through an iterative process that involved 16 PCPs who practice in clinics serving un- and under- insured patients and 9 patients from our partnering FQHC network. During three rounds of design and testing, we tuned the amount of information, its format, and the patient-provider communication workflow until both PCP and patient participants were confident *Nutri* would facilitate collaborative diet goal setting. Subsequently, in our user testing in simulated primary care appointments, 100% of participating clinicians achieved *Nutri*'s main objective: selecting one high impact diet goal during a collaborative goal setting

discussion with the patient actor. PCPs increased their diet counseling self-efficacy after using *Nutri* in just one simulation. In usability assessments, all PCPs agreed or strongly agreed that *Nutri* would be a positive addition to chronic disease management, would make setting a nutrition goal easier and more likely, and would be useful in improving provider collaborative diet goal setting. The PCPs participating in our simulation study found *Nutri* to be easy to use, efficient, and helpful in collaborative dietary goal setting, one stating, *"I aspire to spend so much more time on nutrition, but I think [Nutri] would help anchor me, certainly...so I don't feel so lost talking about nutrition to patients."*

Then, we conducted a 2-arm pilot cluster randomized controlled trial (NCT05436041) at our partnering FQHC network to assess *Nutri*'s feasibility. *Nutri* earned above-average System Usability Scale (SUS) scores from PCPs, who were satisfied with how *Nutri* helped them talk about diet with their patients. PCPs used *Nutri* in 100% of appointments during which it was presented. Nutri PCPs significantly improved in diet counseling competence compared to control PCPs. Over the pilot recruitment period, we recruited 16 PCPs. 66 patient participants completed informed consent and baseline demographic surveys and 88% of these patients completed ASA24. We recruited an average of 17 patients per monthly text message recruitment push and successfully followed 100% of enrolled patient participants through post-test, including post-test diet data collection with ASA24.

Our pilot trial indicates Nutri's feasibility in a real clinic setting: PCPs in different clinics used Nutri with patients during appointments and improved their diet counseling competence by using Nutri. Furthermore, our results suggest that most patients whose PCPs used Nutri with them had initiated their goal at 1 week. These are important precursors to metabolic improvements, indicating the potential for Nutri to meaningfully impact health. Finally, patients were successful with diet data collection and all those enrolled in the trial were successfully followed through the endpoint.

Outcomes

AIM 1: Developing a user-centered and clinical workflow-compatible CDSS by engaging key stakeholders in iterative feedback and testing.

In phase 1 we identified four main themes from PCP participants and four main themes from patient participants regarding patient-provider discussions about nutrition, as described in Table 3.

Table 3. Themes from Generative Interviews with PCPs and Patients

PCPs	Patients
there is limited time in primary care for personalizing dietary goals	clinicians are authority figures, and patients want to discuss their diets with them
current processes for collecting dietary data and goal setting are subjective and non-standardized	having dialogues with their clinicians, who listen, is necessary to generating trust and sharing decision-making
patients' reported diet information is often inaccurate and cannot generate holistic views of patients' diets	data about patients' current diet should drive dietary goal setting discussions
existing clinical workflows make setting and monitoring dietary goals cumbersome	setting goals is different from actually achieving them

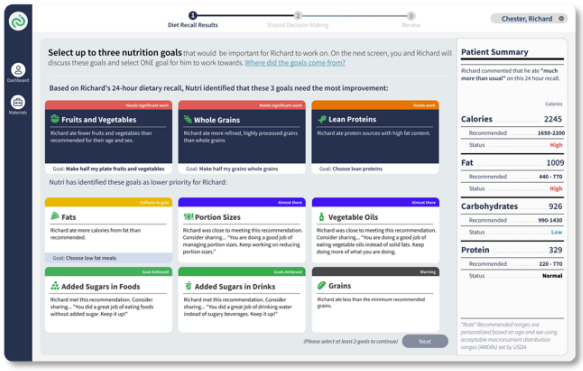
These themes yielded design parameters for our initial prototype:

a. clinician-patient dietary goal setting discussions using Nutri should take 2 min or less;
b. clinicians should not be inundated with excessive patient diet data; and
c. clinicians would share Nutri's screens with their patients by swiveling their laptop computers, so the interface had to be understandable to both clinicians and patients.

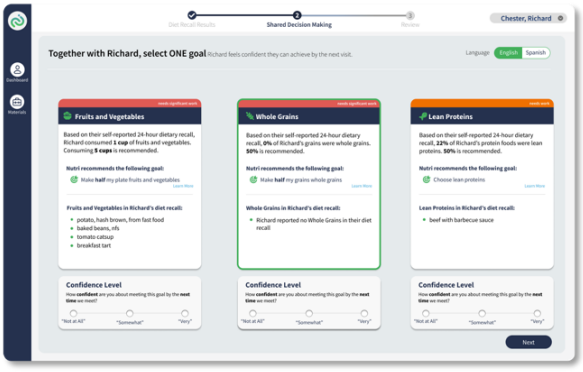
In our first round of "think aloud" usability interviews, PCPs suggested improvements to the interface. We also noted that PCPs selected their "favorite" goal to talk about with the patient, rather than focusing on the goal recommended by Nutri's algorithm. In a second interface design iteration, we enhanced the prominence of the Nutri-recommended goals, which seemed to alleviate this issue. During this round of think aloud usability interviews, PCP participants recommended including more patient data in the interface to support the goal recommendations. A final round of usability interviews confirmed a viable prototype for collaborative goal setting. In our think aloud usability interviews with patients, they reacted to printable patient nutrition education

handouts. In the first round, patients sought more information to facilitate goal success and less quantitative information about how close or far they were from the goal. In a second round of usability interviews with a revised handout, patients confirmed the value of including tips and recommendations, but indicated the need for more clarity. This information guided the final design (Figure 2).

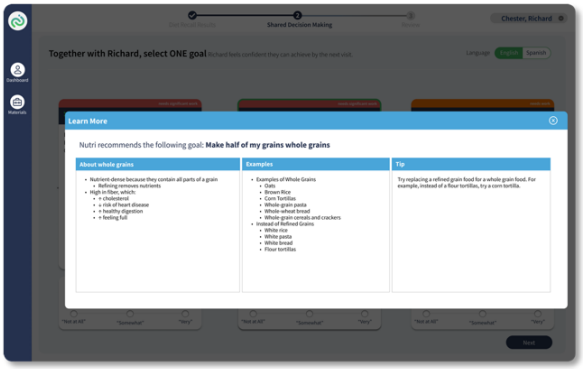
Figure 2. Final Nutri Prototype.



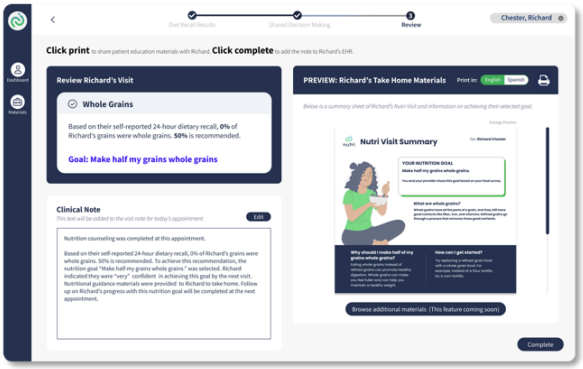
Nutri Screen 1, Diet Recall Results Page



Nutri Screen 2, Shared Decision Making Page with goal selected



Nutri Screen 2, Shared Decision Making Page with learn more pop out displayed



Nutri Screen 3, Review Visit Page

AIM 2: Testing the CDS in a controlled "lab" setting and refining it based on results.
We tested a HiFi clickable prototype of Nutri with 10 practicing PCPs in a simulated telehealth appointment with a standard patient (i.e., patient actor). Participant characteristics are presented in Table 4.

Table 4. Demographic Characteristics of Lab Testing Participants (n=10)

Characteristics	Mean ± SD(Range) or n (%)
Age (years)	
Mean (SD), years	43.5 ± 8.09 (37-62)
Years of post-graduate practice	
Mean (SD), years	11 ± 7.94 (2-25)
Time discussing nutrition in typical appointment	
Mean (SD), self-reported in minutes	2.9 ± 1.79 (1-7)
Gender	
Male	4 (40%)
Female	6 (60%)
Ethnicity	
Hispanic/Latinx	1 (10%)
Race	
Asian	3 (30%)
White	3 (37.5%)
Credentials	
MD/DO	10 (100%)

The proportion of PCP participants completing each step of the Nutri collaborative diet goal setting workflow with the patient actor is presented in Table 5. 100% of participating clinicians achieved Nutri's main objective: selecting a high impact diet goal during a collaborative goal setting discussion with the patient.

Table 5. PCPs Completing Nutri Collaborative Diet Goal Setting Workflow, By Step (n=10)

Nutri User Interface Step	Shared Screen with patient	Discussed with patient
Results Summary Screen 1	90%	90%
Collaborative Goal Setting Screen 2	100%	100%
Learn More Pop-out	50%	50%
Confidence (part of Screen 2)	n/a	90%
Review Screen 3	100%	60%
Patient Handout (part of Screen 3)	n/a	70%

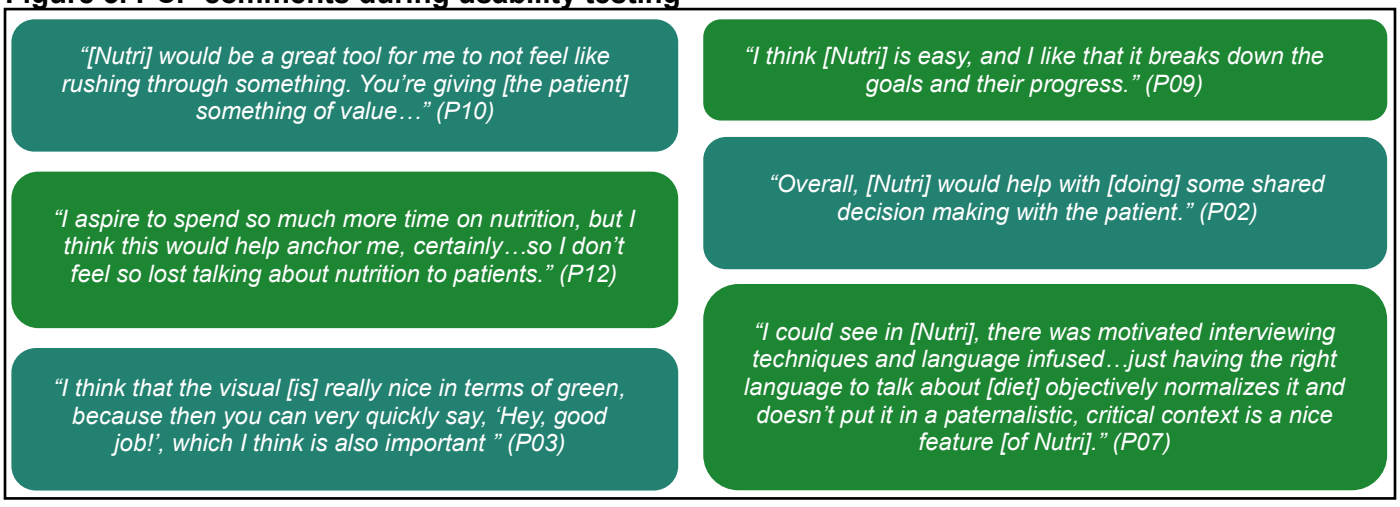
PCP participants found Nutri to have good usability on general and HIT specific measures, shown in Table 6.

Table 6. Nutri Usability as Rated by PCPs at Conclusion of Lab Testing (n=10)

	Mean (SD)	Median (Range)
System Usability Score (SUS)	**77 ± 16.4**	**75 (45-97.5)**
Health ITUES	**4.1 ± 0.8**	**4.2 (3.1-5)**
Notes: SUS is industry standard for usability, 68 considered above average usability. Health ITUES is scored 5-point scale where 1=Strongly Disagree and 5=Strongly Agree		

Qualitative interviews with PCP participants indicated they found Nutri usable, potentially timesaving, and increased their diet counseling self-efficacy, with key quotes shown in Figure 3.

Figure 3. PCP comments during usability testing



AIM 3: Deploying the CDS in a clinic-based pilot cluster randomized trial to evaluate trial and intervention feasibility.

Trial feasibility

Of 33 eligible PCPs, 16 (48%) agreed to participate, consented, and completed post-test. We sent 4239 recruitment text messages to medically eligible patients of these PCPs throughout the 6-month patient

recruitment period. The recruitment flyer was viewed 355 times, 157 screeners were completed, and the consent form was viewed 137 times. Sixty unique patients consented to participate, and 53 (88%) completed baseline measures, including ASA24, prior to their appointment. Of these, 30 (57%) kept a scheduled appointment during the trial period and were initiated; all were retained through follow up, as shown in Figure 4. Participant characteristics are presented in Tables 7 and 8.

Figure 4. CONSORT Diagram for Nutri Pilot Trial.

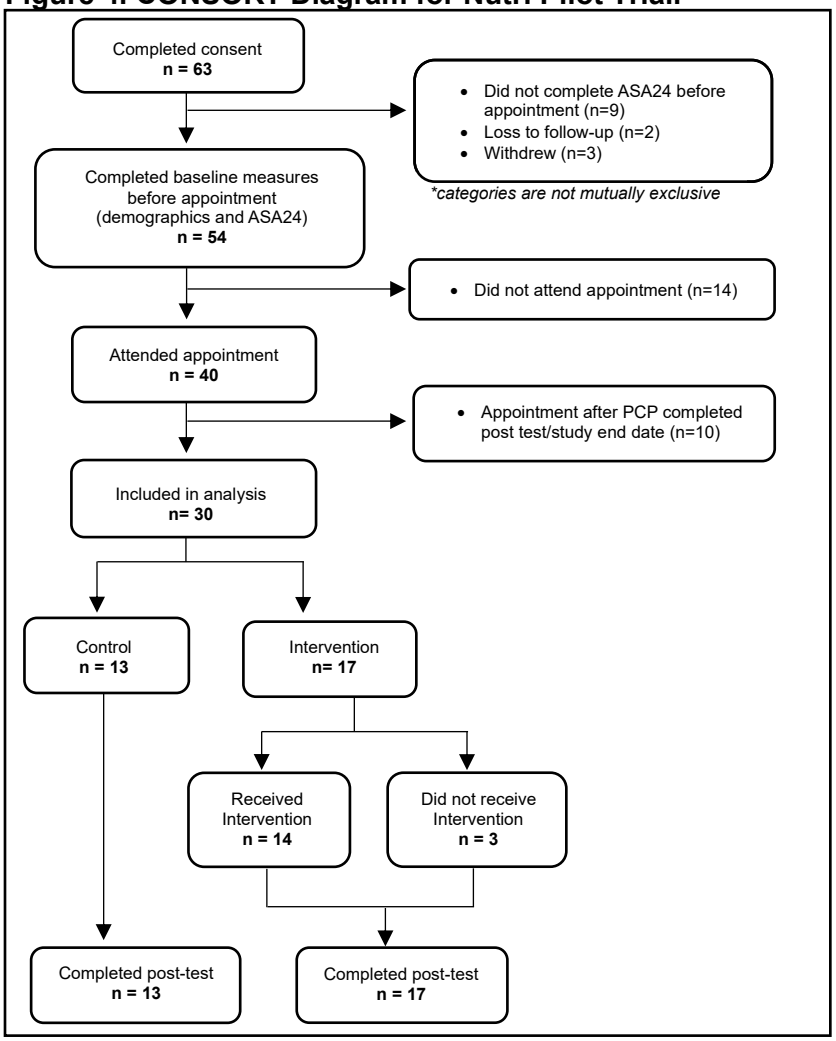


Table 7. Description of Nutri Pilot Trial Participant Primary Care Providers (n=16)

	Control (n=8)	**Nutri** (n=8)
Age (years)		
Mean (SD), years	39.9 ±11.4	44.9 ±15.3
Years of post-graduate practice		
Mean (SD), years	4 ± 2.1	14.6 ± 13.4
Time discussing nutrition in typical appointment		
Mean (SD), self-reported in minutes	6.13 ± 3.3	6.5 ± 4.1
Gender		
Male	0 (0%)	4 (50%)
Female	8 (100%)	4 (50%)
Ethnicity		
Hispanic/Latinx	1 (0%)	2 (25%)
Race		
Asian	4 (50.0%)	3 (37.5%)

	Control (n=8)	**Nutri** (n=8)
Black	2 (25%)	1 (12.5%)
White	1 (12.5%)	3 (37.5%)
Credentials		
MD/DO	4 (50%)	4 (50%)
PA/NP	4 (50%)	4 (50%)
Spanish-speaking		
Yes	2 (25%)	2 (25%)

Table 8. Description of Nutri Pilot Trial Participant Patients

	Control n=13	**Nutri** n=17
Age (years)		
Mean (SD)	48.6 (12.0)	47.6 (9.3)
Biological Sex		
Male	5 (38.5%)	6 (35.3%)
Female	8 (61.5%)	11 (64.7%)
Ethnicity		
Hispanic/Latinx	5 (41.7%)	11 (64.7%)
Not Hispanic/Latinx	7 (53.8%)	6 (35.3%)
Race		
Black or African American	2 (15.4%)	2 (11.8%)
American Indian/Alaska Native	1 (7.7%)	0 (0%)
Asian	0 (0%)	0 (0%)
Native Hawaiian/Pacific Islander	0 (0%)	0 (0%)
White	10 (76.9%)	13 (76.5%)
Other	0 (0%)	1 (5.9%)
Language		
English	13 (100%)	13 (76.5%)
Spanish	0 (0%)	4 (23.5%)
Income		
Does not have enough to get by	6 (46.2%)	6 (35.3%)
Enough to get by	5 (38.5%)	11 (64.7%)
More than enough to get by	1 (7.7%)	0 (0%)
Missing	1 (7.7%)	0 (0%)
Computer Use		
No	11 (84.6%)	9 (52.9%)
Yes	2 (15.4%)	8 (47.1%)
Health Literacy		
Mean (SD)	3.6 (1.0)	3.7 (0.9)

Intervention feasibility

Of consented patients (n=63), 55 completed ASA24. 20 received assistance from a bilingual research assistant with training in diet recalls and ASA24, ranging from asking the RA a question to dictating the recall for the RA to enter in the ASA24 system. PCPs set a diet goal with their patient 100% of times Nutri was presented during an appointment. 16 of 18 goals set (89%) were a Nutri-recommended or warning-related goal (some occurred after the trial end date and patient participants were not included in the trial analysis). Mean ±SD PCP satisfaction post-encounter for 13 encounters with Nutri for which PCPs recorded satisfaction scores was 3.8±0.2 on a 1-5 scale. At the conclusion of the pilot, each intervention group PCP who used Nutri with at least one patient (n=6) completed the SUS and the average (SE) score was 75±6.9.

Effect on PCP diet counseling and proximal indicators of patient dietary behavior change.
Although the pilot trial was not powered to assess efficacy, we compared PCP diet counseling and proximal indicators of patient dietary behavior change between treatment and control to assess direction and magnitude.

PCPs. Nutri PCPs (n=8) had greater diet counseling competence at posttest compared to control (n=8) (b=0.72; p=.003) controlling for baseline competence, model F=15.9; p=.0003; adjusted R squared=0.66). Other PCP outcomes are described in Table 9.

Table 9. PCP-reported competence, self-efficacy & attitudes, mean (SD) (4-point scales)

	Control (n=8)		Nutri (n=8)				*Model*		
	Pre	Post	Pre	Post	*b*	p	F	p	Adj.R2
Competency[a]									
Total Score[b]	2.83 (0.61)	2.82 (0.63)	2.41 (0.50)	3.15 (0.64)[d]	0.73	0.003	15.91	0.0003	0.67
Assess Subscale	2.90 (0.58)	2.94 (0.64)	2.40 (0.50)	3.10 (0.68)	0.77	0.02	6.37	0.01	0.43
Advise Subscale	2.88 (0.58)	3.00 (0.89)	2.69 (0.65)	3.19 (0.70)	0.34	0.33	4.00	0.04	0.29
Agree Subscale	2.79 (0.73)	2.71 (0.70)	2.33 (0.84)	3.29 (0.62)[d]	0.85	0.01	6.88	0.01	0.46
Assist Subscale	2.69 (0.80)	2.50 (0.76)	2.25 (0.60)	3.00 (0.80)	0.83	0.01	7.08	0.008	0.45
Arrange Subscale	2.75 (0.65)	2.75 (0.46)	2.44 (0.42)	3.06 (0.68)	0.50	0.07	3.87	0.05	0.28
Self-Efficacy[c]									
Confidence in ability to have effective discussion about nutrition with a patient	3.25 (0.71)	2.88 (0.64)	3.12 (0.35)	3.38 (0.52)	0.55	0.06	2.97	0.09	0.21
Confidence that patient leaves an appointment with an achievable nutrition goal	3.00 (0.76)	2.88 (0.64)	3.00 (0.53)	3.38 (0.52)	0.50	0.11	1.65	0.23	0.08
Attitudes[c]									
Bias/Discomfort	1.75 (0.50)	1.54 (0.50)	1.42 (0.43)	1.17 (0.36)	-0.11	0.40	23.1	<0.001	0.75
Success	2.83 (0.47)	2.75 (0.58)	2.75 (0.39)	2.88 (0.73)	0.18	0.58	1.38	0.29	0.05
Positive Outcome Expectancy	3.00 (0.53)	3.00 (0.50)	3.00 (0.53)	3.19 (0.63)	0.19	0.48	2.47	0.13	0.17
Negative Outcome Expectancy	2.50 (0.65)	2.31 (0.65)	2.38 (0.88)	2.14 (0.75)	-0.02	0.94	11.49	0.002	0.60

Note: Models are differences in treatment and control at post, controlling for baseline
[a] Scale: 1=know very little about, not able to perform; 2 = know something about and somewhat able to perform; 3 = able to perform well; 4=able to teach others how to perform
[b] PCP overall competency score computed by averaging completed responses of validated measure
[c] Scale:1=strongly disagree; 4=strongly agree
[d] n=7, missing data

Patients. We found limited variability in patient-reported outcomes measured on 7-point Likert-like scales. Therefore, for behavioral intention (mean ±SD = 6.2±1.4) and self-efficacy (mean ±SD = 5.9±1.8), we calculated a binary variable representing high (score=7) vs. any response <7. We detected no significant differences in goal setting, behavioral intention, self-efficacy, or HEI in patients at post-test. Response prevalence (binary outcomes) and median scores (continuous outcome) in treatment and control and ICC are presented in Table 10.

Table 10. Patient Behavioral Outcomes

	Median	**95% Credibility Interval**	
Goal Setting Prevalence			
Control	74%	47%	93%
Nutri	83%	60%	95%
ICC	0.12	0.03	0.67

	Median	95% Credibility Interval	
Behavioral Intention Prevalence			
Control	64%	34%	87%
Nutri	60%	36%	83%
ICC	0.14	0.03	0.76
Self-Efficacy Prevalence			
Control	56%	29%	81%
Nutri	54%	30%	77%
ICC	0.15	0.04	0.87
Healthy Eating Index Mean			
Control	52.5	43.7	61.0
Nutri	52.6	45.5	59.7
ICC	.09	0.03	0.23

Finally, we assessed the degree to which Nutri patients' post-test diet recalls indicated that they changed their diet in the area related to the diet goal they set in their appointment (i.e., goal initiation), presented in Table 11. Patients initiated the selected goal approximately half the time.

Table 11. Nutri Goal Initiation by Patients Who Received Nutri in Primary Care (n=14)

Goal	Frequency Selected	Goal Initiation at 1 week
Make half my plate fruits and vegetables	5	4
Make half my grains whole grains	1	0
Choose lean proteins	1	0
Choose low fat meals	1	1
Choose vegetable oils over solid fats	1	0
Drink water instead of sugary drinks	2	2
Choose meals without added sugar	1	0
Reduce the portion sizes on my plate	2	1
Make one fourth of my plate grains	0	NA
TOTAL	**14**	**8 (57%)**

Notes: initiation defined as an improvement in Nutri goal ranking on the selected goal at post-test compared to pre-test.

Discussion

That PCPs used Nutri on 100% of occasions we presented it to them indicated we achieved our goal of developing a CDSS that PCPs found valuable enough to use for a few minutes during an appointment. By comparison, 30-40% is considered an effective CDSS usage rate.[33] In SPHERE, a pragmatic pilot trial of a CDSS to improve patient-provider communication about lifestyle behaviors for stroke prevention, the interactive tool was used with 25% of eligible patients during a 1-year study.[34] Our high usage rate may be explained by having involved PCPs from this network (and their patients) in designing Nutri[11] in order for Nutri to be useful, not just useable. For example, in usability testing, PCPs reported Nutri's goal setting process made them feel they were providing something of value to the patient.[35] Nutri earned above-average usability scores from PCPs, who were satisfied with how Nutri helped them talk about diet with their patients. This is similar to provider satisfaction results from SPHERE.[34]

Despite our pilot not being powered to detect differences in behavioral outcomes, we gained valuable insight for future trials of Nutri. First, despite our hypothesized theoretical pathway between self-efficacy and behavior change, we identified limited variability in patient diet goal self-efficacy and were thus unable to evaluate self-efficacy's role in our results. This is consistent with research identifying ceiling effects in many patient experience survey measures.[36] Future evaluations should use more comprehensive measures to assess self-efficacy in this context. Additionally, while post-test diet recalls indicated no difference in HEI between Nutri and control patients, our exploratory analyses found over half the Nutri patients initiated the diet goal they set in their appointment. Improving in one area of the dietary guidelines by initiating a Nutri goal could be an important first step to improved diet quality. This should be tested in a larger, longer-term trial.

We recruited individual PCPs, thus our sample may have been subject to selection bias and limit the generalizability of our results. A future trial may reduce this bias by randomizing clinics or clinic networks instead of individual PCPs. PCPs who volunteered to participate may have been inherently more interested in talking about diet with patients, which could also explain why many control patients reported setting a diet goal

with their PCP. Second, a single 24-hour diet recall precludes estimation of usual intake. In designing Nutri, we balanced this against participant burden and chose to train PCPs to recognize that Nutri presents a “diet snapshot” and should be used to collaboratively set a diet goal with the benefit of insight into what the patient had recently eaten. Finally, this pilot feasibility trial was not powered to detect significant differences in patient or PCP outcomes. Therefore, our null result should not be considered confirmatory evidence that Nutri has no effect on goal setting, behavioral intention, self-efficacy, or diet quality. On the other hand, the statistically significant improvement in PCP counseling competence does indicate a meaningful effect of Nutri on this outcome.

Conclusions

PCPs successfully completed the Nutri workflow, with moderate satisfaction and high usability ratings. Diet counseling competency significantly increased among Nutri PCPs compared to control. Self-efficacy trended positively. Therefore, Nutri can play an important role in supporting efficient, evidence-based dietary counseling in primary care.

Significance

Our results suggest that Nutri, a user-centered clinical decision support tool for collaborative diet goal setting is feasible for use in primary care. Point of care tools that support shared decision making, like Nutri, may therefore influence relevant healthcare quality outcomes, and should be tested in a future trial.

Implications

This pilot project evaluated the feasibility of a user-centered clinical decision support tool. While providers often ignore and avoid CDS because it interrupts their workflow, we demonstrated with Nutri that CDS can be highly usable when designed with a breadth of input and testing with end-users to do something that providers find to be valuable to providing care.

Publications and Products

2023 Tierney WM, Henning JM*, Altillo BS, Rosenthal MM*, Nordquist E, Copelin K, Li J, Enriquez C, Lange J**, Larson D*, **Burgermaster M.** User-centered design of a clinical tool for shared decision making about diet in primary care. *Journal of General Internal Medicine;* 38(3): 715-729.

2023 **Burgermaster M,** Rosenthal M*, Tierney WM, Altillo BS, Nordquist E, Enriquez C, Andrews S, Klatt C**, Daniels G. Nutri: A behavioral science-based and patient data-driven clinical decision support for chronic disease management. *Proceedings of the 2022 AMIA Annual Symposium* 2022:299-308.

2024 **Burgermaster M**, Rosenthal MM*, Altillo BS, Rendon Flores M*, Nayak E**, Larson DN*, Custer J, Okunade A, Tierney WM, Andrews S, Daniels G, Rathouz PJ. Pilot trial of *Nutri©*, a multi-level digital behavior change intervention for personalized dietary management of diabetes in safety net primary care clinics [Under Review at *Journal of Nutrition Education and Behavior* 2/8/24]

INVITED TALKS

2023 Two Examples of Applied AI in Nutrition Education Research, SNEB Webinar Innovations in Nutrition Education: Leveraging AI in Teaching and Research, November 19.

2023 Diabetes, Diet, Data, and Disparities: Leveraging Technology to Make Nutrition Education Interventions Actionable and Equitable, Digital Physical Activity and Diet Collaborative Symposium, UT School of Public Health, September 28-29.

2023 Teaching the clinical experience of nutrition: *Nutri©* as a resident physician training tool. Summit on Medical Education in Nutrition, American Council on Graduate Medical Education, March 12-14.

2022 Endocrine Grand Rounds: Making Precision Nutrition Actionable and Equitable. University of Alabama Birmingham, April 14.

2022 Diabetes, Diet, Data, and Disparities: How *Nutri©* Came to Be. UT Austin School of Human Ecology School Advisory Committee Annual Meeting, April 22.

2021 Diabetes, Diet, Data, and Disparities: Making Precision Nutrition Actionable and Equitable. AMPATH México (collaboration between UT Austin and Benemérita Universidad Autónoma de Puebla (BUAP)), May 27.

Peer-reviewed conference presentations

2023 Altillo BA, Rosenthal M*, Tierney WM, Okunade L, Rendon-Flores M*, Nayak E**, Andrews S, **Burgermaster M**. Nutri: preliminary results from a feasibility pilot trial of a clinical decision support for collaborative diet goal setting in primary care. Society for General Internal Medicine Annual Conference, Aurora, CO, May 10-13, 2023.

2023 **Burgermaster M**, Rosenthal M*, Altillo B, Tierney W, Okunade L. Interactive Diet Goal Setting Software for Primary Care Improves Provider Obesity Counseling Competence: The Nutri Pilot RCT. *Journal of Nutrition Education and Behavior*. 2023 Jul 1;55(7):25.2023

2023 Rosenthal M*, Flores MR*, Randecker A*, **Burgermaster M**. P24-108-23 Automated Self-Administered 24-Hour Dietary Assessment Tool (ASA24) for equitable diet data collection in primary care. *Current Developments in Nutrition* 2023 Jul 1

2023 **Burgermaster M,** Rosenthal M*, Nayak E*, Larson D*, Altillo B, Tierney W, et al. P28-009-23 Nutri©, clinical decision support to incorporate precision behavioral nutrition in primary care: preliminary results from a pilot trial. *Current Developments in Nutrition* 2023 Jul 1

2021 Rosenthal M*, Larson D*, Henning J*, Nayak E**, Dala G**, Martinez K**, Altillo BA, **Burgermaster M**. P93 Precision behavioral nutrition: development of the NutriPCP inference engine for data-driven diet goals in primary care. J*ournal of Nutrition Education and Behavior*. 2021 Jul 1;53(7):S67.

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